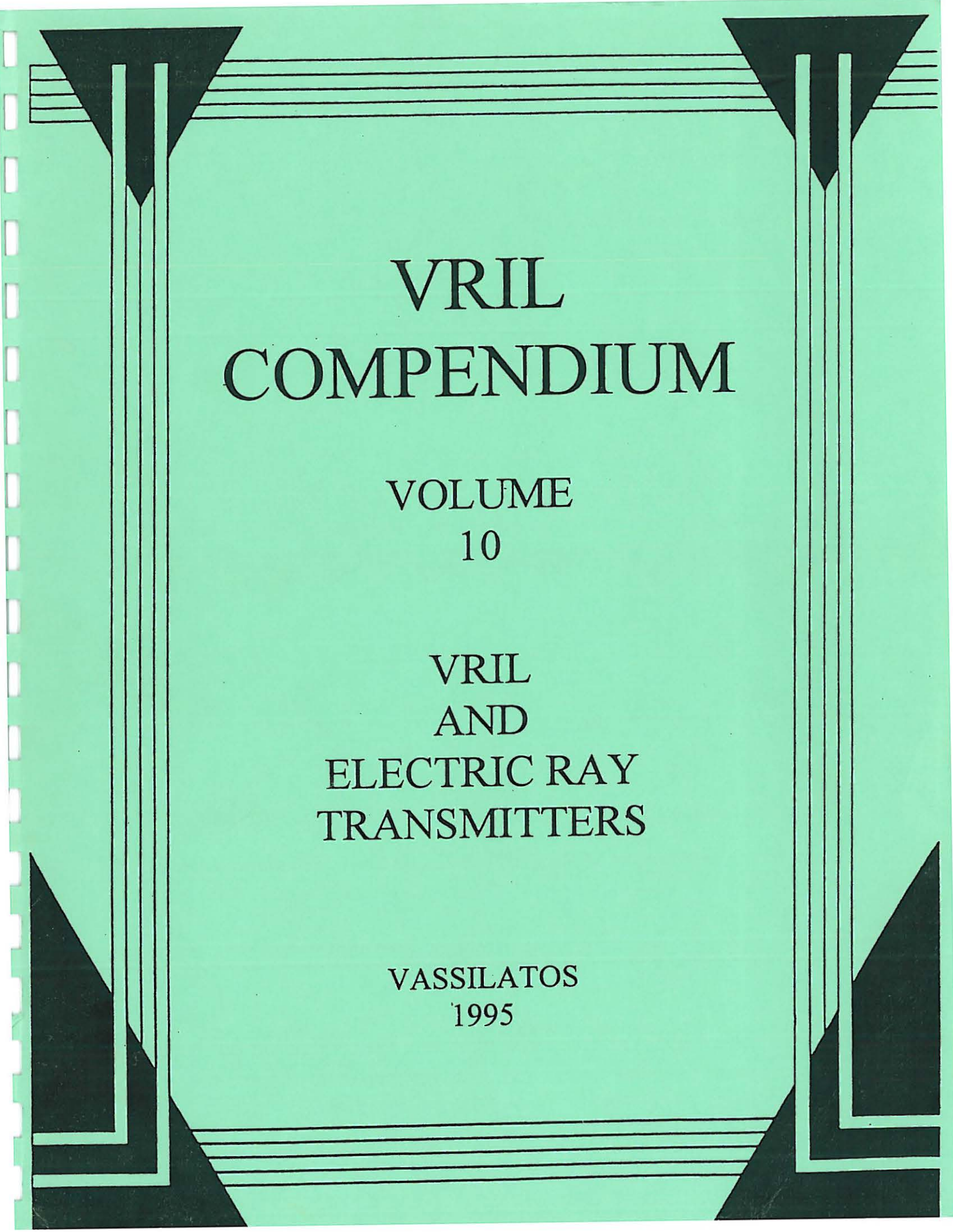




VRIL COMPENDIUM

VOLUME
10

VRIL
AND
ELECTRIC RAY
TRANSMITTERS

VASSILATOS
1995

VOLUME
10

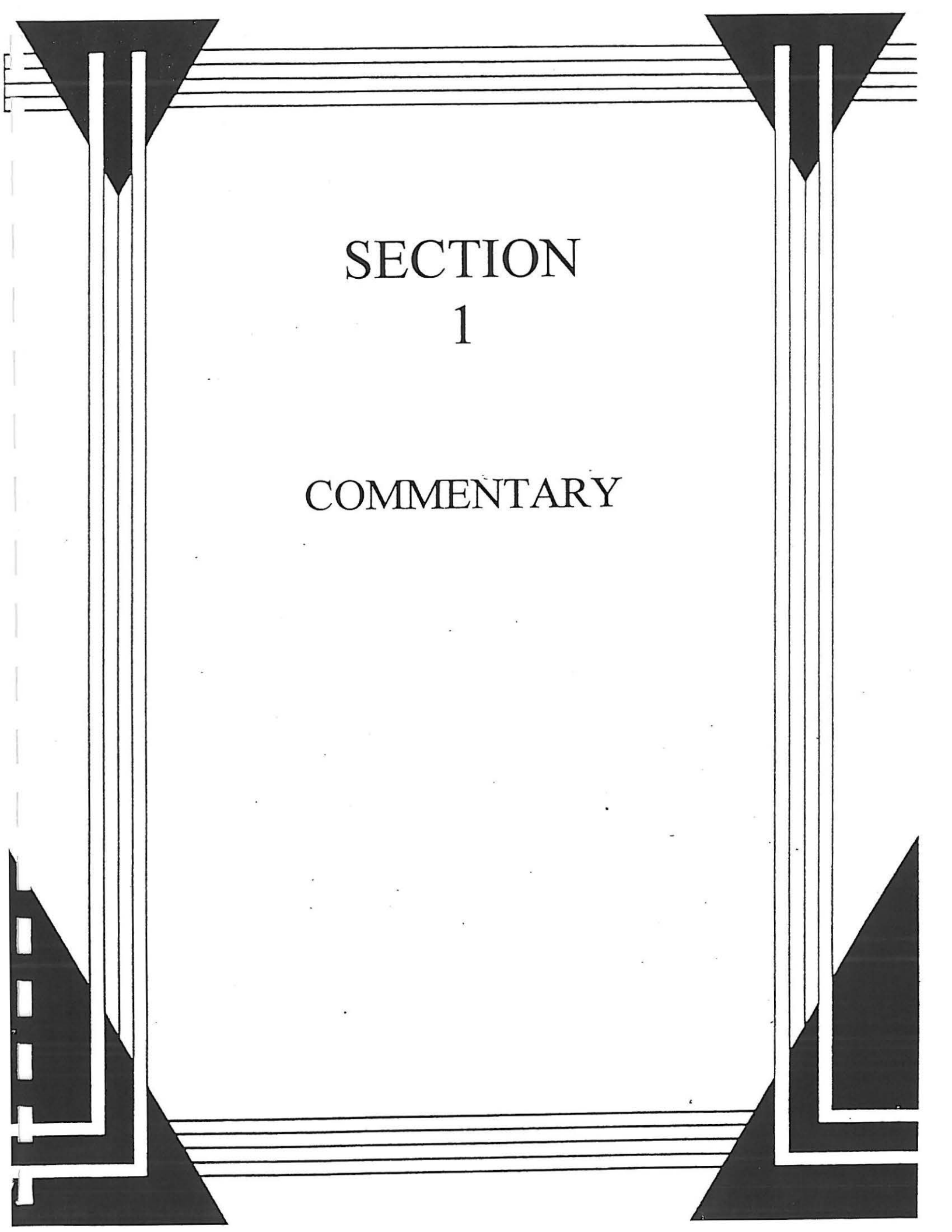
TABLE OF CONTENTS

COMMENTARY

PHOTOPHONES
AND
RADIOPHONES

RAY GENERATORS
AND
TRANSMITTERS

VRIL SIGNALS
AND
RAYS



SECTION

1

COMMENTARY



VOLUME 10

VRIL AND ELECTRIC RAY TRANSMITTERS

10.1 VRIL AND CONSCIOUSNESS

No treatise which deals with energetic rays and beams can be considered complete without discussing the conscious interactions which they stimulate when passing through the terrestrial environment. New understanding always begins with basic examinations of how we perceive and how we know. This epistemological examination of the world becomes experiential only when combined with qualitative method, the ancient scientific means. Conscious examinations of the world require guidance and discipline. It is only then that students are able to recognize the distinctions in experience which normally eludes their ordinary perception of the world.

Conscious examinations engage the process which modernists refer to as metacognition. Examining one's awareness is a skill which quantitative analysts do not any longer engage as a valuable world-examining tool. Nevertheless, our own consciousness is the laboratory through which the most remarkable realizations concerning the world are made. In fact, it is only through the laboratory of our consciousness that we discover the most wonderful fact concerning the world and its condition, a fact which children innately know and experience: that the world is based in consciousness, and not in matter. The world is a magickal composite of projected realities; a nexus of blended experiential terraces. Of this however, deeper mention will be made as we progress in our treatise. We must first address certain accessible modes by which the world may be known in the deepest manner. Rediscovering the conscious foundations of the world is rediscovering the magick by which it is both generated and sustained.

Before we begin, we must clearly distinguish the terms "inertial space" and "experiential space". Experiential space is a shared reality. Experiential space does not stop at the boundary of our skin. It permeates us completely. We are thus completely fused with experiential space. The Vril Matrix is this experiential space, a stratum from which consciousness and sensation are both drawn. More than this, the Vril Matrix is a stratum where our deepest feelings and imaginal representations can be wordlessly projected and shared. Vril changes modify our experience. Our experience modifies Vril. Through Vril connectivities, real connective discharges through our bodies, we are in total communion with our world. Rare and furtive in occurrence, there are times when it seems as though a window to this world communion opens. Other times this experience is absent. We notice that these world communions occur with greatest frequency in certain places. What then is it which blocks and resists us?

Inertial space occludes the full experience of the deepest Vril domain. How does it accomplish this? Vril experience, eidetic experience, occurs entirely in the auric anatomy. The aura is the seat of all sensation and consciousness. Vril is the source and

sustainer of the aura, feeding it through innumerable connections which permeate the skin. These thready and feathery discharges enter into the specific physiological locus associated with the solar nerve plexus, exiting through the lumbar region. We infer that auric "terminals" indicate auric anatomy, a structure which remains mysteriously cloaked in flesh. Only medieval drawings reveal somewhat of the auric anatomy, having been intuitively derived by visionary sensitives. The chambers and interdigitating layers drawn by these pre-dissection medical practitioners reveals physiological infrastructure which determines physiology. Auric threads continuously enter and exit physiology because they maintain auric integrity. When this process is in any way occluded, greatly diminished perception, consciousness, and physiological vitality are experienced.

It has been found that personal experiments, conducted in the immediate accessible environment, best stimulate and initiate the student. Such personal experiments are simple. They form the collective thesaurus upon which the ancient sciences were based. Subjective experiments deny the explanations and filters which have been absorbed by academic encounters. This is a qualitative science which has not been widely proliferated in our time. Through it, one may acquire sufficient initiatory awareness before reaching a complete appreciation of the Vril thesis.

Penetrated focus on any specific world point brings the examiner into and through layers of conscious experience. Continued penetration of matter through this conscious focussing process reveals the power of mind over inertia. Matter can be permeated by the mind. One can literally think through objects. But our intention is first to present the reader with a small personal experiment which will initiate awareness on the interactions occurring between mind and matter.

Vociferous objections to this experimental procedure usually come from objectivists, whose worldview is completely quantitative in nature. Nevertheless, what they refer to as "Ganzfeld phenomena" are not satisfactorily explained as visual displays entirely produced in the retina. Ganzfeld phenomena are only partly explained by assuming them to be the projections of mind on the eye. They are most certainly the result of conscious projectivity through the ocular region, producing photochemical effects. Assuredly, the actual experience gained through this method is not photochemical in nature. Photochemistry follows the flow of energy which joins observers and objects. Knowing the photochemistry does not in any way inform experience or modify that experience.

Because these visual displays are most certainly modified by object geometries and substance, they indicate a fundamental unity between the observer and the observed. Experiments have been performed by using identical objects made of differing substances. The results would produce a revolution in the quantitative camp, were they not ignored. In Ganzfeld phenomena we recognize the forgotten and often derided visual gates of consciousness. Furthermore, observers experience Ganzfeld effects when gazing toward objects in absolute darkness! The Baron Karl von Reichenbach proved that this phenomenon was not produced by changes in retinal photochemistry, but by an energetic emanation from matter which had

previously not been known. Photographs of these luminous emanations were produced. Were it not for the resistance with which academes continually thwart the acceptance of experience-derived facts, we would not suspect them to be entirely predisposed and prejudiced in their approach to natural phenomena; a poise unbecoming for those who claim to be seeking truth.

Ganzfeld phenomena were not always considered to be the autonomous projections of mind chemistry as they are today. Representatives of the very highest scientific credentials considered Ganzfeld phenomena to be visual displays produced by body-external energies which were actively permeating the examination space. It is yet possible to utilize large white screens in order to prove the Victorian doctrine. One has simply to gaze into a white screen to first sight the visual displays which emerge. These displays alter considerably when calmly shifted both the screen and the viewing angle within a test space. If the displays were wholly projected by the retinal chemistry alone, why then would new screen positions produce such drastic and diverse visual displays? The eidetic television system of Nikola Tesla was entirely based on studies of visual phenomena and the nervous system.

The experimental art of GAZING is ancient and initiatory, requiring guidance and detailed identifications. Gazing into objects reveals a most startling series of observations, phenomena which reveal a new domain of experience. This process is gentle, a quiet consideration of qualities and aspects observed around and in any object. The realizations received through this process are valuable to the acquisition of further knowledge concerning Vril. What we will see through this method signifies a forgotten skill and perceptual awareness. The visual changes which are experienced when viewing objects are normally ignored. While these fundamental perceptual processes are not normally noticed or valued, they nevertheless form the infrastructure of our daily consciousness. Personal experiences form the sum, the fund of our being. Personal experiences are the foundations of our being, constituting ultimate proof of reality.

Our experiment is simple, but profound in its implications. It may be conducted in one's study or living room. The short time during which we will examine some very ordinary objects requires patience and sharp observational skill. You will require fifteen quiet minutes. There is to be no disturbance during this time. Though simple, it is a process which few ever undertake. If and when they do, few are ever equipped to externalize their experience enough to isolate the sequence of displays which they see, Fewer yet can communicate what they have observed. Nevertheless, on concentrating the gaze on any ordinary object, one experiences a gradually process by which the object becomes transparent.

One gazes intently on any chosen object, taking care to focus all attention there. One must continue to blink, not maintaining any unnatural condition. One must not keep the eyes opened continuously. This is not hypnosis, nor is it trance. We do not wish to engage these states at all. This is not meditation in the modern use of the term. We want to make visual observations of objects with completely focussed attention, the necessary

component. We must maintain our sharp level of conscious focus, never lapsing into passivity. This requires practice. Choose an object in a room. For reasons elsewhere mentioned, choose a large iron object. If possible, the iron object should be close to the ground. Although all objects produce variations of these results, grounded iron gives better success. This first experiment should be an encouragement to the process.

Focus your gaze on this object, keeping alert and conscious. While intently focused on this object, notice closely the visual changes which transpire with time. The experiment requires no more than fifteen minutes. If you decide to make such observations a part of your scientific method, rest between experiments. Prolonged gazing will fixate too much of your conscious focus on the eyes. You do not want that to occur, since headache often results. Be patient, this is a natural process which requires time. Once successfully engaged, one learns to perform the experiment everywhere. The simplicity of the process is alarming to some, but in qualitative method we utilize our own consciousness as the first tool of world exploration.

From the moment you begin you will notice changes in the room space. You will note that a strange shrinking effect seems to be occurring, with the chosen object being the center. This shrinking effect reveals striated lines which enter the objects from all sides. You may sense that a current of energy is passing through you, entering the object. This effect indicates that the process is successfully engaged. Proceeding into the object, you will feel that you are actually approaching the object in some mysterious manner. The object and the surrounding space seem to be sinking toward the ground. You also may sense that you are sinking into a deeper position. What you are experiencing is the expulsion of excessive inertia from the object and its surrounding space. Your gaze is driving out this pressure field. It is truly fascinating to watch the vertical expulsion of this pressure, and the groundward settling of both the object and yourself. You will begin to actually feel the pressure release. Now the object will become mildly luminous. The object first gradually acquires a bright surface layer. This layer becomes flooded with strange rotations and swirls, thready discharges constantly radiating from the surface in different directions. Amoeboid-like shapes in your visual field will suddenly develop, dissolving objects in the surrounding space. Some parts of this space will actually vanish! Blink your eyes and keep gazing. Do not lapse into sleep. Keep alert. Each time you blink, keep alert. You will notice that as your body is engaged in visual focus, your awareness is being heightened. The two seem to be separate. Nevertheless, maintain alertness and keep gazing at the object.

At this stage in our procedure, sudden puffs and foggy expulsions may be seen. These foggy emanations suddenly emerge from the whole object, gradually beginning to flimmer and swirl. Swirls such as this often follow the form contours of the object. These puffs and foggy expulsions are an excess surplus of absorbed inertial space. The object releases this surplus under the force of our penetrating gaze. It is a necessary stage before we are able to permeate more of the matter. Moving toward us, these inertial

expulsions dissolve in the intervening space. It is interesting to note that they move toward the source of attentive focus: toward the experimenter. The penetrating power of our visually projected consciousness is a forgotten and unused sense. It is curious and instructive to note that each object differs in its luminous displays. Each object passes through these luminal stages at different rates, revealing different color species.

Some visual afterimages move when the eyes are moved, evidencing prolonged auric emanations from the eyes after staring. But these are not such afterimages, occurring while gazing. Repetitious such experiments convince that the effect is object-specific and not merely ocular or photochemical in nature. Notice that these luminous discharges do not disappear from the object even after blinking the eyes. Our focussed gaze has actually caused matter to behave in a peculiar responsive manner. This can be realized by suddenly looking away toward another object in the room. One finds that the new object does not sustain the displays which we have seen in the first object. In fact, if we suddenly look back at the first object, we see that it actually maintains the state in which we have last left it. The very response which matter displays under focussed consciousness, is a phenomenon which quantitative science is not prepared to make.

While Baron von Reichenbach performed these experiments in absolute darkness to eliminate doubt, his sensitives were effortlessly able to sight these preliminary "Odic luminations" in completely illuminated rooms. We require more effort, and must intently focus our gaze on a single object before eliciting their energetic emanations. Having begun with the surficial inertial products, which are expelled as foggy white puffs, we have progressed through the several luminous layers radiated from matter. In this material lumination under focussed conscious gaze, we rediscover a long lost secret. In it is contained the very heart of ancient science which declared that "all is light". Realize then that our simple experiment reveals that matter contains light and radiates light. One may apply successive such projections upon a single object and never drain its luminous surplus. This fundamental light is an eternal source (Reichenbach). Each object may thus be permeated when concentrated gaze is focussed thereon.

The luminous layers are permeated by our gaze in successive stages. Each stage represents a luminal energy which different Victorian investigators discovered and named. Each luminal display is distinct and different. Objects "open" and "blossom" in succinct layers. Each object releases each such layer in differing proportions. Continuing this process does not cease revealing new stages of permeation. It is important to realize that we both see and experience each of the transitions through which matter passes under our focussed attentions. In other words, the matter-permeating process also affects the viewer. We ourselves are permeated when gazing into matter. Realize then that gazing process exceeds our surficial sight with which most of our living is spent away. We see but do not perceive (Doyle).

In the Vril model, consciousness infuses the eye with a special extra sense. When consciousness combines with sensation, there is a more communal experience of what is perceived. The eye

can behave as an independent ornament which is capable of blinding consciousness. This occurs only when the eye acts independently of conscious involvement. It is possible to see and not perceive. This condition is greatly desired by quantitative analysts who insist that observers withdraw from experience and subjective examinations of the world.

Gazing involves more than the sense of sight. Gazing involves consciousness. Gazing suffuses the eyes with a conscious emanation, the emanation identified with the aura. These emanations are thready, feathery, and highly organized. When we stare or gaze, we focus and externalize our consciousness. In a very real way, our consciousness moves across space to permeate the objects upon which we gaze. It is obvious that such focussed attention actually radiates from the eyes, out into space. This phenomenon is well known by esoteric science, and was termed the VISUAL RAY.

Gazing intently at objects reveals a communal interaction which suddenly joins the percipient and the perceived, the seer and the seen. As we focus attention, we project conscious emanations. These emanations alter matter and space. Matter and space which is thus permeated by our consciousness begins to open up to us. The alchymysts referred to this process as the "blossoming" of materials. With progressive permeation of successive luminous shells and layers, materials open and emanate their essence to us. Materials have an auric nature. Gazing causes materials to reveal their auric anatomy to us. This continual blossoming, in shell-like manner, is a progressive permeation of material auras.

We then become permeated by the matter which we have opened through gazing. This interaction is a process by which percipients merge with the objects which they have opened. This is the heart of the ancient theory concerning vision and consciousness. In this theory, perception was treated as a conscious fusion with the eyes. Rayic emanations, termed "eidola", were projected through the eyes of observers. Objects also had "eyes", specific points from which objects projected their "eidola". The ancient theory teaches that only the blending of eidola, between observer and object, constitutes true perception (Platon).

In this startling concept, we realize that the eyes of both observers and objects project and absorb a fundamental consciousness across external space. Objects project a consciousness to us. It is only when this kind of perception occurs that we truly commune with nature. The process does require patience. Such focussed attentions are not our usual experience. It is for this reason that the personal experiment, which we have just described, requires a small amount of personal discipline and exertion. Practice makes perfect. With a small amount of practice, one can enter these quiet studies without exerting any effort. The process becomes skill. All of ancient science began with such simple subjective observations.

The successive luminous layers, which we have examined, were identified and named by Victorian researchers. The specific initial colorations of minerals, chemicals, metals, elements, plants, stars, planets, sun, and moon were first discovered (Reichenbach). The phenomenon of space axial luminations (Watson) and human lumination (Kilner) came toward the turn of the Century. Having

discovered successive luminal layers in matter, the succinct luminal species, excited experimenters made errors in judgement. Thrilled by what they had experienced, each declared their discovery was the fundamental energy of the world...the world foundation. One can understand their excitement. The rediscovery of these spontaneous material luminations proved to be revolutionary. Discovered during a time when quantitative analysis was beginning to dominate and dictate the "permissible science", these experimenters had proof positive that the world required the qualitative approach. Indeed, this attitude followed its former course well into the mid-Twentieth Century.

There were those who discovered the lumination of iron capacitors, erroneously assuming it to represent some permeating world condition or biological space (Reich). But no luminary discharge, save the black radiance, is the fundamental space. The black radiance floods all world reality, being the very core of all experiential creations. Vril is the all permeating creative black radiant space from which all world reality springs.

A few who discovered new luminous layers in matter by these methods became so fixated on their findings that they declared their discovery to be the only world foundation (Reich).

Such qualitative observations were reviled by the academes. Changed by qualitative experience, researchers evidenced that a new conscious state had been conferred to them by their very method. Nevertheless, new discoveries in this realm of qualitative research continued to make their appearance. A great plethora of luminous species were discovered, named, and circulated. The resulting confusion required a unifying frame in which all of the phenomena (mostly displays of strange light) could be cohesively interrelated. A few experimenters, fixated on their unique discoveries, resisted this kind of mutual sharing to the detriment of qualitative science. Had they known what was about to develop in academic circles, these Victorian researchers would have willingly participated in the project to find the world fundamental energy.

Perhaps the most astounding aspect of all these luminal discoveries remained concealed until the very end of the Century. A few experimenters found that patient, progressive, and continued gazing does not cause the visual phenomena to cease. There exist experiential stages which exceed these succinct luminous layers. It becomes apparent that most Victorian experimenters, excited with what they had found, did not continue the process long enough for the deepest foundation to begin appearing. Making observations in the last stage of the gazing process requires great patience. Patience and care, for not every object will yield its deepest manifestations easily. The deep foundation from which matter emanates may be experienced through the gazing method simply because our consciousness exists at that foundation. Matter exists at this deep foundation, and can reveal these manifestations. Unfortunately, the interactive process between percipient and perceived causes a strange resilience, slowing these last stages.

After gaining familiarity with the first sequence of displays, one may yet continue the gazing process to the very last stages. There are deeper manifestations to be reached. Though all materials can reach this stage, there exist specific substances in which this

very last stage occurs with speed. We may bias our experiment to best advantage by implementing these materials and ground connections. Considered to be elaborate and complex, most laypersons do not seem willing to engage such arrangements. In order to complete this very last phase of the experiment, we must then be patient, avoiding every inclination to be distracted and leave. Can we leave the experiment and continue our familiar daily routine? To what advantage? Is there anything else to be desired but obtaining this mind altering information once and for all? Yes, it is natural to suddenly want to rise and wander about. But we can resist this natural inclination for a few more minutes, deriving greater conscious benefit. Here is seen the biological activity of the body, and the weakness of the conscious focus. Here is seen the patience of the ancients, who often engaged these exercises for hours. Scribes wrote what the conscious navigators experienced, the thesaurus of ancient seers and visionaries. Through this method, the visionaries peered through the world.

Stars, moon, planets, trees, mountains, seas, meadows, wells, caverns, metals, minerals, crystals, geometric forms...all blossomed before the trained gaze of visionaries. Most dismiss all of these phenomena as optical or ocular, effects which are produced in the eye. We are one with the world when we apply and maintain our awareness during sensation. Sensation does occur without awareness, but no deep knowledge of the world is gained by this passivity. Qualitative observations require focussed gaze and focussed attention throughout the experimental process. The tendency to sleep is actually a precursor to the last stage, the fundamental manifestation which we seek. We must avoid every such tendency, maintaining our conscious focus on the object. One must not withdraw the conscious attention, lapsing into a gaze without awareness. This slows the dissolution process, bringing a halt to the rate at which materials will blossom.

You may have noticed that the object was surrounded by a strange rippling wave phenomenon, like the appearance of heatwaves. These black ripples seem to be heat emanations, but are not (Blondlot). Return your focus on the object once again. It is at this stage that one experiences a variety of patternate colors, normally associated with ocular "phosphenes". Only the object of our attention becomes covered with these strange patterns. No other part of the room displays these patterns. One may notice that a lobate space immediately surrounding the object has become affected. proof that consciousness modifies space. Astute observers will note and map the outline of this lobate region. They will also notice that the shape of this region alters with objects, being modified by both geometry and material.

The eyes have been opened in the gazing procedure, not pressured by any force save that which the object is radiating toward us. What we see are therefore not ocular phosphenes. They are deep layers within the material, possibly containing residual inertial occlusions. With continued focus, the most intense tiny spots of various sizes and colors then appear from the object's innermost regions. The visual display is not photochemical, since each object reveals its own luminous species in these regards. This sparkling phenomenon continues a good long while until the very

last is reached. Remember that the great experimenters left the process at this point, being satisfied that they had reached the "ground" of such visually derived manifestations. Have you noticed at all that your whole being has been very gradually suffused with a glowing blackness? When you blinked your eyes to clear them, this black glow did not disappear. It began almost as soon as you began the gazing process.

One eventually begins to perceive a dark and uniform coloration which spreads across the whole object. This glow will focus and hold the concentrated gaze on a specific part of the object. It is impossible to relax and not be drawn to that part. Each object has such a focussing point. These are the material "eyes" of which the ancients spoke, the "eidola" from which spring material auras. The very last stage is about to open now. Keep alert. You may have noticed a gradual darkening of your perceptive space while engaged in this last phase. The effect is not a "retinal washing", the effect of fixed gazing which most suppose. We now begin to recognize a uniform and gradually suffusive black radiant light, emerging all around and through the material surface on which we have been intently focussed.

The black radiance brings a warm and vibrant sensation when contacted. Consciousness will begin to elevate at this stage. Ideations which suddenly occur to us are actually receptions which objects discharge into our minds. Specific objects discharge specific kinds of impressions. Prized for the specific mindstates which they yield by grounded treatments, ancient mystics and visionaries employed certain minerals, metals, stones, and combinations thereof. That the black radiant light appears in matter as well as in lightbeams, revealing its fundamental presence in all things. Experiments, made through thick ebonite filters, produced remarkable photographs. Clear images of outer gardens were made through laboratory walls, proving that a dark light floods space (Le Bon). Layered structures of iron or steel produce the black radiance almost immediately. Grounded iron objects produce strong black radiant emanations at the edges almost as quickly.

One quickly discovers that certain room angles best facilitate and hasten the process of gazing experiments. Viewing angles which produce exceptional black radiance are the Vril Axes of your neighborhood. In learning of these axes, we begin to glimpse the permeating and absolute structure which courses through our living space and neighborhoods. These may be mapped, being exceeding complex and not at all predictable. The structure resembles an organic crystal, complex beyond recognition. As such, one must empirically determine these axes in each locale.

These can be mapped by various such means, each requiring the laboratory of human experience for their delineation.

In these considerations we have an experiential base upon which to comprehend the nature of radiobeam systems and their associate anomalies. How are materials and material systems modified by geometric shape, ground-aerial placement, and electrification?

There will be some who doubt the reality that consciousness can be projected through the visual gates. First, there is the "nerve effect" by which the rapid sweeping of eyes against one's own hand causes a distinct and long lasting irritation (Constable).

The ordinary observation that a glance can disturb other persons proves to be an exceptional display of visual ray projection. This is especially true among the opposite sexes. The mere passing of an individual, though completely out of sight, causes a literal whole body movement in that direction. It is not uncommon for us to sense the presence of "piercing eyes", when upon turning toward the source, we locate the individual who has been watching. These remarkable displays of long range visual ray projection should serve as some consolation for the doubters. nevertheless there exist other more "objective" proofs of the visual ray and its abilities.

Numerous qualitative experiments have brought forth some intriguing facts in this regard. Plants which have been connected with galvanic skin response meters reveal amazing displays of plant sensitivity (Bose, Backster, Lawrence, Theroux). The method irritates plants with a small electrical application, monitoring changes in conductivity through leaves and stems. These changes indicate the modifications brought about in the articulate structures of the plant. Ostensibly, an articulate influence could enter and merge with this structure, In so doing, the structure evidences minor changes in conductivity which then can be amplified and read. Because of the electrical irritation, the plant becomes "hysterical" for a brief time before failing altogether. It is during this "window time" that plant sensitivity reaches maximum expression. It is also during this time that we are able to observe and identify extraordinary feats of sensitivity.

A point is reached, in these curious experiments, where plants become suddenly and exceedingly sensitive to all surrounding perturbations. In this method one may show the sensitivity of plants to auric stimulation. A mere approach of the hand toward the instrumented plants results in wild signal variations whose overall forms do not appreciably differ from those obtained through direct touch. It had been found that a mere glance at a highly sensitized plant produce the same response. Radionic instruments have proven capable of projecting such auric influences toward plants from a distance (Vassilatos). Radionically instrumented persons have produced more powerful responses in plants at greater distances than is ordinarily observed. Finally, it has been found that mere visual glance can perturb a plant. Glances can perturb inorganic systems also. Glances have proven capable of altering the conductivity of an articulate sensor at a distance (Bradford, Vassilatos).

There are those who wonder whether the visually projected consciousness can be harmed when "thrust beyond" the body proper. Can one's aura experience harm when projected out through the eyegates? Is the aura vulnerable at all to inertial assaults in such a case? Note that the experiment brought a certain few moments where inertial currents and pressures may have been experienced. This is the only exposure with which we would ordinarily be concerned. When these exercises are aided and magnified through Radionic instrumentation, we experience very little inertial assault. Radionic instruments, of the kind with which we engage physical connection, actually enable the dissolution of all such inertial currents through direct grounding. One's aura cannot be

harmful, though projected outside the body in these exercises. The Vril Matrix rules the inertial space which has suffused the ground surface. Vril is the natural and primary terrestrial environment. It is therefore most accustomed to coursing beyond the body along its threadways. By this means we are able to enjoin remote views and other anomalous perceptual phenomena termed "paranormal".

10.2 BLACK LIGHT

Gaze into space now and see. Gaze between the stars into the glowing blackness. See its radiance. It is not a dull or absorptive blackness. It is a glowing blackness. Look into the stars. Do you realize that starlight comes out of the glowing blackness? Can you discern the black striations which flicker within starlight? Starlight proceeds from space ex nihilo. Light emerges from blackness, the sensate projection of qualities. Within every shaft of sensate light there exists the primary and persistent black light presence. We call this VRIL, the primary black light. That presence is the core and axis around and along which all light shafts proceed. Look deeply within light sources, you will see and feel the black radiance. Black light is everywhere. It is in everything, and can be discerned in everything. Black radiance suffuses the world, both generating and sustaining it. Black radiance exceeds the power of light. Staring long into light sources of insignificant intensity floods the visual field with black radiance. Black radiant Vril permeates light, all luminary spaces.

Deeper examination of this primary light reveals it to be capable of flooding its recipients with vibrant thoughts and images of a greatly magnified intensity. Black radiance reveals itself as the most fundamental ground of consciousness. In this Volume of the COMPENDIUM we will undertake a primary study of light and rays. The manner in which Vril interacts with irritating beam energies will form the necessary substance of our discussion. Why radioelectric communications systems operate, whether through the ground or through aerials, has little to do with processes termed "electrical". The conjugate nature of inertial energies, and the manner in which they contour and follow primary Vril actions, constitutes what engineers have traditionally called a "dynamic action". One must learn the difference between fundamental cause and subsequent effect before true understanding can be obtained. True understanding permits new progress in Vril Technology which can forcibly expand our consciousness.

Egyptian observers had long known of the black radiance, having mythologized its beginnings. Ornamented with metaphors and verse, the black radiance formed the foundation of their sciences. It is in fact the world foundation. The black radiance which floods space is not the annihilation of reality. The radiant blackness is the very basis and generative source of reality, the foundation out of which all experiential reality emerges. The black radiance is the backdrop and contrasts against which all consciousness, sense perception, observation, and empirical tests are made. This is VRIL, called by Anglo-Saxon geomancers for the "weaving" paths which it carves through forests. VRIL is the black radiant core of all energetic manifestations. VRIL vectors define the nature of our

terrestrial experience; the fundamental world energy.

Though Baron von Reichenbach made extensive dark room observations of aetheric luminations in consortium with sensitives, he failed to recognize the singular fact in which he was daily immersed. All natural luminations emerge from the blackness of the primary stratum. The blackrooms he constructed for the deliberate study of natural Odic radiance formed the necessary prerequisite of all such observations. In this blackness, luminous displays could extend their noumenous and paranormal permeations on sensitives and insensitives alike. The archane knowledge resurged throughout the time after Baron von Reichenbach's brilliant work was completed.

Experimenters discovered energetic manifestations which brought them closer, and finally into, the very black radiant light. These naturally sensitive visionaries found themselves in possession of technological artifices whose function in a new domain made mind expansion possible. A close examination of grounded iron masses and iron composites, such as those arranged by Franz Anton Mesmer, stimulates several remarkable personal experiences. It is within these experiences that we will recognize logical pathways leading first to explanations of communication technology anomalies, and then to a thorough comprehension of both ancient world models and their forgotten technologies.

It is also through the agency of subjective sensation that we, once again, recognize and validate the existence of a fundamental spatial domain in which we are absolutely suffused. Through these special and repetitious experiences, we realize that subjective experience is a summit; a singular and immediate access to the most fundamental world space. It is through our own senses, our perception and the field of our own consciousness, that we are empowered toward superlative science; a science through which the most unusual and potent technologies may be forged.

The careful and sensitive examiner notices, on approaching grounded iron rods and iron configurations, that a mysterious black aureole permeates the surrounding space. Entrance into this black space zone produces an instantaneous and extraordinary clarity of mind and body, the very precursor to phenomena noticed by Mesmer. When driven into specifically Vril active points, iron poles or ground rods become highly energized with black radiance. Rendered noumenous, these rods flood over with continual eidetic discharges. Those who merely approach these become filled with a gentle and penetrating flow of images, often foreign to one's experience and memory. In this we recognize the eidetic flow. Eidetic images are not "memories". They are not products of mind chemistry, not solipsistic experiences produced wholly within the percipient by neurological process. Eidetic images are visionary dioramas and landscapes, communications of real places which have "never been seen before". Later investigation revealed the existence of an auric anatomy which was bound in the physiological agglomeration. It was found that eidetic images are received through connective Vril discharges. These proceed from the ground, entering and bypassing neurology. Eidetic vision occurs within the auric anatomy, experienced by the recipient first as a remote view. This magnified conscious state becomes permanently fixed in the recipient, so that continued exposures become cumulative. Beginning

with small initial sensitivity, great and magnified consciousness is thus gradually acquired.

Thready Vril discharges are the generative agencies responsible for remote viewing. Discharges proceed from the ground, usually passing through the abdominal region. Spreading out into the auric anatomy, these currents convey their visual treasury, discharging back to ground from the lumbar region of the spine. We are continually receiving these energetic floods, being sustained and directed in Vril currents. Quantitative science has difficulty separating cause and effect. Unable yet to meter the eidetic currents which proceed from the ground, quantitative analysts observe biochemical changes in eidetic recipients which they conclude are the source, and not the effects of eidetic reception. Subsequent inertial examinations of eidetic recipients reveal only physiological effects and by-products.

One experiences brief eidetic visions when walking across a small section of certain grounds. Whether covered through architecture or city planners, such eidetic groundspots retain their activity and power. These points continually discharge imaginal energies, feeding emotive tone to the neighborhood which is built about them. There are natural places in which the black radiance reaches great intensity. These are the sacred spots, each one of which exhibits the fundamental black radiance as it reaches magnified states on ground surface. Within the black radiance, one experiences eidetic light...images, moods, and remote views. They are experienced when recipients move toward an eidetic groundpoint, terminating when recipients move off the point. At times, depending on the projective focus of the point, we experience these eidetic transitions with dramatic sharpness.

There are minor eidetic points and major eidetic centres. Eidetic ground points are not distributed in a symmetrical grid form. There is an asymmetric distribution of these eidetic powerpoints across the ground surface. Black radiant points are the deepest energetic centres, identified by certain sensitives as luminal sources, as ley lines. They convey eidetic consciousness to the sensitive observer, the deepest conscious reception. Eidetic powerpoints are the most fundamental of all the energetic manifestations, being the generative black radiant centres of world dioramas. These are the points which ancient science referred to as the "pillars of the earth". These are the points through which consciousness may penetrate and surpass inertial space. It is here that the ground suddenly becomes "hollow". It is here that percipients pass through the world, reaching its "hollow centre". The "hollow" is the inertia free black radiance from which emerge qualities, sensations, archetypes, visions, thoughts, ideations, dioramas, and experiences. The black radiance is the world foundation, generating, projecting, and sustaining solid objective reality.

There are those whose sensitive examinations bring only identifications of luminous phenomena, of ley lines, when near these powerpoints. The more experienced examiner first recognizes black radiant foundations from which the luminosities actually emerge. The black "radiant" zone has been consistently observed and identified by those who have experienced its remarkable presence in

natural settings. Ground emanating black radiance has been identified throughout the anecdotes of rural people, as well as in the scientific bibliography. Contained in the folklore of more rural people we find remarkable identifications of these phenomena. The "black damp", well known to farmers and woodsmen, is a "cold, shining blackness" which hovers in distinct weblike formations among rocks and trees. Different from ordinary shadows, the cold of the black damp passes directly and completely through the body, chilling "from the inside out".

Experienced in meadowlands as very sharply delineated spots of exceptional cold, the black damp habitually glimmers and shimmers among certain rock and tree clustres. While usually having a fixed locus of manifestation, the black damp seems to wander across the woods and meadows in a fixed perimeter. It is a defined black radiance, different from shades and shadow, varying in intensity during certain times (W. Williams). Not the "black damp" known to miners, the phenomenon is distinguished by its permeating effects on humans who are intercepted by its discharges. Observers of this phenomenon have referred to the mysterious "black damp", described as a shining blackness which flimmers among trees, rocks, and meadows, as a source of great fascination.

When the "black damp" shimmers near the ground during the darkest night, it appears to form a glowing black crown. Hovering and often moving above a fixed surface of earth, the "black damp" produces strange visceral effects. Revealing its smooth and uniform glow, the black damp radiance often discharges sudden striations which contain potent personal transformations. The characteristic frigid sensations, experienced when touched and permeated by this glowing blackness, brings with it a clarity of mind which cannot be explained by conventional models. Such Vril cold spots, and their complimentary hotspots, are experienced in a far deeper manner than temperatures explain (Reich). Evidencing a more permeating presence, these temperatures are permeating, being felt "from the inside out" rather than from the "outside in" (Williams).

Instances in which this mysterious black radiance extends from grounded iron poles are not rare, they merely require proper ground emplacement. Specific natural groundpoints draw the black radiant energy up to the surface. Iron gives the sharpest and most potent transaction with this ground flow. Copper softens the surge, but diminishes the total power. The black radiant aureole from such ground rods expands so much during certain seasons, that sunlight is visibly diminished. The effect is often observed among certain evergreen trees and rocky ridges. This black radiance is no mere removal of light, the result of material absorption. Vril permeates all apparent realities, revealing their ephemeral poise upon its rugged existential foundation. This black radiant space is the most fundamental consciousness, the ground of being.

10.3 BLACK RAYS

The Victorian Epoch not only overflows with numerous instances of natural "black spaces" and "black light" manifestations, but includes accounts of "black radiant" laboratory phenomena. Plucker, Faraday, and others had observed electrostatic light phenomena in mildly evacuated glass globes. Geissler tubes represented a new

step in these regards, revealing a world of light and fascinations. Physicists noted that long evacuated tubes gave striated electrical discharges: alternate bands of light and dark in fixed positions. These alternate white black bands processed along the tube at various velocities; the driving process never adequately explained.

When better vacuum pumps had been developed, a new study of discharge phenomena commenced with one individual. It is Crookes! A defined humorous twinkle is seen glimmering through his sparkling eyes, evidence of a spritely nature. The very name of Crookes is associated with the most magickal of scientific artifices and studies. Sir William Crookes spent years examining electrical phenomena in highly evacuated glass vessels. His initial reason for doing so are shrouded in a deeply personal theme. Believing space to contain invisible spiritual worlds, he surmised that electrical discharges in highly evacuated globes might grant a telescopic window on the angelic or aetheric material of those worlds.

Spending his time in passionate search of ectoplasm, Sir William is often pictured at various locations, holding the globes along various sight angles. By now, these globes were fitted with concave mirrors; the improved electrodes for a new breed of scientific instrument. Pointing his large globular scrying devices in various directions, he directed his "spirit telescope" in order to find his beloved long lost brother. It was with these highly evacuated globes that Sir William first proposed that aetheric communications systems could be developed. Stimulating the tremulous aetheric spaces, Crookes stated that resultant glowing pulses could be visually observed in large receptor globes. These magick lamps could effect communications despite great distances.

It was while intensifying the electrostatic potentials applied to his special globes that Sir William made a rare discovery. He identified a mysterious "dark space" which appeared over his highly charged cathode plates. The velvety dark or black space held an essential secret which few investigators have appreciated. Was this blackness itself not a superior presence which actually entered the electrified space...and repelled it? Recognizing that this dark space effectively repelled and eradicated all electrical manifestations from his globes, Sir William began speculating on the nature of the blackness itself.

If analyzed in a hydraulic or aerodynamic sense, one could have considered this black space to be a deeper vacuum; intensified and separated through the active elimination of residual glowing ions. But, if this black space was an absence of ions, then Sir William's radiometer tests proved it to be remarkably dynamic. The Crookes radiometer was connected in series with a large interrupted induction coil. The vane support stem was connected to negative, an external tinfoil wrap was made positive. Voltages being properly adjusted, the black space was electrostatically stimulated to fill the radiometer. When and only when the black radiance filled the globe, vanes spun with incredible speed. He began referring to this dark space as a "radiant state of matter". What he, in essence, suggested the existence of a "fourth material state".

But, where was this special matter sourced? Sir William began looking OUTSIDE of his globes for the answer to these perplexing mysteries. Believing the black glow to be evidence of a finer space

substratum, he suggested it to be an ultragaseous agent capable of passing through glass and entering the active space. Hitorff, Lenard, Spottiswoode, Aston, Tesla, and many others searched for more anomalous examples of radiances such as the Crookes dark space. Victorian investigators examined all natural luminous phenomena, many new found discoveries proving that manifestations of the "black radiance" flooded nature. Electrophotographs, made by Lichtenberg, reveal the effects of electrical discharges in dust. Those made by cathodes in air prove, on examination, to be interspersed with black dendritic trails.

Nikola Tesla often observed the black radiant spaces without evacuated bulbs, one of the many phenomenon which originally attracted Sir William Crookes to his work. The high intensity electrostatic transformers of Tesla not only produced whitefire discharges, but also effectively developed a deeply suffusive black radiance. In these regards, Tesla discovered that suddenly interrupted high voltage fields projected special electroactive rays. These rays were described by him as being "not unlike light rays", and elsewhere as "dark rays". They had nothing to do with electrical waves, propounded by Maxwell and supposedly proven by Hertz. They had nothing to do with the waves of light which physicists define. Tesla consistently claimed that sunlight contained several "species of light", each having special characteristics.

Though invisible to the eye, the "dark rays" of Tesla performed remarkable feats at great distances from his systems. It was with these energies that Tesla effected all of his claims; effects impossible to obtain with other systems. These remarkable phenomena have been corroborated by a few researchers (Dollard, Theroux). Tesla also conducted extensive studies on cathodic rays, improving the Lenard tubes in order to discover aetheric gaseous components. Not as intrigued with the X-Rays as some Tesla students suppose, Tesla searched for a means of externalizing the Crookes black space. In this, he recognized an extremely potent dynamic at work; one which he would later summon to achieve otherwise impossible goals.

He tested several forms of raybeam projectors throughout the years following this period of research, having finally claimed success in developing a tube which would not explode under the severe electrostatic stresses required for its operation. Teslian "black field" discharges through gases have been more recently observed (Dollard). Single electrode low pressure discharge tubes were found to maintain their dark state despite the high potentials employed. This evidences the severe potential drop at the free end. Pointed toward receptor tubes, they transmit measurable dielectric current through space. Such experiments, where black radiant space is externalized through electrostatic discharge tubes, proves Tesla's claims that "very special rays" can be produced by such means. Black rays.

Elsewhere, Nikola Tesla describes a spatially voluminous black radiance; a radiance which suffused local space for miles, taking specific topographic directions in the natural environment. An "inky and velvet blackness", both during and long after the operation of his Colorado Springs Experimental Station was

reported. Never recognized as such, the deliberate reports made by Tesla in these regards suggests that he began investigating the perceptual modifying power of grand scale electrostatic discharges.

When properly examined, black radiance was at the core of all energetic phenomena. It was found in magnetism, light, and minerals (Reichenbach). Black radiance was found in evacuated discharges (Crookes), electrostatic fields (Tesla), in natural environments (Le Bon), in physiology (Kilner), in lightbeams (Goethe, G.S. White), and in beams of sound (Watts-Hughes). This mysterious presence, inherent in every release of energy, seemed to be the fundamental manifestation of natural intent; the very foundation upon which all inertial energies simply subsisted.

Careful examination of the black radiance convinced many that it was THE primary energy, that generative axis from which matter emerged directly. Matter and energy, emerging from the black radiant space "ex nihilo". Numerous researchers were surprised to identify black radiance as the fundamental space from which matter seemed to both emerge and dissolve. The scientific bibliography is suffused with physical evidence of the black radiance. Careful examination of all photographic, electrographic, and sonographic records will convince that each energetic trace has an intensely concentrated black core axis.

Prof. Gustav Le Bon dubbed the black radiant emanations with the phrase "dark light". Neither referring to infrared or ultraviolet spectra, Le Bon insisted that "dark light" existed as an entirely separate energy domain; a distinct permeative space. Its presence persistent, Dr. Le Bon was able to expose special photochemical emulsions to this naturally extant "dark light"; producing remarkably clear images of gardens directly through thick laboratory walls.

Other research focussed on the phenomenal realm between fundamental black radiance and ordinary light; researchers compiling a very thorough accounting of black space phenomena (Kilner, G.S. White). Dr. Walter Kilner discovered the suffusive black radiant core of human auras. It was this black radiant space from which all subsequent layered auric luminosities were observed. Dr. Kilner observed that this black radiance not only spatially preceded the manifestation of luminous auric shells, but also extended beyond the luminosities into space. This extension to indeterminate distances formed the basis of a true mystery. In this spaceward extension, Dr. Kilner and others saw the auric connection with upper space worlds. Congested striations in the black radiant zone revealed the physiological presence of disease, a diagnostic tool of the greatest importance.

Other aspects of the black space were noticed, aspects through which attention itself...consciousness...was powerfully drawn. Crookes was powerfully attracted to peer, for hours, into the black radiance. It seemed generative and projective. Stimulating thought and ideation, Crookes applied the discharge tube to the investigation of other worldly phenomena. Having noticed that the extra-cathodic space was darker than the space surrounding the tube, it was clearly suggested that here was an instance of aetheric expansion. On these concepts, Tesla built and demonstrated

a technology which successfully implemented true aetheric currents.

Black space, unfettered by inertial resistance, directly fuses perception and consciousness. It is the bridge linking the physical and metaphysical worlds. Examining black radiant phenomenon from a deeper metacognitive poise, one recognizes an absorptive attraction between this blackness and the observer. The Crookes dark space, as with other related manifestations, seems to attract and hold attention. All thought lines seem to move into the densified black space. Black radiance is a zone into which perception is powerfully focussed. Scrying devices of the Electrical Age, his attentions were drawn to mysterious behaviors surrounding his apparatus. Black radiance and luminous forms conjointly passed and permeated one another in the flickering ghostly blue light. It was Sir William who first suggested that signals could be sent between a system of such glowing bulbs, whose medium of exchange was found in the world-suffusing black radiance.

10.4 VRIL AND GROUND

The construction of iron capacitors produces extraordinarily powerful suffusions of this curious black radiance. Such capacitors yet demonstrate the power to eradicate and heal away certain maladies on simple contact. There are numerous variations of iron capacitors, no one of which qualifies as the "only design". Mesmer designed his capacitor in imitation of natural settings; using contact layers of iron slag or powder against germinating seeds or moss. Others combined iron layers with crushed coal, wetting these down with spring water. Yet others combined layers of sheet iron with cotton or wool. Each of these combinations with iron obtains wonderfully varied results. Despite the rigid and dogmatic assertions of some in regards to these designs, one must see that the presence of iron and carbonaceous materials together conduct a fundamental energy whose presence is ground sourced.

The employment of iron, in excess of all other metals, most powerfully endrains this energy to the surface. The exact nature of the carbonaceous matter used in such iron capacitors modifies the aspects and qualities of this ground emerging energy with new definition. Despite the blue aura which iron and carbon together project, one must recognize that the black radiant energy forever precedes the luminous products. Black radiance holds a most powerful secret; a remarkable realization which revolutionizes our thoughts concerning energy and true power. Through such knowledge, our experience of the world obtains the "missing qualities" and "details" which academically acclaimed inertial forces can never explain.

When rediscovered by Reichenbach, the natural radiance of matter was no minor announcement. Threatened by the implications of a flowing, biological, conscious world foundation, academic colleagues actively rejected Reichenbach. Himself a veritable laureate of highest esteem, with proven scientific record of greater academic proportion, the Baron derided their frightened response in his numerous privately funded publications. Baron von Reichenbach remains a scientific giant who spanned the research world with achievements in both quantitative and qualitative

sciences. He is the modern father of Radionic Science.

Radionics first studied and employed the natural luminosity of matter in various applications. It was employed in medical diagnosis (White, Abrams), in therapeutic modes (White, Drown), in analysis and field survey (Hieronymus), and numerous other scientific functions. The natural luminosity of matter was thought to be the most fundamental world-energy, but subsequent focussed examinations proved that much deeper energies lay within the former. In its more recent development Radionic Science examines the most primary black radiance of world-matter. It does so now specifically for the primary eidetic functions inherent in Vril.

While all of these luminous phenomena were observed and studied, successive discoveries proved that the very core of all these luminations was, paradoxically, a black radiance. Thready and endowed with other remarkable properties, the black radiance became the focus of intense research during the latter portion of the Twentieth Century. Being the projective center of energetic emanations, the black radiance was studied through subjective and ultimately personal contact. Access to this black radiance was had through several grounded means, iron poles and driven rods being the primitive first sources. Testimony to the glorious power radiating through these iron poles, rods, and buried plates is the uncorroded state by which they are preserved for centuries. The earth batteries of several inventors were notable for their uncorroded performance (Stubblefield).

Wide varieties of natural substances, examined by Radionists, displayed spontaneous black radiant phenomena. Black radiance was visibly increased when system components were directly connected with the ground, and powerfully magnified when "tuned to ground" by means of rheostats and variable capacitors. Black radiance was visibly increased when system components were directly connected with the ground, and powerfully magnified when "tuned to ground" by means of rheostats and variable capacitors.

While numerous radionists observed and focussed attention only upon aerial black radiant phenomena, it was the "ground-radionists" whose discoveries reopened an anciently forgotten secret. This led to the development of ground communications systems. In the systems of Stubblefield, electrical power is not utilized. While this sounds fanciful at best, it must be recognized that the Stubblefield system was never deactivated. Operation with any single one of his famed earth batteries persisted for weeks on end. During this time period, several thousand watts were expended in driving motors, powering arc lamps, supplying telephone exchanges, and maintaining heaters. Never once was there a power loss or a cause for replacing the earth batteries.

Through an extensive series of experiments, designed to discover its more external characteristics and behaviors, the black radiance was directed into varieties of material media. It was then found that both material form and behavior actually proceeded from the energy, if energy is what we might call it. The black radiance proved to be the most fundamental agent, found actively present and central in every bioform. Black radiance was found to be the discharge form of the most foundational energy yet known. When constrained to transit across spaces, the black radiance

spontaneously constricts to form thready veins.

These thready veins may be glimpsed in among objects, both natural and humanly made, in the natural environment. There, emanated from the ground, these manifestations evidence their own natural expression. It is not uncommon to watch the progressive absorption of humanly made artifices in the ground emanated black radiance. Thus "accepted" into the Vril matrix, these objects frequently become one with the natural surroundings. This is the often made observation throughout older neighborhoods and districts, where old cottages and their gardens, towered churches, iron posts, and rockwalls visibly flow in black radiant currents.

Connective and glowing, one glimpses these "fascia" among and between certain natural topographies. Vril manifests in inertial space as black radiant threads. The sometimes faint observation of black radiance and black radiant thready veins derives from interactions between the black energy and inertial space. When inertial space interactions are strong, one literally sees the black radiance. When inertial space interactions are weak, one sees a faint luminosity with an equally faint black radiant center.

During the earlier years, Telegraph System engineers employed local dowzers to delineate the appropriate or "right path" of the line. The dowser was hired by local telegraph companies which sprang up throughout the countryside. These sensitives determined the meandering course which wirelines took. When being settled in woods and across meadows, it was the telegraph-dowser who felt the "right path" which the line should take for it to best perform. These lines became the famed "self-activated" lines which required no applied battery power.

When station groundsites were sought, dowzers employed their sensitivity in determining the presence of necessary telluric currents. It was then believed that these ground currents actually facilitated and empowered the subterranean "charge return". Systems constructed by this means demonstrated a superiority over those later telegraph projects built by engineers and geologists alone. By then, the oldtime dowzers were replaced by an armada of insensitives; early geophysicists. Armed only with their electrical meters, these engineers found it impossible to determine "good ground" despite their accurate registration of high soil conductivity levels.

The dowzers already knew that electrical soil conductivity alone did not always make "good ground" for telegraphic signals in single-line systems. Other subterranean energies were obviously determining the success of both electrotelegraphic and later electrotelephonic systems. These subterranean signals were erroneously termed "electrical waves, magnetic waves, underground water channels" and other such inappropriate metaphors. When neither electrical, magnetic, and hydal currents were physically found, academicians derided and rejected the entire issue concerning telluric currents.

Weak electrical currents, when hunting and registering telluric flux, does not imply weak cause. Telluric currents, Vril currents, are not sufficiently sensate and do not sufficiently interact with inertial space to manufacture electrical products. The telluric currents thus appear "weak" and "subtle". They have a

far greater, and insensitively unrecognized eidetic content, which is their principle strength. The currents which are received through grounded rods in wooded areas evidence a strong and continuous eidetic flow, a dialogue among trees. The weakly received currents evidence the weak interaction which occurs when insensate eidetic currents penetrates inertial space.

Carbon, incapable of producing strong electrolytic currents in seawater baths, produces prodigious registrations at specific "sensitive" groundpoints. The use of carbon ground rods reveals that eidetic currents are present and active in subterranean depths. These currents are enormously powerful with increased depth. They are eidetic currents, their effect in passing through matter is to produce electrical manifestations. This is the source of all the observed anomalies in grounded technologies. Vril currents, drawn from iron-carbon ground rods, grow in strength with time. When these energies are hastily brought to the surface, they radiate a dangerously powerful Vril signal. In such cases, we experience choking congestion, the result of inertial hysteresis in the potent Vril emergence. It is not wise to incur these kinds of Vril currents to the surface. Insensate and semisensate Vril currents require special Radionic instrumentation for their conversion into accessible sensate expressions. These are truths which Father Athanasius Kircher clearly outlined in the Sixteenth Century, knowledge obviously gleaned from contact with the Templars.

Nikola Tesla inadvertently proved the existence of deep metaphysical strata, those propounded centuries before by Fr. Kircher, by deriving a continuous stream of whitefire electricity by the application of but a second's worth of impulse energy. Struck like a bell by a single hammer blow, the ground delivered up well over twenty minutes' worth of free electrical power in Colorado Springs. Careful examination of his cryptic notes, captions of photographs made, reveal the "secret" which Tesla wished to keep from Morgan. Tesla, focussed only upon the electrical aspects of the earth, did not immediately recognize the implications of this strange electrical manifestation. It was during this time however, that Tesla began observing powerful perceptual distortions all around his experimental station. These lingering conditions permitted extraordinary and truly paranormal perceptions. Stimulating him with fresh insights concerning perception, space, and consciousness, Tesla was inspired to design a radically new kind of television system.

Well before this breakthrough however, and with far less complex means at their disposal, inventors of telegraphic systems began making strange observations. ANOMALIES. Through extensive contact with ground applied and ground derived electricity, a few astute and scholarly observers recognized that the true source of static and static disturbances in lines was not electrical in origin. They recognized that these anomalous manifestations were due to the incursive influence of a neutral energy. Having origins, most certainly arriving in systems through the ground connection, a few inventors went directly to this source for various applications. Some used these energies to raise the efficiency of lightning rods (Bryan). Others utilized these energies for

therapeutic purposes (Mellon). Yet others obtained the ground energy in multiple plate and wound receivers, employing it to operate electrical machines (Bain, Snow, Dieckmann).

These energetic currents were thought by some to be the result of mere electrolytic action, a product of ground moistened metal plates. When it was realized that this energy could perform far more work than was actually determined by measuring it, theorists remained completely baffled. Stubblefield managed to obtain commercial amounts of power from ground receivers whose electrolytic output rarely exceeded four watts. The fact that this energy could actually operate machines termed "electrical" was equally baffling. In these anomalies was glimpsed a forgotten reality. It seemed as though "electrical machines" could operate in two modes. This curious "double function" continued to haunt experimenters until the advent of Radionics.

It was about this time that such individuals began noticing the "other effects" which the telegraph lines had on natural environments. Some noticed that the space surrounding large tar-clad wooden telegraph poles seemed surrounded by a violet aureole at times. Usually at sunrise and at sunset, the violet aureole can yet be seen by astute observers. One notices sharp black striations which flood the interior of these mysterious violet aureoles. In addition, several experimenters noticed the black radiance which surrounded iron wirelines when supported by these poles. The black radiant appearance which surrounds such wires also extends a noumenous state which is difficult to ignore. One sees a flood of black radiant discharges extending toward the wires from specific grounds over which the lines pass. These lines also discharged black radiant discharges to the ground, when having conducted them from specific grounds to specific grounds. The telegraph system actually became a means for deranging district Vril current integrity (V.4).

Of all the elements which one may employ in experiencing Vril consciousness, one stands out above the others. IRON. Iron evidences a Vril articulation impossible to duplicate with other substances. It is no wonder then that iron wires, far inferior to copper lines, operated with great efficiency in grounded telegraph and telephone systems. Small iron masses have far greater Vril articulate capacity than any other metal or substance except for one other. CARBON. Iron, Carbon, and Vril are inexorably linked. Handheld iron, extended outward across space, produce strong visceral "thrill responses" along very place-specific axes. Likewise, handheld Carbon rods produce an inimicable sensation of "nullification". Together they form an important diodic component of Vril systems.

The attributes of Iron and Carbon may be successfully tested in any location. The resulting axial distribution produces a map of extraordinary implication. One finds that such maps give the very axes along which strong ideational pulses continually flow. Matching personal experience against such a map reveals surprising continuity. It may yet be observed that properly poised iron poles flood nearby objects with a powerful and uncommon clarity. This black radiance, this Vril space engages the percipient in those extraordinary experiences with which the ancient geomancers were

familiar. Experience in Vril space is different from normally inertialized experience. Vril space is radiant, the generative source of all consciousness, ideations, thoughts, and visions. One cannot be exposed to Vril space for long before being flooded by a host of wonderful mindstates and abilities. Vril space grants special senses and sensations. Vril space is consciousness. Suffusion in Vril space gives us our consciousness.

In certain instances, technicians found that simple non-electrified ground connections were capable of discharging simple eidetic images directly into physiology. The mere connection of responsive systems into ground strata made intercommunications at the most fundamental level possible. These anomalies revealed the fundamental mode in which natural communications are accomplished among local districts and wider regions. In certain cases, these eidetic transmissions from the ground produced sufficient electrical impulse to drive telephonic systems.

Iron rods, whether handheld or grounded, draw Vril threads into a constricted focus. Such access is necessary for scientific examination of and conscious expansions in Vril. Iron produces a stinging response in the human percipient, requiring "softening agents" for smooth auric transactions with the ground Vril. Carbon and iron together form the basis of a successful auric transactor, but other metallic additions secure much smoother transitional coatings which the experimenter will find increasingly necessary with frequency of connective exposure to Vril threads.

Quantitative analysis interrupts direct conscious examinations with mechanistic measuring devices. Measuring devices are placed between ourselves and the world. They filter and interpret what only human experience should engage. Objects filter conscious projections into space. These projections are inhuman ones, being reserved for the realm of objects and their dynamic processes. We cannot receive filtered conscious data through measuring instruments. We do receive magnified conscious energy through the connectivity which Radionic instruments bring. Radionic instruments do not behave inertly. They become suffused with Vril, becoming quasi-organismic in nature. Only Radionic instruments connect us with the consciousness which suffuses world space.

In this we glimpse the forgotten knowledge which Templars inherited, employed, and improved. Special placement of architectural mass renders a structure capable of powerful correspondence with specific distant locales. Such buildings relate directly with others in distant locations, behaving as if directly connected through the ground. The bilocal aspects of certain architectural placements are unmistakable when experienced. We each know buildings whose mere presence provokes sudden sensations of distant locales. Placement in certain groundpoints makes building foundations Vril conductive. The interconnective nature of the subterranean Vril Matrix reveals local points in which it is possible to engage eidetic communications with specific greatly distant points. New York can connect directly with Paris.

Finding the best location for establishing VLF radioelectric stations began with Marconi. Needing these Vril advantages in establishing radioelectric circuits across the world, Marconi placed heavy emphasis on geologically advantageous sites. Marconi

stations were always found at the very sea edge, usually near a saltwater bog or marshland. This feature was used as a conductive "wavechute" or "launchway", ostensibly for the conveyance of radiowaves out to sea. We find that Marconi engineers chose sites which also had some rocky inlet or valleylike geologies. Placing his aerial deep within these sea openings gave the advantage afforded by stone conductors in seawater. These wavechutes were the most highly prized. It is no wonder then that we find his stations in numerous rocky sea openings, having large saltwater lagoons.

When early wireless systems were later connected both to ground and to extensive aerial capacities, effects such as these both strengthened and modified. Determined by the aerial alignment and station placement, operators discerned that each station became suffused with a characteristic mood and tone. In this respect, stations displayed their peak manifestation during specific seasons. Because of these station-fixed emotive tones, certain observers recognized a mysterious connective correspondence with space energies. In other related radio transmission phenomena, researchers noted that shortwave stations operated with greatest efficiency during certain astrological times (Nelson).

It is intriguing that certain ground-coursing Vril Axes do not connect with Vril lines in every bordering neighborhood. In these features, we will learn of the world structure and true geography, whose experiential dioramas envelope "unknown" regions. Wherever we find "broken" Vril Axes, there we will find a "hidden zone", lands which remain curiously insensate and unmappable. Local lore is replete with tales of "disappearing lands" whose appearances and disappearances are determined by georadionic process. VLF and shortwave stations noted numerous "blindspots" where no signal could ever be heard. These anomalies defy conventional explanations which involve purely electrostatic or electromagnetic parameters.

In certain cases, wireless stations demonstrated ground-relationship with other stations, as well as aerial relationship directly through the aerial strata. The secret listening device which T. Henry Moray developed required no electrical energy for its operation, detecting and tuning into biologically related sound activity. In the case of certain beam transmitters, resultant multiple groundward beams were capable of directing signals through terminal contact with upper space strata (Tesla, Ulivi, Hettinger). In these phenomena we comprehend the fundamental operation of Vril in radioelectric signalling. In rare places where Vril axes are submerged, there can be no radiowave propagation or "passage". Vril makes radioelectric communications possible. The electrical components simply irritate the Vril Matrix into radiating magnified eidetic patterns.

The "stationary" approach to communications lost popularity, when mobile military requirements during World War II employed shorter wave transmitters. Then it became possible to establish point to point communications from any position. These systems employed the Aerial Vril Matrix, antennas behaving as terminal connections within the insensate matrix. But these zones are peculiar indications that insensate geographic lands are present. The curious complete absence of signals, the radioworld "dead zones", requires serious Vril examination on an expeditionary

level. The famed "Fata Morgana" are an astounding species of mirages, repetitively observed in specific locales (Corliss). Not at all being the optical mirages of temperature inversions and other such atmospheric disturbances, the Fata Morgana is a free standing anomalous "geographic presence".

Having historic repetitious appearance in a region, they are noteworthy living remote views on an astounding huge scale. One cannot see through them. One frequently sees persons and animals, machines, trees...all the evidence of a settled habitation, where no mapped lands exist. The phenomenon has occurred in the Straits of Messina, near Sicily. There it gained its first fame. The phenomena has been observed in Portbalintrea, Ireland, and is not unknown in New York Harbor.

It was well known by operators that a mere brush against the mammoth capacity aeriels could result in death. Not rare in operating these stations were the dark blue discharges which launched from aeriels and room sized inductors, striking operators and rendering them unconscious. There were those instances when operators became suffused with an elevating energy. Being "under the influence of the spark" made them light-headed and giddy. In this state of mind and body it was possible for them to know which station would signal next, and what the nature of the message would be. When more developed shortwave systems were established everywhere, newer paranormal phenomena began making themselves apparent. These stations were more potent eidetic transactors than certain VLF stations. As with the mammoth VLF stations wireless, mere proximity to shortwave systems brought sudden eidetic discharges to the operators.

It was found that station sites, even when non-operational, frequently continued to discharge such eidetic signals for hours. A condition was often reached, in well used stations, where eidetic discharges remained the common paranormal feature. Bilocal experiences were especially powerful for specific distal sites. This repetitive observation of specific distant locations, complete with moods and emotions of those places, was a reminder of those phenomena well-known to telegraphers. If a shortwave station was properly placed, it had its connections to a specific distant location.

This Vrill psychotopographic effect was realized by military station operators. The signals frequently displayed eidetic images of the very same unrecognizable landscapes, magnified remote viewing through an artifice. In this function, stations behaved both as eidetic receivers and transmitters. But a single electrical activation was sufficient to bring these effects to a station. Once this focalizing process had been established, one could deactivate the system and continue receiving the eidetic images. Land surrounding these stations also became suffused by eidetic energies. Mere proximity to these systems is sufficient for these eidetic discharges to suffuse us, bringing their remote views.

10.5 VRILL IN ELECTROTECHNOLOGY

Electrical energies irritate the primary Vrill function. It is in this antagonistic relationship alone that radioelectric systems become communications systems. Their supposed electrical operation

is an illusory result of "lumped" empirical observation. Lacking the detailed discrimination which comes only through anomalous observations, electrical engineers pursued their electrical objectives. Electrical theory then developed. This further entrenched awareness that primary Vril functions were solely responsible for radiosignalling. One has only to reexamine the powerful radiosystems developed by Loomis to learn again of this fact. Systems which used no applied current save those which suffused components from ground connection were not limited to Loomis. Those of Meucci (V.5), Stubblefield (V.7), Rosetti, Strong, Lockwood, Tompkins, and Brown (V.6) are only a few representatives of an armada in unpowered grounded systems.

Readers must recall that the development of radiosystems proceeded from a convoluted science, one which continually confused cause and effect. The empirical nature of observations often leads to erroneous associations among conjugate phenomena. It is in the nature of Vril to drive conjugate phenomena. These form a veritable cloak which surround Vril black radiant threads, the generative discharges. One thus finds in every natural expression evidence of the generative Vril presence. Not knowing or recognizing the primary cause or function of components, subsequent academic models produced an "inverse technology". By this we mean that technologies did not deliberately develop around Vril black energy. Technology developed around inertial applications which stimulated the Vril energy. Were it not for instances in which distant communication was actually engaged entirely without electrical agencies in any stage, we could not make such statements. But the overwhelming conclusion, derived from thousands of patents and associated treatises, brings us to these assertions. More than this, we have the evidence of hundreds of corroborative experiments with which we have been engaged since realizing these facts. The discovery that numerous apparatus actually did engage a primary communication mode altered our views on the subject completely.

The principle need for study in the historical bibliography of patents, articles, and texts, empowers the development of more fundamental technology. The technology which we seek actively engages the deepest world foundations, enabling a new world condition. Both the anticipated technology and its foundation, whose components we perceive in the midst of forgotten treasures, has materialized itself. Forgotten observations, stored up for the future in Victorian bibliographies, best chronicle the tale. Found in the plethora of forgotten Victorian texts and patents, we find information which contradicts the most advanced conceptions concerning radio and why it works.

The functional relationships observed in ground system components were details which their designers could not immediately assess. Telegraphy, Telephony, and then early Wireless each brought an amazing archaism of associated anomalous phenomena. Such empirical discoveries were simply admixed within the scientific and engineering consciousness without question. The phenomena were all collectively termed "electrical". It was not until attention was actually focussed on each aspect of the strange associate phenomena that researchers made distinguishing critiques between their observations and the terminology by which they tagged the

anomalies.

Some of the observations were mildly electrical in nature. Others seemed to be "inflections" of electrical phenomena. Yet others had nothing at all to do with electrical effects. This menagerie of anomalies displayed a variety which threatened academic integrity on all counts. The invasion of these anomalies brought new questions which could not be tolerated, simply because they could not be answered. And answer-magick, not truth, had become the currency of academic science.

Vril suffusion of radio systems proceeds from the ground connection. Permeating the components in distinctive fashion, the entire station often assumes the black radiant glow which is also noumenous in sense. Close examination of system components reveals a host of remarkable Vril responses and dynamic behaviors. When encountering certain component combinations, Vril arcs across connections, choosing its own desired paths. Passage through components alters Vril to an extent which may trigger true permutation. Willingly moving into the components which bring it permutational change, Vril evidences intelligent motivations; avoiding certain components and tunneling through others.

Vril discharges, which articulately cross circuit components, often connect terminals which normally would be physically joined. Vril automagnifies when crossing spacegaps in order to reach its next entry point. Radionic arrays which feature disconnected circuit portions have always brought derision from academes who mock Radionic circuits which "lack wired connections". Vril also evidences preferences which must be empirically learned. Vril current moves into and through iron rods. Vril ensheaths the outer surface of carbon rods and produces distinct nodes, called "rates" by radionists.

Electric rays were first observed by Joseph Henry in 1862. Electric rays, accidentally released through Leyden Jar sparks, ruined a sensitive astatic galvanometer which had been housed several floors beneath the laboratory...in a vault. Dr. Henry found to his amazement that steel needles, though hundreds of feet distant from these sparks, were completely magnetized. He published these wondrous findings in 1842. It was difficult for his contemporaries to conceive that such energetic transactions could result without wired connections.

Elihu Thomson, a young high school instructor, accidentally observed the activity of electric rays in 1872. While experimenting with a large Ruhmkorff induction coil, Thomson decided to intensify the spark display with an additional capacity. Connecting one high tension terminal to a large metal tabletop, he saw that the spark became more intense. Thinking that this intensity could be further boosted, he connected the other terminal lead to a cold water pipe. When this was done, the spark discharge took on an entirely different characteristic. The penetrating, and somewhat explosive crackle was accompanied by brilliant silver-white sparks. Surprised and excited by this discovery, Thomson attempted to contact his friend, Edwin Houston. Intending to run down the hall, Thomson received an unexpected shock when he grasped the brass doorknob. Though fixed in the midst of the large oak door, the insulated brass knob was highly and continuously charged.

The astounded Thomson found that **every** insulated metal object in room was also highly charged. He and Houston ran through the building, drawing out long violet-white sparks with a penknife from every metal object in the building. They found it possible to draw off sparks from metal objects several floors above the spark source. Thomson wrote up his accidental findings. Scientific American allotted him in a minor column for posterity, and the matter was forgotten...until Nikola Tesla rediscovered the phenomenon by accident. In this remarkable account, the phenomenon of distant charging matches that discovery of Joseph Henry, nearly thirty full years before. The manifestation of these intense wireless energies provoked a storm of controversy among those who attempted their duplication. Unable to reach these intensity levels, most cast the account off as spurious and exaggerated.

In 1886, Heinrich Hertz attempted a more stringent search for the "electromagnetic waves" which James Clark-Maxwell predicted. His results were weak and furtive. Nonetheless, the entire scientific community seized on his findings with great zeal. All except for one noteworthy individual. Incapable of duplicating the electric wave experiments of Hertz, Nikola Tesla continuously performed several different experiments employing high voltage arcs. He discovered a great variety of effects with these experimental arrangements, mostly disappointing ones. One arrangement, however, produced astonishing results with uncharacteristic high power. With abrupt interruptions of high voltage direct current, Tesla felt powerfully shocks at some distance from his apparatus. His methodic inspection of this phenomenon proved that a powerful radiant emanation was dynamically projected from his apparatus "like rays of dark light".

In this experimental accident (1891), Tesla successfully reproduced the results which, prior to this event, only Joseph Henry and Elihu Thomson had obtained. Completely determined by circuit parameters of voltage, capacity, and resistance, Tesla realized why this condition was nearly impossible to achieve by casual experimental arrangement. In most experimental instances, the component values chosen by researchers were insufficient to produce the strong "electrical rays". Tesla corroborated the loud crackling sparks of brilliant silver-white which Thomson reported nearly twenty years before. Tesla travelled to Germany in order to consult with Dr. Hertz on these findings. The two discovered that each had found completely different modes of electrical radiance. Hertz was shown that he had not in fact generated true electromagnetic waves. Hertz was deeply disappointed over this fact. His subsequent research shift to ultraviolet light and photoelectric phenomena was no accident. Tesla later stated that he was truly sorry he ever mentioned these things to Dr. Hertz.

On returning to New York, Tesla published a seldom mentioned and rarely discussed article in The Electrical Experimenter periodical (1892). In this he casually describes the fact that certain high voltage arrangements can be made to release "electrical soundwaves". He goes on to say that this condition is reached only when proper attention is given to the parameters comprising the circuit. When invited to speak before the Royal Society, Tesla saw this as an opportunity to announce his startling

breakthrough. Taking his audience through the history of electrical phenomena, he demonstrated some of his early high frequency alternators. Intending to show the weak and furtive output of these rotary designs, Tesla planned the unveiling of his newer devices. His new electrostatic induction coil, a device which did not operate through magnetic induction at all, astounded the onlookers. He strove to explain that his discovery of electric rays was outclassed only by his discovery of a new kind of induction phenomenon.

Electrostatic induction, he claimed, occurred when electrostatic shock fields collimated upon aircore solenoids of specific resistance. The abrupt application of the electrostatic field to these coils caused a remarkable transformation. This transformation was an unaccustomed one, resembling a short circuit. Electrostatic field lines actually leapt along the long coil...from end to end. In doing so, the coil voltage surged beyond predicted values, jumping as much as ten thousand volts per inch of coil length! This was not magnetic induction. The coils did not behave like magnetic transformer coils. They behaved like curious cylindrical capacitors. The coil resistance was the key. When once the sharp and powerful electrostatic shock field was applied to this coil, the strange voltage conversion took place. It was as if a new and more potent electrostatic energy had been discovered, a pulsating one having anomalous penetrating powers. This energetic ray passed through shields and substances alike. Tesla developed and patented numerous ray transmitters, each producing truly anomalous effects.

Most associated his name and work so strongly with alternating current, that they were unable to grasp that Tesla had already abandoned that line of research. Unidirectional impulses being proclaimed as the only means for producing the electric rays, Tesla clearly states that these potent results should not be expected if very stringent circuit parameters were not carefully met. Most did not obtain them. The consequent response by such persons as Sir Oliver Lodge, was that the "emotional" Tesla was exaggerating. As Tesla predicted, those who did not keep to his parameters succeeded in developing only weak electromagnetic waves. Results obtained and improved by Tesla differed completely from systems developed by most experimenters of the day. Tesla developed true and penetrating electric ray transmitters. Others, notably Marconi, proliferated a radio technology which implemented the weak electric Hertzian waves. While Tesla developed a great number of systems for liberating these rays, the most powerful species are liberated when high voltage DC arcs are repeatedly disrupted "without alternation or oscillation".

Engineers and theorists have begun again to study these electric ray manifestations, attempting theoretical proof that they actually exist! Discovered through accidental arrangement, Nikola Tesla perfected the means for implementing these rays in a host of designs. Each of which representing technologies which have remained dormant for nearly seventy five years, their reemergence would completely revolutionize world power production and distribution. Throughout the twentieth Century, there would appear several inventions which clearly duplicated Teslian methods. These

systems worked in their ray transmitting modes (DeMoura, Reno, McCullough). As electronics and vacuum tubes came into vogue, a progressive divergence from Tesla electric ray technology produced pure Hertzian mode radio and radiobeam technology. This progressive trend eventually explored higher alternating frequencies and shorter waves. Engineers maximized "electronic" carriers and avoided electric rays altogether. Tesla proved that only the violence of DC arc "disruptions" could release the most powerful ray varieties. Inherent in the electrostatic field, Teslian methods prove to be the most prolific way for releasing these energies.

Nevertheless, engineers sought the creation of Hertzian wavebeams in UHF and, eventually, RADAR. The invention of the single cavity magnetron tube provoked a revolution in Hertzian electron technology, producing the multicavity magnetron, powerhorse of the World War II battle arsenal. Eventually, all mention of electric rays was relegated to works of science fiction. Having lost the knowledge which Tesla plainly declared in all too numerous lectures and patent texts, engineers completely forgot that electric rays exist. Now they deride the notion, believing that electrical longitudinal propagations are impossible. Recently termed "electro-kinetic" rays, several researchers are studying new means for generating them (Aspden, Jefimenko). Engineer Eric Dollard has had the earliest and most evident success in duplicating those results claimed by Tesla. His research remains unequalled in the study.

Fragmental analysis of electrical systems often becomes nightmarish, especially with extensive combinations of components. It is relatively effortless to recognize the form-related Vril function of these very same systems, recognizing in this primary function the very reason why they worked in electrical parameters at all. These systems worked in electrical parameters only because they were good Vril conductors. Our research is a necessary retrospective survey of electrical communications systems with these facts in mind. To comprehend the exact features which should be sought in such study, one needs to learn more of what Vril is and how it behaves when engaged by a structural design.

Vril is electrically neutral. Inertial space is neutral also, unless penetrated by Vril threads. The focussed Vril penetration of inertial space stimulates inertial cavitation and dissolutions. It is in this interaction that we see the composite nature of inertial space, which dissolves as a continuously infinitesimal series of droplets. We see electrical charge manufacture wherever Vril impinges a densified inertial layer. Proceeding from the Vril channel, the radiant flow of negative charges rides the inertial surface outward. Positive charges enter the Vril channel. The opposed charge flux occurs in radial lines from the Vril channel. The manufactured currents may be weak or strong depending on the degree of sensate interactivity.

In this interaction, there are no fixed electrical charges or electrical masses. Contrary to academic assertions, one observes a spectrum of charges and masses which are manufactured in situ. Both Tesla and Le Bon made reference to this charge manufacture process, a fact recently brought to attention by radioengineer, Eric Dollard. It is imperative that we realize the constricted site in

which charges are observed during this Vril penetrative process. One measures electrical currents only along the dissolving inertial surface. Beneath this surface is a far deeper world, one of sense and conscious reality.

There is no detailed understanding in the reductionism by which engineers group and equate empirical observations. In truth, any whole observation is a composite of innumerable interactions. Knowing the most fundamental order and grade of interactions is critical to the improvement of any system. Knowing the most fundamental cause of an effect is the key to designing new technology. By what fundamental means are we then to obtain such knowledge? Electrical activities are not the most fundamental order and grade. Despite the fact that we apply electrical energies to radio circuits in order to "make them work", our thesis denies that electrical energies fulfill the function of communications systems.

There are reactivities between Vril and electric fields, which are specific. Tesla noted that the extraordinary preponderance of electropositive charge in his ray transmitters produced the most exalted distant communication effects. Other investigators corroborated these observations, noting that such "polar" preferences produced very distinct black radiant phenomena (Piggot). It can be experimentally verified that Vril discharges enter electropositive terminals, avoiding electronegative concentrations. Vril patterns are especially magnified when pulsating electric vectors remain unidirectional. Early wireless system patents are replete with such observations. Enraged Vril responses to all inertial irritants occur on behalf of bio-organisms. Vril moves toward the life of living things, preserving their life by auto-magnifying its presence whenever and wherever inertial occlusions are densified. One therefore finds that black radiant concentrations suffuse the ground just before and during storms. Vril automagnifies on behalf of bioorganisms, the electric rays serving as penetrating irritants.

Why each communications system operates successfully has little to do with electricity per se. The action which radioelectric signalling systems engage, in the natural Vril environment, is a reversal of the natural process observed before and after lightning storms. There are aperiodic intervals in which inertial space has so densified in an area that Vril discharges autonomically intensify to pierce and dissolve its presence. Vertical black striations and thready discharges emerge from the ground, piercing the densified inertial layers. Normally this process is quiescent and continual. The minor daily variations in experiential consciousness do not find their cause in "humidity" or "air pressure". They find their variations in the accretion of inertial space as it is ground absorbed and metabolized in the Vril Matrix. During these times, it is possible to visually sight the faint groundward moving white beams. Some have erroneously taken these to be the direct sighting of vital energies (Reich).

There are times when excessive inertial accretions require excessive dissolutions by the Vril Matrix. This is when lightning storms occur. Strongly constricted ground emerging Vril threads pierce the inertia, bringing down sharp white sheaths better known

as "heat lightning". The white sheath is the inertia, not Vril. Vril is black radiant when sensate. When insensate, Vril cannot be seen. Lightning strokes are highly constricted white inertia sheaths, which surround Vril discharges and rapidly descend into the ground. There they are dissolved and dispersed. The cavitation of inertia against the central Vril core of a "bolt" manufactures electrical detritus in situ. This is the "electricity" which researchers measure in a lightning bolt. That lightning is fundamentally triggered by a natural Vril process is evident in the numerous accounts of "black lightning", which suddenly appear without shock and without thunder (Corliss).

Numerous accounts had been given of "black lightning", and "black auroras", reports which have been continuous throughout the last century. Though numerous photographs of black lightning are fortuitously made each year, academic science cannot accept the physical evidence laid before their eyes. Taken by most to be "overexposures" in photochemical emulsions, black lightning has been visually observed. Obviously a breach of electrical science, black lightning proves much more ancient theories concerning natural environments and natural energies. A powerful manifestation of black lightning twice produced remarkably distinct thick dark forked shadows against a large terrace window (Vassilatos). The phenomenon repeating itself twice during a single storm, revealed far more than electrical dynamics could produce. In this instance, the "black lightning" forks literally stood out of the ground in the middle of a road.

The electrical strikes which precipitated the black lightning had not occurred in the road at all, but had brightened the sky further up on a hill. The black lightning was not a simple tree shadow on the glass, being radiant and deep and distinctly non-electric in sense. In fact, while the electrical phenomena of the storm brought considerable physiological irritation, the sudden and unexpected appearance in the road of two distinctly different black forked shapes were accompanied by a warming sensation. In this is comprehended the Vril rulership over natural electroactivity. Vril precedes the appearance of electrical discharges, being the core of these white displays. Drawing out inertial currents, black Vril threads often become ensheathed in foggy white displays. The excessive constriction of primary Vril thread discharges reaches upward and powerfully congeals the residuum of aerial inertia...its chief function. Thus, the natural Vril discharge is a protective function, where Vril cleanses the aerial stratum on behalf of bioorganisms. Furthermore, and most astounding, is the fact that black lightning displays are articulate manifestations. They are dendritic and highly detailed, the patternate emanations which proceed from the ground toward space (Corliss).

Thus, irregardless of transmissive mode or operational frequency, radioelectric irritations cause sufficient irritation in the Vril environment to provoke a greatly magnified Vril response. This response brings the eidetic current strength beyond its normal levels or distributions. Magnified and expanded in size, these currents flood whole districts with their imagery, being often received by sensitive individuals as sudden "remote views". On close inspection therefore, any electrical irritant will stimulate

such long range effects. Though this fact explains the successful operation of all electrical communication systems in general, we exemplify those systems which employed RAYS and not WAVES.

10.10 VRIL AND ENERGETIC BEAMS

The most effective Vril irritants are the electrical rays which Henry discovered, Thomson rediscovered, and Tesla developed into a revolutionary technology. In a previous investigation, Tesla describes strange and ghostly streamers. These were mysterious to Tesla, seeming to be externalized displays of phenomena to which Sir William Crookes alluded. When Sir William, in detailed descriptions of vacuum tube phenomena, observed the very same white flimmering streams, he strongly believed them to be ectoplasmic streamers. Flooding his special high vacuum tubes with their entrancing smooth glow, Crookes used the tubes as a telescope of "astral space": the spirit world. But here, in Tesla's sight were the very same displays. The difference was that these did not require vacuum enclosure at all. These "misty white" streamers were "cool to the touch". They projected outward into space "...phantom-like". In these yard long streamers, Tesla saw more evidence for the fact that his Electrostatic Transformers were channeling an aetherial gas. His terminology became quite "hydraulic", and later "aerodynamic" in describing these white flowing discharge phenomena. In fact, his later Transformers began appearing ever more streamlined.

Raybeam systems were first recognized in the hands of Tesla, who used them in epochal power transmission systems. The potent and penetrating rays produced a great number of phenomena which indicating that a mysterious "extra energy" was entering the devices. One such phenomenon was casually mentioned by Tesla after public demonstrations of his remote control systems. In this, Tesla reported that the operation of his impulse transmitters produced a continual flow of usable electrical energy for an hour after they were deactivated. He also described an anomalous form of ionization by which it was possible for him to draw long silvery threads of light from organic matter everywhere in the demonstration space. The description of these clingy and fluidic silvery threads greatly resemble the phantomlike streamers produced in an oil insulated version of his Electrostatic Transformer.

Tesla also describes an ever expanding column of electrical lumination which proceeded from his power transmitters during nighttime operations in wide open spaces. This manifestation of ever-expanding light indicated the articulate growth characteristics associated with his impulse applications. Grounded, these spiral transformers stimulated voluminous Vril currents. Described by Tesla in terms of spatial volume and surface area, the ever growing column of light is not one which radioelectric currents customarily exhibit. These luminal manifestations were not produced by electrical impulses, they were stimulated in the Vril Matrix by electrical impulses.

Tesla later discovered the exact impulse frequency for stimulating extraordinary luminous displays in free space. These displays, surrounding his capacity aerial broadcasters with a white light, rapidly grew in volume and radiance. With these, Tesla

declared it possible to illuminate the night. He also planned to beam such impulses skyward, stimulating voluminous radiance across great expanses. The applied energy, an impulsing current of intense electrostatic force, served merely to stimulate radiance, not supply the energy to generate it. The use of electric ray beams provokes a conjugate enraged Vril regime, a tightly constricted beam of thready black ray discharges whose first function is to neutralize the effects of the irritating beam. Intensified Vril beams remain in their enraged state until the electrical beam is removed. Vril then resumes its relaxed normal state after a gradual period of deexcitation.

There exists a remarkable Colorado Springs photograph in which electro-impulsive discharges take on the appearance of smoothly collimated light beams. Beamlike arcs pass among several disconnected transformers. Clearly seen within the large Magnifying Transmitter array, one glimpses but one aspect of Tesla's research on which he was later to place total emphasis. Rays, conjugately propagating along with Vril threads, produced the most intense antagonisms. These antagonisms result in powerfully concentrated eidetic exchanges. In pure ray propagation modes, Vril magnifications are overwhelming and linger with time. The experience of Tesla in these regards can be found in his Colorado Springs Diary. Perceptual distortions being the heart of his remarkable account, his Diary tells that both visual and auditory distortions suffused the region surrounding his plateau. Most imagine the account to describe the familiar effects of mountain living on city slickers such as Tesla. But Nikola Tesla spent the whole of his young life in mountainous lands, never observing these phenomena. Obviously he is telling us that a new effect has been observed; one which explains some ancient astronomical observations. Permitting the accurate unaided observation of train wheels and passengers across ten or more miles, Tesla tantalizes his readers with a new conundrum.

It is assumed that, in this vast projection of black radiant phenomena into the natural environment, Tesla discovered something of the geoaanatomical structure. It was obvious that these perceptual distortions were anisotropic in distribution, revealing specific paths through the ground and space; a vital piece of information which leads to special views concerning all wireless forms of communications. In addition to those truly strange empirical discoveries by which Nikola Tesla is principally known there came others, whose bizarre and often accidental findings produced equally paranormal manifestations. The use of rays and rayic beams occupied theoreticians in pedantic recapitulations. Expending all their intellectual energy in describing the anomalies associated with rays in conventional terms, certain discoveries refused to be so easily reduced. Strange and wonderful, each of these new anomalies has more to do with Vril than the electricity whose irritations triggered the natural response.

The elimination of ground connections did not eradicate the dynamic engagement of the Vril Matrix. Shortwave and beam radio systems remained thoroughly suffused by ground discharged Vril. These systems also powerfully interacted with the aerial strata of the Matrix. In this manner, shortwave aerials and beam projection

tubes became CONNECTIVE TERMINALS through which eidetic signal components were projected to great distances. With this primary mode securely in operation, shortwave, VHF, UHF, Radar, arclight projectors, Ray projectors, and other beam systems became effective extensions of the ground discharged Vril. Suffused by local and impressed eidetic currents, these beam systems effected strong and clarified transmissions of eidetic currents. It was not uncommon for these systems operators to experience repetitive and scene-fixed eidetic discharges. Suffused with the primary Vril components, radiobeam systems operated primarily in Vril functions.

Beams of electrical rays, impulses, oscillations, or alternations each irritate the aerial Vril stratum by direct connection. Antennas act as terminals, touching specific aerial Vril strata. The powerful consciousness modifying effects of VHF, UHF, Radar, Arclamps, and other Rays are first experienced in the strong attraction which powerfully draws human attention. Beam transmission systems, whether for power transactions or communications, were extremely effective in certain parameters. Mysterious in their appearance and activity, such beams systems are pictured by Tesla as capable of intelligently tracking targets with no additional guidance components. Other designers successfully managed the detection of distant radio signals through compact ray tube receivers (McCullough, Moray, Farnsworth).

Communications systems had always been developed by experts in the energy known as electricity. It was thus hastily assumed that electrical components and applications produced all the observed effects in these systems. The electrical function of radiosystems, imagined now as their only operative mode, contained too many "lumped interactions". Few ever perceived that the real function of electricity in these systems was to act merely as an irritant of more extant energies, energies whose role in human interactions has always remained primary. Since these systems had been developed through empirical observations, all the observed signal exchanges were thought entirely due to electrical applications. In this we see that the lack of detailed understanding in these regards promoted a erroneous theoretical base upon which all of modern communications theory is based. What is the chief benefit of unravelling these conundrums? The development of transcendent technologies requires a detailed knowledge of the Vril Matrix, the natural environment which it generates and sustains, and the responses of this suffusive Matrix to human artifice.

The electrical components, whose operative functions were learned through empirical observation, served merely as Vril irritants. Eidetic signals exist entirely in the Vril Matrix, whose extent floods the world. Power is not required for exchanging eidetic signals. PATTERN CLARITY is the required function in this regard. But electrical irritation of the Vril Matrix does not require the detailed and complex componentry of radiosystems. Electrical light energy can produce concomitant Vril magnifications through specific kinds of irritation. It was found that certain electrified gases actually radiated emissions which had powerful effects on the Vril Matrix. Inventors experimented with the consciousness-modifying phenomena associated with low pressure

gases (Crookes, Tesla). Besides the therapeutic effects, and exceeding the mere aesthetic beauty of colorful light, gases emanate perception modifying energies when electrified. Astute observation reveals that experiential space is considerably modified through exposure to the light of various electrified gases.

It is possible to stimulate powerful visually sensate black radiant pulsations, waves, and currents by the use of a strong flashlamp. The impulse and intensity establishes black radiant conditions which may be seen. Irritated into a magnified state, black radiant Vril begins to move into the photoirritant. Sudden, isolated lightflashes produce an instantaneous black flash which floods the eyes. It is the familiar result of photoflash. When lightflashes are repetitive and continuous, the black flash becomes a continuous flow. Prolonged operation of quick impulsed Xenon flashlamps produces a special blackwave phenomenon. First flooding the eyes, a black radiant flood gradually works its way throughout the body. This blackwave is accompanied by a distinct relaxing sensation. Peering around the white flashing light, one sees a continuous black radiance which moves into the lamp. The lamp may cease flashing, but the blackwave continues for a minute or more afterwards.

Experience conveys exact information. Experience does not require the quantitative interpretations gained through inertial assessments of the world. The two approaches, subjective and objective, are mutually exclusive. Quantitative data cannot inform experience. Experience is the ultimate criterion, the only gateway into the conscious world foundation. Quantitative analysts judge the blackout phenomenon to be a photochemical reaction, one which occurs entirely in the retina. In their view, afterimages and blackwave phenomena do not indicate space suffusing conditions. They have not taken care to notice that unmistakable physical sensations follow the movements of blackwaves. Seeing the light itself does not produce the effect, the common assertion. Flashlamps do not cease producing these body permeating sensations when eyes are covered. They do not cease when we turn our backs to the light sources. The blackwave sensation may be felt both with eyes covered and with progressive distance away from the lamps. Blackwaves flood regions of space which have been substantially irritated by flashlamps.

Lamp-stimulated blackwaves are a real external space phenomenon, a Vril manifestation which focusses on the irritating bright light sources. Vril responses flood space whenever irritations such as these are released in the environment. The responses match the irritant. Sensate irritants evoke sensate Vril responses. Insensate or semisensate irritants, such as shortwave transmitters, produce equivalent responses. It is not uncommon to visually sight blackwaves near intense shortwave radio transmitters. In all of this, we must see that focussed energetic beams become conscious channels. Such channels permeate matter and space, opening them up and releasing their essential radiance. When this state is achieved, both matter and space change. The essential feature of the Naval dark wave experiment, albeit devastating, was contained in this kind of interaction.

When one comprehends that communications systems require far more than code and code-carriers, one is faced with the singular problem of explaining the transaction of whole meanings through the ground or through aerial space. There are the eidetic functions which operators of VLF stations experienced. When absorbed Vril patterns are electrically magnified, they become powerfully and dangerously enlarged. Irritated into greatly expanded and highly clarified states, these patterns process into the surrounding strata. The enlarged Vril processions instantly reach those for whom the messages are intended. Vril engagement between communicants is truly complete only through Radionic instrumentation.

The contemporary awareness that lightbeams contained vital energies began with the historic experiments of Baron Karl von Reichenbach. Baron von Reichenbach verified the Odic energies contained in space sourced lights. The isolated lightshafts of sun, moon, planets, and stars each flooded over with Odic energy. The Baron successfully treated these Od-rich lightbeams with large crystal prisms, discovering that select spectral portions concentrated specific Odic contents, whether vitalizing or depressing. He also observed and described the Odic interactions with both magnets and light. His classic experiments proved that the luminous Odic emanations from large magnets could actually be focussed by a large lens into bright mid-air suspensions. The Baron also successfully managed to photograph Od luminations with very sensitive emulsions.

Thereafter in America, Dr. Albert Abrams managed to photograph lens-focussed auric emanations from the bodies of his subjects. T. G. Hieronymus discovered that the natural radiant emanations of materials could discharge from electrical components and circuitry, traversing optical components such as prisms and lenses. He termed this energy "electrooptic" or "eloptic" energy, since it demonstrated conductivity through wires along with lightlike properties. The energetic interaction between these radiant discharges and the quartz optical components proved remarkably revealing, especially when the discharges of various elements and substances were examined. Noticing the physiofrictive reactions, sensed in the fingers when contacting special plate capacitors, Dr. Hieronymus realized that he was able to analyze unknown chemicals by simply rotating the conductive prism. This proved that the radiant emanations were capable of being diffracted, each element projecting succinct spectral components.

The interactions of lightbeams and magnets were implemented in a similar diagnostic instrument by the DelaWarrs in England. These interactions are especially potent when loaded with special Radionic combinations. The concept that directed beams of light can carry eidetic information is taken directly from natural example. Capable of suffusing other energetic substrates besides light, eidetic currents can be directed toward specific sites with deliberate intent. In addition, numerous eidetic currents can be combined to convey several eidetic messages simultaneously. Experiments have shown that Radionic signatures can be both impressed and detected through lightbeams alone. This is the central principle which rules all beam systems of communication.

The endless collection of anomalies observed with beam systems originate with eidetic dynamics. It is in this frame that we comprehend why the designers of electric raybeam communication systems had observed their anomalies.

Projecting their irritations in straight lines through the aerial Vril strata, the eidetic signals tunnelled pathways away from the transmitter site. Beam transmitters were characterized by unusual anomalies, whereby energies were drawn into the transmitters as if by "touch contact". Thus it was found that transmitters behaved as if extending some kind of physical channel through which contact from the outside could reply with rare entrant energies. Such penetrating beams stimulated the release of multiple vertical Vril manifestations. These simultaneously sprang from the ground in special groundpoints, and also rayed down from space from special spacepoints. In this, beam communications systems provoked an entire regime of lost Vril realities and behaviors which have great import in the With beams came several remarkable phenomena. Hettinger observed that vertical arclight beams could be pulsed by radioelectric currents, effectively forming aerials of extraordinary vertical length without the necessary wire conductors. In addition, these vertical beams became charged with groundward flowing currents similar in effect to those observed in the aerial batteries of Vion, Ward, Dewey, Palincsar, Pennock, and Plausen (V.1).

Healing systems exposed the body of patients to a vibrant flux of numerous electrical impulses simultaneously. While many imagined that the electrical impulses held the principle healing function, most did not realize that the electrical vibrations simply acted to collimate the suffusive Vril flow which came in response to the irritation. One finds that medicinal applications of rayic energies stimulate vitality long after the initial exposures. It has been reported that blackwave processions flow through a properly constructed Lahovsky double coil arrangement which employed grounding (Lehr). Healing beams were generated in various gases, being applied to the body directly. Their principle therapeutic power was derived from the antagonistic responses of Vril and the applied electrical beams. Having been derived through special gases and gas mixtures, these beams were Radionically active. Being suffused by the specific Vril currents of those gaseous elements, Vril response was biased toward those elements. Therapeutic absorption of these elemental currents was empirically found advantageous in healing certain conditions. Most of the time, various argon-nitrogen mixtures were employed. In one case, minerals and other substances were employed (Moray).

We again recall the observations made by Sir William Crookes with regard to vacuum tubes and the surrounding environment. The electrical action of a vacuum and low pressure gas tubes is not limited to the glass or metallic envelopes forming the containment structure. Sir William observed that space suffusive articulations of the most delicate fluidic varieties actually flood the discharge space of such tubes, having passed directly and effortlessly through the glass walls. Glass is transparent to these Vril suffusions, isolating neither the electrical irritants nor the gases contained from the Vril Matrix. Quartz glass seems especially

transparent to these suffusions. Although we are taught to view vacuum discharge tubes as isolated entities, such discharge tubes connect directly with the Vrill Matrix. They are infused with Vrill threads, irregardless of whether they are grounded or insulated from ground. Tesla's early work with Lenard tubes reveal connections to ground.

De Moura discovered that cathode ray beams could literally extend, focus, and magnify the projection of electrical rays. Reno also discovered the powerful radiant effects of rapid and abruptly impulsed electrical beams. His patent is a textbook on anomalous rays. Thus, true mysteries of the Vrill aerial stratum were delineated through the antagonistic influence of energetic beams...an impoverished means by which to learn of Vrill responses and Vrill behavioral phenomena.

In a more dramatic exhibition of space-suffusive interactions, we examine the most advanced vacuum tubes ever devised: the remarkable work of Dr. Philo Farnsworth. Philo Farnsworth produced an enormous series of truly remarkable electron tubes, the most complex designs scholars will find in the historic archives. Anomalous in their exceptional efficiency, these tubes provided Dr. Farnsworth with a powerful arsenal for creating beam energy devices. His attentions not simply focussed on the radio effects of these devices, Dr. Farnsworth recognized the purely aetheric implications inherent in the operation of multipactor designs. In the operation of these tubes, extra energy seemed to enter along the tube axis...from surrounding space. The multipactors of Dr. Farnsworth were miniature solar furnaces in terrestrial glass vessels. Farnsworth's magnificent electron tubes were prolific generators of UHF impulses. The concept of photomultiplication was, in his laboratories, brought to an incredible level of perfection.

Farnsworth multipactors reached anomalous levels of efficiency, highly problematic for contemporary physicists. In effect, the multipactor tube is an "electron reactor", in which electron emissions from Thoriated filaments produce chain reactions through bombardment in Caesium.

Electric rays from the multipactors proceed directly through the tubes, producing external effects capable of charging objects and triggering Geiger emissions. The effects are not caused by X-ray or other identifiable such energies. Others have duplicated these effects, having discovered that photomultipliers may be used as bioresponsive instruments (Dollard).

10.11 VRILL EIDETIC IMAGERY

The Vrill discovery process is experiential, not objective. Those whose science tended toward an apologetic quantified treatment of QUALITATIVE realities, devised the Victorian aether theories. Originally codified in the elegant ectoplasmic theories of Swedenborg, Reichenbach, and Crookes, scientific researchers began to isolate features of the connective bioconscious stratum. Glowing ectoplasm, the fine and hairlike space-filling medium, was identified through a number of intriguing and diverse experiments. Electrical discharges (Crookes, Tesla), biocrystallizations (Littlefield), sonic shadowgraphs (Hughes), darklight photographs (Le Bon), black heatlike ripples (Blondlot), sensitive responses at

a distance (Bose, Abrams), these and many others found increasing evidence for the existence of the bioconnective Vril Matrix. The Vril Matrix is consciousness and life. It creatively generates bioforms within media which it has previously projected.

While a few scholarly devotees maintained the integrity of this wonderful and revelatory thesis across the century's turn, some decided to construct a theory which satisfied all of the "academic requirements" for an interspatial medium. The ill-famed aether theory, put forth by Lodge and other quantitative analysts, proposed that a chaotic gaseous medium filled and permeated all spaces. All such apologies, based on quantitative maxims, are almost immediately consigned to failure.

Normally indolent, but focussing all their efforts in these instances, academicians delight in picking such theories apart. Whether through criticisms of experimental accuracy or penetrating experimental proofs, no manner of quantitative proofs can ever satisfy academicians that any bioconnective medium exists. Predisposed against and fearful of the bioconnective medium, academicians consistently shirk the issue. nevertheless, personal experience constitutes personal proof. Ultimate proof. Experience alone is the personally cherished proof of value. Through repeated experience with Vril currents we learn that the world is not built on inertial matter, but rather on consciousness. Permeating in the black radiance, we receive the necessary penetrating vision to peer beyond the inertial bounds of our environment. Once this reality is securely fastened in our minds through direct vision, we can begin to intellectually accept the notions anciently written and here expounded.

There are too numerous experimental demonstrations clearly indicating the existence of Vril and its marvelous qualities. Most conclusive among all of these proofs is the personal one. It is through PERSONAL CONNECTION with the Vril currents that we receive experiential expansions of consciousness. The acquisition of these experiences requires the simplest grounded apparatus. It is only through the medium of Vril current then, that we realize that consciousness is the foundation from which the material world springs full. Experience in the Vril currents reveals a fundamental world-structure which differs completely from that which is perceived by the dulled, inertialized senses alone. Vril distributions permeate experiential space with a light seen directly through the aura. It is through this personal experience alone, a vision empowered through Vril Light, that we comprehend the connective Matrix in which we live. It is in this awareness that ancient designers conceived special Vril technologies, employing the Matrix directly. The Matrix, as a providential utility, supplied the needs of certain societies. When once these ideas are firmly internalized, one conceives of inter-regional communications in a new and greatly enlarged domain. The use of the Vril Matrix for establishing communications requires a knowledge of its own energetic expressions.

Continual exposures in Vril produces continual collectivization of seemingly separate realities. The science of qualitative analysis suddenly becomes more precious than that which is learned or obtained through inertial meters. One sees the

homogeneous integrity which infuses numerous qualitative thesis. Continued exposure in the Vrill current reveals the fact that it generates all experiential reality, including the very ability to apprehend its endless creations. Mind-permeating space topographies, which reveal the external and suffusive structure of the world, can be modified by the application of special technologies. This topography which, with practice, can easily be mapped in any location can be used to benefit by the adept designer.

Vrill discharges, eidetic in content, form discrete patterns of the most complex composition when passing through eido-conductive matter. Vrill effects mindstates and sensations from the outside world, having mappable topographies. Vrill is not the luminous displays of auras and aethers. Vrill is the black radiant core of existence, the creative and projective core of ALL experiential manifestations. Vrill is black, but is not void. Vrill black radiance is creative and projective, the generative source of all whole visions. Vrill projective visions are the experiential DIORAMAS which compose our world experience. Qualities, and their complex compositions, reveal the previsionary ancient aeons of Vrill. Knowledge of world-structure precedes understanding of all too numerous radioelectric anomalies. One sees that, as with telegraphic and telephonic VLF, raybeam systems also powerfully interact with aspects of the Aerial Vrill Stratum.

In black radiant space, one senses a powerful conscious focus which brings a wonderful sequence of personal elevations. Direct physical contact with this black radiant energy causes a sudden withdrawal of all personally surrounding "pressures". Those who enter into such black radiant spaces first become relieved of all negative emotions and internalized physical pressures. One at once feels the freedom of a more permeating and fundamental space.

In this magnified special perceptive state, one discovers new vistas. Visual vistas. The black radiant space extends in all directions. It is deep, expansive, and exhilarating. The black radiant space is simultaneously an objective observation and a subjective experience. It is in this awareness that new visual-mental functions reawaken. With sufficient exposure within the black radiance, one envisions the true and deeper world. The black radiant space suddenly appears to have details and topography. One finds it to be immense and unmoved, pulsating and glowing, flooding the percipient with new ideas and visions. It is in this radiance that we perceive the true World-Structure.

Through the consciousness derived from contact with black radiance, sensitive men and women became priests. The black radiance is the supernal light which precedes the development of sensate light.

Black radiance is more than insensate light. It is generative source of consciousness, the generative source of existence, the generative source of worlds. Vrill is the only means for deriving, comprehending, and communicating the ancient knowledge of the World-Structure, of the World-Foundation. It is an experience, not a lesson. Far below the foundation to which physical instrumentalities can penetrate, our ordinary consciousness imagines metaphysical depths which exceed inertial bounds. The Vrill

magnified mind perceives these realities with great power, visually examining the very deepest accessible planes and strata.

Called the "hollow in the earth", this deepest foundation marks the locus through which images become materials. It is in this deep stratum, this Plynth, from which dreams emerge and souls go wandering. The metempsychosis of the ancients was not a myth. They recognized in this stratum a nexus where all minds could meet if properly trained or equipped. This zone was termed by many names. But The KRATON, the "all upholding one" served the meaning best. The Kraton is the only foundation in which dualities dissolve, being the generative source from which realities emerge. Inertial space splits experience into dualities.

Black radiant Vril can suffuse the space above a small groundpoint, emanating upward in a glorious display. One may see the black radiance in wavelike processions, glimmering across an opened field. In places where the black radiance densifies and constricts, one perceives the wriggling and sinuous trails, noted by ancient geomancers. In other instances, one may observe black radiant Vril discharges as they flow among rocks, or from ridges to trees. Vril is blackness...but is a radiant blackness. Vril current does not enjoin the avid investigator with a life-destroying stratum of shade and gloom. It is not the smokey dreaded darkness which inertial space brings. Vril is not shadow and death. When one enjoins Vril ground currents, one receives a magnified consciousness state which excludes and dissolves all ephemeral thought structures. Those pressures and constraints which invade our being unawares are suddenly removed.

In the flow of Vril ground currents, now powerfully obtained through contact with iron posts and grounded iron rods, one is suffused in the Vril black radiance. It is a light which is world-generative and world-suffusive. In this flood, one views a creative dynamic which surrounds and permeates one's very being. Intensified in vitality, one recognizes that this current projects an expressive and creative language. The language comes forth as experiential dioramas...as images and imaginal impressions. Here, one recognizes that world-experience inhabits these superposed and interpermeating dioramas. Together these compose our world-experience. The World-Structure is composed of the whole imagery which is experienced and directly represented in visions. Vril interconnects the world in dialogues whose content is a language of images. Vril interconnects the environment with imagery.

Chladni discovered that collimated beams of sound contained cross-sectional patterns which could make permanent impressions. His discovery realized what the reductionistic analysis of sound (Helmholtz) failed to reveal: that sonic beams are suffused in variegated patterns which are bioorganismic in form. His discovery that some of these patterns oscillate through time also gave evidence that these cross sectional patterns had volumetrically distributions. By these discoveries, it was understood that sound beams were not mere stratified air columns, having alternately bands of compression and rarefaction.

In 1885, Margaret Watts-Hughes produced some of the most remarkable sonographic records ever made. In a trumpet-like device, which she called the "eidophone", articulate vocal utterances were

focussed on a dust-covered diaphragm. Bearing no relationship to the harmonic sonograms of Chladni, singular vocal sounds made by Mrs. Hughes produced dendritic trails and cross sectional patterns. The "Eidographs", as she referred to them, became intensely complex with longer utterances and varied dust media. Varied host substances often produced elaborate and distinctive bioorganismic patterns.

Thoroughly suffused with shadowforms and black trails, the EIDOGRAPHS of Mrs. Hughes reveal startling connections between simple words, ideations, and the signals transacted through vocal sound. Certain vocalizations produced treelike forms of such topographic clarity that they suggested themselves to be photographic impressions of remote views. Other soundings produced floral varieties such as those found in local meadows. Here was proof that more-than-inert acoustic signals were being transacted through speech.

Speech contains ideations which require special objective retrieval means. Ordinarily, communicants transmit and receive such ideations directly while speaking. They are the result of auric interactions which are transmitted in the black radiant core of vocal utterance. In this is the basis of our discussion on wireless communications. The electrical systems, developed with wireless electric functions in mind, achieved far greater effects than convention allowed. Paranormal perceptual effects were immediately noticed by ordinary operators. Having intimate association with the systems, these persons were the first privileged to experience the eidetic and heightened conscious states found in Vril currents.

It has been commonly observed that sudden exposures to bright light bring a corresponding ocular darkening effect, a phenomenon with which most are familiar. In this regards, however, are spatial phenomena, which differ widely from this variety. If we are exposed to the constant flashing of bright lamps (Xenon flashlamps for example) a suffusive and continuous black radiance suddenly appears. Not the mere oculo-chemical phenomena which most equate with darkened "after images", this black radiant suffusion can be both seen and felt. The suffusion can be felt throughout the body, despite well-covered eyes, as a spreading numbness. Within this numbing sensation, one feels a strange warmth, phenomena of incredible importance in our discussion on wireless communications.

One discovers that sudden, irritating stimuli will summon this black radiance from the ground itself, most commonly with electrical impulses. Electrical impulses stimulate sudden responses which proceed from the ground upward. It is this phenomena which is responsible for the consistent appearance of "black lightning" strokes; which are not electrical manifestations in themselves, being responses to electrical irritations. For certain researchers, these sorts of phenomena suggested the possibility that black radiance in signals could actually be used to transmit whole imagery (Tesla, Abrams, Drown).

Vril precedes every characteristic termed "biological". Vril is the living quality in matter, granting it life. Vril pulsates, throbs, grows, assimilates, bifurcates, magnifies, discharges, and projects itself across vast distances. It crystallizes and

recrystallizes in smooth fluidic processions of black radiant threads. When these threads coalesce, they entwine and combine into a thready vinelike mass. With successive such entwinements, it becomes difficult to distinguish black radiant Vril threads and channels from rays. And these are often visibly seen throughout the natural environment. But these purely objective discernments are not the essential Vril characteristics, certainly not the ones through which Vril is differentiated as a distinguished space domain. While not devoid of physical attributes, Vril threads, channels, and rays evidence their more potent conscious and sensual effects.

Being the source and core of our own being, each Vril manifestation powerfully attracts and holds our attention. We take notice, whether aware or unaware, whenever Vril is processing, self-modifying, or discharging across our experiential space. How often do we not look away from our occupations, staring off into space? We each frequently peer deeply into some vague stretch of ground, aware that some vitalizing change has taken place. Sharpened senses will focus directly into the very spot in which these Vril modifications are taking place, trained through experience to isolate black radiance. While these objective Vril behaviors were all too evident to certain astute developers of early line and wireless communications systems, there were deeper and more permeating characteristics which captured their zeal. A few awe-struck individuals were quick enough to recognize and distinguish the effects which Vril radiance generated.

The central Vril Quality, upon which sensitive experimenters were focussed, is EIDETIC information. Vril currents translate our experience from the inertio-physical space into EIDETIC SPACE, the generative Vril Domain. Vril processions carry a message to us the fundamental information by which the human race remains a sentient community. Vril carries information of its own, the vital mind-fundamental information by which our world survival is determined. Strong biological discharges stimulate ground veins, eidetic currents being exchanged across great physical distances. Mystical trees, boulders, and rocky ridges connect with these deep veins, discharging visionary energies. Thready Vril discharges project receivable eidetic images, living pictures of remote locations. Engaging phenomena which are simultaneously unexpected and astounding, we realize that whole images are actually transacted among specific ground points as a natural occurrence. Vril interconnectivity is often revealed in a most astounding manner. The bizarre preservation of images follow lightning storms.

The strange, well documented phenomenon having to do with lightning, is the preservation of Vril-conveyed images by lightning strikes. The process produces the images in varied ways, direct strike not being the only means by which images are deposited. In one such transfer mode, a lightning discharge occurs in proximity to an array of objects. The figures of these objects are often impressed directly into matter, being found after the lightning strike has occurred. These images are remarkably distinct and sharp, evidencing both a volumetric and cross-sectional patternate nature which is not properly equated with lightning. The supposed electrical plasma is ordinarily thought to be too chaotic and

scrambled to preserve any kind of pattern, much less an imaginal one. One does not usually think of lightning as having a coherent beam nature, capable of transferring patterns from one point to another across a space.

The mode of transfer reveals a variety of interconnections. Objects which have been touched by the lightning channel contain the images, being deposited at a distance from the source site. The image of objects, merely in proximity to intense lightning discharges, have been deposited on distant objects without direct strike. Others are deposited by ground emergent bolts which occur far from another strike. These side-bolts confer images which the distant main channel touched. By what means is this conveyance of images from one place to another accomplished? Lightning strikes have themselves produced figures of objects they have not contacted. These anomalous and curious phenomena cannot be electrically explained.

Lightning figures themselves are deposited on very ordinary substances; substances which are not usually thought as photosensitive. These extraordinary figures include images of coins, of combs, of horseshoes, of numerals, of whole printed sentences, of church steeples, of cruciforms, of a passing railroad train, of a robin perched on a branch; whole images of countryside; exact replications of nearby trees, complete with leaves and branches; and images of farm animals. There have also been numerous observations of lightning shadowgraphs, images which are made by bright lightning flashes on exposed surfaces. An exact image of a nearby house was imprinted by this means on a white porcelain telephone line insulator. A ship officer noted the formation of fading images on freshly painted woodwork, made when bright lightning flashed outside. The officer made shadowgraphs of his hand and of a ship instrument by waiting for the flashes to come. The image of a wastebasket was imprinted on plain, bleached floorboards.

Numerous attempts are made to explain the images in conventional fashion. Some have suggested that these figures, deposited in painted surfaces, are mere optical depositions. Brought about by intense illuminations, the figures are supposedly flashed onto the receptive material in an unknown photochemical process. This would not explain the deposition of images on wooden planks and floorboards. Some of these images fade, other remain as permanent imprints. This contradictory deposition cannot be photochemically explained.

Some have asserted that these lightning images are rare natural electrophotographic depositions. The notion that local dielectric potentials, requisite for electrical image formation, combine with intense light to make clear images are farfetched. Both these optical explanations fail to explain the extremely sharp detail which such lightning figures and shadowgraphs evidence. Made in absence of focussing lenses, each of these figures are clear, having sharp edges. It is obvious that whole images are carried across space through a non-chaotic agency. Though carried through an electrical channel, a singularly chaotic medium, this agency maintains its orderly character. What energy is empowered to so resist the intensely disorganized electrical plasma with this

degree of insulate order?

However strongly impressed and geometric the original design may be, it is not possible to cause strong artificial lightning bolts to produce such images. What process is responsible then, during the course of a lightning channel, for the conveyance and deposition of such images? It is most likely that the electrical components of lightning neither contribute to the reception, conveyance, or deposition of figures and patterns. Rather it is the black Vril thread, forming the deep core of lightning discharges, which contains and confers the patternate figures. These figures are clear photographic representations of objects.

Black radiant emanations is often seen in old films of television performances. This old method of preserving live television performances reveals a remarkable black radiant effect which is very evident on casual inspection. One easily observes the black haloes which surround the images of performers and bright reflective objects. These haloes often pulsate and show noticeable expansion when performers become emotionally projective. Similar black haloes are preserved in black and white cinema as well as in photographic stills. Conventional explanations of the television black radiance refer to photoelectric saturation. The mechanism behind this supposed explanation requires that the photosensitive layer of the image dissector tube becomes unresponsive through over intensified illumination, the result of reflective glare.

Sequins and mirrored objects were always prohibited in early live television performances for this reason. But the reason does not hold up under further examination. Excessively illuminated photosensitive screens are made of the same substance which is used in one of Dr. Farnsworth's other inventions, the photomultiplier. In this device, intensified light is used to stimulate the emission of more electrons from photosensitive screens. Because of the photomultiplication effect one should receive a brighter image from a highly reflective source, not a black radiant halo. Photographic images often show black radiant haloes, especially when over-illuminated.

It is now believed that intense illumination so stimulates the auric emanation from performers and materials that the black auric layer becomes visible. The black auric layer was observed at the turn of the Century, being referred to as the primary projective layer for all other auri-luminal displays. These black radiant displays can be rendered visually sensate through certain illuminations. The illuminations, usually from carbon arc lights, actually stimulates Vril into sensate responses (Lehr). It may thus be conveyed through video apparatus and can be preserved in appropriate film emulsions. One observes auric anatomy from bioorganisms, minerals, and carbonaceous matter. Of these three varieties, the auras of bioorganisms are the most dynamic and complexly articulate.

This alteration of Vril radiance from insensate to sensate, through successive stages, can be experienced through yet another simple personal experiment. Eidetic currents may be brought into lower energetic expressions through a strange fractioning process. By deliberately forcing eidetic Vril to encounter sufficient organismic resistance, Vril will actively dissolve inertial space

until its eidetic content no longer remains sensate or accessible. In every encounter with inertial space and its densifications, Vril automatically shifts the eidetic patterns into higher states. In this manner, the eidetic contents are preserved safe away from inertial distortions and eradications. This shifting into a higher geometric pattern state makes eidetic imagery often impossible during highly inertial conditions.

Another simple personal experiment serves as an adequate illustration of this Vril principle. Eidetic currents flood the aura, potentially spreading throughout the entire body under certain circumstances. We see scenes and forms, receive thought impressions and ideations as a normal part of our consciousness. This wondrous flood is incessant, and it is only our training which has covered the eidetic flood in which our beings are bathed. One of the familiar misrepresentations of these externally received impressions names the phenomenon "imagination", as if to infer that these original and unexpected images are the projections of our own minds. How curious that such scenes often match places we have never yet visited, with an exactness which defies statistical analysis on locating them in the external world.

Eidetic scenes may thus be seen by touch contact. But when eidetic currents enter the aura through touch, they always seek out the oracular orifice and enter without hesitation. The auric vision precedes the optical retina, being the conscious reality behind the physical form. More often, however, they enter the region of the body around the oracular orifice. One may see eidetic images with eyes lightly closed. Covering the eyes masks some of the intensity of these images, but does not entirely block their entrance. What are describing is therefore not limited to an optical activity.

Shutting the eyes very tightly results in a condition in which we may visually sight the rapidly vibrating bright yellow specks which mark the entrance of eidetic threads into our aura. These bright and vibrating yellow spots do not permit access to eidetic images which flow in them, having been forced to destroy the densified inertia in our eyelids; the result of clenching our eyes unnaturally. We will also notice, if we are astute, that our consciousness has momentarily been thrown forward, diminishing our awareness of all other surroundings for that highly focussed instant.

On relaxing our eyes once again, and taking careful notice, we can receive the normal eidetic flow once again. While the hysterical bright yellow light allowed us to visually sight entrant Vril threads in front of our eyes, a more delicate attention is required to now recognize the inflowing eidetic stream. There is a time during which Vril relaxes its hysterical poise, slowly resuming its normative state and allowing its precious eidetic contents to become sensate once again. Thus, we may see yellow spots for a time after relaxing our eyes. The process is not caused by a photochemical response. The photochemical response is an effect of primary Vril energy. The phenomenon has enormous implications in understanding numerous Vril activities. It is found to be especially capable of explaining wireless phenomena which occur in radiosystem components.

10.12 BLACK RADIANT TECHNOLOGY

The subtle grades and levels of natural material radiance were discovered throughout the Victorian Era. These luminal phenomena were isolated and studied in great detail. As successive anomalies were recognized, some investigators began realizing a wonderful thematic integrity which began to organize the data. Not every phenomenon termed "electrical" had anything at all to do with electricity. Theoretical work in this regard began with Reichenbach, who studied energies closer to the fundamental. His investigation of natural and spontaneous material radiances extended the physical study of magnets, crystals, minerals, chemicals, biological, and celestial science. Baron von Reichenbach was truly the first one to implement electrical laboratory components in his study of natural material radiance. Thereafter, Dr. Albert Abrams designed and implemented his own components, determining with great exactness, the discharges of Radionic emissions. Pictured elsewhere as long skyward light-like beams, these eloptic energies (Hieronymus) were to provide energy and weaponry for the nation which would undertake the construction of landbased Magnifiers. Crookes believed that the supply of radiant matter, so obviously dynamic in his highly evacuated globes, actually came into the glass from the outside; more specifically, from the cathode side of the assembly. Previously and cryptically described in Tesla's numerous articles and patents, aetheric energy was energy of an interstellar "ultragas" predicted and described by Dmitri Mendeleev. The enormous pressure fields produced by stellar crucibles supplied humanity with an endless supply of kinetic energy free for the taking, provided an ultragaseous channel could be created.

While many believed all terrestrial and interstellar space to be suffused with an inertial aether, Sir William Crookes extended the gaze of academic minds beyond the limits of inertial physical considerations. Calling the attention of the scientific world to more spiritual pursuits, he described his examinations of vacuum discharges. The mysterious forms and shapes which drifted through his high vacuum electrical discharge globes, in smooth flowing streams, did not have the nature of an inert substance. In these, the sensitive Sir William perceived more of an imaginal nature: one in which strong interactions could be personally observed within one's own consciousness. Exposure to these otherwise dangerous emanations raised one's awareness and sensitivity levels considerably. It was Sir William Crookes who especially believed that the nature of the "Aetherial" or "Astral" medium was biological, and not inertial. Seeing these interactions between electrical discharge lamps and the lamp-suffusive space, many began designing "ghost telescopes".

Of critical importance is that we appreciate the remarkable awareness of these researchers. Seeing the strong interaction between technological artifice, space, and consciousness represents an astounding leap. It was in fact the reemergence of aesthetics which had long been forgotten. Though the centuries covered these awarenesses, yet they emerged once again. In our every examination of older technologies, the general principle is therefore to note interactions within systems and the Vril Matrix. Vril suffuses

systems, suborning them to its own functions. Such systems conversely modify Vril, causing substantial responses and conversions. These conversions occur in two principle inflections: first among its sensate range, and second in its eidetic components. It is possible to cause insensate Vril to become sensate. It is also possible to culture the emergence of specific eidetically derived qualities from Vril currents. Whenever technological artifice performs both functions by force, Vril responds with violent antagonism.

Those whose sensitivities were exercised by exposure to Vril learned how to cooperate with the generative energy. These are the individuals who learned to raise consciousness through special technological varieties. VRIL TECHNOLOGY. The object of this technology is first to raise and expand awareness. Once this is secured, Vril Technology has as its aim the reestablishment of lost world conditions, lost worldstates on behalf of society. Vril, the vitalizing generator, does not participate in any negative functions. Vril does not enter designs by which antibioorganismic functions are intended. In such cases, Vril deviates its course, and vacates the designs. These Vril vacated designs have been produced by various individuals throughout the centuries. They wreak havoc both to their designers and the surrounding cultures, becoming powerful conductors of lethal inertial currents.

The sea of wonders, from which new conscious states are realized, Vril manifested endless responses and behaviors to the blind probings of humanity. Those researchers who gradually came to recognize these realities became the developers of the greatest science which the centuries have produced. That science is Radionic, which studies and implements the natural radiance of matter. The reader is reminded of the central thesis brought to light in Compendium Volume 2 on Vril and Telegraphy, where grounded telegraphic systems became suffused with eidetic imagery. Witnessed through Ground Radio systems, operators effortless entered into complete empathic accord through specific Ground Radio systems. The remarkable and otherwise inexplicable empathy contained strong visual components which suffused the systems in absence of light or complex tuning apparatus. These effects seemed especially empowered as shortwaves were employed, having been experienced with the lightbeams of photophones and radiophones.

All ground connected matter became visibly radiant when sensitively examined. When turning their focus on the environment and the whole dioramas of which it is composed, new and startling realizations were obtained. Active experimentation with the ground-sourced black radiant energies brought a new revolution in scientific thinking. It was then recognized that the black radiance contained conscious modifying characteristics. Instrumentation, used for both telephonic and radio systems, actually clarified the black radiant effects. These realizations extended to the aerial strata thereafter, experimenters constructing large aerial capacities and multibraided cable lattices.

It was while observing the activities of these wireless systems that certain Radionists noted natural ground-projected beams of light (Reich). How these interact with both aerial and space entrant energies became a subject of intense study for some.

These numerous observations gave rise to several revolutionary developments in Radionics which learned methods for modifying terrestrial conditions. In this regards, the stunning work of George Starr-White is first to be recalled. His implementation of ground-derived Vril was directed toward therapeutic means. The deeply insightful work of Thomas Hieronymus was directed toward the dramatic improvement of agriculture, elevating it to a truly futural level. The grounded radiodiagnostic instruments of Ruth Drown utilized Vril in medical diagnosis and therapeutic applications. Her system for photographing internal anatomy, Radiovision Photography, used Vril alone as the activating energy.

Vril signals require only instruments of entunement for eidetic reception. No extra energy need ever be employed in this fundamental mode of response. Ground projected Vril reaches up in thready discharges toward space, touching specific aerial points throughout the day. These mysterious spacepoints, which remain fixed throughout the day, project their currents groundward. The amazing rediscovery that these spacepoints do not move constitutes a major thesis. These spacepoints remain fixed while stars, planets, moon, and sun circulate. Wherever these space energies are drawn down, whether by natural features or humanly structured artifice, they flood the recipient ground with vivifying effects. These realities were first observed in recent times by Galvani. Spasic energies are Vril discharges. They merge with ground emanated Vril threads. The fusion of these two strata are equated with elements and elemental compositions.

When electrical systems are simply grounded, they become Vril suffused. Entering grounded components and circuitry as threads, Vril preconditions the system with eidetic currents. When such grounded systems are suddenly electrified, the internalized Vril threads produce powerful antagonistic responses. These antagonistic manifestations appear as numerous varieties of strange anomalies, developing inertial by-products and releasing energies which modify local perception. In this, the fulfillment of Radionic Technology has not yet been fully approached or realized.

In more deliberate ancient technologies, eidetic processions were intercepted through grounded technology. The operation of these curious technologies reveal the connectivity with eidetic currents afforded through local Vril Axes. When personally experienced, these experiential realizations completely revolutionize us. They empower the transformation of our objectivist world-model into an empirical world-view. The notions sound alien only to those misinformed who have not recognized the essential mystery encrypted in the Templar Cathedral System. Other societies discovered the eidetic functions inherent in ground Vril currents, implementing the wonder of eidetic communications. Australian aborigines gaze into the "Tsuringa Stones", vortex patterns carved into rock outcrops, in order to determine tribal happenings at great distances. By this method, still in active use to this very day, a tribal member can determine the identity of a soon-arriving person, where they are travelling, when they will arrive, and why they have come.

There is nothing superstitious about this eidetic visual process. It does not involve sorceries. These primitive people have

inherited an archane system in which Vril eidetic imagery is directly engaged. Though primal, representing a much older Vril world system, this natural communications mode permits whole-image remote viewing. Profound in its implications, the geoeidetic system was once the central communications system of the archane world. A little practice reveals "how to see" through these stones. The images appear "within", passing through and past the retina. Being entirely auric in nature, the black radiance is the light by which we see remote scenes. One must simply trust the sensations when viewing. practice proves the reality of the intuitive receptions. Though semisensate, from stone to eye, the eidetic image comes through a real light stream. The stream is thready, feathery, and yet articulate. The images never fail. The components of old wireless, and then of Radionics, have produced greatly improved eidetic communicators which far surpass the megalithic systems. All of these improvements yet rely on the natural distribution of Vril lines and channels.

Later radio transmitter and detector designs disengaged their grounded circuits completely from all electrical supply. Empirical observation taught that exceptional receptions were obtained with special high-Q circuits and groundpoint selection. This was especially true for crystal receivers, many of which exhibited anomalous receptivity. Several designers have noted that reception increases in strength with ground saturation time (Moray, Parker, Meinke). Signals from one such receiver had to be volume limited because the loudspeaker, which it gradually drove to full volume, was disturbing neighbors several hundred yards distant (Meinke).

Each of these experimenters, obediently conforming to the insights granted them through eidetic image, have revealed the future intended course of world technology. Irregardless of the manner in which bureaucrats will accept the systemology, these Radionic designs will continue to be suffused with wonder. The very noumenous presence of Vril in their components, such devices and their makers become legends. In the most recent Vril permutation, one which began with Stubblefield, we have been taught that Vril current alone is sufficient for the transaction of meaningful signals (White, Drown). Requiring a perceptual shift and acquired skill in recognizing eidetic signals, these systems have proven their communal effectiveness across great distances (Theroux, Vassilatos).

It is intriguing to note the Radionic employment of components, originally developed by electrically oriented engineers and experimenters. How is it that these two completely opposed systemologies can share the very same accoutrements? Only careful examination of the historical flow of electrical technology reveals that all such designs began in naturally extant Vril phenomena. The work of Galvani and Mesmer began the contemporary flood which led to our Radionic Science. Those who devised the grounded hoop-and-ball telegraphs were unaware of the force which actually made their signals possible (V.2). Entirely empowered by grounding, no batteries ever being used in the system, one communicated individual letters by simply moving a pith ball to an outer dial. The distant wire-connected recipient watched as the pith ball of their corresponding apparatus bobbed toward the proper letters.

Signals were thus communicated to the delight of all who participated. This most certainly was not electrostatic force, which is incapable of intelligent or articulate response through a single line.

Careful study reveals that each of these components or systems have a primary function related to their overall form. This FORM-RELATED FUNCTION does not require additional energy for its operation in the primary substratum. The form-related function spontaneously engages transactions in the primary substratum immediately after being formed. Vril threads literally enter these components, creating their own articulate pathways therein. Components rendered Vril conductive become imbued with eidetic patterns, storing or losing these patterns in a substance-dependent relationship. This activity gradually reaches a maximum level, growing in the ability to transduce both non-radiant and radiant currents. We observe that systems or components which behave excellently in such Radionic parameters thereafter behave well in electrical parameters. The electrical function of each component or system is understood only through a clear understanding of Vril functions. These studies have indicated that none of the systems here presented can operate without their collective primary form-related function in which Vril is the active agency. Our retrospective study examines thousands of systems, mostly electrical, which clearly operate first in Vril parameters. It is in this understanding that we realize their efficient operation in electrical parameters. Electrical systems work well because they are first good Vril conductors.

Vril incursions being strongly evidenced in all of early electrical history, we see that experimenters totally missed "the right path". Developing a technology which employed bioirritating electrical currents, later designers completely lost awareness of the wondrous Vril presence which enabled such strange and dream-fulfilling technologies. Nevertheless ground Vril continued to suffuse their grounded systems, haunting their operations with anomalies. Telegraphy, Telephony, and Old Wireless. The anomalies multiplied with each development. Eventually systems were developed which returned to those first steps, those empowered entirely by Vril currents. This finally generated the Technology which has been termed Radionics. In our present development of Radionic Technology, we are yet at the stage which compels us to retrace the historical steps revealed in Telegraphic, Telephonic, Wireless, and Modern Radio arts. In this recapitulation we discover the pure Vril functions of these much older systems perhaps for the first time. Thus we implement components which had their origins in "electrical systems".

We yet construct and examine the Vril function in variable capacitors, transmission capacitors, vacuum capacitors, vacuum tubes, both Carbon and Nichrome rheostats, aircore inductors and element-loaded inductors, sparkgaps, gaseous conduction tubes, groundrods and groundcoils, capacity aerials, articulate aerial terminals, and braided cables. Confessing our extreme ignorance of Vril dynamics among such components, we are gaining the expanded consciousness in stages. In building these small systems, we receive new bursts of vision whose purpose is to raise us from this

present state to an intended higher level. Old components, in combination as special Vril conductors and transducers, form Radionic circuits. It is as though we are seeing the Vril functions of this system components for the very first time, utilizing pure Vril currents rather than biolethal electricity. Similar to much older system designs, operators require only exposure to the currents derived through Radionic circuits. The most recent inspired advancements in Radionics seem to be those which employ minerals, crystals, optics, organic and metallic cavities, gases, and elements. These are being combined in visionary manner to produce new Radionic components.

Necessary in the development of qualitative science is the first "internal" recognition of fundamental dynamics which are observed through consciousness alone. Peculiarities and inconsistent features of the conscious environment provoke the greatest qualitative discoveries, being based on observations which are both internal and personal. This was the basis on which Baron von Reichenbach actually began his revolutionary investigations. While internal sensations recognize conscious peculiarities, helping us to recognize more of the worldstructure in which we have our being, we require more externalized means for the liberation of more detailed knowledge.

The "internalized" experience makes progressive scientific exposition difficult, if not impossible. The possibility that such conscious sensitivities may be externalized at first sounds impossible and unreasonable. Nevertheless, it was gradually realized that special instrumentalities could actually behave as extenders of our deepest sensitivities and consciousness. Comprising the school of research which came to be known as "psychotronics", these researchers reached a dead wall when attempting examinations of the world beyond their forced thoughts. It was later found that grounded instruments permitted the complete externalization of these otherwise personal and internal" sensitivities, allowing fusion with the external world of eidetic currents. In this flood of externally generated consciousness, personal thoughts could relax into a passive reception. The dissolution of "internal-external" conscious boundaries was rediscovered through these grounded instrumentalities.

Sensitives learned to discern the natural radiance of matter through direct visual engagement. But this only came through successive exposures to Vril currents. How do grounded Radionic Instruments now provide a more graphic and expanded experience of these otherwise "internal sensitivities"? Why, in fact, do our deepest sensitivities seem so "internal"? Inertial space represses the normal externalization of our consciousness. Held in by this gelatinous pressure, our consciousness experiences degrees of closure which vary with locale. This inertial closure dissolves in levels when we encounter natural Vril powerpoints. It is by conscious contrast that we actually recognize these places. Inertial dissolution precludes expanded consciousness, that which is experienced as externalized sensation.

In this inimicable mindstate, one experiences what the ancients knew. Expanded externalized consciousness is the means through which they gained knowledge of the fundamental

worldstructure, that by which their worldview consists entirely. The modern inability to seriously consider the ancient metaphysical worldview is based on inertial consciousness, an uninitiated state. Eidetic Vril information is world-language, the natural world dialect by which geomantic districts communicate. Thus, the fundamental world mode of communications is a natural and personally experienced eidetic imagery; whose transactional mode communicates directly to auric anatomy. One sees eidetic imagery through and beyond the retina. Vril eidetic images project in the black radiance itself, not by secondary or tertiary luminosities with which our eyes are accustomed.

Each nonpowered ground radiosystem, irregardless of geometry, both receives and transmits eidetic signals in succinct manner. Each geometry effects specified directional aspects to the naturally occurring Vril patterns. When electrified, these systems produce extraordinary resultant emanations. Such study remains valuable for those who wish to resort directly to natural Vril phenomena, utilizing ground-energized Radionics to probe the world structure. Our Radionic probing instruments effectively receive eidetic currents, fusing us directly with the Vril Matrix.

Human sentient responses in Radionic grounded circuits remain our central means for experiencing Vril directly. The entuned eidetic currents modifying our consciousness. What remains then is the aggressive pursuit of natural Vril phenomena, peering deeply into natural dioramas where Vril manifestations teach us more specific facts concerning the development of Radionic components and their concomitant Vril responses. It is in Vril active groundpoints that new technological artifices may be employed to greatest personal and regional advantage. Grounded Radionic instruments permit very pure Vril currents to be obtained. Through capacitative components with which one may come into physical contact, one receives images and associated visceral impressions in the Vril current.

When suffused with Radionically entuned Vril currents, one may actually clarify the eidetic visions which surge through the local Vril topography. Eidetic visions form the primary and fundamental world-communications mode. Intercepting eidetic visions is intercepting the primary and fundamental world-language. Technological components which intercept this flow, either deliberately or inadvertently, become special vessels of world Vril dynamics. These experiences came together, requiring years for their separate identification, definition, and implementation. We may trace the development of later emerging special technologies, grouped under the heading "Radionics", in which the pure archetypal forms had been freed from their developmental origins.

Laboratory components, previously developed for electrical systems, became the focus of intense Radionic research.. Bathed in Radionic sensitivities, the Victorian Epoch produced an academic bibliography which successfully discerned and divided inertial phenomena from their generative Radionic infrastructure. Victorian technological innovators inadvertently developed systems ruled by the anomalous black radiant phenomena; telegraphy and telephony leading the Radionic path of discovery toward wireless. Eventually, the more sensitive researchers divorced themselves completely from

electrical usages. Fewer yet divorced themselves from electrical terminology, preferring to maintain inaccurate engineering descriptions such as "rate, impulse, vibration, and wave" for their obvious apologetic content.

Radionic Science emerged from forgotten archane depths, being rapidly developed among a few now-legendary names. Baron von Reichenbach, George S. White, Albert Abrams, William Boyd, Thomas G. Hieronymus, Ruth Drown...these sensitives empirically discovered radiant phenomena which actually preceded and generated the phenomena of ordinary light, and developed instruments which collimated, magnified, and clarified the primary energetic emissions of matter. Codified in the patents, articles, and lectures of early Radionists, we learn some of both the objective and subjective dynamics which appear during Vril conductions.

Certain sensitive naturalists had long observed that strongly connective "sight lines" could be discerned from wooded areas directly into space. During the day, such sight lines brought down a wonderful energetic presence from the blue skies. During the night, stars which coincided with these spacepoints shuddered down in wonderful frosty white displays. These sight lines remained fixed throughout the day and year. In ancient times they were marked with stones. later, these same locations were marked with ornamented pillars and hewn altar stones. Yet later they were the sites on which temples stood. As centuries rolled, these spots became the site where cathedrals or chapels were raised. The energetic flood from space never waned despite all these centuries' old changes. When radio aerials were erected, the more intuitively guided inventors chose these very spots for their transmitter sites. Such stations became notable for the wonderful signals which they projected. The stations themselves became imbued with an equally wonderful ambiance, strangely spacic in aspect and inflection. Clearly the result of space-drawn currents, these locations became famous in the trade. Vril points which exhibit such Kratonic-Spacic blends are powerful eidetic exchange terminals. It is here that radionists will find the strongest kinds of natural eidetic communication.

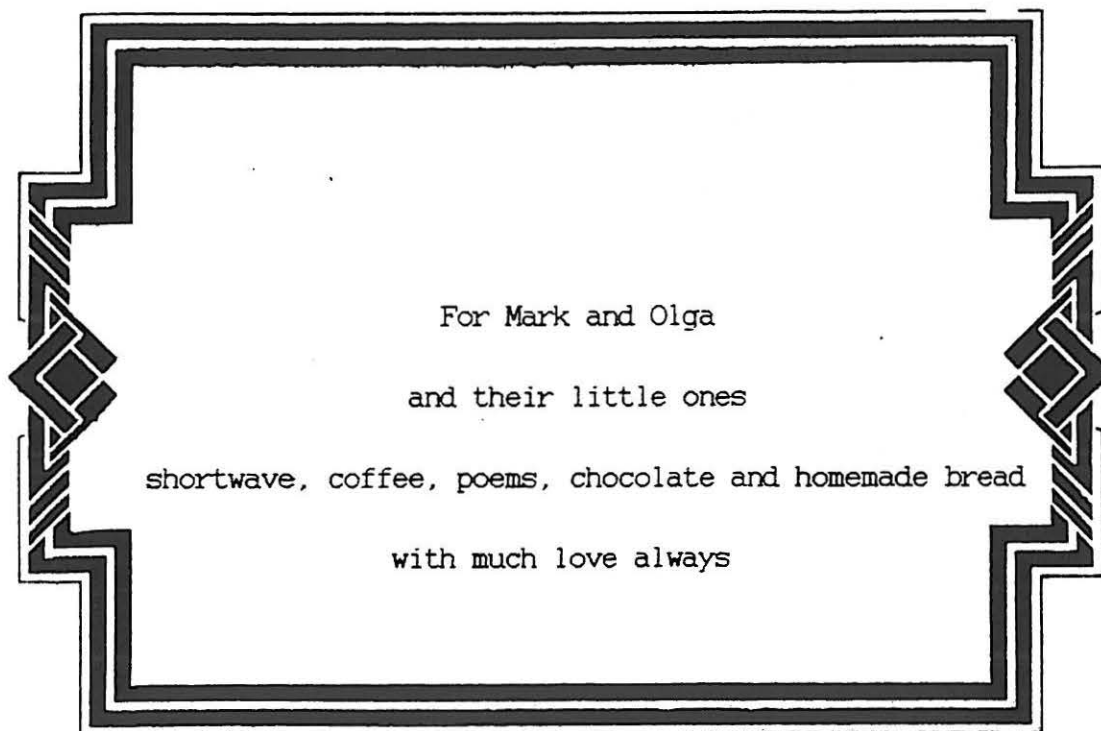
When tall buildings are founded on Vril powerpoints, quite extraordinary phenomena proceed forth from the building structure itself. besides the radiance which discharges outward from the building toward other local groundpoints, eidetic discharges of great signal volume, there emerges a vertical Vril column of great intensity. Such tall towers become Vril column projectors. Emergent Vril columns strike upwards toward space, touching specific points at various angles throughout the day. These points lie within the Vril Matrix in upper space. Between ground and space there is a constant eidetic exchange. Ground sends to space, and space responds.

Each district has one such ground-to-space connection. Towers enhance the connectivity of a district, the various structural features being appropriated as a terminal connector by suffusive Vril currents. Collectively, a group of districts forms a region. Regions connect ground with space through a great number of these vertical Vril discharge columns. Vril actively articulates in architectural, appropriating both internal and external structures.

Vril columns suffuse towers, flooding through internal halls and chambers, winding through stairwells, and emerging out from specific stone window frames.

Various electrical beam systems were developed by a great number of inventors throughout the early Twentieth Century. Each of these were designed with specific functions in mind. One variety was established for communications. Others were developed to transmit and receive usable electrical power. Yet others were developed to strike out defensively against hostile actions. Each of these systems behaved as towers, becoming Vril column projectors of remarkable coherence when properly emplaced in a district. These devices projected vertical beams directly to the zenith, differing from structured towers only in the capacity to allow Vril articulation.

In a similar manner, Vril suffusions were found to flood electric beam projectors. These effects are seen in pictorial representations of Teslian World Broadcast Towers. What functions these beam projectors were intended to perform, through electrical irritations, were powerfully magnified in Vril responses. Electric power transmitters incurred excessive inertial projections from the ground. Unfortunately utilizing electrical force to do so, they offered their district grounds no advantage through this process. Because of the electrical activations, all inertial projections through the vertical beam column were simply replaced by an incoming inertial flood. Electrical devices simply proliferate the inertial presence. In most cases they actually cause heightened and more densified inertial conditions. The vertical beam transmitters of power were surrounded by visible white inertial sheaths. When power projectors were excessively pumped, these same white sheaths became lightning-like (Tesla, Hettinger, Reno, Grindell-Matthews). In communication modes, these systems produced remarkable eidetic exchanges as well as passing strong vocal signals. Vertical plasma beam systems grew to special levels of strength when allowed to "grow" through prolonged operation (Tesla, Hettinger).



SECTION
2

PHOTOPHONES
AND
RADIOPHONES

(No Model.)

A. G. BELL & S. TAINTER.
Selenium Cells.

No. 235,497.

Patented Dec. 14, 1880.

Fig. 4.

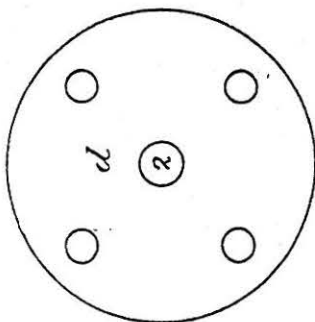


Fig. 3.

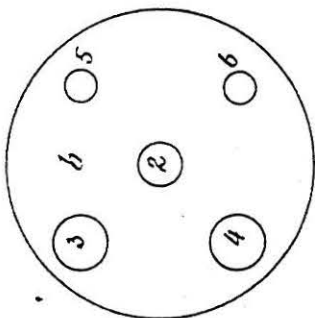


Fig. 2.

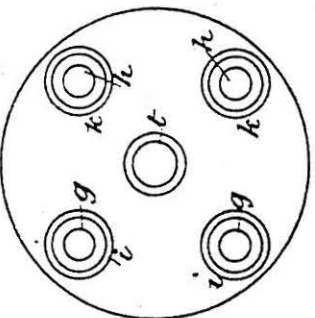


Fig. 1.

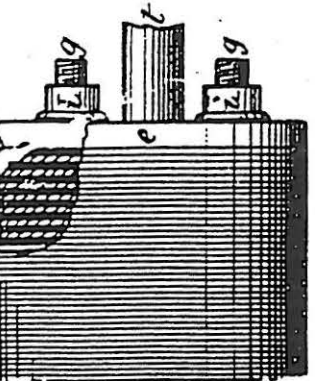


Fig. 9.

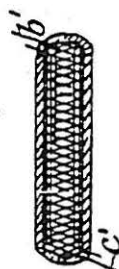


Fig. 8.



Fig. 7.

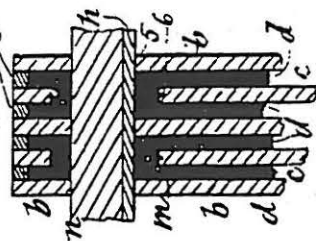


Fig. 6.



Fig. 5.

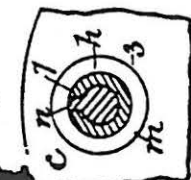


Fig. 12.

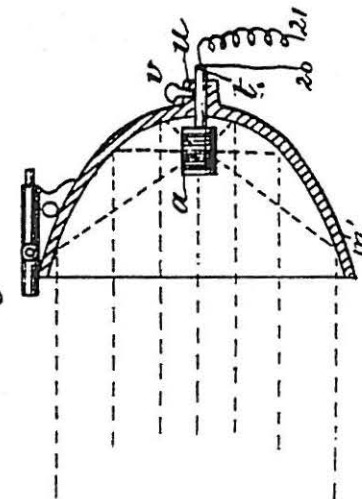


Fig. 11.

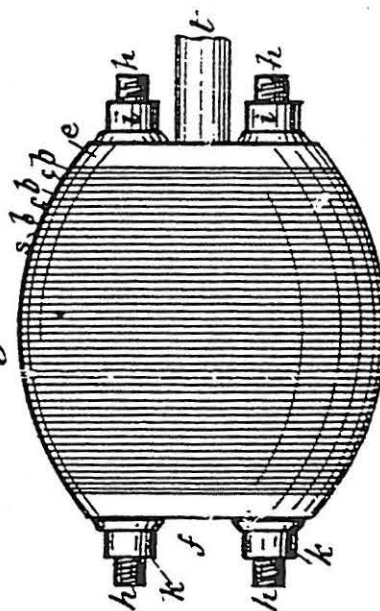
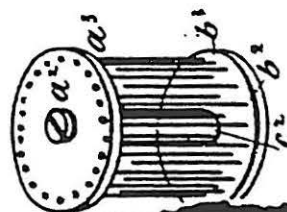


Fig. 10.



UNITED STATES PATENT OFFICE.

ALEXANDER G. BELL, OF WASHINGTON, DISTRICT OF COLUMBIA, AND
SUMNER TAINTER, OF WATERTOWN, MASSACHUSETTS.

SELENIUM-CELL.

SPECIFICATION forming part of Letters Patent No. 235,497, dated December 14, 1880.

Application filed September 25, 1880. (No model.)

To all whom it may concern:

Be it known that we, ALEXANDER GRAHAM BELL, of Washington, District of Columbia, and SUMNER TAINTER, of Watertown, county of Middlesex, and State of Massachusetts, have
5 invented an Improvement in Selenium-Cells, of which the following description, in connection with the accompanying drawings, is a specification.

10 Our invention relates to selenium-cells or instruments containing selenium as a part of an electric circuit.

In an application of Alexander Graham Bell, filed August 28, 1880, an apparatus was shown
15 and described for transmitting sound or producing variations in electric currents by the action of a beam of rays from the sun or other radiant bodies. The said apparatus contained an instrument having selenium in an electric
20 circuit, the resistance whereof is varied in accordance with variations in the active force of the rays falling on the said selenium. In the said application various forms of instruments or cells containing selenium were described,
25 some of which were not therein claimed, as they were not invented by the said Bell. One of the forms therein described consists generically of two or more pieces of conducting material, held separated from one another by insulating material arranged to leave spaces be-
30 tween the said two conductors and insulating material to be filled with selenium, which thus completes the electric circuit between the said pieces of conducting material. The form specifically claimed in the said application consisted of rectangular plates of conducting material supported by insulating material arranged to leave a portion of the space between
35 the said plates unoccupied thereby. The said space is filled with selenium, which connects the conducting-plates and lies in a plane surface to be exposed to radiant action. In one form of receiving-instrument shown in the said application a parabolic mirror was used to concentrate the rays on the sensitive selenium,
40 and when such a mirror is used it is found advantageous to construct the cell so as to afford a curved surface to be acted upon on all sides by the rays. An instrument of this kind (shown
45 in the said application, but not therein specifi-

cally claimed,) together with several modifications thereof, forms the subject of the present application.

Figure 1 is a side, and Fig. 2 an end, elevation of a cell constructed in accordance with
55 this invention; Fig. 3, one of the plates of conducting material, and Fig. 4 one of the plates of insulating material detached; Figs. 5, 6, and 7, sectional details showing the method of connecting the plates of conducting material;
60 Figs. 8, 9, and 10, modifications showing a different arrangement of the conducting and insulating materials; Fig. 11, a modification showing a different form of curved surface, nearly normal throughout, to the rays falling
65 thereon; and Fig. 12, a view of the condensing-mirror and selenium-cell therein.

The cell *a* (illustrated in the first seven figures, together with Figs. 11 and 12) is composed,
70 mainly, of circular disks *b c*, of conducting material, and disks *d*, of insulating material, of slightly smaller diameter, interposed between them. By this arrangement annular channels are left between the edges of the conducting-
75 disks *b c* around the periphery of the insulating-disks *d*.

The disks *b c d* are all provided with central holes, 2, to enable them to be held in proper position on a mandrel in the process of making
80 the cell, where they are clamped between two suitable end plates, *e f*. The disks of conducting material, which is preferably brass, are alternated on the said mandrel with disks *d* of insulating material, which may be mica. The
85 conducting-disks are electrically connected together in two sets of alternate plates, *b c*, between which the circuit is completed by the annular rings of selenium *s*, filling the channels around the disks of insulating material *d*. This
90 connection is accomplished as follows: The disks are provided with holes. (Shown as four in number.) In the conducting-disks two of the holes, 3 4, are of larger diameter than the other two, 5 6, which are of the same size as all
95 four of the holes in the insulating-disks.

In placing the disks on the mandrel the holes are all placed with their centers in line, and the large holes 3 4 of each conducting-disk are in line with the small holes 5 6 of the
100 conducting-disks on each side of it; or, in other

words, in a given line of holes all those of the plates *b* will be of different diameter from those of the plates *c*.

A cylinder of conducting material, of a diameter equal to that of the small holes, driven through a line of holes, will touch and electrically connect the alternate conducting-plates having their small holes in that line, and will not touch the other plates.

Two of the cylinders, *g*, will connect together all the disks of one set, as *b*, which can be connected with one terminal of the circuit, and the other two cylinders, *h*, will connect the disks of the other set, *c*, which can be connected with the other terminal; but the two sets *b* *c* will be connected only by the selenium *s*.

In order to insure a more perfect connection between the plates *b* and cylinders *g*, and the plates *c* and cylinders *h*, the said cylinders are made tubular and one or more slots, *7*, cut longitudinally through their sides.

Washers *m*, of insulating material, are placed within the large holes *3* *4*, in the conducting-disks, so that the said washers completely insulate and separate that portion of the said disks from the cylinders.

Conducting material in a fluid or mobile state—as, for example, melted type-metal or metal filings—is poured into the tubes *g* *h*, and, passing through the longitudinal slots *7*, makes a perfect connection with the plate, having small holes *5* *6* around the said tubes, as shown in Figs. 6 and 7, where the mobile metal is indicated by the letter *n*, but is prevented by the washers *m* from making a contact with the plates having the large holes adjacent to it, as shown in Fig. 5.

Instead of the washers *m* of insulating material, smaller washers or rings of any material—as, for instance, metal—may be used to confine the mobile metal and prevent its contact with the plates at the large holes, the said rings themselves being too small in external diameter to touch the said disks. When the parts of the cell are thus properly put together it is heated to a temperature somewhat higher than the melting-point of selenium, which is rubbed over the surface of the cell and melts into and fills the annular channels between the disks *b* *c*, thus connecting the two said disks in such manner that an electric current can pass from one to the other through the annular rings of selenium *s*.

When solidified, on cooling, the selenium is to be treated by a suitable process, in order to acquire the properties of conductivity and sensitiveness to the action of rays, which properties it does not possess when solidified from a liquid.

A process of treatment is fully described in another joint application for United States Letters Patent, filed by us August 28, 1880, to which reference may be had.

It is sufficient to state here that the selenium should be heated as nearly as possible to its temperature of fusion without allowing it

to actually melt, and then cooled, when it will be found to possess the desired properties.

When the selenium is fused upon the surface of the instrument it covers the exposed edges of the conducting material, besides filling the channels between the said edges. The best results have been obtained by removing (by filing or otherwise) the selenium covering, the surface of the conducting material leaving only that lying between the plates of conducting material to be exposed by the rays.

In the form shown in Figs. 8 and 9 the two electrodes *b'* *c'*, instead of consisting of a large number of separate pieces electrically connected together, are shown as single electric conductors or wires arranged near but not in contact with each other for a considerable portion of their length. The wires *b'* *c'* are supported on and held in proper relative position to one another by a cylindrical mass of insulating material, (shown in Fig. 8 as a glass rod,) upon the outside of which the two wires are wound in parallel coils, and in Fig. 9 as a glass tube containing the wires similarly coiled inside of it. In this instance spiral channels are formed between the wires and the insulating material, which may be filled with selenium to electrically connect the said wires. The selenium will afford a cylindrical surface to be acted upon by rays from all sides as when placed at the axis of a parabolic mirror.

In Fig. 10 the two electrodes *a*² *b*² are mechanically connected by a standard, *c*², which is electrically insulated from the electrode *a*². Each electrode is provided with a series of projections, *a*³ *b*³, extending toward the other electrode, those of one series lying between, but not in contact with, those of the other series. When the spaces between these projections are filled with selenium the latter connects the electric circuit between the electrodes and affords a cylindrical surface to be acted upon by rays from all sides.

In the form shown in Fig. 11 the construction is the same as that of the instrument shown in Fig. 1; but the surface is spheroidal instead of cylindrical, so that when the cell is placed with its center corresponding to the focal point of the condensing-mirror, the rays will all fall upon it in a direction substantially normal to the surface, so as to produce the greatest effect.

Nuts *i* *k* on the ends of the cylinders *g* *h* hold the disks together, making the whole cell a solid durable structure. The nuts *i* in the ends of the cylinders *g* and the said cylinders are insulated from the end plate *c*, while the cylinders *h* and nuts *k* thereon are insulated from the end plate *f*, so that the said end plates cannot complete the electric circuit between the two sets of plates *b* *c*, respectively connected together by the cylinders *g* and *h*.

When the cells are completed the mandrel, if of conducting material, should be removed, and a rod or tube, *t*, may be inserted in one of the end pieces, as *c*, to serve as a handle or

standard for manipulating or supporting the cell.

In Fig. 12 a cell, α , is shown on a reduced scale as supported with its center near the focal point of a parabolic condensing-mirror, m' , the tube t being held in a socket, u , at the vertex of the mirror by a set-screw, v . The electrodes 20 and 21 pass out through the said tube u , and may be connected with any desired electrical apparatus.

I claim—

1. In an instrument containing selenium as a portion of an electric circuit, a series of electric conductors arranged to form a cell having a curved bounding surface, and selenium interposed between the said conductors in the said curved surface to complete the electric circuit, substantially as described.

2. In an instrument containing selenium as a portion of an electric circuit, a series of electrically-conductive disks and disks of insulating material to separate them of slightly smaller diameter than the adjoining conducting-disks, and selenium in the annular channels surrounding the periphery of the insulating-disks to connect the conducting-disks, substantially as described.

3. In an instrument to interpose selenium in an electric circuit, a series of electrically-conductive disks and insulating-disks of smaller diameter to separate them, and selenium to connect them at their edges, combined with electrical connectors arranged to connect the alternate conductive disks together in one set and the remaining interposed conducting-disks as another set, substantially as described.

4. A selenium-cell composed of plates of conducting material separated by plates of insulating material and connected at their edges

by selenium, all the said plates being provided with holes arranged in line to form a continuous passage through the entire cell, the holes in the alternate conducting-plates in one line being larger than those in the interposed conducting-plates in the same line, which are all uniform in size, combined with a conductor of the same size with and inserted in the small holes, to electrically connect together all the plates having the small holes without forming electrical contact with those having the larger holes, substantially as described.

5. In a selenium-cell, a series of conducting and insulating plates provided with holes of different size arranged in line, as described, to form a passage through the cell, combined with electric conducting material inserted in the said passage in a mobile state, and washers placed within the large holes, whereby the conducting-plates containing the small holes are electrically connected by the inserted conducting material, and the said conducting material is prevented from making electrical contact with the plates containing the large holes, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

ALEXANDER GRAHAM BELL.
SUMNER TAINTER.

Witnesses to the signature of Alexander Graham Bell:

ALFRED J. MAYO,
C. H. GREAVES.

Witnesses to the signature of Sumner Tainter:

PHILIP MAURO,
BARTRAM ZEVELY.

(No Model.)

2 Sheets—Sheet 1.

A. G. BELL & S. TAINTER.

Photophonic Receiver.

No. 241,909.

Patented May 24, 1881.

Fig. 1.

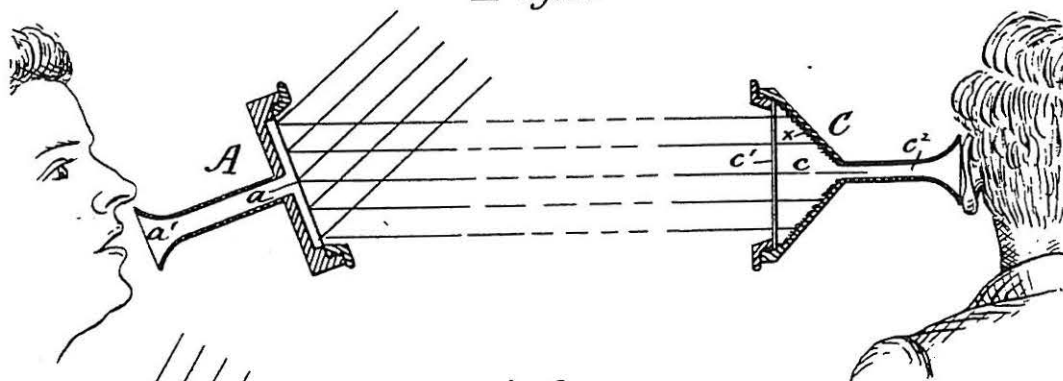


Fig. 2.

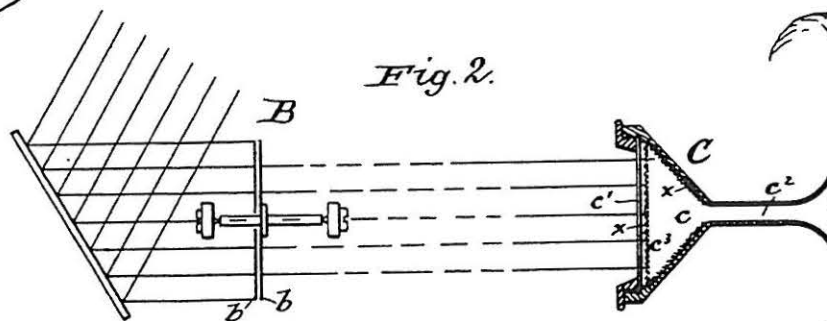


Fig. 2^a

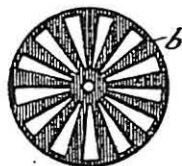


Fig. 2.^b



Fig. 3.

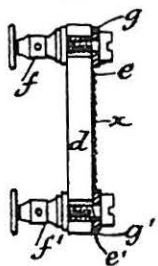
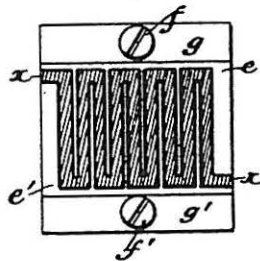


Fig. 4.



Witnesses:
E. E. Masson
Philip H. Bunn

Inventors.
Alexander Graham Bell &
Sumner Tainter by
A. Pollok their attorney

(No Model.)

2 Sheets—Sheet 2:

A. G. BELL & S. TAINTER.

Photophonic Receiver.

No. 241,909.

Patented May 24, 1881.

Fig. 5.

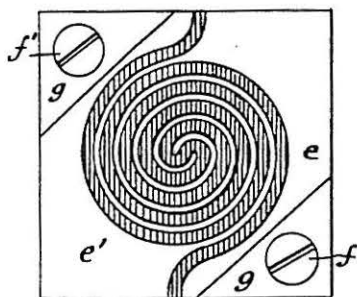


Fig. 6.

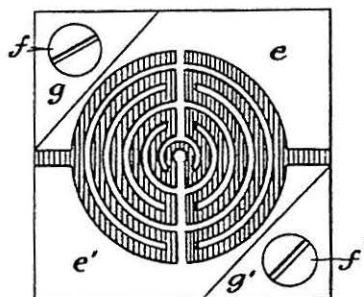


Fig. 7.

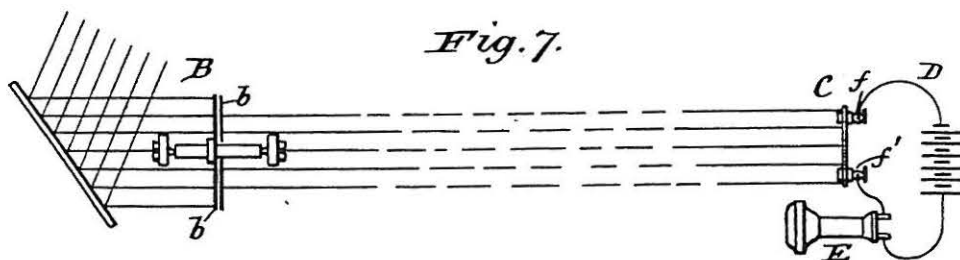
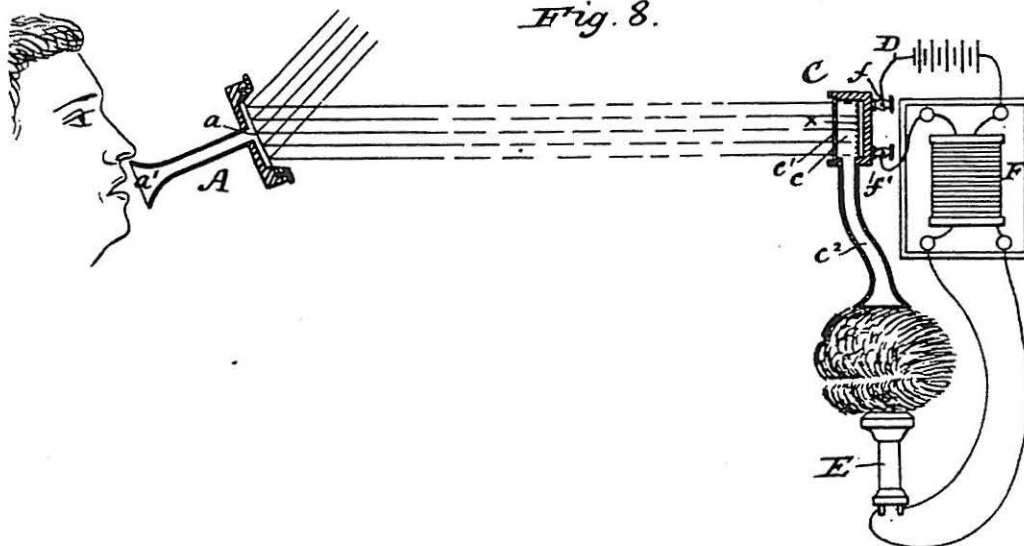


Fig. 8.



Witnesses:

E. E. Masson
Philip M. Lawrence

Inventors:

Alexander Graham Bell &
Sumner Tainter by
J. Pollok their atty

UNITED STATES PATENT OFFICE.

ALEXANDER G. BELL AND SUMNER TAINTER, OF WASHINGTON, D. C.

PHOTOPHONIC RECEIVER.

SPECIFICATION forming part of Letters Patent No. 241,909, dated May 24, 1881.

Application filed March 24, 1881. (No model.)

To all whom it may concern:

Be it known that we, ALEXANDER GRAHAM BELL and SUMNER TAINTER, both of Washington, in the District of Columbia, have invented a new and useful Improvement in Photophonic Receivers for the Production and Reproduction of Sound by the Action of Radiant Energy, which invention is fully set forth in the following specification.

The invention relates more particularly to the reproduction of articulate speech photophonically—that is, by the action of radiant energy from the sun or other suitable source—but is also applicable, in whole or in part, to the production or reproduction of other sounds, to the production of electrical and other effects, and to other purposes. It is intended as an improvement upon the photophone for which Letters Patent No. 235,199 were granted to Alexander Graham Bell, December 7, 1880.

The said photophone consists, generally, of a photophonic transmitter, by which a vibratory or undulatory beam or pencil of rays is produced, corresponding in its vibrations or undulations with the atmospheric vibrations that represent the sound to be produced or reproduced, and a photophonic receiver, by which the vibrations or undulations in the said beam or pencil of rays are converted into sound-waves, or into vibrations in an electric current that can be converted into sound-waves.

The present invention has reference to the photophonic receiver, and comprises means for converting the “radiant vibrations,” as the vibrations or undulations of the beam of rays may be called, into sound-waves, and also into electric vibrations.

As described in the aforesaid patent, the radiant vibrations were converted into sound-waves by means of thin diaphragms of hard rubber, mica, and various other materials, upon which the radiant vibrations were allowed to fall. The sound was conveyed to the ear by a bearing-tube connected with a sound-chamber in the rear or unexposed side of the diaphragm, which itself formed one side of said chamber, or a part of one side. With this apparatus, although it is not very sensitive, musical notes were produced by rapidly interrupting a beam which was allowed to fall upon the diaphragm. The musical notes corresponded in pitch to the

rate of interruption, and were loud enough to be easily heard.

We have discovered that the loudness of the sound is increased by having the illuminated or exposed side of the sensitive medium in contact with the air of the sound-chamber with which the ear-tube is connected, and by allowing the radiant beam to fall upon said medium through a plate of glass or similar material which is transparent to radiant energy, but opaque or less transparent to sound-waves. In this way the full effect of the radiant vibrations upon the sensitive medium is obtained, and the resulting sound-waves are shut in and conveyed to the ear with approximately their full force.

We have further discovered that a dark or black color in the sensitive medium is advantageous, and that with substances in an open, porous, or subdivided condition louder sounds are in general obtained than with diaphragms. The best effects are obtained with lamp-black deposited upon a surface of glass or other hard or rigid material. With a layer of this substance as the sensitive medium, articulate speech has been reproduced by the direct action of radiant energy upon said medium. In the experiments in which this result was obtained sunbeams were reflected from a mirror of thin glass silvered, (as described in Letters Patent No. 235,496, granted to us December 14, 1880.) and the mirror, being thrown into vibration by the voice, caused more or less of the sunbeams to fall upon the lamp-black. The latter was deposited upon the inner walls of a sound-chamber having one side formed of a glass plate to transmit the radiant beam, and having an ear-tube communicating with the interior, as explained above.

Articulate speech has also been reproduced with a receiver containing a mass of lamp-black in a loose pulverulent condition. A lump of lamp-black, when exposed in the sound-chamber to the action of an intermittent beam, gives a loud sound, but inferior to that given by the same substance in the form of loose powder or a deposited layer.

Instead of smoking the walls of the sound-chamber, a plate of glass, mica, or other material can be smoked and placed in said chamber so that the light falls upon the smoked surface.

The loudest sounds with the intermittent beam have been obtained by means of an open wire-gauze smoked or covered with a deposit of lamp-black. With a tubular resonator having the interior smoked a loud sound is produced when an intermittent beam having the proper rate of vibration is allowed to fall into it.

Numerous experiments have been made with various other substances. Black worsted may be mentioned as giving, with the intermittent beam, a good sound, although much inferior to lamp-black. Fibrous material coated with lamp-black has also been used.

Conducting-bodies generally, in a physical condition similar to lamp-black, especially if of dark or black color, yield good sound. Spongy platinum should be particularly mentioned. Other metals or metallic compounds—as silver, copper, black oxide of manganese, and the like—are also sensitive to radiant energy, and give out sound by the direct action of a vibratory beam. The production of sound in this way is conceived to be due to an absorption and expulsion of the air by the vibratory medium acting, as it were, like a sponge. Thus when the energy of the radiant beam increases the particles composing the vibratory medium expand and expel the air from between them, and when it decreases the reverse action takes place and the air is again absorbed. These repeated expulsions and absorptions are proportionate to the rise and fall of radiant energy, and produce corresponding condensations and rarefactions—or, in other words, sound-waves—in the surrounding atmosphere. Heat due to the absorption of the radiant energy seems therefore to be the principal agent in producing the sound-waves.

In the photophone as described in Patent No. 235,199, above mentioned, the radiant vibrations were converted into electrical vibrations by a different material from any used for the direct production of sound-waves, the peculiar substance selenium being employed. The resistance which selenium, when properly prepared, offers to an electric current was known to vary under the influence of rays from the sun or other suitable source of radiant energy, and it was therefore employed as the medium for converting the radiant into electric vibrations. It was included in the circuit of a galvanic battery and placed in such position that the radiant beam fell upon it. The variations in the radiant energy due to the vibrations in the beam produced corresponding variations in the resistance of the selenium and in the galvanic circuit of which it formed a part, and consequently in the tension of the current on said circuit, or, in other words, they produced electrical vibrations in that circuit. By the aid of cells constructed to expose a large surface of the selenium, and the proper preparation of the latter, an apparatus was produced so sensitive to variations in radiant energy that, with a suitable photophonic transmitter and with an ordinary hand-telephone

and galvanic circuit connected with the photophonic receiving apparatus, articulate speech was reproduced photophonically.

We have discovered that the same medium used to produce musical notes or to reproduce speech by the direct action of the radiant vibrations can be used to convert the latter into electric vibrations.

If a layer of lamp-black is included in an electric circuit and is exposed to the action of a vibratory beam of rays from the sun or other source, variations are produced in the electric resistance of the lamp-black, which variations correspond to those in the energy of the vibratory beam. If an intermittent beam is allowed to fall upon the lamp-black, electrical impulses are produced in the circuit in which the lamp-black is included corresponding to the radiant impulses of the beam, and if a telephonic receiver is also included in the circuit a musical note will be heard. If an undulatory or vibratory beam from the reflecting-transmitter before mentioned, or other speaking-transmitter which gives to the beam vibrations similar in rate, amplitude, and quality to the sound-waves of articulate speech, is allowed to fall upon the lamp-black, the electric undulations or vibrations in the galvanic circuit will represent the words and sentences which produced the vibratory beam, and if the apparatus is sufficiently sensitive these words and sentences can be reproduced by an ordinary telephonic receiver. The use of selenium, which is objectionable for reasons based upon the nature of the substance itself, as well as upon its high price and scarcity, can therefore be dispensed with. The same objections do not apply to lamp-black.

The action of radiant energy upon the vibratory medium to produce variations in the electrical resistance of the latter appears to be similar to that in producing sound by direct action—that is to say, the particles are brought together or moved apart according to the increase or decrease of the energy of the beam. They consequently furnish to the electric current a path of less or greater resistance.

All conductors in a physical condition similar to lamp-black have their electrical resistance affected by radiant energy. Spongy platinum is an example.

We have devised a form of cell whereby any desired extent of surface of the lamp-black can be exposed to the radiant energy without introducing undue resistance into the electric circuit.

Reference has hereinbefore been made to the cells used with selenium. These cells, the construction of which is fully described in Letters Patent Nos. 235,497 and 235,588, both dated December 14, 1880, consist, mainly, of two or more conducting strips, plates, or disks, placed side by side and separated by thin sheets of insulating material, which extend nearly to the edges of the plates, so as to leave a narrow

and shallow but long space to receive the selenium. The poles of the battery being connected with the plates which form the conductors of the cell, the current flows from one to the other through the selenium, meeting with small resistance on account of the thinness of the selenium layer. In some cases the selenium was cast around metallic pins embedded in insulating material connected with the poles of the battery.

In the present invention the conductors are formed of thin strips, plates, sheets, wires, or films fixed or mounted upon an insulating backing or support with their edges opposed and near together, so as to leave one or more narrow channels to receive the sensitive medium. Cells of this character are much simpler than those already patented, and they are, besides, better adapted to use in connection with lamp-black. The improved cells can be made with a curved or cylindrical surface, although a flat surface would generally be preferred, and the conductors can be made of various forms and metals.

Excellent results have been obtained with a cell having two conductors which resemble in appearance combs with wide-spaced teeth, and which are secured to the insulating-backing in such relative position that the teeth of one comb alternate or intermesh with the teeth of the other, but are not in contact with them. The sensitive medium fills the spaces between the teeth of the two conductors, and by increasing the number and length of the teeth the surface can be increased to any desired extent. The resistance to the electric current will, of course, depend upon the mass or area of sensitive medium, and upon the distance which separates the teeth of one comb from those of the other.

In order that the electric current may flow equally from the several teeth, or generally from one conductor to another, it is necessary that the spaces between their adjacent edges should be everywhere the same.

We have found that a film of silver deposited upon a glass plate by the methods ordinarily employed for silvering mirrors is possessed of great toughness, and can, with a suitable tool, be ruled or scraped off in stripes, so as to leave sharp edges which appear clean and well defined, even under a microscope. As the silvered film is not affected injuriously by lamp-black, it is, from its great conductivity and the accuracy with which it can be ruled, eminently adapted to use in this invention as the conductor of the photophonic receiver. The silvered film can be deposited upon a curved or flat surface, and can be scraped off in straight, zigzag, circular, spiral, or other suitable lines. The width of the stripe or stripes removed is regulated by the scraping-tool, and the position of the latter in operation is controlled and adjusted by mechanical means, so that the utmost exactness can be obtained.

In the cell before referred to as giving ex-

cellent results the intermeshing combs were formed by scraping a silvered film from a flat glass plate, as just described. This form of conductor is, however, obviously of general application, and can be employed with various metals. For example, the combs can be cut from tin-foil and pasted upon glass. The lamp-black is applied to these cells by smoking the proper surface over a flame from a coal-oil lamp or other suitable burner. The lamp-black will be deposited on the conductors as well as between them; but this does not interfere with the practical workings of the apparatus. The depth of the layer deposited may be just sufficient to render the surface sensibly opaque. The character of the result is affected by the depth and also by the extent of surface exposed to the radiant energy. Although no special extent is requisite, a very large surface is not desirable, and there is a certain limit at which the best results are obtained in any case; but this limit varies with the energy of the radiant beam, the strength of the battery, and other conditions, so that no simple rule can be given. By depositing upon the silvered glass, ruled or scraped as explained, a layer which is sensibly opaque and wiping it off gradually around the edges, a spot of suitable size and character can be readily obtained.

The cell is ordinarily secured in position in a sound-chamber having a glass plate for the entrance of the radiant beams, and it is so placed that said beams fall upon the lamp-black. If it is desired to receive a message or signal directly, as well as through the intermediary of the electric current, the sound-chamber is provided with one or more ear-tubes.

The lamp-black cell can be located in the main circuit in which the electrical or telephonic receiving apparatus is placed, or it can be connected with a receiving-circuit by means of an induction coil or coils, as telephonic transmitters using a battery have been connected.

Having explained the general principles of our invention, we will now proceed to describe apparatus constructed in accordance with the same, reference being had to the accompanying drawings, which form a part of this specification.

Figure 1 is a sectional view, illustrating apparatus for transmitting speech photophonically without the aid of an electric circuit; Fig. 2, a sectional view of a slightly altered form of a receiver, shown in connection with the apparatus for producing an intermittent beam; Fig. 2^a, a front view of one of the disks of the intermittent-beam apparatus; Fig. 2^b, a similar view of a wire-gauze disk used in the receiver; Figs. 3 and 4, views, in section and plan, of the lamp-black cell with intermeshing combs of silver film; Figs. 5 and 6, plan views of other forms of the cell; Fig. 7, a view showing the cell in circuit with galvanic battery and hand-telephone and the intermittent-beam apparatus as the photophonic transmitter; and Fig.

8, a view, partly in section, illustrating the apparatus for transmitting speech, and showing a photophonic receiver connected with a telephonic circuit, and also provided with means for collecting and conveying to the ear of the listener sound-waves directly produced.

The same letters of reference indicate like parts in the several figures in which they occur.

10 A is a reflecting photophonic transmitter; B, the intermittent-beam apparatus; C, the photophonic receiver; D, a galvanic circuit; E, an ordinary hand telephone; F, an induction coil.

15 The reflecting-transmitter A consists of a mirror of thin silvered glass, *a*, which is thrown into vibrations by the voice of a person speaking into the tube *a'*, and reflects more or less of the beam of sunlight or other radiant beam toward the receiver C.

20 The intermittent-beam apparatus B comprises two disk-wheels, *b*, with a series of radial openings in the path of the beam. One of these disk-wheels is stationary and the other revolves, or they both revolve in opposite directions, or in the same direction at unequal velocities. The beam, being consequently cut off by the blank spaces and allowed to pass through the openings when those in one disk register with those in the other, is intermittent in its action. A beam from the sun or from an artificial source can be employed with this apparatus. The beam can be concentrated before or after passing through the disk-wheels, and can be reflected by mirrors to the proper path, or allowed to fall directly upon the wheels.

35 These two forms of transmitting apparatus are shown as types. Any photophonic transmitter of ordinary or suitable construction can be used with the improved receiver.

40 In Fig. 1 the receiver C consists of a funnel-shaped sound-chamber, *c*, the interior flaring walls of which are smoked or covered with a deposit of lamp-black, *x*. The mouth is covered with a glass plate, *c'*, and a sound-conveying tube, *c''*, communicates with the contracted portion in the rear. Speech or other sound uttered into the tube *a'* of the transmitter A can be heard by listening at the tube *c''* of the receiver C. The distance over which speech can be transmitted in this way and the distinctness of the sounds reproduced depend upon the energy of the beam employed.

45 In Fig. 2 the receiver C contains a piece of wire gauze, *c'*, upon which the lamp-black *x* is deposited. The walls of the sound-chamber *c* can also be smoked, as shown, or not, as desired. The sound is received by the tube *c''*, as before.

50 In Figs. 3 and 4 the receiver is a lamp-black cell, and comprises the glass plate or insulating support *d*, the intermeshing combs or conductors *e e'*, of silver film, the binding-posts *f f'*, connected with the conductors *e e'*, respectively, by the metallic plates *g g'*, and the lamp-black *x*.

55 In forming the cell the silver is deposited in

any ordinary or suitable way. The desired portions are removed or scraped off by means of a tool with a flat end. This tool can be made like a chisel, or a punch with conical point can be ground off or cut at right angles to the axis, so as to leave a flat end with a diameter equal to the desired width of the stripe to be removed. The mechanical ruling or scraping of the plate can be easily effected by means of an ordinary lathe provided with a slide-rest. The tool is held in a frame supported between centers. The plate is clamped to a bed-plate beneath with the silvered side uppermost, in such position that when the tool is pressed down and penetrates the film its operating end rests flat upon the surface of the glass. The bed-plate carrying the silvered plate can be worked lengthwise of the lathe to rule or scrape off the lines in one direction, and then moved across at right angles to the length to bring the plate into position for scraping a new line.

It is not necessary to remove the tool from the plate. The lengthwise movement under the tool removes the film so as to form the spaces between the teeth of the combs, and the transverse movement connects these spaces with each other alternately at opposite ends.

The binding-posts are fastened to the glass plate in any ordinary or suitable way, and are in electrical connection with the two parts of the conducting-film. To apply the carbon the silvered side of the glass plate is smoked over a suitable burner.

100 In Fig. 5 the silver film is scraped off in the form of a double spiral, leaving the conductors *e e'*. In Fig. 6 the conductors *e e'* have curved intermeshing teeth. In these figures the lamp-black *x* is shown as confined to the spaces between the conductors in order to show the latter more clearly; but in practice the conductors would ordinarily be themselves coated.

105 In Fig. 7 the poles of the galvanic circuit D are connected with the binding-posts *f f'*. A musical note produced by the action of the intermittent beam can be heard by applying the telephone E to the ear.

110 In Fig. 8 the lamp-black cell is placed in a sound-chamber, *c*, and is connected with a battery in the primary circuit of the induction-coil F, the telephone E being connected in the secondary circuit of the coil. The chamber C has a glass plate, as in Fig. 1, through which the radiant energy is transmitted, and a hearing-tube, *c''*, for conveying the sound-waves produced in the receiver to the ear. Sounds uttered into the tube *a'* of the transmitter can be heard either by listening at the tube *c''* or by means of the telephone E.

115 It is obvious that various modifications may be made without departing from the spirit of the invention, and that parts of said invention could be used without the others. The forms of cells used for selenium can be used with lamp-black, and the improved cell can be em- 130

ployed with any suitable form of sensitive medium; but the metal composing the conductors should be such as not to be injuriously affected by the action of the sensitive medium.

- 5 The insulating-plate with the ruled or scraped silver film thereon can be employed to measure the electric conductivity of various substances, liquids, and gases by connecting the binding-posts with the poles of a galvanometer-circuit and immersing the plate with the substance to be tested, or covering the silvered side with the same. In some cases the silver film can be deposited on both sides of the plate and ruled as before described.
- 15 Telephonic transmitters and receivers can be formed by means of apparatus like the lamp-black cell; but these will form the subject of separate applications.

That part of the invention which relates to the conversion of the radiant vibrations into electrical vibrations is not limited to lamp-black, but includes other forms of carbon, and also other materials which operate in a substantially similar manner to lamp-black.

- 25 Having now fully described our said invention and the manner of carrying the same into effect, what we claim is—

1. In a photophonic receiver, the sound-chamber for containing the sensitive medium, having a wall transparent to light or radiant energy, but opaque or less transparent to sound, substantially as described.

2. The combination of the sound-chamber, having a wall transparent to radiant energy, but opaque or less transparent to sound, with the sensitive medium therein contained, and a sound conveyer or opening communicating with the interior of said chamber, substantially as described.

3. In a photophonic receiver, the sensitive medium, composed of vibratory material in an open, porous, or subdivided condition, substantially as described.

4. In a photophonic receiver, a sensitive medium of lamp-black or similar material, substantially as described.

5. A photophonic receiver having as the sensitive medium a deposit of vibratory material in a loose, porous, subdivided, flocculent, or spongy condition, substantially as described.

6. In a photophonic receiver, the combination of a sensitive medium conductive of electricity, in a loose, porous, or subdivided condition such as lamp-black, and conductors for including the same in an electric circuit, substantially as described, so that radiant vibrations can be thereby converted into electric vibrations, as set forth.

7. The combination of the lamp-black or other vibratory conducting material in loose particles, the rigid or substantially inextensible sup-

port of insulating material, and conductors by which the lamp-black can be included in an electric circuit, as set forth.

8. A cell comprising sheets, plates, or strips of conducting material, fixed or mounted upon a support of insulating material, with their edges opposite each other and separated by a suitable distance, and sensitive conducting material in the space or spaces between said edges, substantially as described.

9. A support of insulating material, having comb shaped conductors fixed or mounted on said support, as indicated, so that the teeth of the combs intermesh but are not in contact with each other, substantially as described.

10. A silvered plate having the silver film mechanically ruled or scraped, as described, so as to leave parallel lines or stripes of equal width, and with sharp, clean edges, substantially as set forth.

11. The insulating-plate having on one or both sides a silver film ruled or scraped, as described, so as to divide the silver film into two or more conductors, in combination with binding-posts connected with the parts of said film or films, substantially as set forth.

12. The combination of the insulating-plate and ruled silver film with the lamp-black or sensitive medium included in the ruled or scraped spaces in said film, substantially as set forth.

13. The combination, with a galvanic circuit, of a photophonic cell comprising a glass plate with ruled silver film thereon, lamp-black deposited in the ruled spaces in said film, and connections for completing the galvanic circuit through said cell, substantially as described.

14. The combination, with a photophonic cell, of an induction-coil, electric connections for including said cell in one circuit of said coil, and a telephone-circuit connected with the other circuit of said coil, substantially as described.

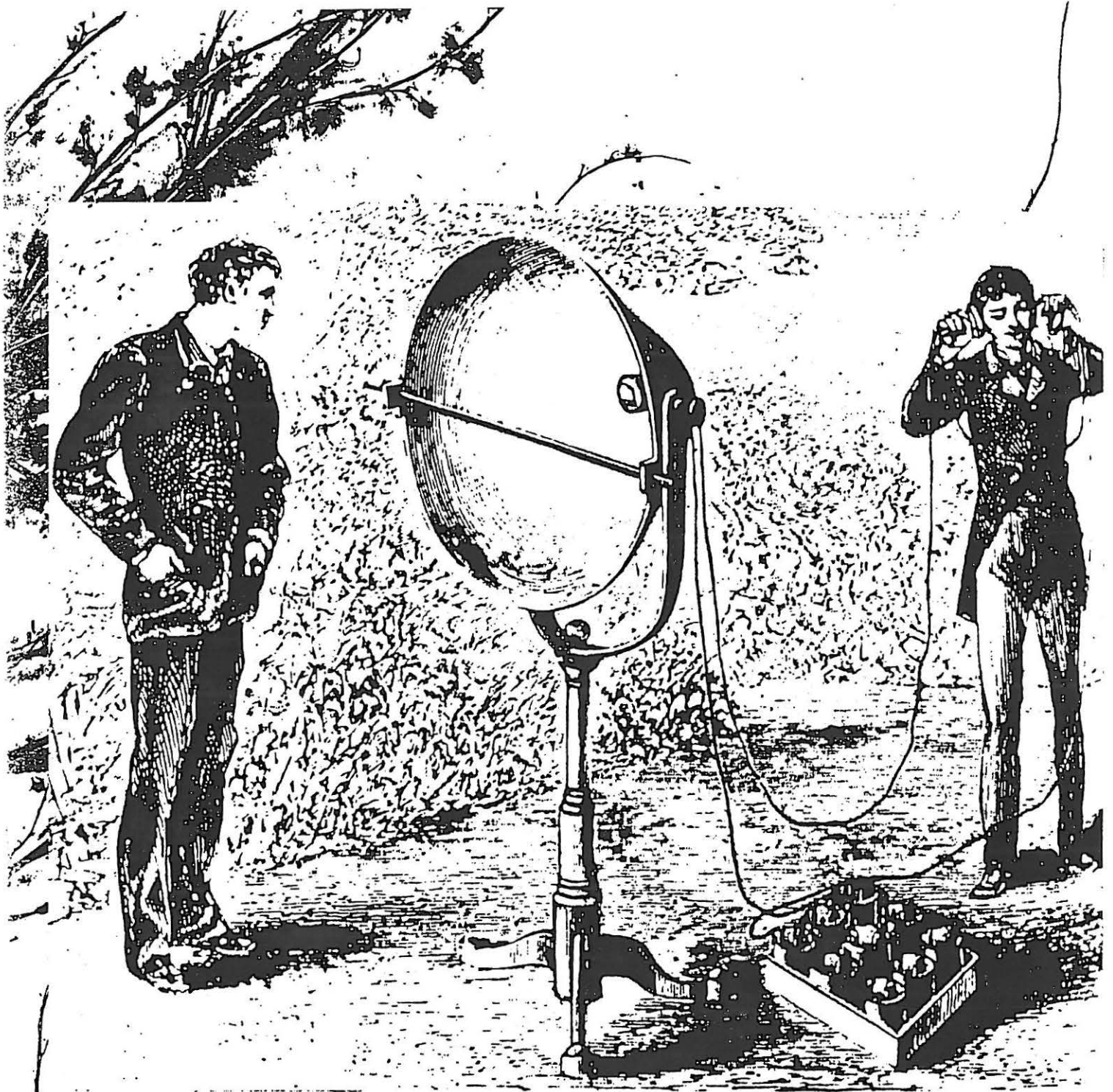
15. A photophonic receiver comprising a sound-chamber having a wall transparent to radiant energy, but opaque or less transparent to sound, a cell having a vibratory sensitive medium, such as lamp-black, electrical connections for connecting said cell in an electrical circuit, and a hearing-tube connected with the interior of said sound-chamber, substantially as described.

In testimony whereof we have signed this specification in the presence of two subscribing witnesses.

ALEXANDER GRAHAM BELL.
SUMNER TAINTER.

Witnesses:

PHILIP MAURO,
A. POLLOK.



At the receiving end of the photophone, a detector made of selenium (at the back of the receiving "dish") caused electricity in the receiver to vary in intensity with the light. Hook a telephone up to the receiver and one could hear Bell on the other end.

PHOTOPHONES

LIGHT-STIMULATED VRIL GROWTH
AND MEANINGFUL COMMUNICATIONS

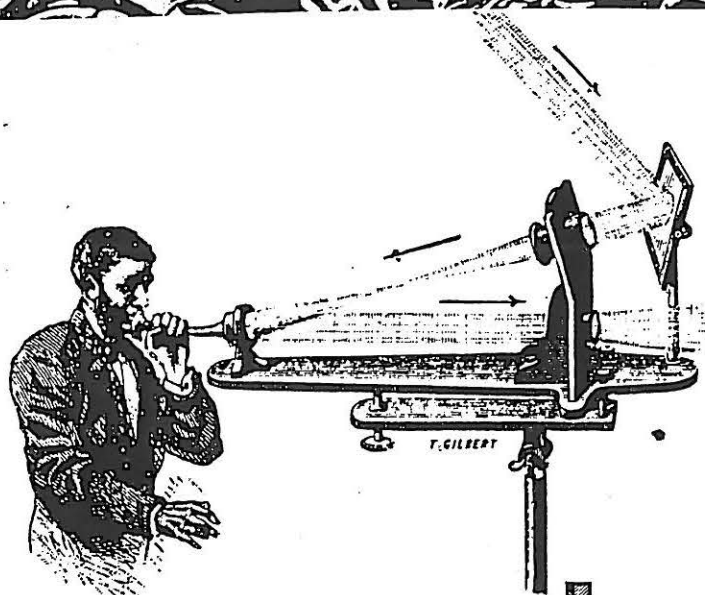
PHOTOPHONY OPERATED ON ANOMALOUS "MODULATIONS IN ILLUMINATION"

WHEN SPEECH INTERACTED WITH SUNLIGHT.

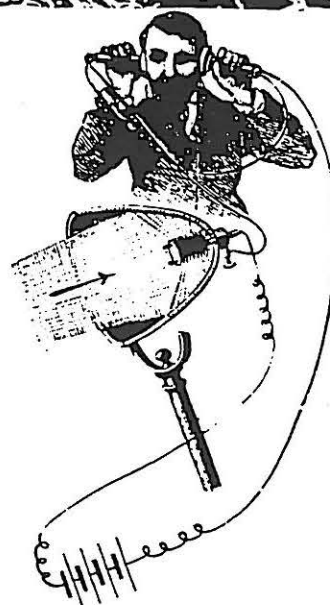
PHOTOPHONY REPRESENTS PROOF THAT SOUNDS (VOCAL UTTERANCES)

EFFECT LONGITUDINAL PATTERNS IN SPACE

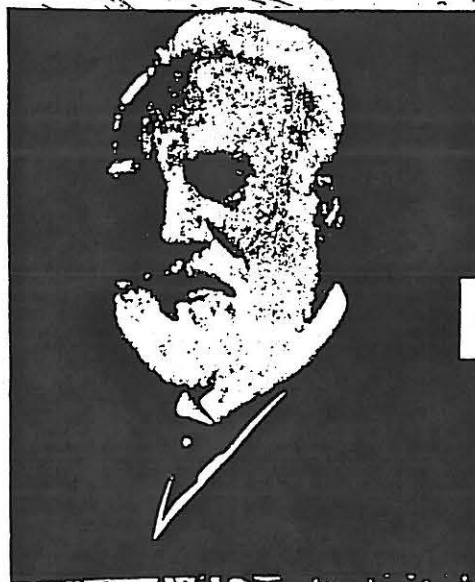
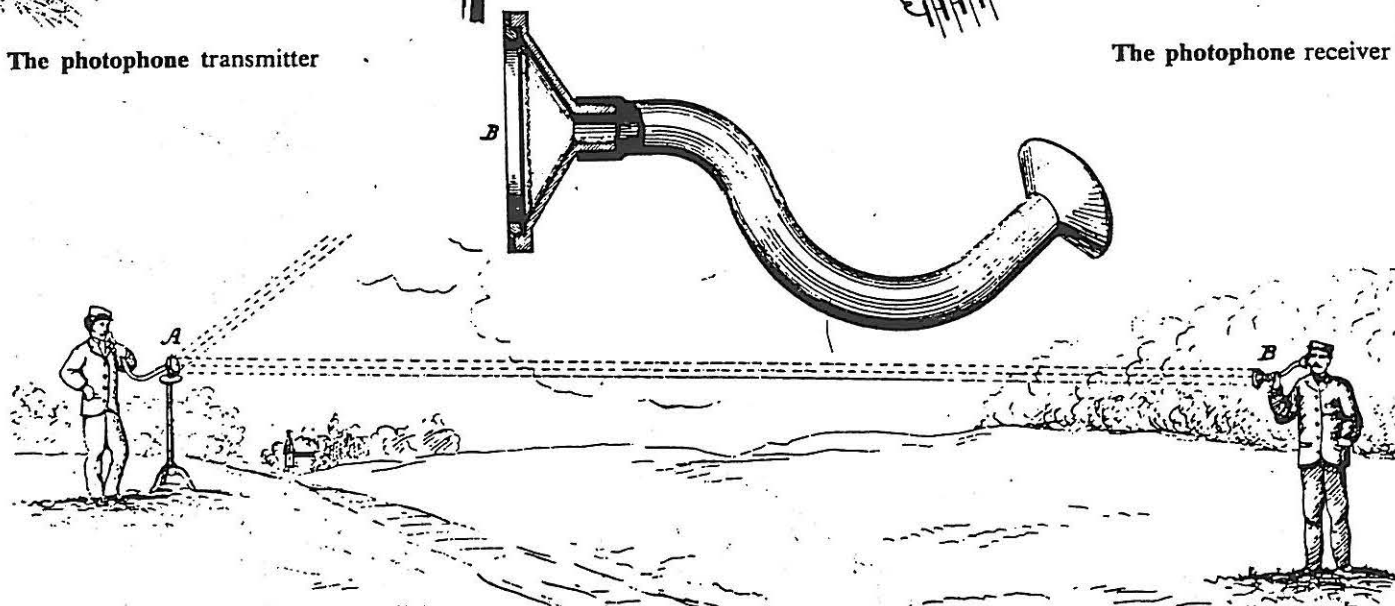
PATTERN-SENSITIVE MINERALS AND METALS RESPOND



The photophone transmitter



The photophone receiver



ALEXANDER GRAHAM BELL

Photograph from MacKenzie: "Alexander Graham Bell" published by Houghton Mifflin Company

No. 625,823.

Patented May 30, 1899.

K. ZICKLER.

TELEGRAPHY BY MEANS OF ELECTRIC LIGHT.

(Application filed June 24, 1898.)

2 Sheets—Sheet 1.

(No Model.)

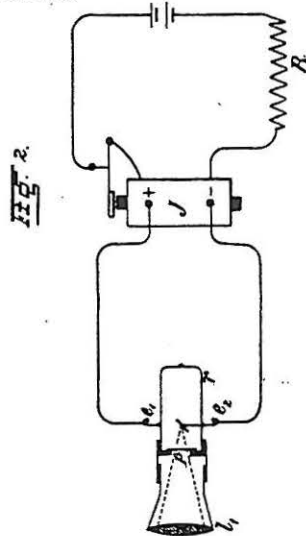


FIG. 3.

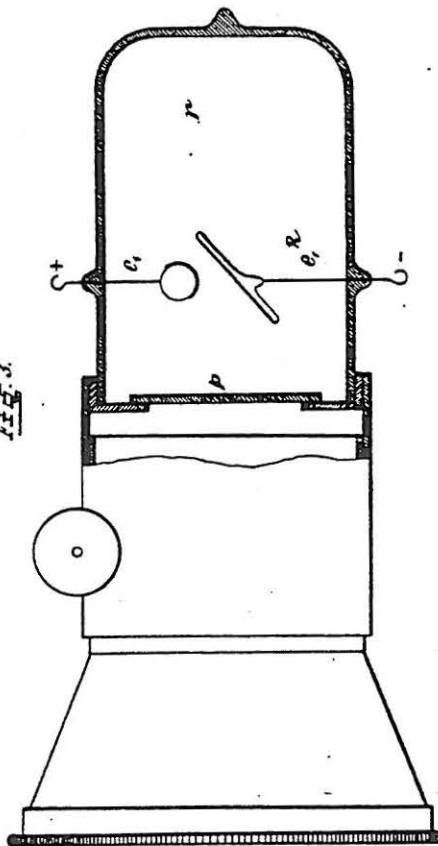
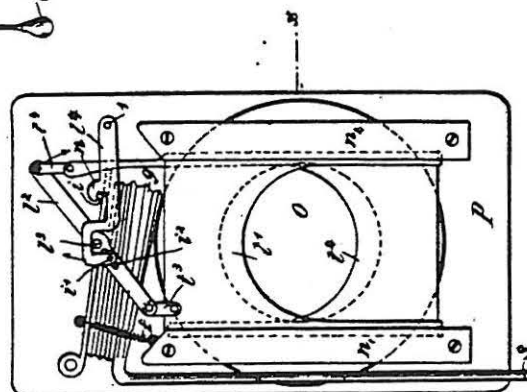
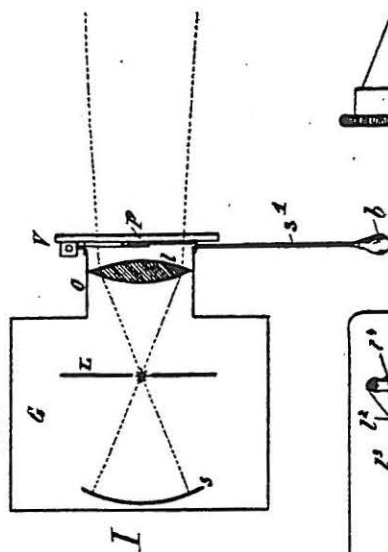


FIG. 1.



Witnesses:
Alfred Weibull
Walter Zwick

Inventor:
Karl Zickler
by *Emerson Hopping*
Att'y.

No. 625,823.

Patented May 30, 1899.

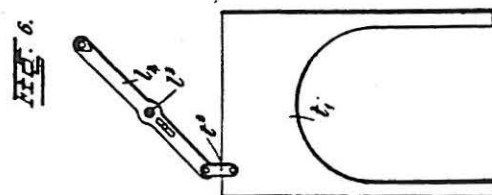
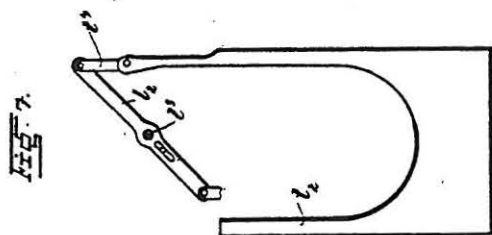
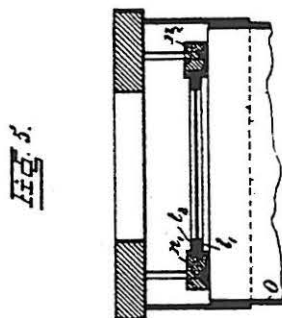
K. ZICKLER.

TELEGRAPHY BY MEANS OF ELECTRIC LIGHT.

(Application filed June 24, 1898.)

(No Model.)

2 Sheets—Sheet 2.



Witnesses:
Wm. Winkler
Wm. J. J. J.

Inventor:
Karl Zickler
by *Eustace Hopkins*
Atty.

UNITED STATES PATENT OFFICE.

KARL ZICKLER, OF BRÜNN, AUSTRIA-HUNGARY.

TELEGRAPHY BY MEANS OF ELECTRIC LIGHT.

SPECIFICATION forming part of Letters Patent No. 625,823, dated May 30, 1899.

Application filed June 24, 1898. Serial No. 684,392. (No model.)

To all whom it may concern:

Be it known that I, KARL ZICKLER, a subject of the Emperor of Austria-Hungary, residing at Brünn, in the Empire of Austria-Hungary, have invented certain new and useful Improvements in Telegraphy by Means of Electric Light; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

In this new method of wireless telegraphy the telegraphic signals are transmitted by means of rays emitted from an electric-arc light. The rays of short-wave length, (mostly ultra-violet rays,) which the electric-arc light emits copiously, are those which are made use of. These rays are sent out from the sending-station at intervals corresponding to those of telegraphic signals in the direction of the receiving-station, where they are made to produce weak electric waves, by which the signals are made visible as sparks, or are made audible by a telephone or electric bell, or, if preferred, may be printed by a Morse apparatus.

The arrangement of the apparatus at the two stations is shown in the accompanying drawings, in which similar letters of reference denote similar parts throughout the several views.

Figure 1 is a diagram of the apparatus for generating the rays; Fig. 2, a diagram of the receiving apparatus; Fig. 3, an elevation, partly in longitudinal section, of the receiving apparatus, drawn to a larger scale; Fig. 4, a front elevation of the closure for the ray-generating apparatus, also drawn on a larger scale; Fig. 5, a section on line *x x* of Fig. 4; Fig. 6, a detail elevation of the closure-plate, and Fig. 7 a similar elevation of the other closure-plate.

At the sending-station I is an apparatus for producing the rays in the form of an electric-arc light *L* of suitable power, which is inclosed in a case *G*, that can be turned around in the manner of a search-light or otherwise in a vertical and in a horizontal plane. The arc-light may be regulated either by mechanism or by hand, so that the arc is always in the same place. The pencil of light thus produced is transmitted through an opening *O* in the case

and projected in the direction of the receiving-station. In order to send as many rays as possible in this direction, the employment of reflecting-mirrors or of lenses, or of both in combination, is requisite. The lenses *l* must then, however, not be made of glass, but of rock crystal, so that they may allow the ultra-violet rays to pass through them. The closure *V* for the ray-emitting opening consists of a plate *P*, having an orifice for the objective *o*, Figs. 1 and 4. Two guide-rails *n'* and *n''* are attached to the said plate *P* by means of screws, glass plates *t'* and *t''* being guided in these guide-rails. These plates are shaped as shown at Figs. 6 and 7, and plate *t'* is linked to one end of a lever *l'*, pivoted at *l''*, by means of a link *l'''* and plate *t''* to the opposite end by means of link *l''''*.

By means of a pin-and-slot connection at *i'* a lever *l''* is coupled to the lever *l'*, said lever *l''* being pivotally connected to the plate *P* at *l*. The said lever *l''* is provided with a hook *n*, in which a pin *i* of the bellows *g*, attached to the plate *P*, engages. When the said bellows are compressed, the plates *t'* and *t''* cover the orifice of the objective *o*; but if air is forced into the bellows *g* by compression of the pneumatic ball *b*, Fig. 1, attached to the air-tubes *s*, the levers *l'* and *l''* will be turned on their pivots in the direction of the arrows, as indicated, the lever *l'* drawing the plate *t'* upward and pressing the plate *t''* downward, thus opening the objective *o*. This movement of the parts stretches the spring *f*, attached at one end to the guide *n'* and at the other to the bellows *g*. As soon as the pressure on the ball *b* is released the bellows fall down, assisted by the spring *f*, thus closing the plates *t'* and *t''* over the opening of the objective. Fig. 4 shows the plates *t'* and *t''* when the objective is half-open. As soon therefore as the lamp is lighted the pencil of light is emitted, even when the opening is closed, since the visible rays pass through the glass shutter. The effective ultra-violet rays are, however, absorbed by the glass plate. They are only emitted when the glass shutter is removed. By leaving the shutter open for a longer or shorter time the ultra-violet rays can be sent out in a manner to correspond to the dots and dashes of the Morse alphabet. Instead of the glass plates for the shutter ex-

tremely thin transparent mica sheets may be used.

At the receiving-station, Fig. 2, there is a ray-receiver. This consists of a tubular glass vessel r , which in front is closed air-tight by a quartz plate p . In this tubular-shaped glass vessel two electrodes e' e^2 are fused, one at each of two opposite points. One of these electrodes e' is spherical, having a diameter of a few millimeters. The other, e^2 , is a small circular disk whose plane is so inclined to the axis of the glass vessel that the pencil of light entering through the transparent quartz plate p easily falls upon it. Both electrodes are covered with platinum-foil and are about ten millimeters distant from each other. The air in the glass vessel is rarefied to a suitable degree, or the vessel is filled with a rarefied gas. To the glass vessel there is attached in front of the transparent quartz plate a metal tube, in which a second tube fitted with a quartz lens l' is adjustable by means of a screw, so that by adjusting the lens the rays coming through the quartz plate from the sending-station can be concentrated in a small oval slightly-illuminated spot. For the proper adjustment of the lens l' by daylight it is desirable to inclose the glass vessel in an opaque covering and to observe the lighting of the electrodes through a peep-hole in the covering. The electrodes are electrically connected with the secondary windings of a small induction coil or apparatus J in such a way that the spherical electrode e' becomes the anode and the disk-shaped electrode e^2 becomes the cathode. In the primary circuit of the induction apparatus, which requires to have a sparking distance of only one or two centimeters, there is a variable-resistance coil R , which admits of a gradual alteration of the strength of the primary current. For receiving a telegram the induction apparatus is set in operation, the variable resistance having been beforehand so adjusted that the intensity at the electrodes is as yet insufficient to cause sparks to pass between them. As soon as the ultra-violet rays are emitted from the sending apparatus at the sending-station I, Fig. 1, by opening the glass shutter and fall upon the disk-shaped electrode at receiving-station, Fig. 2, their luminous electrical effect causes

a release of the sparks, which, however, cease as soon as the projection of these rays is stopped by closing the glass shutter. The opening and shutting at the sender-station I in accordance with Morse signals produces also at the receiving-station a transmission of sparks of shorter or longer duration according to the same signals. In this way the signals may at once become visible, or otherwise electric waves are caused by the sparks in the space surrounding the ray-receiver corresponding to the signals. By these the signals can be rendered audible or reduced to writing by any of the well-known apparatuses.

What I claim is—

1. In a system of wireless telegraphy, the combination of a sender apparatus having means for producing and intermittently projecting a pencil of ultra-violet rays in the direction of a receiving apparatus, and a receiving apparatus having an air-tight electrode-chamber, having rarefied gas therein, a disk-shaped cathode-electrode to receive the rays projected from the sender and an anode mounted in proximity to said cathode and means for utilizing the sparks produced between the electrodes by the ultra-violet rays substantially as described.

2. In a system of wireless telegraphy, the combination of a sender and means in connection therewith for intermittently projecting a pencil of rays of light of short-wave length in the direction of the receiving apparatus, and a receiving apparatus having an air-tight electrode-chamber r with froth quartz plate p said chamber being filled with rarefied gas, a disk-shaped cathode e^2 and a spherical anode e' mounted therein in proximity to each other and a variable resistance inserted in the primary circuit of the said electrodes and means for concentrating the rays received by the plate e^2 substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

KARL ZICKLER.

Witnesses:

LUDWIG CZERIVENY,
ARTHUR SCHOEINBURG.

No. 654,630.

H. V. HAYES & E. R. CRAM.
RADIOPHONY.

Patented July 31, 1900.

(Application filed June 7, 1897.)

(No Model.)

Fig. 1.

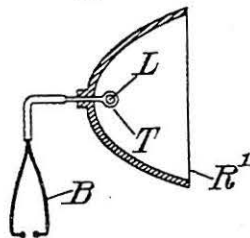


Fig. 2.

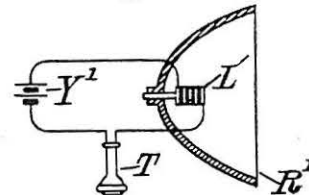


Fig. 3.

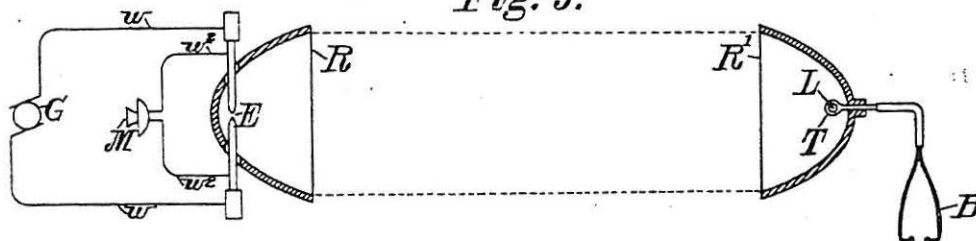


Fig. 4.

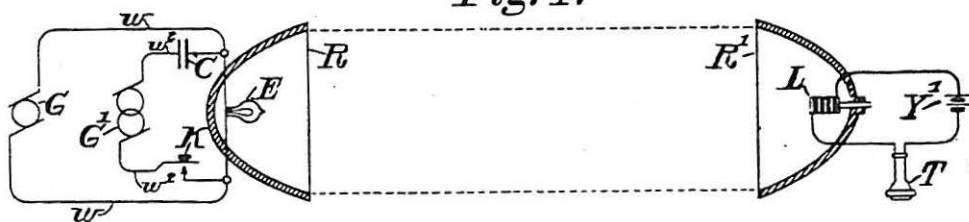


Fig. 5.

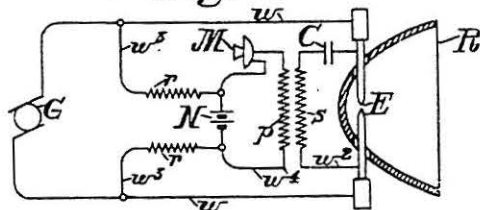
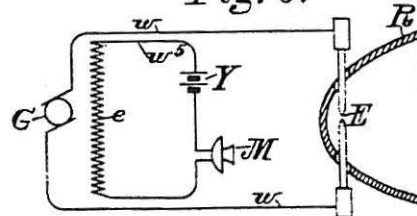


Fig. 6.



Attest,
William H. Swan
Chas R. Cwpa.

Inventors
Hammond V. Hayes.
Ernest R. Cram

UNITED STATES PATENT OFFICE.

HAMMOND V. HAYES AND ERNEST R. CRAM, OF CAMBRIDGE, MASSACHUSETTS, ASSIGNORS TO THE AMERICAN BELL TELEPHONE COMPANY, OF BOSTON, MASSACHUSETTS.

RADIOPHONY.

SPECIFICATION forming part of Letters Patent No. 654,630, dated July 31, 1900.

Application filed June 7, 1897. Serial No. 639,635. (No model.)

to all whom it may concern:

Be it known that we, HAMMOND V. HAYES and ERNEST R. CRAM, of Cambridge, Massachusetts, have invented a new and useful Improvement in Radiophony, whereby sounds and signals of any description impressed upon and causing interruptions or variations in the strength of an electric current in a local circuit are transmitted from a station where they are so impressed to a distant station and there repeated or given out by radiophony without the use of intervening wires, of which the following is a specification.

The radiophones employed in carrying out our invention do not differ substantially from radiophones already in use or already fully described in printed publications. Certain substances, as is well known, will so vary in electrical resistance when subjected to rapid changes in radiant energy that when so subjected, if placed in an electric circuit containing a telegraph or telephone receiver, such receiver will give out signals or sounds corresponding to variations or interruptions in the source of radiant energy. So, again, as is also well known, certain substances will give out sounds directly if subjected to rapid changes in radiant energy. Radiophones whose mode of operation is based on either of these phenomena are employed in carrying out our invention. We show both forms in the drawings hereto annexed; but for convenience hereinafter the radiophones of either kind at the distant station by which sounds are given out are termed "radiophone-receivers," and for want of a better designation the apparatus at the transmitting-station in and by which sounds or signals are sent, consisting of the device for generating an electric current, the device for converting the said electric current into radiant energy, and means for varying the strength of the electric current whereby the amount of radiant energy undergoes similar variations, is termed a "radiophone-transmitter" or "radiophone transmitting apparatus."

The invention consists in interrupting or varying an electrical current in a local circuit according to a code of signals or by articulation converting the energy of the

said electric current thus interrupted or varied into radiant energy, thereby producing similar interruptions or variations in said radiant energy and causing rays of said radiant energy thus interrupted or varied to fall upon a distant substance so sensitive to rapid changes in radiant energy as to give out sounds under such variations or a substance whose electrical resistance varies under rapid changes in radiant energy.

In carrying out this invention we provide at the transmitting-station an electrical working circuit containing the source of electric current and a device for developing radiant energy, together with means for producing the desired or characteristic alterations of said radiant energy, the said means comprising an auxiliary circuit associated either conductively or inductively with said working circuit and a transmitting apparatus in said auxiliary circuit adapted to alter the current thereof and thereby correspondingly modify the current supplied by said working circuit to said device for developing radiant energy.

The invention also consists in details of construction and circuit arrangement.

The modifications in the strength of the electric current resulting from modifications produced by the operation of the transmitting instrument in the auxiliary circuit, whereby corresponding modifications or alterations in the amount of radiant energy are obtained, may be effected in various ways—such as, for instance, by shunting a portion of the electric current from the source of the radiant energy, by superimposing a variable current upon the direct current at the source of the radiant energy, or by varying the intensity of the direct current at the source of the electric current. The variations in the electrical current of the transmitting-circuit may be effected by any suitable transmitting or circuit-changing device—such as, for example, a microphone-transmitter or a Morse key.

In the drawings, Figure 1 is a radiophone-receiver such as is employed to emit sounds directly under the rapid variations or interruptions of radiant energy falling upon it.

Fig. 2 is a radiophone-receiver provided with an electric circuit containing a telephone to be operated indirectly by the rapid variations of the radiant energy falling upon the radiophone. Fig. 3 is a diagram representing a radiophone-transmitter designed to operate a radiophone receiver of the kind shown with it and also shown at Fig. 1, or it may be used with a radiophone-receiver of the kind shown at Fig. 2. Figs. 4, 5, and 6 are diagrams representing each a separate modification of radiophone transmitting apparatus, or, more especially, modifications in the form of the auxiliary circuit containing the transmitting apparatus. In Fig. 4 is shown also a radiophone-receiver of the kind shown at Fig. 2.

The same letters are used through all the figures to represent the same or corresponding devices.

Describing first the simplest form of transmitter (shown in Fig. 3,) G is a generator of the electric current. E is the source of radiant energy, in this instance being an arc-light, or, more exactly speaking, the arc of an arc-light in circuit with the generator by wires $w w$, as shown. w^2 is a shunt-circuit containing a microphone-transmitter M, and R is a parabolic reflector.

In the radiophone-receiver shown at Fig. 1 and also at Fig. 3 in connection with the transmitting-radiophone just described, R' is a parabolic reflector. L is a substance extremely sensitive to heat, (burnt cork or lamp-black well answers the purpose,) and T is a glass tube containing the said sensitive substance L, closed at the end within the reflector and open at the other end. For convenience a flexible tube B, provided with ear-pieces, is employed, as in the phonograph. In the operation the energy of the electric current generated by the generator G is converted into radiant energy in the arc of the arc-light E, and this energy is modified by the microphone-transmitter M when the latter is spoken to in the ordinary manner—that is, by shunting a portion of the electric current from the source of the resonant energy and thereby varying the radiant energy. The parabolic reflector R faithfully reflects in parallel lines rays of energy in all their changing conditions due to the action of the microphone in the shunt-circuit, and these rays in every condition are received by the parabolic reflector R' and focused upon the sensitive substance or lampblack L, which will now emit articulate sounds corresponding to the changes produced in the microphone M by talking to it in the ordinary manner.

In Fig. 4, G is an electric generator. E is the source of radiant energy, being in this instance an incandescent light in circuit with the said generator by wires $w w$. G' is an auxiliary generator furnishing an alternating current in a shunt-circuit w^2 , containing also a Morse key K and a condenser C, and R is a parabolic reflector. When the key K is de-

pressed, the condenser C permits the alternating current of the shunt-circuit to pass through the source of radiant energy, but prevents the direct current of the main circuit from passing into the shunt-circuit. The mode of operation needs no further description. In this instance the desired variations in the radiant energy are effected by superimposing a variable current upon the direct current at the source of the radiant energy. With this radiophone-transmitter either form of radiophone-receiver may be used.

In Fig. 5, G is the generator. E is an arc-light in circuit with the generator by wires $w w$. C is a condenser in a shunt-circuit w^2 , which contains also the secondary of an induction-coil. w^3 is a second shunt or branch circuit from the main circuit provided with two equal resistances $r r$ and connected in turn, as shown, with a shunt from itself, (circuit w^4 .) This last-named shunt-circuit w^4 contains the primary p of the induction-coil, already mentioned, a Planté cell N, placed equidistant from the said two resistances $r r$, and a microphone-transmitter M. The operation is obvious with either form of radiophone-receiver herein described and shown. In this instance also a variable current is superimposed upon the direct current at the source of radiant energy.

In Fig. 6, G is the generator, E is an electric light, and $w w$ the main circuit containing both, as before described; but in this instance upon the field-magnets of the said generator G are wound convolutions of wire e , which are included in an auxiliary circuit w^2 , (in this instance having only inductive association with the main circuit,) in which is in turn included an auxiliary source of current, in this instance a battery Y and a microphone-transmitter M. Here the variations in the auxiliary circuit increase and decrease the strength of the magnetic field of the generator. Thus the desired variations in the radiant energy developed at E are produced by varying the intensity of the direct current.

It will be observed that in Fig. 4 we show an incandescent lamp as a source of radiant energy and also that in the said Fig. 4 we show a make-and-break key for causing signal interruptions or variations in the electric current, while in Figs. 3, 5, and 6, illustrating transmitting apparatus, we show arc-lights and microphones. We should say that for transmitting speech practically or otherwise than theoretically and experimentally we find the more powerful arc-light essential, and when using keys for varying the electric current according to a Morse or other code the arc-light for the radiant-energy device is much more satisfactory than the incandescent light. A direct electric current relatively large in comparison with the variations which are superimposed upon it will in the production of radiant energy, as described above, result in the most perfect re-

production in the radiant energy of the variations of the electric current. So, too, when the variable component of the total current is quite small, even then by the use of a sufficiently-large direct-component current the variable component of the radiant energy produced may be made as large as desired.

We claim—

1. The combination with a radiophone-receiver, of an electrical circuit containing a source of electric current and a device for developing radiant energy under the action of said source, and means for producing characteristic alterations of said radiant energy, consisting of an auxiliary circuit associated with said first-named circuit and a transmitting apparatus contained therein and adapted to alter the current thereof and thereby correspondingly modify the current supplied in said first-named circuit to said device for developing radiant energy, substantially as described.

2. The combination with a radiophone-re-

ceiver, of a transmitting apparatus consisting of an electric circuit containing a generator or other source of electric current and a device for developing radiant energy under the action of said generator or other source of electric current, a shunt-circuit about said device for developing radiant energy, and a transmitting apparatus within said shunt-circuit for altering the amount of said radiant energy, substantially as described.

3. The combination with a radiophone-receiver of an electric circuit with a generator of electricity and an arc-light therein, a shunt to said circuit with a circuit-changing device therein, and a reflector adapted to direct rays of radiant energy developed in the said arc-light to the said radiophone-receiver, substantially as described.

HAMMOND V. HAYES.
ERNEST R. CRAM.

Witnesses:

WILLIAM W. SWAN,
CHAS. R. CROSS.

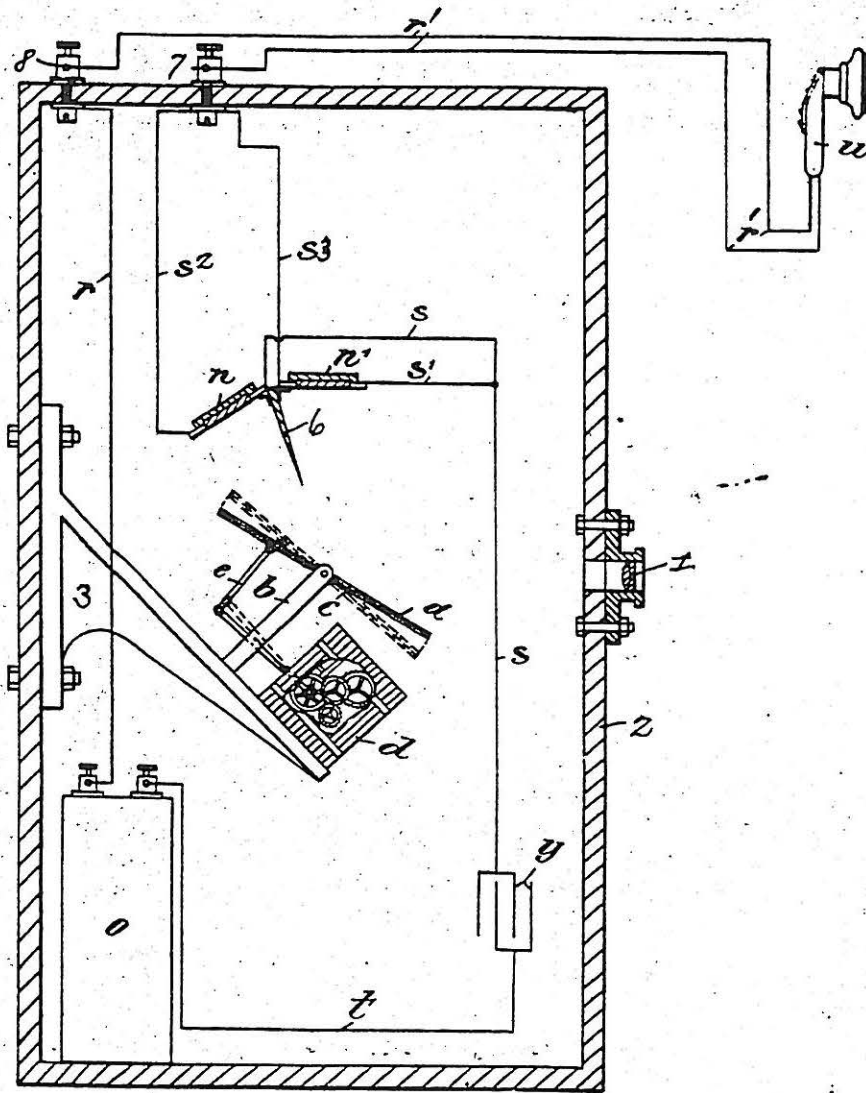
No. 680,614.

J. POLIAKOFF.

Patented Aug. 13, 1901.

PHOTOPHONOGRAPH-PHOTOPHONE OR SIMILAR DEVICE.

(Application filed July 17, 1900.)



Witnesses:

G. H.

B. Sommers

Inventor.
Joseph Paliaikoff
by Henry M.
May.

UNITED STATES PATENT OFFICE.

JOSEPH POLIAKOFF, OF CHARLOTTENBURG, GERMANY.

PHOTOPHONOGRAPH-PHOTOPHONE OR SIMILAR DEVICE.

SPECIFICATION forming part of Letters Patent No. 680,614, dated August 13, 1901.

Application filed July 17, 1900. Serial No. 23,921. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH POLIAKOFF, a subject of the Emperor of Russia, residing at Charlottenburg, near Berlin, Germany, have
5 invented certain new and useful Improvements in Photophonograph-Photophones or Similar Devices; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable
10 others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters and figures of reference marked thereon, which form a part of this specification.

15 This invention relates to photophonographs, photophones, and similar devices, and especially to that class of these instruments in which are employed selenium-cells, and has for its object to preserve as far as possible
20 the intensity or power of these cells during the operation of the instruments. It is well known that a cell of this character when continually exposed to the action of light will decrease in sensitiveness, its resistance not
25 varying according to the intensity of the light thrown on it, and if exposed long enough to the action of light the resistance becomes practically constant, in which state it is useless for the purposes of the instruments mentioned.

30 It is the purpose of this invention to maintain constant the photo-electric properties of the cells used and use novel features of construction, to be particularly described, and pointed out in the claims.

Referring to the drawings, in which like parts are similarly designated, Figure 1 shows a section of a photophone embodying my invention; Fig. 2, a top plan view of the same;
40 Fig. 3, a section through a similar device or photophonograph, showing the use of a permanent sound-record. Figs. 4 and 5 are modifications in section of photophones, and Figs. 6 and 7 detail views of photophonic receivers.

45 A beam of light is focused from a lens 1 on a mirror *a*, secured to a two-armed vibrating lever *c*, made of conductive material and pivoted at or approximately at its center at 9 in a pair of standards or supports *b*, fastened to a bracket 3. The lens 1 is shown as secured
50 to the casing 2 of the instrument, though not

necessarily so positioned, to throw a beam of light on the mirror. The lever *d* carries at either end yielding contacts *q* and *q'*, adapted to touch contacts *p* and *p'*, the former supported on an insulated standard 4 and the latter on a similar standard or pin 5, located for convenience on one end of the solenoid *e*, secured to the bracket 3, and one terminal wire of said solenoid *e* is connected by wire *g*
55 to a contact 7, insulated from and carried by the lever *c*, the other end of the solenoid being connected by wire *h* to one pole of the battery *i* or other source of electricity. The standard *b* carries a contact *k*, cooperating with the contact *l*, between which the solenoid-circuit is broken, and said contact *k* is directly connected to the other pole of the battery *i*. An armature *d*, secured to one end of the lever *c*, is attracted by the solenoid *e*.
60

A pair of selenium-cells *n* and *n'* are placed above the mirror *a*, with a partition or screen 6 between them, and in such relative position to the mirror *a* that the ray reflected from the mirror *a* will when said mirror is vibrated
65 first fall on one cell and then on the other, the screen 6, which, if desired, may be omitted, shielding each cell from the light falling on the other. The cell *n* is connected by wire *s* to the insulated contact *p* and the cell *n'* by wire *s'* to the insulated contact *p'* and both cells connected in parallel to a common binding-post 7 by their respective wires *s*² and *s*³. This binding-post 7 forms one terminal of a metallic circuit *r*, connected to a telephone-
70 receiver *u*, the other terminal of said circuit being a similar binding-post 8, directly connected by wire *r* to one terminal of a second battery *o*, the other terminal thereof being connected by wire *t* to the pivots 9 of the vibrating lever *c*.
75

The operation of the device is as follows: The mirror *a*, carried by the conductive lever *c*, is caused to vibrate by the attraction of the armature *d* to the magnet against the stress of the spring *f*. The solenoid-circuit, including the battery *i* and independent of the other circuits, is as follows: Current flows from battery *i*, wire *h*, solenoid *e*, wire *g*, contacts *l* and *k*, wire 10, back to battery *i*. The solenoid *e* will be energized, the armature *d* and its attached parts attracted, circuit
80
85
90
95
100

broken at *h*, and the lever *c* and armature *d* returned by spring *f* to the position shown in the drawings. Light coming through the lens *l*, whose vibrations are varied by sound either in or across the path of the light, will be reflected from the vibrating mirror first on one and then on the other of the selenium-cells, their resistances being varied according to the modified reflected-light vibrations, and at the same time that light is on a cell circuit will be closed through it, the circuit through the other cell being open—viz., current flows from the battery *o* by wire *t* to pivot *9*, lever *c*, yielding or spring contact *q*, contact *p*, wire *s*, cell *n*, wire *s*², post *7*, wire *r*¹, telephone *u*, back to post *8*, wire *r*, back to the other terminal of the battery *o*. When the armature is attracted, the light is caused to fall on the other cell *n'* and circuit is closed from battery *o*, through wire *t*, pivot *9*, lever *c*, spring-contact *q'*, contact *p'*, wire *s'*, cell *n'*, wire *s*³, post *7*, and back to battery *o*, as previously described.

In Fig. 3 the same arrangement is shown with a different means for producing variations in the light-waves, and this is done by means of a positive photographic sound-record, which can be made as follows: A sensitive ribbon *r* is mechanically fed past an opening or slot *11* and exposed to light whose vibrations are varied by a polished sound-vibrated diaphragm *12* or one carrying a mirror that reflects a ray through the lens *1* from a lens *13* in a tube *14* at an angle to the tube *x*. This negative is developed and a positive is made from it and fed at the same rate past the same opening *11*, through which uniformly-vibrating light is passed to the mirror *a*, and these waves of varying intensity due to the difference of intensity of the film are then reflected to the cells and sound transmitted to the phone, as before described.

It is not absolutely necessary that the selenium-cell of the receiver described above, which at the time being is not exposed to light, be shunted off from the circuit as long as provision is made that the two selenium-cells do not disturb one another. In order to avoid reciprocal disturbances of two selenium-cells included in the circuit of a telephone apparatus, condensers or induction apparatus can be used with advantage. The condenser operates in this manner that the continuous or slowly-undulating currents cannot be transmitted thereby, but that the currents alternating in direction or intensity are transmitted without hindrance. The current that is led to one coating of the condenser produces a corresponding current in the second coating, from which it may be gathered that in the operation of one of the selenium-cells the other selenium-cell has no action on the telephone.

In Fig. 4 a condenser *y* is employed, one coating of which is connected with the branch circuits *s* and *s*², leading from the selenium-

cells *n* and *n'*, respectively, and the other coating with the battery *o* by the wire *t*. Thus the above-described contact-breakers *p* *q* and *p'* *q'* are replaced by the condenser *y*. Instead of a condenser an inductor may be employed. In both instances the effect will be the same as described with reference to Figs. 1 and 2. The electric interrupter shown in Figs. 1 to 4 may also be replaced by a mechanical interrupting device.

In Fig. 5 a clockwork *w* is employed for the same purpose, which imparts to the mirror *a* the necessary vibratory motion by means of suitable connecting rods or levers.

Having thus described my invention, what I claim as new therein, and desire to secure by Letters Patent, is—

1. In instruments of the class described, means for producing sound-modified light, devices for vibrating a reflected ray of such, and means arranged to receive said rays to affect an electric current, substantially as set forth.

2. In instruments of the class described, the combination with photo-electric cells, of devices for vibrating a ray of sound-modified light to one and then to another of said cells, substantially as set forth.

3. In instruments of the class described, the combination with photo-electric cells, of a light-screen between the cells and devices for vibrating a ray of sound-modified light from one cell to another, substantially as set forth.

4. In instruments of the class described the combination with selenium-cells connected in a telephone-circuit of a vibrating mirror, whereby a reflected ray of sound-modified light is sent alternately to one cell and to the other.

5. In instruments of the class described the combination with two selenium-cells connected in a telephone-circuit of a vibrating mirror and a vibrating lever carrying the armature of an electric interrupter and the said mirror.

6. In instruments of the class described, the combination with photo-electric cells arranged to be successively connected to a telephone-circuit, devices for vibrating sound-modified light-rays first to one cell and then to another, and means for cutting out of circuit those cells on which the sound-modified rays of light do not fall.

7. In instruments of the class described, the combination with photo-electric cells arranged to be successively connected to a telephone-circuit, of a screen between adjacent cells, a vibrating mirror a circuit-breaker connected thereto, whereby a reflected ray of sound-modified light is sent to and current simultaneously sent through the cells, substantially as set forth.

8. In instruments of the class described the combination with a pair of selenium-cells connected in a telephone-circuit, contacts electrically connected to said cells, a conductive electrically-vibrated lever adapted to close

circuit through either of the said contacts, a solenium-cell and the telephone-circuit an electrical connection between said lever and a source of current and a mirror carried by said lever, substantially as set forth.

9. In instruments of the class described, the combination with photo-electric cells arranged to be successively connected to a telephone-circuit, a screen between adjacent cells, an electrically-vibrated circuit-breaker and a mirror arranged to direct current through and sound-modified light successively to said cells, substantially as set forth.

10. In instruments of the class described, the combination with a pair of selenium-cells arranged to be alternately connected to a telephone-circuit, of a pair of contacts each electrically connected to a cell, a conductive vibrating lever arranged to alternately close circuit through one contact, cell and telephone-circuit, electrical connections between said lever and a source of electric supply, a mirror and an armature on said lever, a solenoid opposite the armature, an independent circuit for said solenoid and a circuit-breaker included in the solenoid-circuit and carried by said vibrating lever, substantially as and for the purpose set forth.

11. In instruments of the class described, in combination, a lens, a vibrating mirror at its focus, a mechanically-moved positive photographic record of sound-modified light-waves moving across the path of light focused from said lens to the mirror, a pair of selenium-cells arranged to alternately receive light-impressions from said vibrating mirror to said

cells included in parallel in a telephone-circuit, substantially as set forth.

12. In instruments of the class described in combination, a lens, a vibrating mirror at its focus, a positive photographic sound-record mechanically moved across the path of light between the lens and mirror, a pair of selenium-cells included in a telephone-circuit and arranged to alternately receive the focused light from said mirror, screens for said cells to shield them from all light but that reflected from said mirror to the respective cells, and means for placing only that cell in circuit, which is affected by the reflected ray from the mirror, substantially as set forth.

13. In instruments of the class described, in combination, a photo-electric cell included in a telephone-circuit, a moving photographic sound-record, and means for passing light through said record to the cell, substantially as set forth.

14. In instruments of the class described in combination, a photo-electric cell included in a telephone-circuit, a moving positive photographic sound-record, and means for passing uniformly-vibrating light through said sound-record and focusing it on the cell, substantially as set forth.

In testimony that I claim the foregoing as my invention I have signed my name in presence of two subscribing witnesses.

JOSEPH POLLAKOFF.

Witnesses:

MAX C. STAEHLER,
HENRY HASPER.

No. 685,954

Patented Nov. 5, 1901.

N. TESLA.

METHOD OF UTILIZING EFFECTS TRANSMITTED THROUGH NATURAL MEDIA.

(Application filed Aug. 1, 1899. Renewed May 29, 1901.)

(No Model.)

2 Sheets—Sheet 1.

Fig 1.

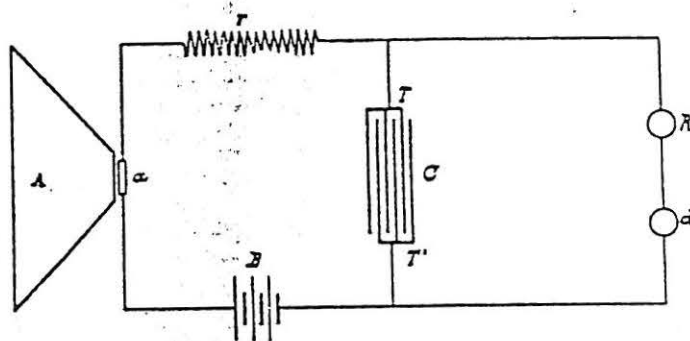
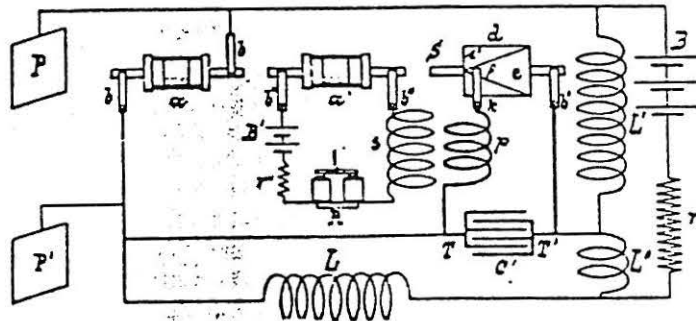


Fig 2.



WITNESSES

Benjamin Miller.
M. Lamon Syer.

INVENTOR

Nikola Tesla

BY

Kerr, Page & Cooper

ATTORNEYS.

No. 685,954.

Patented Nov. 5, 1901.

N. TESLA.

METHOD OF UTILIZING EFFECTS TRANSMITTED THROUGH NATURAL MEDIA.

(Application filed Aug. 1, 1899. Renewed May 29, 1901.)

(No Model.)

2 Sheets—Sheet 2.

Fig. 3

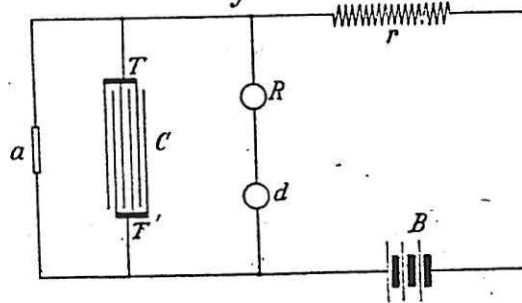


Fig. 4

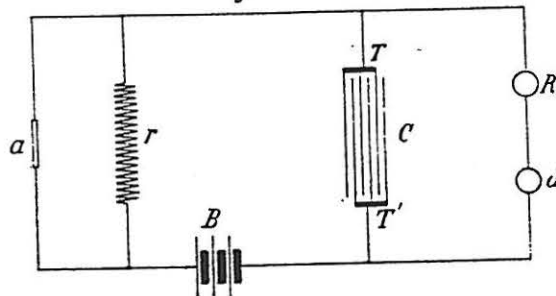
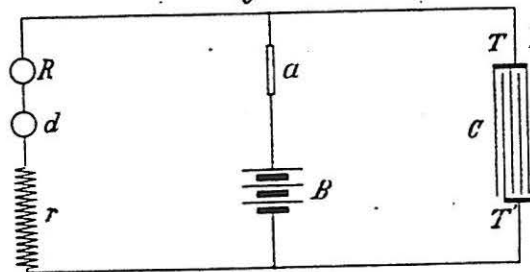


Fig. 5



Witnesses:

Raphael Tetter
Benjamin Miller

Nikola Tesla Inventor
by Rev. Paget Cooper Attys

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

METHOD OF UTILIZING EFFECTS TRANSMITTED THROUGH NATURAL MEDIA.

SPECIFICATION forming part of Letters Patent No. 685,954, dated November 5, 1901:

Application filed August 1, 1899. Renewed May 29, 1901. Serial No. 62,316. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York city, in the county and State of New York, have invented a new and useful Improvement in Methods of Utilizing Effects Transmitted from a Distance to a Receiving Device Through the Natural Media, of which the following is a specification; reference being had to the accompanying drawings, which form a part of the same.

The subject of my present invention is an improvement in the art of utilizing effects transmitted from a distance to a receiving device through the natural media; and it consists in a novel method hereinafter described.

My invention is particularly useful in connection with methods and apparatus for operating distant receiving devices by means of electrical disturbances produced by proper transmitters and conveyed to such receiving devices through the natural media; but it obviously has a wider range of applicability and may be employed, for example, in the investigation or utilization of terrestrial, solar, or other disturbances produced by natural causes.

Several ways or methods of transmitting electrical disturbances through the natural media and utilizing them to operate distant receivers are now known and have been applied with more or less success for accomplishing a variety of useful results. One of these ways consists in producing by a suitable apparatus rays or radiations—that is, disturbances—which are propagated in straight lines through space, directing them upon a receiving or recording apparatus at a distance, and thereby bringing the latter into action. This method is the oldest and best known and has been brought particularly into prominence in recent years through the investigations of Heinrich Hertz. Another method consists in passing a current through a circuit, preferably one inclosing a very large area, inducing thereby in a similar circuit, situated at a distance another current and affecting by the same in any convenient way a receiving device. Still another way, which has also been known for many years, is to pass in any suitable manner a current through a portion of the ground, as by connecting to two

points of the same, preferably at a considerable distance from each other, the two terminals of a generator and to energize by a part of the current diffused through the earth a distant circuit, which is similarly arranged and grounded at two points widely apart and which is made to act upon a sensitive receiver. These various methods have their limitations, one especially, which is common to all, being that the receiving circuit or instrument must be maintained in a definite position with respect to the transmitting apparatus, which often imposes great disadvantages upon the use of the apparatus.

In several applications filed by me and patents granted to me I have disclosed other methods of accomplishing results of this nature which may be briefly described as follows: In one system the potential of a point or region of the earth is varied by imparting to it intermittent or alternating electrifications through one of the terminals of a suitable source of electrical disturbances, which to heighten the effect has its other terminal connected to an insulated body, preferably of large surface and at an elevation. The electrifications communicated to the earth spread in all directions through the same, reaching a distant circuit, which generally has its terminals arranged and connected similarly to those of the transmitting source and operates upon a highly-sensitive receiver. Another method is based upon the fact that the atmospheric air, which behaves as an excellent insulator to currents generated by ordinary apparatus, becomes a conductor under the influence of currents or impulses of enormously high electromotive force which I have devised means for generating. By such means air strata, which are easily accessible, are rendered available for the production of many desired effects at distances however great. This method, furthermore, allowed advantage to be taken of many of those improvements which are practicable in the ordinary systems of transmission involving the use of a metallic conductor.

Obviously whatever method be employed it is desirable that the disturbances produced by the transmitting apparatus should be as powerful as possible, and by the use of certain forms of high-frequency apparatus which

I have devised and which are now well known important practical advantages are in this respect secured. Furthermore, since in most cases the amount of energy conveyed to the distant circuit is but a minute fraction of the total energy emanating from the source it is necessary for the attainment of the best results that whatever the character of the receiver and the nature of the disturbances as much as possible of the energy conveyed should be made available for the operation of the receiver, and with this object in view I have heretofore, among other means, employed a receiving-circuit of high self-induction and very small resistance and of a period such as to vibrate in synchronism with the disturbances, whereby a number of separate impulses from the source were made to co-operate, thus magnifying the effect exerted upon and insuring the action of the receiving device. By these means decided advantages have been secured in many instances; but very often the improvement is either not applicable at all, or if so the gain is very slight. Evidently when the source is one producing a continuous pressure or delivering impulses of long duration it is impracticable to magnify the effects in this manner, and when, on the other hand, it is one furnishing short impulses of extreme rapidity of succession the advantage obtained in this way is insignificant, owing to the radiation and the unavoidable frictional waste in the receiving-circuit. These losses reduce greatly both the intensity and the number of the coöperative impulses, and since the initial intensity of each of these is necessarily limited only an insignificant amount of energy is thus made available for a single operation of the receiver. As this amount is consequently dependent on the energy conveyed to the receiver by one single impulse, it is evidently necessary to employ either a very large and costly and therefore objectionable transmitter or else to resort to the equally objectionable use of a receiving device too delicate and too easily deranged. Furthermore, the energy obtained through the coöperation of the impulses is in the form of extremely-rapid vibrations and because of this unsuitable for the operation of ordinary receivers, the more so as this form of energy imposes narrow restrictions in regard to the mode and time of its application to such devices. To overcome these and other limitations and disadvantages that have heretofore existed in such systems of transmission of signals or intelligence and to render possible an investigation of impulses or disturbances propagated through the natural media from any kind of source and their practical utilization for any purpose to which they are applicable, I have devised a novel method, which I have described in a pending application filed June 24, 1899, Serial No. 721,790, and which, broadly stated, consists in effecting during any desired time interval a storage of energy derived from such impulses and utilizing

the potential energy so obtained for operating a receiving device.

My present invention is intended for the same general purposes, and it comprises a modified method and apparatus by means of which similar results may be obtained.

The chief feature which distinguishes my present from my former invention just referred to is that the energy stored is not, as in the former instance, obtained from the energy of the disturbances or effects transmitted from a distance, but from an independent source.

Expressed generally, my present method consists in charging a storage device with energy from an independent source controlling the charging of said device by the action of the effects or disturbances transmitted through the natural media and coincidentally using the stored energy for operating a receiving device.

A great variety of disturbances produced either by suitably-constructed transmitters or by natural causes are at present known to be propagated through the natural media, and there are also a variety of means or devices enabling energy to be stored, and in view of this I wish to say that I consider the utilization of any such disturbances and the employment of any of these means as within the scope of my present invention so long as the use of the general method hereinbefore stated is involved.

The best way of carrying out my invention which I at present know is to store electrical energy obtained from a suitable electrical generator in a condenser and to control the storage or the application of this energy by means of a sensitive device acted upon by the effects or disturbances, and thereby cause the operation of the receiver.

In the practical application of this method I usually proceed as follows: At any point where I desire to investigate or to utilize for any purpose effects or disturbances propagated through the natural media from any kind of source I provide a suitable generator of electricity—as, for example, a battery and a condenser—which I connect to the poles of the generator in series with a sensitive device capable of being modified in its electrical resistance or other property by the action of the disturbances emitted from the source. To the terminals of the condenser I connect the receiver which is to be operated in series with another device of suitable construction which performs the function of periodically discharging the condenser through the receiver at and during such intervals of time as may be best suitable for the purpose contemplated. This latter device may merely consist of two stationary electrodes separated by a feeble dielectric layer of minute thickness, but sufficient to greatly reduce or practically interrupt the current in the circuit under normal conditions, or it may comprise terminals one or more of which are movable

and actuated by any suitable force and are adapted to be brought into and out of contact with each other in any convenient manner. The sensitive device may be any of many devices of this kind which are known to be affected by the disturbances, impulses, or effects propagated through the media, and it may be of such a character that normally—that is, when not acted upon—it entirely prevents the passage of electricity from the generator to the condenser, or it may be such that it allows a gradual leaking through of the current and a charging of the condenser at a slow rate. In any case it will be seen that if the disturbances, of whatever nature they may be, cause an appreciable diminution in the electrical resistance of the sensitive device the current from the battery will pass more readily into the condenser, which will be charged at a more rapid rate, and consequently each of its discharges through the receiver, periodically effected by the special device before referred to which performs this function, will be stronger than normally—that is, when the sensitive device is not acted upon by the disturbances. Evidently, then, if the receiver be so adjusted that it does not respond to the comparatively feeble normal discharges of the condenser, if they should occur, but only to those stronger ones which take place upon the diminution of the resistance of the sensitive device, it will be operated only when this device is acted upon by the disturbances, thus making it possible to investigate and to utilize the latter for any desired purpose.

The general principle underlying my invention and the operation of the various devices used will be clearly understood by reference to the accompanying drawings, in which—

Figure 1 is a diagram illustrating a typical arrangement of apparatus which may be used in carrying my method into practice, and Figs. 2, 3, 4, and 5 similar diagrams of modified arrangements of apparatus for the same purpose.

In Fig. 1, C is a condenser, to the terminals T and T' of which is connected a charging-circuit including a battery B, a sensitive device *a*, and a resistance *r*, all connected in series, as illustrated. The battery should be preferably of very constant electromotive force and of an intensity carefully determined to secure the best results. The resistance *r*, which may be a frictional or an inductive one, is not absolutely necessary; but it is of advantage to use it in order to facilitate adjustment, and for this purpose it may be made variable in any convenient and preferably continuous manner. Assuming that the disturbances which are to be investigated or utilized for some practical end are rays identical with or resembling those of ordinary light, the sensitive device *a* may be a selenium cell properly prepared, so as to be highly susceptible to the influence of the rays, the action

of which should be intensified by the use of a reflector A, shown in the drawings. It is well known that when cells of this kind are exposed to such rays of greatly-varying intensity they undergo corresponding modifications of their electrical resistance; but in the ways they have been heretofore used they have been of very limited utility. In addition to the circuit including the sensitive device or cell *a* another circuit is provided, which is likewise connected to the terminals T T' of the condenser. This circuit, which may be called the "receiving-circuit," includes the receiver R and in series with it a device *d*, before referred to, which performs the duty of periodically discharging the condenser through the receiver. It will be noted that, as shown in Fig. 1, the receiving-circuit is in permanent connection with the battery and condenser terminal T, and it should be stated that it is sometimes desirable to entirely insulate the receiving-circuit at all times except the moments when the device *d* operates to discharge the condenser, thus preventing any disturbing influence which might otherwise be caused in this circuit by the battery or the condenser during the period when the receiver should not be acted upon. In such a case two devices, as *d*, may be used—one in each connection from the condenser to the receiving-circuit—or else one single device of this kind, but of a suitably-modified construction, so that it will make and break simultaneously and at proper intervals of time both of the connections of this circuit with the condenser T and T'.

From the foregoing the operation of the apparatus as illustrated in Fig. 1 will be at once understood. Normally—that is, when it is not influenced by the rays at all or very slightly—the cell *a* being of a comparatively high resistance permits only a relatively feeble current to pass from the battery into the condenser, and hence the latter is charged at too slow a rate to accumulate during the time interval between two succeeding operations of the device *d* sufficient energy to operate the receiver or, generally speaking, to produce the required change in the receiving-circuit. This condition is readily secured by a proper selection and adjustment of the various devices described, so that the receiver will remain unresponsive to the feeble discharges of the condenser which may take place when the cell *a* is acted upon but slightly or not at all by the rays or disturbances; but if now new rays are permitted to fall upon the cell or if the intensity of those already acting upon it be increased by any cause then its resistance will be diminished and the condenser will be charged by the battery at a more rapid rate, enabling sufficient potential energy to be stored in the condenser during the period of inaction of the device *d* to operate the receiver or to bring about any desired change in the receiving-circuit when the device *d* acts. If the rays acting upon the

cell or sensitive device a are varied or intermitted in any arbitrary manner, as when transmitting intelligence in the usual way from a distant station by means of short and long signals, the apparatus may readily be made to record or to enable an operator to read the message, since the receiver, supposing it to be an ordinary magnetic relay, for example, will be operated by each signal from the sending station a certain number of times having some relation to the duration of each signal. It will be readily seen, however, that if the rays are varied in any other way, as by impressing upon them changes in intensity, the succeeding condenser discharges will undergo corresponding changes in intensity, which may be indicated or recorded by a suitable receiver and distinguished irrespectively of duration.

With reference to Fig. 1, it may be useful to state that the electrical connections of the various devices illustrated may be made in many different ways. For instance, the sensitive device instead of being in series, as shown, may be in a shunt to the condenser, this modification being illustrated in Fig. 3, in which the devices already described are indicated by similar letters to correspond with those of Fig. 1. In this case it will be observed that the condenser which is being charged from the battery B through the resistance r , preferably inductive and properly related to the capacity of the condenser, will store less energy when the sensitive device a is energized by the rays and its resistance thereby diminished. The adjustment of the various instruments may then be such that the receiver will be operated only when the rays are diminished in intensity or interrupted and entirely prevented from falling upon the sensitive cell, or the sensitive device may be placed, as shown in Fig. 4, in a shunt to the resistance r or inserted in any suitable way in the circuit containing the receiver—for example, as illustrated in Fig. 5—in both of which figures the various devices are lettered to correspond with those in Fig. 1, so that the figures become self-explanatory. Again, the several instruments may be connected in the manner of a Wheatstone bridge, as will be hereinafter explained with reference to Fig. 2, or otherwise connected or related; but in each case the sensitive device will have the same duty to perform—that is, to control the energy stored and utilized in some suitable way for causing the operation of the receiver in correspondence with the intermittences or variations of the effects or disturbances, and in each instance by a judicious selection of the devices and careful adjustment the advantages of my method may be more or less completely secured. I find it preferable, however, to follow the plan which I have illustrated and described.

It will be observed that the condenser is an important element in the combination. I have shown that by reason of its unique properties

it greatly adds to the efficacy of this method. It allows the energy accumulated in it to be discharged instantaneously, and therefore in a highly-effective manner. It magnifies in a large degree the current supplied from the battery, and owing to these features it permits energy to be stored and discharged at practically any rate desired, and thereby makes it possible to obtain in the receiving-circuit very great changes of the current strength by impressing upon the battery-current very small variations. Other means of storage possessing these characteristics to a useful degree may be employed without departing from the broad spirit of my invention; but I prefer to use a condenser, since in these respects it excels any other storage device of which I have knowledge.

In Fig. 2 a modified arrangement of apparatus is illustrated which is particularly adapted for the investigation and utilization of very feeble impulses or disturbances, such as may be used in conveying signals or producing other desired effects at very great distances. In this case the energy stored in the condenser is passed through the primary of a transformer the secondary circuit of which contains the receiver, and in order to render the apparatus still more suitable for use in detecting feeble impulses in addition to the sensitive device which is acted upon by the impulses another such device is included in the secondary circuit of the transformer. The scheme of connections is in the main that of a Wheatstone bridge the four branches of which are formed by the sensitive device a and resistances L , L' , and L'' , all of which should be preferably inductive and also adjustable in a continuous manner or at least by very small steps. The condenser C , which is generally made of considerable capacity, is connected to two opposite points of the bridge, while a battery B, in series with a continuously-adjustable non-inductive resistance r , is connected to the other pair of opposite points, as usual. The four resistances included in the branches of the bridge—namely, a , L , L' , and L'' —are of a suitable size and so proportioned that under normal conditions—that is, when the device a is not influenced at all or only slightly by the disturbances—there will be no difference of potential or in any case the minimum of the same at the terminals T and T' of the condenser. It is assumed in the present instance that the disturbances to be investigated or utilized are such as will produce a difference of electric potential, however small, between two points or regions in the natural media—as the earth, the water, or the air—and in order to apply this potential difference effectively to the sensitive device a the terminals of the same are connected to two plates P and P', which should be of as large a surface as practicable and so located in the media that the largest possible difference of potential will be produced by the disturbances between the terminals of

the sensitive device. This device is in the present case one of familiar construction, consisting of an insulating-tube, which is indicated by the heavy lines in the drawings and which has its ends closed tightly by two conducting-plugs with reduced extensions, upon which bear two brushes b , through which the currents are conveyed to the device. The tubular space between the plugs is partially filled with a conducting sensitive powder, as indicated, the proper amount of the same and the size of its grains being determined and adjusted beforehand by experiment. This tube I rotate by clockwork or other means at a uniform and suitable rate of speed, and under these conditions I find that this device behaves toward disturbances of the kind before assumed in a manner similar to that of a stationary cell of selenium toward rays of light. Its electrical resistance is diminished when it is acted upon by the disturbances and is automatically restored upon the cessation of their influence. It is of advantage to employ round grains of powder in the tube, and in any event it is important that they should be of as uniform size and shape as possible and that provision should be made for maintaining an unchanging and very dry atmosphere in the tube. To the terminals T and T' of the condenser C is connected a coil p , usually consisting of a few turns of a conductor of very small resistance, which is the primary of the transformer before referred to, in series with a device d , which effects the discharge of the condenser through the coil p at predetermined intervals of time. In the present case this device consists of a cylinder made partly of conducting and partly of insulating material e and e' , respectively, which is rotated at the desired rate of speed by any suitable means. The conducting part e is in good electrical connection with shaft S and is provided with tapering segments, as f , upon which slides a brush k ; which should preferably be capable of longitudinal adjustment along the cylinder. Another brush b' , which is connected to the condenser-terminal T' , being arranged to bear upon the shaft S , it will be seen that whenever the brush k comes in contact with a conducting-segment f the circuit including the primary p will be completed and the condenser, if energized, discharged through the same. By an adjustment of the speed of rotation of the cylinder and a displacement of the brush k along the axis of the same the circuit may be made to open and close in as rapid succession and remain open or closed during such intervals of time as may be desired. In inductive relation to the primary p is a secondary coil s , usually of much thinner wire and of many more turns than the former, to which are connected in a series a receiver R , (illustrated as an ordinary magnetic relay,) a continuously-adjustable non-inductive resistance r' , a battery B' of a properly determined and very constant electromotive force, and finally a sensitive device a' of the same or similar construction as a , which is likewise rotated at a uniform speed and which with its brushes b'' b'' closes the secondary circuit. The electromotive force of the battery B' is so graduated by means of the adjustable resistance r' that the dielectric layers in the sensitive device a' are strained very nearly to the point of breaking down and give way upon a slight increase of the electrical pressure on the terminals of the device. It will of course be understood that the resistance r' is used mainly because of convenience that it may be dispensed with, in which case the adjustment may be effected in many other ways, as by determining the proper amount or coarseness of the sensitive powder or by varying the distance apart of the metallic plugs in the ends of the tube. The same may be said of the resistance r' , which is in series with the battery B and serves to graduate the force of the latter, so that the dielectric layers of the sensitive device a are subjected to a similar strain and maintained in a state of delicate poise. The various instruments being connected and adjusted in the manner described, it will now be readily seen from the foregoing that under normal conditions, the device a being unaffected by the disturbances, or practically so, and there being no or only a very insignificant amount of energy stored in the condenser, the periodical closure of the primary circuit of the transformer through the operation of the device d will have no appreciable effect upon the primary coil p , and hence no currents will be generated in the secondary coil s , at least not such as would disturb the state of delicate balance existing in the secondary circuit including the receiver, and therefore the latter will not be actuated by the battery B' ; but when, owing to the disturbances or impulses propagated through the media from a distant source, an additional electromotive force, however small, is created between the terminals of the device a the dielectric layers in the same, unable to support the increased strain, give way and allow the current of the battery B to pass through, thus causing a difference of potential at the terminals T and T' of the condenser. A sufficient amount of energy being now stored in this instrument during the time interval between each two succeeding operations of the device d , each closure of the primary circuit by the latter results in the passage of a sudden current impulse through the coil p , which induces a corresponding current of relatively high electromotive force in the secondary coil s . Owing to this the dielectric in the device a' gives way, and the current of the battery B' being allowed to pass the receiver R is operated, but only for a moment, since by the rotation of the devices a , a' , and d , which may be all driven from the same shaft, the original conditions are restored, assuming, of course, that the electromotive force set up by the disturbances

at the terminals of the sensitive device a is only momentary or of a duration not longer than the time of closure of the primary circuit; otherwise the receiver will be actuated a number of times and so long as the influence of the disturbances upon the device a continues. In order to render the discharged energy of the condenser more effective in causing the operation of the receiver, the resistance of the primary circuit should be very small and the secondary coil s should have a number of turns many times greater than that of the primary coil p . It will be noted that since the condenser under the above assumptions is always charged in the same direction the strongest current impulse in the secondary coil, which is induced at the moment when the brush k comes in contact with segment f , is also of unchanging direction, and for the attainment of the best results it is necessary to connect the secondary coil so that the electromotive force of this impulse will be added to that of the battery and will momentarily strengthen the same. However, under certain conditions, which are well understood by those skilled in the art, the devices will operate whichever way the secondary be connected. It is preferable to make the inductive resistances L and L' relatively large, as they are in a shunt to the device a and might if made too small impair its sensitiveness. On the other hand, the resistance L'' should not be too large and should be related to the capacity of the condenser and the number of makes and breaks effected by the device d in well-known ways. Similar considerations apply, of course, to the circuits including the primary p and secondary s , respectively.

By carefully observing well-known rules of scientific design and adjustment of the instruments the apparatus may be made extremely sensitive and capable of responding to the feeblest influences, thus making it possible to utilize impulses or disturbances transmitted from very great distances and too feeble to be detected or utilized in any of the ways heretofore known, and on this account the method here described lends itself to many scientific and practical uses of great value. Obviously the character of the devices and the manner in which they are connected or related may be greatly varied without departing from the spirit of my invention.

What I claim as new, and desire to secure by Letters Patent, is—

1. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in charging a storage device with energy from an independent source, controlling the charging of said device by the action of the effects or disturbances, and coincidentally using the stored energy for operating a receiving device.

2. The method hereinbefore described of utilizing effects or disturbances transmitted

from a distant source, which consists in charging the storage device with electrical energy from an independent source, controlling the charging of said device by the action of the effects or disturbances, and coincidentally using the stored electrical energy for operating the receiving device.

3. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in controlling, by means of such effects or disturbances, the charging of an electrical storage device from an independent source and discharging the stored energy through a receiving-circuit.

4. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in controlling, by means of such effects or disturbances, the charging of an electrical condenser from an independent source, and discharging the stored energy through a receiving-circuit.

5. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in effecting a storage during any desired time interval and under control of such effects or disturbances, of energy derived from an independent source, and utilizing the potential energy so obtained for operating a receiving device.

6. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in effecting a storage, during any desired time interval and under the control of such disturbances or effects of electrical energy derived from an independent source, and utilizing the potential energy so obtained for operating a receiving device.

7. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media, which consists in effecting a storage in a condenser during any desired time interval and under the control of such disturbances or effects, of electrical energy derived from an independent source, and utilizing the potential energy so obtained for operating a receiving device.

8. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in storing, during succeeding intervals of time determined by means of such effects or disturbances, electrical energy derived from an independent source, and utilizing the potential energy so accumulated to operate a receiving device.

9. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in storing in a condenser during succeeding intervals of time determined by means of such effects or disturbances, electrical energy derived from an independent source, and utilizing the poten-

tial energy so accumulated to operate a receiving device.

10. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in storing, during succeeding intervals of time determined by means of such effects or disturbances, electrical energy derived from an independent source, and using, for periods of time predetermined as to succession and duration, the accumulated energy so obtained to operate a receiving device.

11. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in storing in a condenser during succeeding intervals of time determined by means of such effects or disturbances, electrical energy derived from an independent source, and using, for periods of time predetermined as to succession and duration, the accumulated energy so obtained to operate a receiving device.

12. The method hereinbefore described of utilizing electrical effects or disturbances transmitted through the natural media from a distant source, which consists in effecting by means of such disturbances or effects a storage in a storage device of electrical energy derived from an independent source for periods of time corresponding in succession and duration to such disturbances or effects, and discharging the electrical energy so accumulated into or through a receiving device at predetermined intervals of time.

13. The method hereinbefore described of utilizing electrical effects or disturbances transmitted from a distant source, which consists in effecting by means of such disturbances or effects a storage in a condenser of electrical energy derived from an independent source for periods of time corresponding in succession and duration to such disturbances or effects, and discharging the electrical energy so accumulated into or through a receiving device at predetermined intervals of time.

14. The method hereinbefore described of utilizing electrical effects or disturbances transmitted from a distant source, which consists in producing, by means of such effects or disturbances, variations of resistance in a circuit including an independent electrical source and a device adapted to be charged with electrical energy therefrom, thereby causing the storage device to be charged with energy from such independent source, and using the potential electrical energy so accumulated to operate a receiving device.

15. The method hereinbefore described of utilizing effects or disturbances transmitted

through the natural media from a distant source, which consists in producing, by means of such effects or disturbances, variations of resistance in a circuit including an independent electrical source and a condenser, thereby causing the condenser to be charged with energy from the independent source, and using the potential electrical energy so accumulated to operate a receiving device.

16. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in causing, by means of such effects or disturbances, electrical energy from an independent source to be stored in a storage device, using the electrical energy so accumulated to operate a transformer and employing the secondary currents from such transformer to operate a receiving device.

17. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in causing, by means of such effects or disturbances, electrical energy from an independent source to be stored in a condenser, using the electrical energy so accumulated to operate a transformer and employing the secondary currents from such transformer to operate a receiving device.

18. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in causing, by means of such disturbances, variations of resistance in a circuit including an independent source of electricity and a storage device and thereby causing the storage device to be charged from such independent source, discharging the energy so accumulated in the storage device through the primary of a transformer at predetermined intervals of time, and operating a receiver by the currents so developed in the secondary of the transformer.

19. The method hereinbefore described of utilizing effects or disturbances transmitted through the natural media from a distant source, which consists in causing, by means of such disturbances, variations of resistance in a circuit including an independent source of electricity and a condenser and thereby causing the condenser to be charged from such independent source, discharging the energy so accumulated in the condenser through the primary of a transformer at predetermined intervals of time and operating a receiver by the currents so developed in the secondary of the transformer.

NIKOLA TESLA.

Witnesses:

F. LÖWENSTEIN,
E. A. SÜNDERLIN.

No. 685,956.

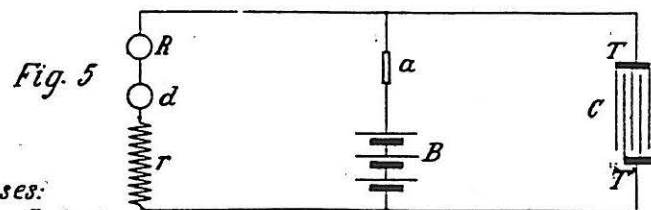
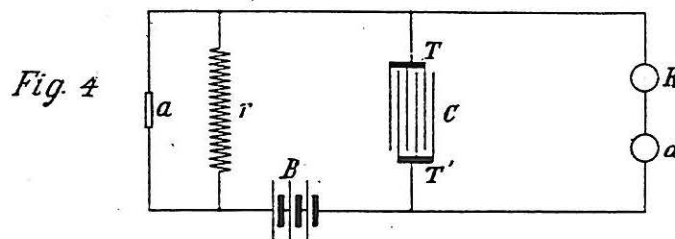
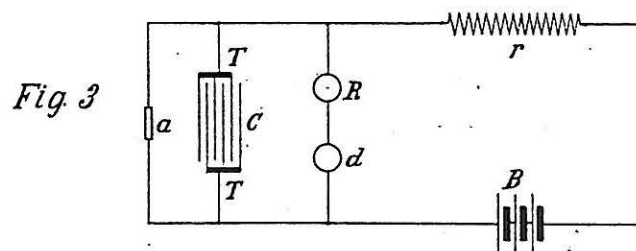
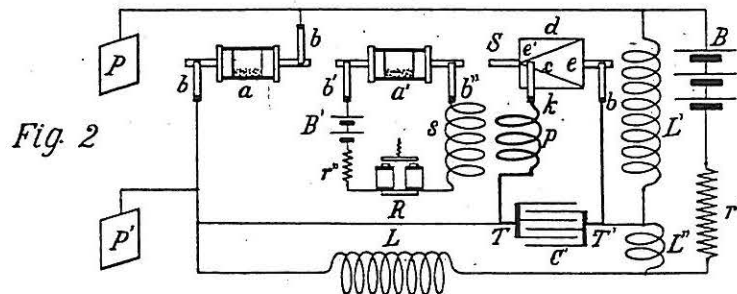
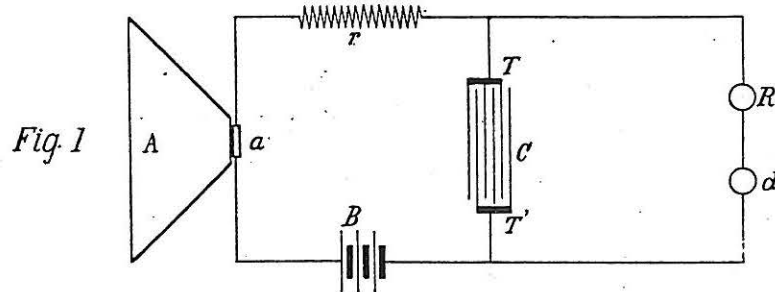
Patented Nov. 5, 1901.

N. TESLA.

APPARATUS FOR UTILIZING EFFECTS TRANSMITTED THROUGH NATURAL MEDIA.

(Application filed Nov. 2, 1899. Renewed May 29, 1901.)

(No Model.)



Witnesses:
Raphael Petter
M. Lamon Esq.

Inventor
Nikola Tesla
by *Kew, Page & Cooper*, Attorneys.

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

APPARATUS FOR UTILIZING EFFECTS TRANSMITTED THROUGH NATURAL MEDIA.

SPECIFICATION forming part of Letters Patent No. 685,956, dated November 5, 1901

Original application filed August 1, 1899, Serial No. 725,749. Divided and this application filed November 2, 1899. Renewed May 29, 1901. Serial No. 82,312. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York city, in the county and State of New York, have invented a new and useful Improvement in Apparatus for Utilizing Effects Transmitted from a Distance to a Receiving Device Through the Natural Media, of which the following is a specification, reference being had to the accompanying drawings, which form a part of the same.

The subject of my present invention is an improvement in the art of utilizing effects transmitted from a distance to a receiving device through the natural media; and it consists in the novel apparatus hereinafter described.

This application is a division of one filed by me August 1, 1899, Serial No. 725,749, and based upon and claiming the method herein described and which may be practiced by the use of the apparatus forming the subject of this application.

My invention is particularly useful in connection with methods and apparatus for operating distant receiving devices by means of electrical disturbances produced by proper transmitters and conveyed to such receiving devices through the natural media; but it obviously has a wider range of applicability and may be employed, for example, in the investigation or utilization of terrestrial, solar, or other disturbances produced by natural causes.

Several ways or methods of transmitting electrical disturbances through the natural media and utilizing them to operate distant receivers are now known and have been applied with more or less success for accomplishing a variety of useful results. One of these ways consists in producing by a suitable apparatus rays or radiations—that is, disturbances—which are propagated in straight lines through space, directing them upon a receiving or recording apparatus at a distance, and thereby bringing the latter into action. This method is the oldest and best known and has been brought particularly into prominence in recent years through the investigations of Heinrich Hertz. Another method consists in passing a current through

a circuit, preferably one inclosing a very large area, inducing thereby in a similar circuit situated at a distance another current and affecting by the same in any convenient way a receiving device. Still another way, which has also been known for many years, is to pass in any suitable manner a current through a portion of the ground, as by connecting to two points of the same, preferably at a considerable distance from each other, the two terminals of a generator and to energize by a part of the current diffused through the earth a distant circuit, which is similarly arranged and grounded at two points widely apart and which is made to act upon a sensitive receiver. These various methods have their limitations, one especially, which is common to all, being that the receiving circuit or instrument must be maintained in a definite position with respect to the transmitting apparatus, which often imposes great disadvantages upon the use of the apparatus.

In several applications filed by me and patents granted to me I have disclosed other methods of accomplishing results of this nature, which may be briefly described as follows: In one system the potential of a point or region of the earth is varied by imparting to it intermittent or alternating electrifications through one of the terminals of a suitable source of electrical disturbances, which, to heighten the effect, has its other terminal connected to an insulated body, preferably of large surface and at an elevation. The electrifications communicated to the earth spread in all directions through the same, reaching a distant circuit, which generally has its terminals arranged and connected similarly to those of the transmitting source and operates upon a highly-sensitive receiver. Another method is based upon the fact that the atmospheric air, which behaves as an excellent insulator to currents generated by ordinary apparatus, becomes a conductor under the influence of currents or impulses of enormously high electromotive force, which I have devised means for generating. By such means air strata, which are easily accessible, are rendered available for the production of many desired effects at distances however great. This method, furthermore, allows ad-

vantage to be taken of many of those improvements which are practicable in the ordinary systems of transmission involving the use of a metallic conductor.

Obviously whatever method be employed it is desirable that the disturbances produced by the transmitting apparatus should be as powerful as possible, and by the use of certain forms of high-frequency apparatus, which I have devised and which are now well known, important practical advantages are in this respect secured. Furthermore, since in most cases the amount of energy conveyed to the distant circuit is but a minute fraction of the total energy emanating from the source it is necessary for the attainment of the best results that whatever the character of the receiver and the nature of the disturbances as much as possible of the energy conveyed should be made available for the operation of the receiver, and with this object in view I have heretofore, among other means, employed a receiving-circuit of high self-induction and very small resistance and of a period such as to vibrate in synchronism with the disturbances, whereby a number of separate impulses from the source were made to cooperate, thus magnifying the effect exerted upon and insuring the action of the receiving device. By these means decided advantages have been secured in many instances; but very often the improvement is either not applicable at all, or, if so, the gain is very slight. Evidently when the source is one producing a continuous pressure or delivering impulses of long duration it is impracticable to magnify the effects in this manner, and when, on the other hand, it is one furnishing short impulses of extreme rapidity of succession the advantage obtained in this way is insignificant, owing to the radiation and the unavoidable frictional waste in the receiving-circuit. These losses reduce greatly both the intensity and the number of the cooperative impulses, and since the initial intensity of each of these is necessarily limited only an insignificant amount of energy is thus made available for a single operation of the receiver. As this amount is consequently dependent on the energy conveyed to the receiver by one single impulse, it is evidently necessary to employ either a very large and costly, and therefore objectionable, transmitter, or else to resort to the equally objectionable use of a receiving device too delicate and too easily deranged. Furthermore, the energy obtained through the cooperation of the impulses is in the form of extremely rapid vibrations and because of this unsuitable for the operation of ordinary receivers, the more so as this form of energy imposes narrow restrictions in regard to the mode and time of its application to such devices. To overcome these and other limitations and disadvantages that have heretofore existed in such systems of transmission of signals or intelligence and to render possible an investigation of impulses or disturbances

propagated through the natural media from any kind of source and their practical utilization for any purpose to which they are applicable, I have devised a novel method, which I have described in a pending application, filed June 24, 1899, Serial No. 721,790, and which, broadly stated, consists in effecting during any desired time interval a storage of energy derived from such impulses and utilizing the potential energy so obtained for operating a receiving device.

My present invention is intended for the same general purposes, and it comprises another apparatus by means of which similar results may be obtained.

The chief feature which distinguishes the method of my present from that of my former invention, just referred to, is that the energy stored is not, as in the former instance, obtained from the energy of the disturbances or effects transmitted from a distance, but from an independent source.

Expressed generally, the present method consists in charging a storage device with energy from an independent source, controlling the charging of said device by the action of the effects or disturbances transmitted through the natural media, and coincidentally using the stored energy for operating a receiving device.

A great variety of disturbances, produced either by suitably-constructed transmitters or by natural causes, are at present known to be propagated through the natural media, and there are also a variety of means or devices enabling energy to be stored, and in view of this I wish to say that I consider the utilization of any such disturbances and the employment of any of these means as within the scope of my present invention so long as the use of the general method hereinbefore stated is involved.

The best way of carrying out my invention which I at present know is to store electrical energy obtained from a suitable electrical generator in a condenser and to control the storage or the application of this energy by means of a sensitive device acted upon by the effects or disturbances, and thereby cause the operation of the receiver.

In the practical application of this method I usually proceed as follows: At any point where I desire to investigate or to utilize for any purpose effects or disturbances propagated through the natural media from any kind of source I provide a suitable generator of electricity—as, for example, a battery and a condenser—which I connect to the poles of the generator in series with a sensitive device capable of being modified in its electrical resistance or other property by the action of the disturbances emitted from the source. To the terminals of the condenser I connect the receiver which is to be operated in series with another device of suitable construction, which performs the function of periodically discharging the condenser through

the receiver at and during such intervals of time as may be best suitable for the purpose contemplated. This latter device may merely consist of two stationary electrodes separated by a feeble dielectric layer of minute thickness, but sufficient to greatly reduce or practically interrupt the current in the circuit under normal conditions, or it may comprise terminals one or more of which are movable and actuated by any suitable force and are adapted to be brought into and out of contact with each other in any convenient manner. The sensitive device may be any of the many devices of this kind which are known to be affected by the disturbances, impulses, or effects propagated through the media, and it may be of such a character that normally—that is, when not acted upon—it entirely prevents the passage of electricity from the generator to the condenser, or it may be such that it allows a gradual leaking through of the current and a charging of the condenser at a slow rate. In any case it will be seen that if the disturbances, of whatever nature they may be, cause an appreciable diminution in the electrical resistance of the sensitive device the current from the battery will pass more readily into the condenser, which will be charged at a more rapid rate, and consequently each of its discharges through the receiver, periodically effected by the special device before referred to which performs this function, will be stronger than normally—that is, when the sensitive device is not acted upon by the disturbances. Evidently then if the receiver be so adjusted that it does not respond to the comparatively feeble normal discharges of the condenser, if they should occur, but only to those stronger ones which take place upon the diminution of the resistance of the sensitive device it will be operated only when this device is acted upon by the disturbances, thus making it possible to investigate and to utilize the latter for any desired purpose.

The general principle underlying my invention and the operation of the various devices used will be clearly understood by reference to the accompanying drawings, in which—

Figure 1 is a diagram illustrating a typical arrangement of apparatus which may be used in carrying my method into practice, and Figs. 2, 3, 4, and 5 similar diagrams of modified arrangements of apparatus for the same purpose.

In Fig. 1, C is a condenser, to the terminals T and T' of which is connected a charging-circuit, including a battery B, a sensitive device *a*, and a resistance *r*, all connected in series, as illustrated. The battery should be preferably of very constant electromotive force and of an intensity carefully determined to secure the best results. The resistance *r*, which may be a frictional or an inductive one, is not absolutely necessary; but it is of advantage to use it in order to facilitate adjustment, and for this purpose it may

be made variable in any convenient and preferably continuous manner. Assuming that the disturbances which are to be investigated or utilized for some practical end are rays identical with or resembling those of ordinary light, the sensitive device *a* may be a selenium cell properly prepared, so as to be highly susceptible to the influence of the rays, the action of which should be intensified by the use of a reflector A. (Shown in the drawings.) It is well known that when cells of this kind are exposed to such rays of greatly-varying intensity they undergo corresponding modifications of their electrical resistance; but in the ways they have been heretofore used they have been of very limited utility.

In addition to the circuit including the sensitive device or cell *a* another circuit is provided, which is likewise connected to the terminals T T' of the condenser. This circuit, which may be called the "receiving-circuit," includes the receiver R and in series with it a device *d*, before referred to, which performs the duty of periodically discharging the condenser through the receiver. It will be noted that, as shown in Fig. 1, the receiving-circuit is in permanent connection with the battery and condenser-terminal T, and it should be stated that it is sometimes desirable to entirely insulate the receiving-circuit at all times, except the moments when the device *d* operates to discharge the condenser, thus preventing any disturbing influence which might otherwise be caused in this circuit by the battery or the condenser during the period when the receiver should not be acted upon. In such a case two devices, as *d*, may be used, one in each connection from the condenser to the receiving-circuit, or else one single device of this kind, but of a suitably-modified construction, so that it will make and break simultaneously and at proper intervals of time both of the connections of this circuit with the condenser T and T'.

From the foregoing the operation of the apparatus, as illustrated in Fig. 1, will be at once understood. Normally—that is, when it is not influenced by the rays at all or very slightly—the cell *a*, being of a comparatively high resistance, permits only a relatively feeble current to pass from the battery into the condenser, and hence the latter is charged at too slow a rate to accumulate during the time interval between two succeeding operations of the device *d* sufficient energy to operate the receiver or, generally speaking, to produce the required change in the receiving-circuit. This condition is readily secured by a proper selection and adjustment of the various devices described, so that the receiver will remain unresponsive to the feeble discharges of the condenser which may take place when the cell *a* is acted upon but slightly or not at all by the rays or disturbances; but if now new rays are permitted to fall upon the cell or if the intensity of those already acting upon it be increased by any cause then

its resistance will be diminished and the condenser will be charged by the battery at a more rapid rate, enabling sufficient potential energy to be stored in the condenser during the period of inaction of the device *d* to operate the receiver or to bring about any desired change in the receiving-circuit when the device *d* acts. If the rays acting upon the cell or sensitive device *a* are varied or intermitted in any arbitrary manner, as when transmitting intelligence in the usual way from a distant station by means of short and long signals, the apparatus may readily be made to record or to enable an operator to read the message, since the receiver—supposing it to be an ordinary magnetic relay, for example—will be operated by each signal from the sending-station a certain number of times, having some relation to the duration of each signal. It will be readily seen, however, that if the rays are varied in any other way, as by impressing upon them changes in intensity, the succeeding condenser discharges will undergo corresponding changes in intensity, which may be indicated or recorded by a suitable receiver and distinguished irrespectively of duration.

With reference to Fig. 1 it may be useful to state that the electrical connections of the various devices illustrated may be made in many different ways. For instance, the sensitive device instead of being in series, as shown, may be in a shunt to the condenser, this modification being illustrated in Fig. 3, in which the devices already described are indicated by similar letters to correspond with those of Fig. 1. In this case it will be observed that the condenser, which is being charged from the battery *B* through the resistance *r*, preferably inductive and properly related to the capacity of the condenser, will store less energy when the sensitive device *a* is energized by the rays, and its resistance thereby diminished. The adjustment of the various instruments may then be such that the receiver will be operated only when the rays are diminished in intensity or interrupted and entirely prevented from falling upon the sensitive cell, or the sensitive device may be placed, as shown in Fig. 4, in a shunt to the resistance *r* or inserted in any suitable way in the circuit containing the receiver—for example, as illustrated in Fig. 5—in both of which figures the various devices are lettered to correspond with those in Fig. 1, so that the figures become self-explanatory. Again, the several instruments may be connected in the manner of a Wheatstone bridge, as will be hereinafter explained with reference to Fig. 2, or otherwise connected or related; but in each case the sensitive device will have the same duty to perform—that is, to control the energy stored and utilized in some suitable way for causing the operation of the receiver in correspondence with the intermittences or variations of the effects or disturbances—and in each instance by a judicious selection of

the devices and careful adjustment the advantages of my method may be more or less completely secured. I find it preferable, however, to follow the plan which I have illustrated and described.

It will be observed that the condenser is an important element in the combination. I have shown that by reason of its unique properties it greatly adds to the efficacy of this method. It allows the energy accumulated in it to be discharged instantaneously, and therefore in a highly effective manner. It magnifies in a large degree the current supplied from the battery, and owing to these features it permits energy to be stored and discharged at practically any rate desired, and thereby makes it possible to obtain in the receiving-circuit very great changes of the current strength by impressing upon the battery-current very small variations. Other means of storage possessing these characteristics to a useful degree may be employed without departing from the broad spirit of my invention; but I prefer to use a condenser, since in these respects it excels any other storage device of which I have knowledge.

In Fig. 2 a modified arrangement of apparatus is illustrated which is particularly adapted for the investigation and utilization of very feeble impulses or disturbances, such as may be used in conveying signals or producing other desired effects at very great distances. In this case the energy stored in the condenser is passed through the primary of a transformer, the secondary circuit of which contains the receiver, and in order to render the apparatus still more suitable for use in detecting feeble impulses, in addition to the sensitive device which is acted upon by the impulses, another such device is included in the secondary circuit of the transformer. The scheme of connections is in the main that of a Wheatstone bridge, the four branches of which are formed by the sensitive device *a* and resistances *L*, *L'*, and *L''*, all of which should be preferably inductive and also adjustable in a continuous manner, or at least by very small steps. The condenser *C*, which is generally made of considerable capacity, is connected to two opposite points of the bridge, while a battery *B*, in series with a continuously-adjustable non-inductive resistance *r*, is connected to the other pair of opposite points, as usual. The four resistances included in the branches of the bridge—namely, *a*, *L*, *L'*, and *L''*—are of a suitable size and so proportioned that under normal conditions—that is, when the device *a* is not influenced at all or only slightly by the disturbances—there will be no difference of potential, or, in any case, the minimum of the same at the terminals *T* and *T'* of the condenser. It is assumed in the present instance that the disturbances to be investigated or utilized are such as will produce a difference of electric potential, however small, between two points or regions in the natural media, as the earth, the water,

or the air, and in order to apply this potential difference effectively to the sensitive device *a* the terminals of the same are connected to two plates *P* and *P'*, which should be of as large a surface as practicable and so located in the media that the largest possible difference of potential will be produced by the disturbances between the terminals of the sensitive device. This device is in the present case one of familiar construction, consisting of an insulating-tube, which is indicated by the heavy lines in the drawings and which has its ends closed tightly by two conducting-plugs with reduced extensions, upon which bear two brushes *b b*, through which the currents are conveyed to the device. The tubular space between the plugs is partially filled with a conducting sensitive powder, as indicated, the proper amount of the same and the size of its grains being determined and adjusted beforehand by experiment. This tube I rotate by clockwork or other means at a uniform and suitable rate of speed, and under these conditions I find that this device behaves toward disturbances of the kind before assumed in a manner similar to that of a stationary cell of selenium toward rays of light. Its electrical resistance is diminished when it is acted upon by the disturbances and is automatically restored upon the cessation of their influence. It is of advantage to employ round grains of powder in the tube, and in any event it is important that they should be of as uniform size and shape as possible and that provision should be made for maintaining an unchanging and very dry atmosphere in the tube. To the terminals *T* and *T'* of the condenser *C'* is connected a coil *p*, usually consisting of a few turns of a conductor of very small resistance, which is the primary of the transformer before referred to, in series with a device *d*, which effects the discharge of the condenser through the coil *p* at predetermined intervals of time. In the present case this device consists of a cylinder made partly of conducting and partly of insulating material *e* and *e'*, respectively, which is rotated at the desired rate of speed by any suitable means. The conducting part *e* is in good electrical connection with shaft *S* and is provided with tapering segments, as *f*, upon which slides a brush *k*, which should preferably be capable of longitudinal adjustment along the cylinder. Another brush *b'*, which is connected to the condenser-terminal *T'*, being arranged to bear upon the shaft *S*, it will be seen that whenever the brush *k* comes in contact with a conducting-segment *e* the circuit including the primary *p* will be completed and the condenser, if energized, discharged through the same. By an adjustment of the speed of rotation of the cylinder and a displacement of the brush *k* along the axis of the same the circuit may be made to open and close in as rapid succession and remain open or closed during such intervals of time as may be desired. In inductive relation

to the primary *p* is a secondary coil *s*, usually of much thinner wire and of many more turns than the former, to which are connected in a series a receiver *R*, illustrated as an ordinary magnetic relay, a continuously-adjustable non-inductive resistance *r'*, a battery *B'* of a properly-determined and very constant electromotive force, and finally a sensitive device *a'* of the same or similar construction as *a*, which is likewise rotated at a uniform speed and which, with its brushes *b' b''*, closes the secondary circuit. The electromotive force of the battery *B'* is so graduated by means of the adjustable resistance *r'* that the dielectric layers in the sensitive device *a'* are strained very nearly to the point of breaking down and give way upon a slight increase of the electrical pressure on the terminals of the device. It will of course be understood that the resistance *r'* is used mainly because of convenience and that it may be dispensed with, in which case the adjustment may be effected in many other ways, as by determining the proper amount or coarseness of the sensitive powder or by varying the distance apart of the metallic plugs in the ends of the tube. The same may be said of the resistance *r*, which is in series with the battery *B* and serves to graduate the force of the latter, so that the dielectric layers of the sensitive device *a* are subjected to a similar strain and maintained in a state of delicate poise.

The various instruments being connected and adjusted in the manner described, it will now be readily seen from the foregoing that under normal conditions, the device *a* being unaffected by the disturbances, or practically so, and there being no or only a very insignificant amount of energy stored in the condenser, the periodical closure of the primary circuit of the transformer through the operation of the device *d* will have no appreciable effect upon the primary coil *p*, and hence no currents will be generated in the secondary coil *s*, at least not such as would disturb the state of delicate balance existing in the secondary circuit including the receiver, and therefore the latter will not be actuated by the battery *B'*; but when, owing to the disturbances or impulses propagated through the media from a distant source, an additional electromotive force, however small, is created between the terminals of the device *a* the dielectric layers in the same, unable to support the increased strain, give way and allow the current of the battery *B* to pass through, thus causing a difference of potential at the terminals *T* and *T'* of the condenser. A sufficient amount of energy being now stored in this instrument during the time interval between each two succeeding operations of the device *d*, each closure of the primary circuit by the latter results in the passage of a sudden current impulse through the coil *p*, which induces a corresponding current of relatively high electromotive force in

the secondary coil *s*. Owing to this the dielectric in the device *a'* gives way, and the current of the battery *B'* being allowed to pass the receiver *R* is operated, but only for a moment, since by the rotation of the devices *a*, *a'*, and *d*, which may be all driven from the same shaft, the original conditions are restored, assuming, of course, that the electromotive force set up by the disturbances at the terminals of the sensitive device *a* is only momentary or of a duration not longer than the time of closure of the primary circuit; otherwise the receiver will be actuated a number of times and so long as the influence of the disturbances upon the device *a* continues. In order to render the discharged energy of the condenser more effective in causing the operation of the receiver, the resistance of the primary circuit should be very small and the secondary coil *s* should have a number of turns many times greater than that of the primary coil *p*. It will be noted that since the condenser under the above assumptions is always charged in the same direction the strongest current impulse in the secondary coil, which is induced at the moment when the brush *k* comes in contact with segment *e*, is also of unchanging direction, and for the attainment of the best results it is necessary to connect the secondary coil so that the electromotive force of this impulse will be added to that of the battery and will momentarily strengthen the same. However, under certain conditions, which are well understood by those skilled in the art, the devices will operate whichever way the secondary be connected. It is preferable to make the inductive resistances *L* and *L'* relatively large, as they are in a shunt to the device *a* and might, if made too small, impair its sensitiveness. On the other hand, the resistance *L'* should not be too large and should be related to the capacity of the condenser and the number of makes and breaks effected by the device *d* in well-known ways. Similar considerations apply, of course, to the circuits including the primary *p* and secondary *s*, respectively.

By carefully observing well-known rules of scientific design and adjustment of the instruments the apparatus may be made extremely sensitive and capable of responding to the feeblest influences, thus making it possible to utilize impulses or disturbances transmitted from very great distances and too feeble to be detected or utilized in any of the ways heretofore known, and on this account the method here described lends itself to many scientific and practical uses of great value. Obviously the character of the devices and the manner in which they are connected or related may be greatly varied without departing from the spirit of my invention.

What I claim as new, and desire to secure by Letters Patent, is—

1. In an apparatus for utilizing effects or disturbances transmitted through the natural

media from a distant source, the combination of an electrical storage device, a charging-circuit connected therewith and including a device sensitive to the action of the effects or disturbances and determining under their control the flow of current in the charging-circuit, a receiving-circuit including a receiver, and means for periodically discharging the storage device through the receiving-circuit, substantially as described.

2. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a condenser, a charging-circuit connected therewith and including a source of electricity and a device sensitive to the action of the effects or disturbances and determining under their control the flow of current in the charging-circuit, a receiving-circuit including a receiver, and means for periodically discharging the condenser through the receiving-circuit, substantially as described.

3. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a circuit including a source of electricity, a storage device adapted to be charged thereby and a device normally of very high resistance but adapted to have its resistance reduced when acted upon by the effects or disturbances, with a receiving-circuit connected with the storage device and including a receiver and a device adapted to open and close the receiving-circuit at predetermined intervals of time, substantially as described.

4. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a circuit including a source of electricity, a condenser and a device normally of very high resistance but adapted to have its resistance reduced when acted upon by the effects or disturbances, with a receiving-circuit connected with the condenser and including a receiver and a device adapted to open and close the receiving-circuit at predetermined intervals of time, substantially as described.

5. In an apparatus for utilizing effects or disturbances transmitted from a distant source, the combination of a circuit including a source of electricity, a storage device adapted to be charged thereby and a device, normally of very high resistance but adapted to have its resistance reduced when acted upon by the effects or disturbances, with a receiving-circuit connected with the storage device and including the primary of a transformer and a device adapted to open and close such second circuit at predetermined intervals of time, and a receiver included in the secondary of the transformer, substantially as described.

6. In an apparatus for utilizing effects or disturbances transmitted from a distant source, the combination of an electrical storage device, a charging-circuit connected therewith and including a device sensitive to the

action of the effects or disturbances and determining under their control the flow of the current in the charging-circuit, and a receiving-circuit supplied with energy from the storage device and including a receiver and a device sensitive to electrical variations in the receiving-circuit, substantially as described.

7. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a condenser, a charging-circuit connected therewith and including a device sensitive to the action of the effects or disturbances and determining under their control the flow of the current in the charging-circuit, and a receiving-circuit supplied with energy from the condenser and including a receiver and a device sensitive to electrical variations in the receiving-circuit, substantially as described.

8. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a circuit, an independent local source of electricity included therein, a storage device connected with the said circuit and adapted to receive energy from the said source, a device normally of very high resistance, but adapted to have its resistance reduced when acted upon by the effects or disturbances, a receiving-circuit connected with the storage device, a transformer, the primary of which is included in said receiving-circuit, a device adapted to open and close the receiving-circuit at predetermined intervals of time, a receiver, and a device, normally of very high resistance, but adapted to have its resistance reduced when acted upon by the effects or disturbances, and included in the secondary circuit of the transformer, as set forth.

9. In an apparatus for utilizing effects or disturbances transmitted from a distant source, the combination with a storage device and an independent source of energy for charging the same, of a receiving-circuit connected with the storage device, a device sensitive to the effects or disturbances and determining under their control the flow of current in the receiving-circuit, substantially as set forth.

10. In an apparatus for utilizing effects or

disturbances transmitted through the natural media from a distant source, the combination with a storage device and an independent source of energy for charging the same, of a receiving-circuit connected with the storage device, a device sensitive to the effects or disturbances and adapted to have its resistance varied by the action thereon of such effects or disturbances and determining under their control the flow of current in the receiving-circuit, substantially as set forth.

11. In an apparatus for utilizing effects or disturbances transmitted from a distant source, the combination of a storage device, a battery or similar independent source of energy for charging the same, a sensitive device adapted to have its resistance varied under the influence of the effects or disturbances, a receiver adapted to be operated by the discharge of the storage device, the sensitive device being in one branch of a Wheatstone bridge, the storage device in one of the cross connections between two opposite points of the bridge, and the battery in the other cross connection, and resistances L , L' and L'' in the three remaining branches of the bridge, as set forth.

12. In an apparatus for utilizing effects or disturbances transmitted through the natural media from a distant source, the combination of a storage device, a battery or like independent source of energy for charging the same, a sensitive device adapted to have its resistance varied under the influence of the effects or disturbances, a circuit connected with the terminals of the storage device, a transformer having its primary in said circuit and a receiver in the secondary circuit of the transformer, the sensitive device being in one branch of a Wheatstone bridge, the storage device in one of the cross connections between opposite points of the bridge and the battery in the other cross connection, and resistances L , L' and L'' in the three remaining branches of the bridge, as set forth.

NIKOLA TESLA.

Witnesses:

E. A. SUNDERLIN,
D. D. LORD.

No. 685,958.

Patented Nov. 5, 1901.

N. TESLA.
METHOD OF UTILIZING RADIANT ENERGY.

(Application filed Mar. 21, 1901.)

(No Model.)

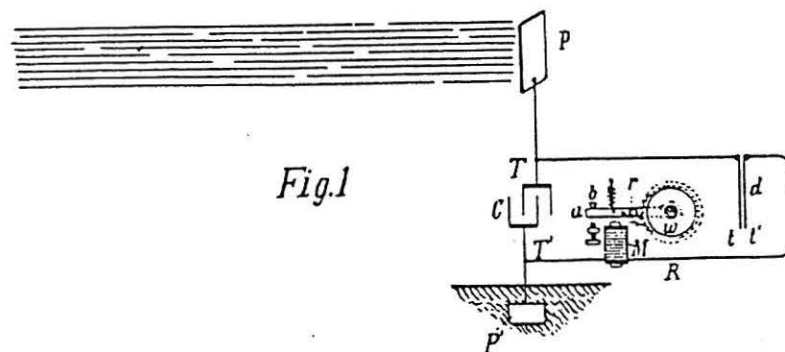


Fig. 1

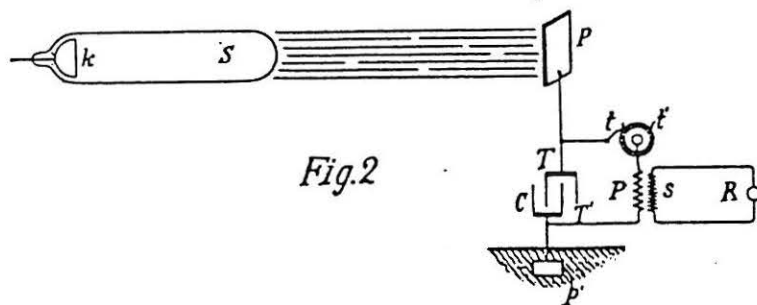


Fig. 2

Witnesses:

Raphael Better
M. Lamson & Co.

Nikola Tesla, Inventor

by Hen. Page & Cooper Attys

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

METHOD OF UTILIZING RADIANT ENERGY.

SPECIFICATION forming part of Letters Patent No. 685,958, dated November 5, 1901.

Application filed March 21, 1901. Serial No. 52,154. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Methods of Utilizing Radiant Energy, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

It is well known that certain radiations—such as those of ultra-violet light, cathodic, Roentgen rays, or the like—possess the property of charging and discharging conductors of electricity, the discharge being particularly noticeable when the conductor upon which the rays impinge is negatively electrified. These radiations are generally considered to be ether vibrations of extremely small wave lengths, and in explanation of the phenomena noted it has been assumed by some authorities that they ionize or render conducting the atmosphere through which they are propagated. My own experiments and observations, however, lead me to conclusions more in accord with the theory heretofore advanced by me that sources of such radiant energy throw off with great velocity minute particles of matter which are strongly electrified, and therefore capable of charging an electrical conductor, or even if not so may at any rate discharge an electrified conductor either by carrying off bodily its charge or otherwise.

My present application is based upon a discovery which I have made that when rays or radiations of the above kind are permitted to fall upon an insulated conducting body connected to one of the terminals of a condenser, while the other terminal of the same is made by independent means to receive or to carry away electricity, a current flows into the condenser so long as the insulated body is exposed to the rays, and under the conditions hereinafter specified an indefinite accumulation of electrical energy in the condenser takes place. This energy after a suitable time interval, during which the rays are allowed to act, may manifest itself in a powerful discharge, which may be utilized for the operation or control of mechanical or elec-

trical devices or rendered useful in many other ways.

In applying my discovery I provide a condenser, preferably of considerable electrostatic capacity, and connect one of its terminals to an insulated metal plate or other conducting body exposed to the rays or streams of radiant matter. It is very important, particularly in view of the fact that electrical energy is generally supplied at a very slow rate to the condenser, to construct the same with the greatest care. I use by preference the best quality of mica as dielectric, taking every possible precaution in insulating the armatures, so that the instrument may withstand great electrical pressures without leaking and may leave no perceptible electrification when discharging instantaneously. In practice I have found that the best results are obtained with condensers treated in the manner described in a patent granted to me February 23, 1897, No. 577,671. Obviously the above precautions should be the more rigorously observed the slower the rate of charging and the smaller the time interval during which the energy is allowed to accumulate in the condenser. The insulated plate or conducting body should present as large a surface as practicable to the rays or streams of matter, I having ascertained that the amount of energy conveyed to it per unit of time is under otherwise identical conditions proportionate to the area exposed, or nearly so. Furthermore, the surface should be clean and preferably highly polished or amalgamated. The second terminal or armature of the condenser may be connected to one of the poles of a battery or other source of electricity or to any conducting body or object whatever of such properties or so conditioned that by its means electricity of the required sign will be supplied to the terminal. A simple way of supplying positive or negative electricity to the terminal is to connect the same either to an insulated conductor, supported at some height in the atmosphere, or to a grounded conductor, the former, as is well known, furnishing positive and the latter negative electricity. As the rays or supposed streams of matter generally convey a positive charge to the first condenser-terminal, which is connect-

ed to the plate or conductor above mentioned, I usually connect the second terminal of the condenser to the ground, this being the most convenient way of obtaining negative electricity, dispensing with the necessity of providing an artificial source. In order to utilize for any useful purpose the energy accumulated in the condenser, I furthermore connect to the terminals of the same a circuit including an instrument or apparatus which it is desired to operate and another instrument or device for alternately closing and opening the circuit. This latter may be any form of circuit-controller, with fixed or movable parts or electrodes, which may be actuated either by the stored energy or by independent means.

The rays or radiations which are to be utilized for the operation of the apparatus above described in general terms may be derived from a natural source, as the sun, or may be artificially produced by such means, for example, as an arc-lamp, a Roentgen tube, and the like, and they may be employed for a great variety of useful purposes.

My discovery will be more fully understood from the following detailed description and annexed drawings, to which reference is now made, and in which—

Figure 1 is a diagram showing typical forms of the devices or elements as arranged and connected in applying the method for the operation of a mechanical contrivance or instrument solely by the energy stored; and Fig. 2 is a diagrammatical representation of a modified arrangement suitable for special purposes, with a circuit-controller actuated by independent means.

Referring to Fig. 1, C is the condenser, P the insulated plate or conducting body, which is exposed to the rays, and P' another plate or conductor, all being joined in series, as shown. The terminals T T' of the condenser are also connected to a circuit including a receiver R, which is to be operated, and a circuit-controlling device d, which in this case is composed of two very thin conducting-plates t t', placed in close proximity and very mobile, either by reason of extreme flexibility or owing to the character of their support. To improve their action, they should be inclosed in a receptacle from which the air may be exhausted. The receiver R is shown as consisting of an electromagnet M, a movable armature a, a retractile spring b, and a ratchet-wheel w, provided with a spring-pawl r, which is pivoted to armature a, as illustrated. The apparatus being arranged as shown, it will be found that when the radiations of the sun or of any other source capable of producing the effects before described fall upon the plate P an accumulation of electrical energy in the condenser C will result. This phenomenon, I believe, is best explained as follows: The sun as well as other sources of radiant energy throw off minute particles of matter positively electrified, which, impinging upon the plate P, communicate an electrical charge to the same. The

opposite terminal of the condenser being connected to the ground, which may be considered as a vast reservoir of negative electricity, a feeble current flows continuously into the condenser, and inasmuch as these supposed particles are of an inconceivably small radius or curvature, and consequently charged to a relatively very high potential, this charging of the condenser may continue, as I have found in practice, almost indefinitely, even to the point of rupturing the dielectric. Obviously whatever circuit-controller be employed it should operate to close the circuit in which it is included when the potential in the condenser has reached the desired magnitude. Thus in Fig. 2 when the electrical pressure at the terminals T T' rises to a certain predetermined value the plates t t', attracting each other, close the circuit connected to the terminals. This permits a flow of current which energizes the magnet M, causing it to draw down the armature a and impart a partial rotation to the ratchet-wheel w. As the current ceases the armature is retracted by the spring b without, however, moving the wheel w. With the stoppage of the current the plates t t' cease to be attracted and separate, thus restoring the circuit to its original condition.

Many useful applications of this method of utilizing the radiations emanating from the sun or other source and many ways of carrying out the same will at once suggest themselves from the above description. By way of illustration a modified arrangement is shown in Fig. 2, in which the source S of radiant energy is a special form of Roentgen tube devised by me having but one terminal k, generally of aluminium, in the form of half a sphere with a plain polished surface on the front side, from which the streams are thrown off. It may be excited by attaching it to one of the terminals of any generator of sufficiently-high electromotive force; but whatever apparatus be used it is important that the tube be exhausted to a high degree, as otherwise it might prove entirely ineffective. The working or discharge circuit connected to the terminals T T' of the condenser includes in this case the primary p of a transformer and a circuit-controller comprising a fixed terminal or brush t and a movable terminal t' in the shape of a wheel with conducting and insulating segments which may be rotated at an arbitrary speed by any suitable means. In inductive relation to the primary wire or coil p is a secondary s, usually of a much greater number of turns, to the ends of which is connected a receiver R. The terminals of the condenser being connected as indicated, one to an insulated plate P and the other to a grounded plate P', when the tube S is excited rays or streams of matter are emitted from the same, which convey a positive charge to the plate P and condenser-terminal T, while terminal T' is continuously receiving negative electricity from the plate

P'. This, as before explained, results in an accumulation of electrical energy in the condenser, which goes on as long as the circuit including the primary p is interrupted.

5 Whenever the circuit is closed, owing to the rotation of the terminal t' , the stored energy is discharged through the primary p , this giving rise in the secondary s to induced currents which operate the receiver R.

10 It is clear from what has been stated above that if the terminal T' is connected to a plate supplying positive instead of negative electricity the rays should convey negative electricity to plate P. The source S may be any
15 form of Roentgen or Lenard tube; but it is obvious from the theory of action that in order to be very effective the electrical impulses exciting it should be wholly or at least preponderatingly of one sign. If ordinary
20 symmetrical alternating currents are employed, provision should be made for allowing the rays to fall upon the plate P only during those periods when they are productive of the desired result. Evidently if the
25 radiations of the source be stopped or intercepted or their intensity varied in any manner, as by periodically interrupting or rhythmically varying the current exciting the source, there will be corresponding changes
30 in the action upon the receiver R, and thus signals may be transmitted and many other useful effects produced. Furthermore, it will be understood that any form of circuit-closer which will respond to or be set in operation
35 when a predetermined amount of energy is stored in the condenser may be used in lieu of the device specifically described with reference to Fig. 1, and also that the special details of construction and arrangement of
40 the several parts of the apparatus may be very greatly varied without departure from the invention.

Having described my invention, what I claim is—

45 1. The method of utilizing radiant energy,

which consists in charging one of the armatures of a condenser by rays or radiations, and the other armature by independent means, and discharging the condenser through a suitable receiver, as set forth.

2. The method of utilizing radiant energy, which consists in simultaneously charging a condenser by means of rays or radiations and an independent source of electrical energy, and discharging the condenser through
55 a suitable receiver, as set forth.

3. The method of utilizing radiant energy, which consists in charging one of the armatures of a condenser by rays or radiations, and the other by independent means, controlling
60 the action or effect of said rays or radiations and discharging the condenser through a suitable receiver, as set forth.

4. The method of utilizing radiant energy, which consists in charging one of the armatures of a condenser by rays or radiations and the other by independent means, varying the intensity of the said rays or radiations and periodically discharging the condenser through
65 a suitable receiver, as set forth.

5. The method of utilizing radiant energy, which consists in directing upon an elevated conductor, connected to one of the armatures of a condenser, rays or radiations capable of positively electrifying the same, carrying off
75 electricity from the other armature by connecting the same with the ground, and discharging the accumulated energy through a suitable receiver, as set forth.

6. The method of utilizing radiant energy, 80 which consists in charging one of the armatures of a condenser by rays or radiations, and the other by independent means, and effecting by the automatic discharge of the accumulated energy the operation or control of a
85 suitable receiver, as set forth.

NIKOLA TESLA.

Witnesses:

M. LAWSON DYER,
RICHARD DONOVAN.

No. 775,846.

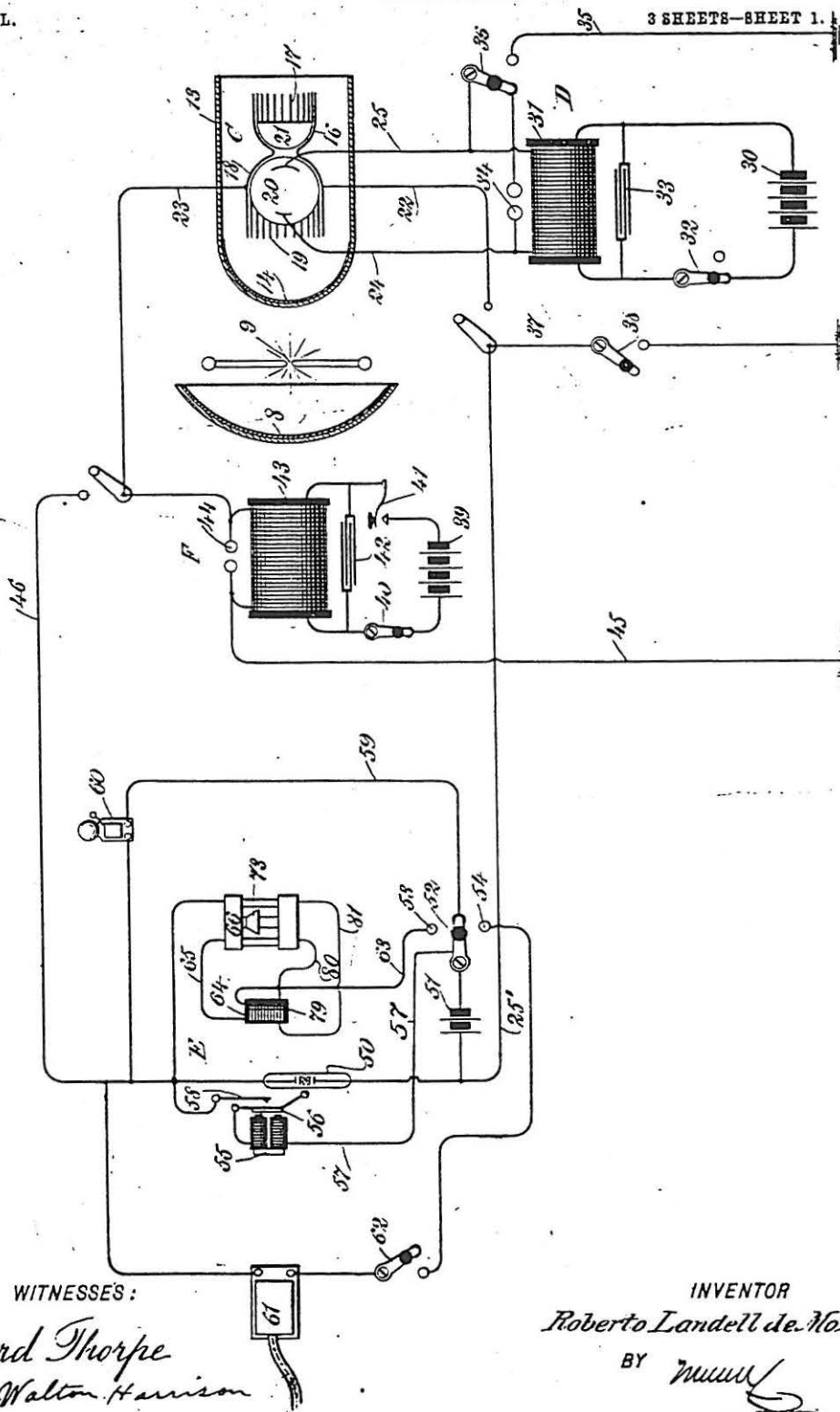
PATENTED NOV. 22, 1904.

R. L. DE MOURA.
WIRELESS TELEGRAPH.
APPLICATION FILED JAN. 18, 1902.

NO MODEL.

3 SHEETS—SHEET 1.

Fig. 1.



WITNESSES:

Edward Thorpe
Walton Harrison

INVENTOR

Roberto Landell de Moura

BY

Mum
ATTORNEYS

No. 775,846.

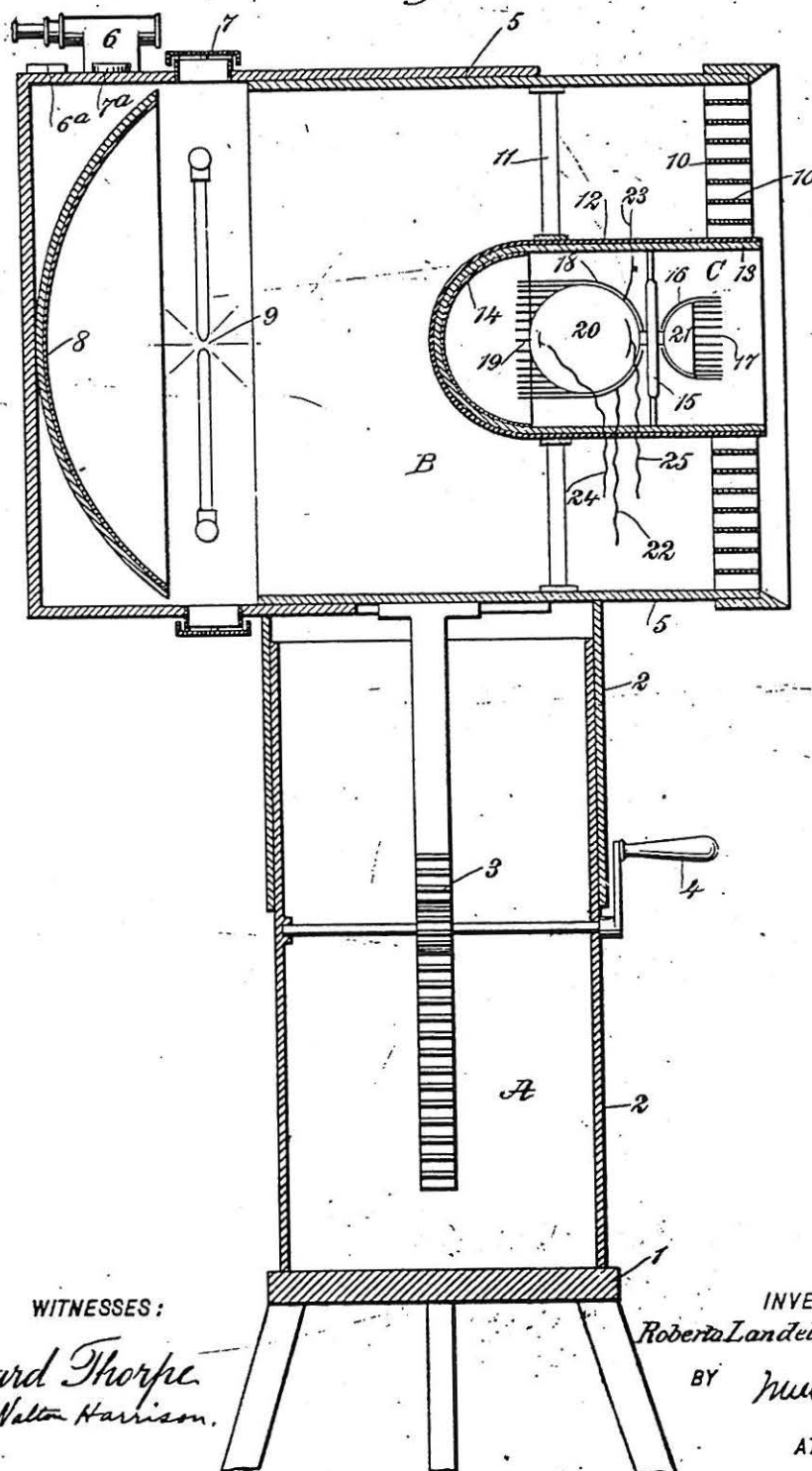
PATENTED NOV. 22, 1904.

R. L. DE MOURA.
WIRELESS TELEGRAPH.
APPLICATION FILED JAN. 16, 1902.

NO MODEL.

3 SHEETS—SHEET 2.

Fig. 2.



WITNESSES:

Edward Thorpe.
Walter Harrison.

INVENTOR

Roberto Landell de Moura

BY

Munich

ATTORNEYS

No. 775,846.

PATENTED NOV. 22, 1904.

R. L. DE MOURA.
WIRELESS TELEGRAPH.
APPLICATION FILED JAN. 18, 1902.

NO MODEL.

3 SHEETS—SHEET 3.

Fig. 3.

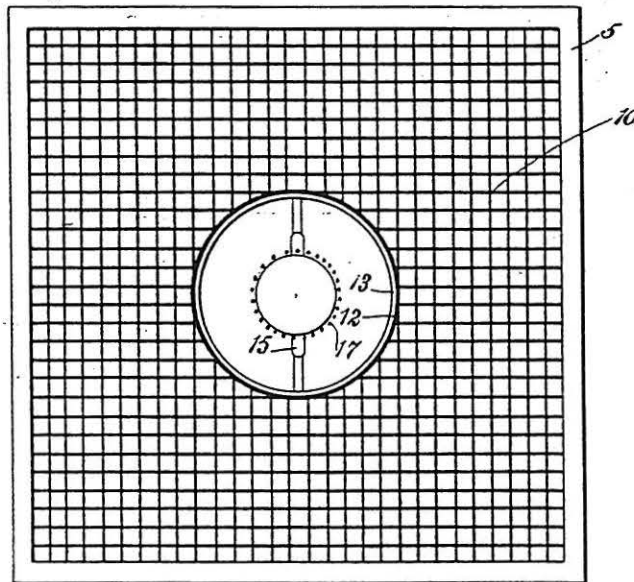
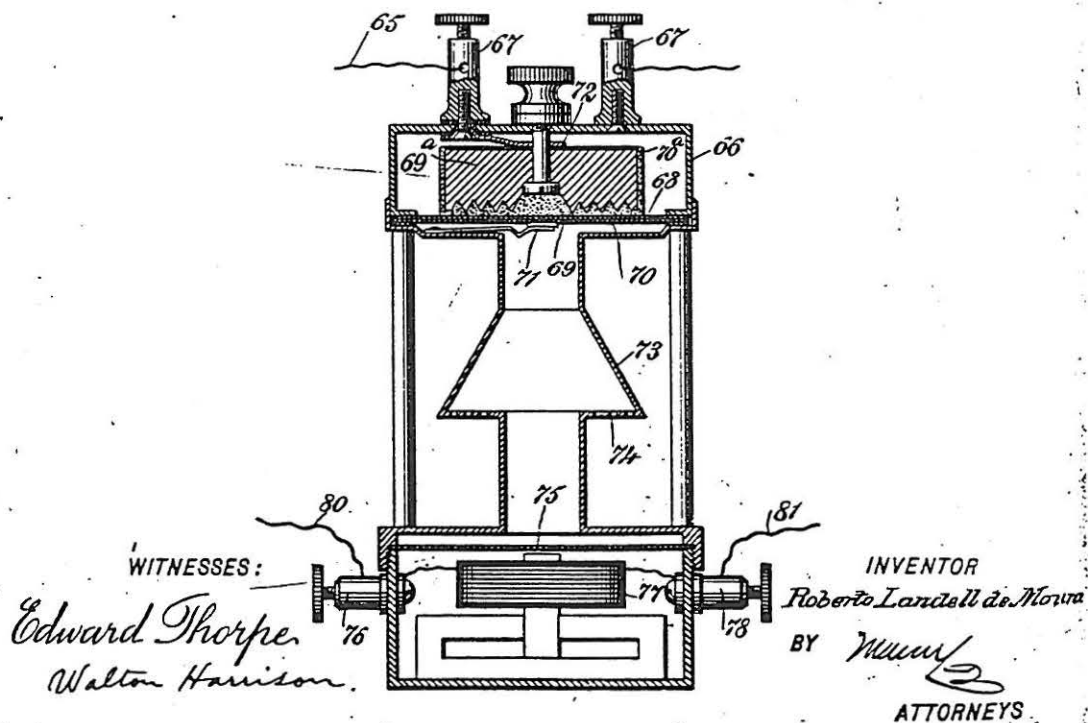


Fig. 4.



WITNESSES:

Edward Thorpe
Walton Harrison.

INVENTOR

Roberto Landell de Moura

BY

Munroe

ATTORNEYS.

UNITED STATES PATENT OFFICE.

ROBERTO LANDELL DE MOURA, OF NEW YORK, N. Y.

WIRELESS TELEGRAPH.

SPECIFICATION forming part of Letters Patent No. 775,846, dated November 22, 1904.

Original application filed October 4, 1901, Serial No. 77,576. Divided and this application filed January 16, 1902. Serial No. 89,976. (No model.)

To all whom it may concern:

Be it known that I, ROBERTO LANDELL DE MOURA, a citizen of the Republic of Brazil, and a resident of the city of New York, (borough of Manhattan,) in the county and State of New York, have invented a new and Improved Wireless Telegraph, of which the following is a full, clear, and exact description.

My invention relates to a wireless-telegraph system employing common electric waves, and contemplates the use of such waves, either directly transmitted—that is, non-reflected—or reflected and of short lengths, in connection with certain apparatus and devices for generating and responding to the same to send and receive graphic and harmonic or phonetic signals through space or, it may be, through fogs or through water.

The present application is a division of my former application, filed October 4, 1901, Serial No. 77,576, for an improvement in wireless telephones and telegraphs.

According to my invention a local circuit is provided which may be either constantly or intermittently closed and in which is connected a device capable of giving a continuous or an intermittent sound. This sound-producing device is energized by a local battery, and its action is modified in intensity in accordance with the intermittent electric impulses from the sending-station, which act upon a variable-resistance device, (which may be a coherer.) For continuous sounds the variable-resistance device does not act specifically as a coherer, but more properly as a very sensitive granular microphone whose resistance is controlled by the impulses from the sending-station, these changes in resistance effecting the intensity in the sound by affecting the local current-supply to the sound-producing device.

Although I thus specify and shall describe the use of a local circuit, however I wish to say that there are other means by which my invention may be practiced. The underlying principle is simply that of modifying the resistance of the local microphone, and the functions of the receiver may be exercised by any radio-detector of the Branly type provided

with a controllable electrode. Furthermore, although I speak of reflected impulses and short-length waves, these are not essential, although I use them in some cases and at relatively short distances in order to obtain improved effects. The same holds with regard to certain light or other active rays used in connection with reflected waves.

My invention is illustrated in the accompanying drawings, in which the same reference characters indicate the same parts in all the figures.

In the drawings, Figure 1 is a diagram representing the entire telegraphic apparatus used at one of the stations. Fig. 2 is a section showing a part of the transmitting and receiving apparatus. Fig. 3 is a front elevation of the upper portion of the same, and Fig. 4 is a detail view showing my device for producing telegraphic signs phonetically.

The apparatus consists of a stand A, (see Fig. 2,) a barrel B, a smaller barrel C, a sparking device D, receivers E, and a sparking device F. (See Fig. 1.) The frame 1 (see Fig. 2) of the stand A is mounted upon vertically-disposed concentric tubes 2, the outer of which is movable and is connected with a rack and pinion 3, actuated by a handle 4, whereby the barrel B may be raised or lowered at will. The barrel B consists of two cubical or cylindrical boxes 5, telescopically adjustable one in the other, upon one of which boxes are mounted a telescope 6, a spirit-level 6^a, and a compass 7^a for the purpose of training the barrel upon a distant station. The barrel is provided with a parabolic mirror 8 and an electric light 9 for use in my wireless telephone, which is fully described in my other application.

A grating 10, made of metal covered with lampblack, is provided in the front end of the barrel for the purpose of rendering the rays of light from the mirror 8 parallel. The smaller barrel C is mounted upon the supports 11 and is disposed centrally of the larger barrel. The smaller barrel consists of an intermediate jacket of an insulating material 12, in which is mounted a metallic cylinder 13, provided with a hemispherical end in which is disposed a

concave mirror 14, made, preferably, of metal. Inside of this barrel is an insulated support 15, and upon this support is mounted a crown-shaped bunch of wires 16 18, having one extremity contracted to support a selenium cell 21, the ends of the crown terminating in points or antennæ 17 19, bent over radially and at right angles to the axis of the tube. The members 10 and C are fully described in my prior application referred to.

A Crookes tube 20 and a hollow hermetically-sealed vacuum-cell 21 of glass, having no pneumatic communication with each other, are provided and are placed within the wires in such manner that the wires form cages partially surrounding them. The hermetically-sealed glass cell is of hemispherical shape and is used for holding a selenium plate, as described in my other application. The selenium cell is shown here, because it may be used for telegraphing by flickerings of light in connection with the lamp 20, which has an action on the selenium plates of the receiving and of the sending stations.

The wire 23 is connected with the bunches of wires 16 and 18 and is also connected with 44 alone for sending and with 46 alone for receiving. The switch 38 is open in sending, but closed in receiving. The wires 46 and 25 and the members 55, 58, 56, and 60 are provided with suitable resistance. Electrical connections 24 25 are provided for the Crookes tube in the usual manner. The Crookes tube is excited in the usual manner by means of a sparking apparatus D, which consists of a battery 30, a Ruhmkorff coil 31, connected thereto and controlled by a switch 32, a condenser 33, and a pair of polished knobs 34, and a ground-wire 35, provided with a switch 36, is used for throwing the polished knobs as exciter out of use when desired and of grounding the wires as a protection against lightning or against accidents. The wire 22 is connected with the wire 37, which is provided with a grounding-switch 38, which must be closed in receiving, as stated. The switch 32 may sometimes be substituted for the key 41—that is, when the secondary connections of coils 43 and 31 coact to augment the potential difference between the ends of the secondaries of coil 31. Then 44 being out of action connects only with the antennæ through 23, and 24 connects with 23, 22 with 25, and at its other extremity 22 connects only with 37. 37 connects with 38 and this with 45 through the ground. In this case the switch 36 connects with 34, where the oscillating discharges are produced, and the conventional interruptions are made by the key 32. For sending by flickerings of light I may use the same arrangement, the switch 36 being in a neutral position, as also the terminals 34. For receiving by flickerings of light I use the same devices described in my previous applications referred to.

A signaling device proper is shown at F and

consists of a local battery 39, a switch 40, a Morse key 41, a condenser 42, and a Ruhmkorff coil 43, provided with polished knobs 44 of the usual pattern. From one of these knobs a wire 45 leads to the ground, and another wire, 46, leads to the crown of wires 16 18. This crown of wires may vary indefinitely in form, and it is used inside of the member C only when working with waves of short length, and then only if it is desired to use the light from 18 or C.

The coherer is shown at 50. It is connected with a local battery 51; provided with a switch 52, the same being adapted to engage the contacts 53 54. The decoherer is shown immediately at the left of the coherer and consists of an electromagnet 55, provided with an armature 56 of the pattern generally used in coherers, said armature being adapted to tap the tube of the coherer 50. The decoherer is connected, through wire 57, with the wire 25, and 57 may connect with 53, 59, and 54 by means of the switch 52. The contact 58, which is adapted to engage the armature 56, is connected with the wire 25'. The wire 59 is for the purpose of establishing communication between the battery 51 and the bell 60.

A Morse recording apparatus of the usual pattern and provided with all of the auxiliaries accompanying such apparatus is shown at 61 and is controlled by a switch 62, connected when closed to contact 54 of switch 52. From the contact 53 a wire 63 leads to the primary 64 of an induction-coil, and from this primary a wire 65 leads to the sonorous receiver 66. This receiver is shown more particularly in Fig. 4.

Binding-screws 67 are mounted upon the frame of the receiver, the screw at the left-hand side being insulated, as shown. A diaphragm 68, protected by a disk 70 of insulated material, is mounted directly across the frame, and over it is a layer of comminuted carbon 69 in loose form. This carbon is engaged by the carbon button 69^a, upon which is mounted an insulating-jacket 70^a. A spring-tongue 71 normally presses the diaphragm 68 gently against the comminuted carbon, and a somewhat similar spring 72 presses the button 69^a downward. A funnel-shaped member 73 is provided with perforations or holes 74, arranged in concentric rings. These holes or perforations are for the purpose of emitting phonetic signals. A diaphragm 75, of iron, is mounted across the frame, and binding-screws 76 and 78 are connected with the magnet 77.

The operation of my apparatus when used with short-length reflected waves and with light-waves is as follows:

The switch 36 is connected to wire 35 and the switch 32 is closed, as shown in Fig. 1, thereby exciting the Crookes tube and causing the same to emit cathode-rays in the usual manner. The signal-key 41 is now disposed

in the manner peculiar to Morse telegraphy. The Ruhmkorff coil 43 causes the polished knobs 44 to spark in response thereto. The wire 45 being grounded, as shown, the antennæ 17 19 (being then connected with 44 through 23) are caused to throw off etheric waves similar to the Hertzian waves, which pass out of the barrel toward the distant station.

The operator by depressing the key 41 merely causes the Ruhmkorff coil 43 to spark continuously while the key is depressed and to cease sparking while the key is raised. The cathode-rays made by the Crookes tube are of course reflected by the mirror 14, and thus given a general direction of propagation, which follows the general direction of the axis of the barrel. These cathode-rays, like the actinic and the etheric waves, above described, apparently reinforce each other in their effects, and the result is that the telegraph is more effective when both are employed. The cathode-rays are emitted in continuous oscillation and are not controlled directly by the transmitting-key. The Hertzian waves alone are controlled by the key, and the cathode-rays merely facilitate the propagation of the Hertzian waves. When the sparking apparatus D is stopped, the telegraphic signals are not as distinct as when the said sparking apparatus is in action.

The device considered as a receiving apparatus will be described.

The Hertzian waves made by depressing the key at the sending-station produce effects in the crown-wires 17 19 and in the member 10, which serves as a capacity connected to the crown-wires or antennæ.

Incoming waves cause surgings in the wires 23 and 46, 38, 37, and 25' to the coherer 50, thereby affecting its resistance. The result is that with the apparatus in the position as indicated in Fig. 1 at E, the battery 51 sends the current through 50, 60, 59, 57, 56, and through wire 58 back to the battery. The bell therefore rings when the coherer is excited and only at that time.

The bell having rung, the operator merely moves the switch 52 in order to receive the message. If he wishes to receive the message upon the Morse recorder, he moves the switch 52 downward so as to engage the contact 54 and also closes the switch 62. The current from the battery now passes through the Morse recorder and through the coherer back to battery. If, however, the operator desires to receive the message upon the phonetic receiver, he moves the switch 52 upward, engaging the contact 53. For receiving messages by means of modifications produced in a continuous sound in accordance with the intermittent impulses sent out by the transmitter the contact 58 should be pressed firmly against the armature 56, the switch 62 should be opened, and switch 52 placed on contact 53. The coherer being excited by the closing of the key at the distant station, the following circuit is estab-

lished: 51, 50, 50', 66, 65, 64, 63, 57, (through 52 from 53,) 58, to battery. The primary 64 being thus energized excited the secondary 79 and established a local secondary alternating current through the wires 80 and 81, Fig. 4, 7c and the magnet 77. The magnet responds to the action of this current by causing the diaphragm 75 to vibrate violently. The vibrating diaphragm causes the column of air in the funnel-shaped member 73 to be alternately 75 compressed and rarefied, thereby causing the diaphragm 68 to vibrate and to vary the resistance offered by the comminuted carbon. The length of the column of air should be such that the diaphragm 75 will cause the diaphragm 70 to vibrate in a predetermined space of time, the idea being to amplify the variations of the battery-current flowing through the comminuted carbon. This phonetic receiver acts to some extent as a relay. It is 85 clear that the mechanical action of the vibrating column of air can be made to increase and decrease the resistance of the comminuted carbon, and if this be done at the proper moments of time the ultimate effect of the current passing through the comminuted carbon can be increased. 90

The vibration of the diaphragm 75, by causing the above-mentioned condensation and rarefaction of the column of air in the funnel-shaped member 73, causes the perforations 74 to emit a musical note, which I find to be somewhat similar to a flute-note. The general effect is about the same as if a person were sounding a Morse signal upon a flute, a short note representing a dot and a comparatively 100 long note or variations in intensity of the note representing a dash. The connection of a relay is necessary for prolonged effects.

Having thus described my invention, I claim 105 as new and desire to secure by Letters Patent—

1. A wireless-telegraph system comprising means to generate two or more sets of waves of different lengths or different periods, means to direct said waves toward a distant station, 110 and to modify those of one or more of the sets in accordance with a code, together with means at the distant station rendered sensitive by some of the waves to respond to changes or modifications in others, to thereby reproduce 115 the signal.

2. In a wireless-telegraph system, a transmitting apparatus comprising a set of Hertz-wave antennæ, a source of cathodic waves, and a source of actinic waves, means whereby 120 the changes of a prearranged code may be impressed on one or more of said sets of waves, and means for directing all the waves to a distant station.

3. In a wireless-telegraph system, a receiver 125 comprising elements sensitive to etheric waves due to light projection and to electrical surgings or oscillatory discharges, means to combine the effects of said elements, and means to effect alinement with a transmitting-station. 130

4. In a wireless-telegraph apparatus, a casing, a source of light therein, a source of cathode-rays therein, discharge - terminals for Hertz-wave propagation, therein, means to
5 control the production of the waves and rays, and means to direct said casing toward a distant station.

5. A wireless telegraph, comprising a sparking apparatus for producing Hertzian waves,
10 means for actuating said sparking apparatus at will for the purpose of signaling, means for producing a cathode-light substantially in the path of said Hertzian waves, and a receiver sensitive to said Hertzian waves and located
15 at a distant station.

6. A wireless telegraph, comprising a sparking apparatus for transmitting etheric waves into space, means for actuating said sparking
20 apparatus at will for the purpose of signaling, a Crookes tube for producing cathode-rays substantially in the path of said etheric waves, and a distant receiving apparatus sensitive to said etheric waves.

7. In a wireless-telegraph apparatus an external casing having a reflector and a source
25 of violet rays, the internal casing having discharge-points and an element sensitive to light-

waves, means to impress changes on the waves of light or those due to discharges from the points, and connections from the sensitive
30 element and the casings for the conveyance of incoming waves or their resulting effects to suitable receiving apparatus.

8. A wireless telegraph, comprising mechanism for producing cathode-rays, a sparking
35 apparatus for producing etheric waves substantially in the path of said cathode-rays, a manually-operated key for controlling said etheric waves, and a receiving apparatus sensitive to said etheric waves.
40

9. A wireless telegraph, comprising a sparking apparatus, a Crookes tube actuated thereby, a reflector adjacent to said Crookes tube, means for generating etheric waves within
45 said reflector, a telegraphic key for controlling the generation of said waves, and a receiving apparatus sensitive to said etheric waves.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ROBERTO LANDELL DE MOURA.

Witnesses:

WALTON HARRISON,

EVERARD B. MARSHALL.

No. 796,254.

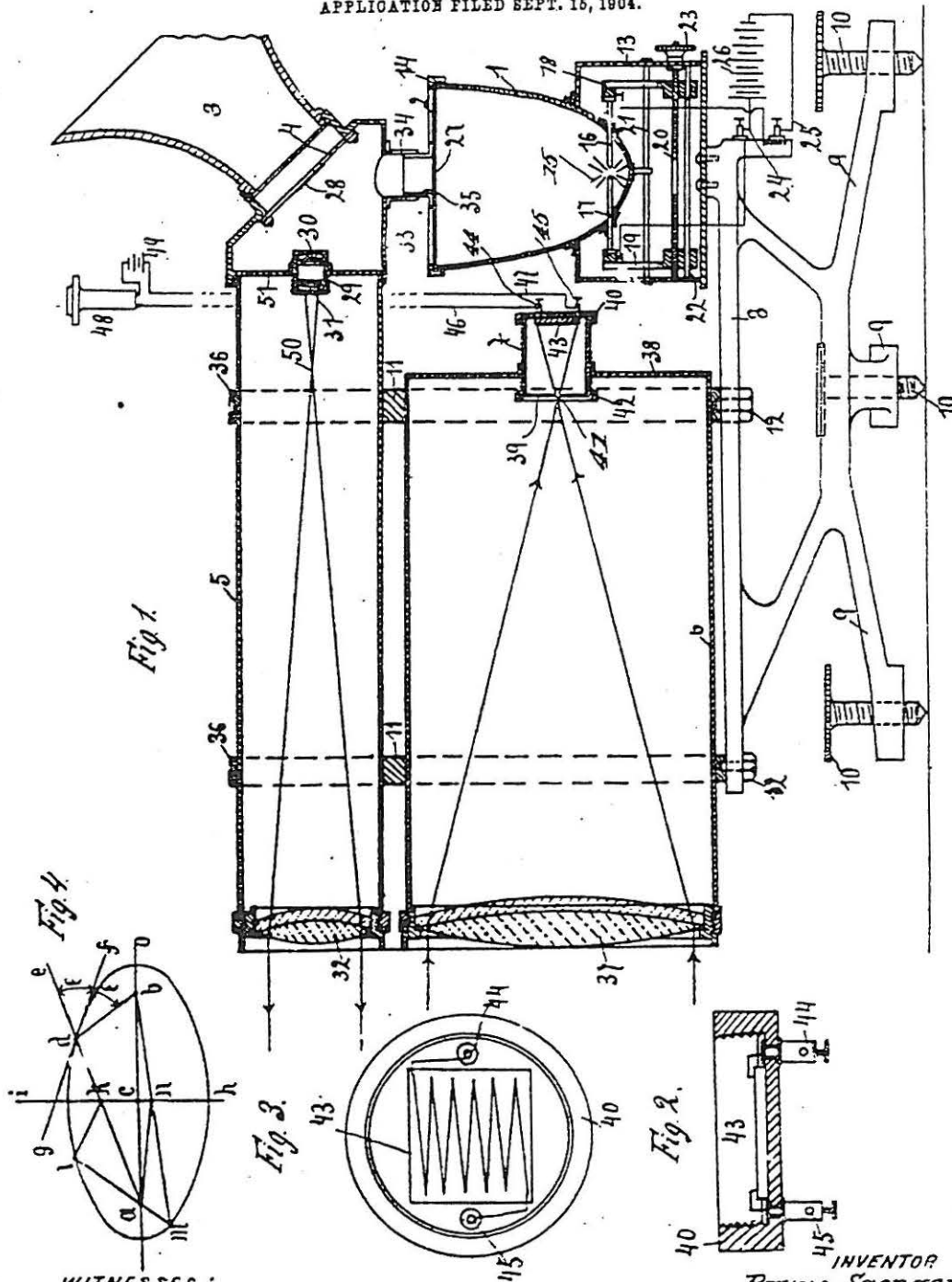
PATENTED AUG. 1, 1905.

R. W. HARTMANN, DEC'D.

B. SAENGER, ADMINISTRATOR.

PHOTOPHONE.

APPLICATION FILED SEPT. 15, 1904.



WITNESSES:

W. M. A.

A. G. S.

INVENTOR
Bruno Saenger.
Administrator of the Estate of
Rudmund Wilhelm Hartmann,
deceased.

BY *M. C.*
ATTORNEYS

UNITED STATES PATENT OFFICE.

BRUNO SAENGER, OF BERLIN, GERMANY, ADMINISTRATOR OF RAIMUND WILHELM HARTMANN, DECEASED, ASSIGNOR TO FRANZ ARNOLD, OF DEGGENDORF, GERMANY.

PHOTOPHONE.

No. 796,254.

Specification of Letters Patent.

Patented Aug. 1, 1905.

Application filed September 15, 1904. Serial No. 224,549.

To all whom it may concern:

Be it known that I, BRUNO SAENGER, a citizen of the Empire of Germany, residing at Berlin, in the Empire of Germany, am the administrator of the estate of RAIMUND WILHELM HARTMANN, deceased, late a citizen of the Empire of Germany, who did invent a new and useful Photophone, of which the following is a specification.

The hitherto-known photophones present the great disadvantage that they disperse too much the light, whereby the conveyance of speech over very large distances and at daylight is rendered impossible. The only means hitherto known for obtaining a pencil of rays of light as parallel as possible is the parabolic reflector. However, the more it is attempted to utilize the properties of the parabolic mirror the less will it be found possible to thereby increase the practical usefulness of the wireless telephony, which is now so much aimed at. For a mutual understanding over a distance of but a few kilometers already gigantic parabolic mirrors would be required, so that the use of such instruments would be quite impossible for military or sporting purposes. The hitherto-known photophones also present the defect that it is not possible to keep secret the conversation, since other receivers near the one to which speech is to be conveyed from the sender are also capable of collecting the dispersed rays of light and thereby receiving the intelligence. The receivers in such known photophones are, moreover, not adapted to receive only the rays of light from the right sender while excluding those from all other senders.

The present invention relates to improvements in photophones, whereby the conveyance of speech over greater distances than hitherto is rendered possible and the size and the weight of the photophone are kept within moderate limits, so that the latter can be easily transported, while a greater secrecy of the conversation both at the sending-station and at the receiving-station is insured.

The objects of the improvement are, first, to provide an elliptic mirror with a plane mirror covering it and having a narrow circular central hole; second, to provide a source of light in the focal point of the elliptic mirror; third, to provide a Bell's mouthpiece at a convenient angle to the axis of the elliptic

mirror, its membrane being adapted to serve as a mirror for reflecting the pencil of rays of light from the elliptic mirror; fourth, to provide a sending-tube similar to an astronomical telescope and adapted for changing the pencil of rays reflected from the membrane to a beam of nearly parallel rays which pass through the space, all the parts hitherto named forming the sender of a photophone; fifth, to provide a receiving-tube having at the rear end a bottom and at the front end an object-glass adapted to bend a beam of rays to the center; sixth, to provide in the bottom of the receiving-tube a longitudinally-movable small camera obscura having a narrow circular central hole in the focal point of the object-glass; seventh, to provide within the small camera obscura a selenium cell or radiophone, and, eighth, to provide a circuit connecting the selenium cell or radiophone with a telephone. These objects are attained by the photophone illustrated in the accompanying drawings, in which—

Figure 1 is a vertical longitudinal section through a photophone comprising a sender and a receiver. Fig. 2 shows, on an enlarged scale in section, the bottom of the camera obscura in the receiving-tube and provided with the selenium cell. Fig. 3 is an elevation of the same; and Fig. 4 is a diagram, which will be referred to later on.

Similar characters of reference refer to similar parts throughout the several views.

The employment of an elliptic mirror in place of the parabolic mirror is based upon the well-known property of the ellipse (see Fig. 4) that the angle $\angle E$ between the radius vector $b d$ from the one focus b to any point d of the ellipse and the lengthened radius vector $a d$ from the other focus a through the same point d is divided into two equal angles $\angle E$ and $\angle E$ by the tangent $f g$ to the ellipse in d . If now in the center c a perpendicular $h i$ is raised, which intersects the radius vector $a d$ at k , and a line $k l$ is drawn from k to the point l on the left of the perpendicular $h i$ at the same distance therefrom as the point d , of course the line $k l$ will be equal to $k d$ and $a l$ equals $b d$, also angle $\angle a k h$ equals angle $\angle l k i$. Now if the radius vector $a d$ be lengthened through the focus a to the point m of the ellipse and the latter point m be connected with the other focus b by the

radius vector mb intersecting the central perpendicular hi at n of course the line na , drawn from the point n to the focus a , will be equal to nb and also angle anb equals angle anb . From an examination of Fig. 4 it will be seen that the distance nc of the second intersection n from the center c is much smaller than that hc of the first intersection h . It is also evident that when in a similar manner as before the line na be lengthened beyond the focus a to the ellipse and from the new intersection a' a radius vector be drawn to the right focus b intersecting the central perpendicular hi at a point the latter will be still nearer to the center c than the second intersection n . It is further obvious that in an elliptic mirror covered by a plane mirror in the plane of the central perpendicular hi any ray of light ak emanating from the focus a and striking the plane mirror at the point k will be reflected to the point l of the surface and from thence through the focus a to the opposite point m of the elliptic mirror, then from thence to the point n of the plane mirror, and from the latter again through the focus a to the respective point (not shown) of the elliptic mirror. In other words, this ray of light will constantly be reflected and more and more approach to the axis ac . The same is true for all the other rays of light produced by a source of light in the focus a .

The photophone shown at Fig. 1 comprises a sender and a receiver. The sender is composed of an elliptic mirror 1, a plane mirror 2, a Bell's mouthpiece 3 with the membrane 4, and a sending-tube 5. The receiver is composed of a receiving-tube 6 and a small camera obscura 7. All the parts are shown as combined and supported by a table 8, provided with, preferably, three feet 9 9 and adjusting-screws 10 10. The two tubes 5 and 6 are parallel to each other and may be superposed and rigidly connected in any known and approved manner—for example, by means of the two frames 11 11, affixed on the table 8 with convenient screws 12 12. The elliptic mirror 1 may be supported on the table 8 with the aid of a suitable frame or casing 13 and is connected with the plane mirror 2 by means of a thread 14 or otherwise. The plane mirror 2 is provided with a narrow circular hole 27 in the axis of the elliptic mirror 1. For producing the rays of light within the elliptic mirror any convenient source of light may be employed. I have shown this to be an electric-arc light 15, produced by a convenient arc-lamp arranged in the frame or casing 13. This lamp comprises two carbon pieces 16 and 17, which pass through two opposite holes in the elliptic mirror 1 and may be therein guided, while their external ends are secured in two holders or arms 18 and 19, respectively. A feed-screw 20, parallel to the two carbon pieces 16 and 17, is mounted to turn in the frame or casing 13 and provided

with two opposite threads of unequal pitch, the pitch of the one thread being about double that of the other thread. These two threads engage in correspondingly-threaded holes of the two holders 18 and 19, which latter are guided by two horizontal rods 21 and 22, parallel to the feed-screw 20 and secured in the frame or casing 13. A small knurled wheel 23 is fastened on the external end of the feed-screw 20, so that by turning this wheel 23 the two carbon pieces 16 and 17 can be simultaneously and longitudinally shifted in opposite directions. The two carbon pieces 16 and 17 are electrically connected by wires 24 and 25 with a battery 26 or other source of electricity. It will be seen that the striking of the arc can be effected by suitably turning the knurled wheel 23 and that by gradually turning the latter in proportion to the consumption of the carbon pieces the arc-light can be regulated and made steady. Owing to the unequal pitches of the two threads of the feed-screw 20 and from reasons well known, the arc-light 15 will remain in the focus of the elliptic mirror 1.

I have shown the two tubes 5 and 6 as horizontal and the axis of the elliptic mirror 1 as vertical—that is, the latter at right angles to the axis of the sending-tube 5. Consequently the mouthpiece 3 is placed in the vertical plane of the sending-tube 5 and of the elliptic mirror 1 and at an angle of forty-five degrees. The mirror 28 may be made separately and affixed on the membrane 4 in any suitable or known manner, or it may be made in one piece with the membrane 4, or the mirror 28 may replace the membrane 4 altogether, it being made thin and elastic. The sending-tube 5 is similar to an astronomical telescope and comprises a small tube 29 with two lenses 30 and 31 near the mirror 28 and a large lens 32 on the external end. The tube 29, with its two lenses 30 and 31, is similar to an eyepiece of the said telescope and has a very small focal distance, either positive or negative, while the large lens 32 has a very large focal distance. The tube 29 is longitudinally adjustable in the tube 5, and while this adjustment may be effected in any suitable way, as shown in the drawings, it is accomplished by screwing the tube into the bottom 51 of the tube 5. Preferably the mouthpiece 3 is connected with the sending-tube 5 by means of a casing 33, and the latter is provided with a vertical tube 34 concentric with the elliptic mirror 1, which tube 34 can engage a similar tube 35 on the plane mirror 2. Thus the photophone can be put together and again taken to pieces, the sending-tube 5 being secured in the two frames 11 11 by means of two detachable bows 36 36, so that it can be vertically removed and again replaced. The inside faces of the tubes 5, 29, 34, and 35, the bottom 51, and the casing 33 and the outside faces of the tube 29 are preferably

blackened in the usual manner for absorbing all foreign rays of light, particularly the diffuse daylight.

The receiving-tube 6 is preferably made larger in diameter than the sending-tube 5 and is provided with a large lens 37, having a large focal distance. The small camera obscura 7 is a tube longitudinally adjustable in the bottom 38 of the tube 6 and provided with a front cover 39 and a bottom 40. The front cover 39 may be secured on the tube 7 by means of a threaded ring 42 or the like and is provided with a narrow circular central hole 41, and the tube 7 must be each time so adjusted as to bring the hole 41 exactly into the focus of the lens 37, as is indicated by the crossing lines in Fig. 1. The bottom 40 may be constructed in the manner shown at Fig. 2, so that it can be screwed on the tube 7 and again taken off. It is to be remarked here that the tube 7 may be arranged to be longitudinally adjustable in any convenient manner. As shown in the drawings, the adjustment is effected by screwing the tube 7 into the bottom 38 of the tube 6. On the inside of the bottom 40 a selenium cell 43 or radiophone of any known construction is secured. I have shown this selenium cell as consisting of a ceramic plate and a zigzagged selenium wire embedded in the surface of this plate. The two ends of this zigzagged selenium wire are connected with two binding-posts 44 and 45 and the latter by two wires 46 and 47 with a telephone 48 and a battery 49, whereby a circuit is formed. The telephone 48 is not shown in the proper size, but merely diagrammatically, as its construction is immaterial for the present invention. The internal faces of the tubes 6 and 7 and the bottoms 38 and 40 and the faces of the cover 39 are also blackened for absorbing the diffuse daylight.

The photophone described so far is operated in the following manner: It is directed toward the respective receiving-station. After striking the arc this arc will emit rays of light in all directions; but only the rays in the axis of the elliptic mirror 1 and those very little deviating therefrom will be able to at once pass through the narrow circular hole 27 in the plane mirror 2. All the other rays of light will be reflected so many times by the surface of the elliptic mirror 1 and the plane mirror 2 as is necessary to bring them nearly into the axis of the elliptic mirror 1 in the manner explained above, when they will pass through the central hole 27 of the plane mirror 2. Thereby an intensive thin and very acute-angled pencil of rays of light is produced, which can easily be subjected to strong variations of the intensity. It is to be remarked that the source of light, here the arc-light, may not always be placed exactly in the focus of the elliptic mirror 1 and that it is not actually in the focus alone, since it has a cer-

tain, though small, length, so that the theory put forward above is not quite exact. However, the elliptic mirror in combination with the centrally-perforated plane mirror is specially suitable for collecting the rays emanating in all directions from a source of light in a single intense pencil of rays of a very restricted cross-section, which hitherto it was not possible to obtain by any known device.

The intense thin and very acute-angled pencil of rays of light passing through the central hole 27 strikes the mirror 28 and is therefrom deflected to the lens 30. The beam of parallel rays passing from the lens 30 to the other lens 31 converges to the focus 50 and thence diverges to the large lens 32, from which nearly parallel rays of light pass through the space, so that this beam is capable of producing an image in a telescope at a very distant station. Of course the receiving-tube is made sufficiently large in diameter for receiving the full image. When assuming the tube 6 to be at the receiving-station and its lens 37 to receive the beam of rays from the lens 32 of the sending-station, the rays will be bent toward the center and made to converge to the focus—i. e., the central hole 41 in the cover 39—after which they will diverge and produce the image on the face of the selenium cell 43 or radiophone.

When the operator talks immediately in front of the mouthpiece 3, the membrane 4, and with it the mirror 28, will be thrown into a complicated state of vibration, which represents the three elements of the speaker's voice—namely, pitch, intensity, and quality. The pencil of rays of light will of course be subjected to these vibrations by the mirror 28, and these vibrations will be transmitted with the rays through the space to the lens 37 of the distant receiving-tube 6 and produce variations in the resistance of the selenium cell 43 or radiophone. The currents circulating in the circuit 46-47 of the battery 49 and the telephone 48 will register all the peculiarities of the speaker's voice and produce changes in the magnetism of the magnet and of the membrane in the telephone 48. The operator at the distant receiving-station placing his ear to the membrane of the telephone 48 will therefore hear the very sounds given out by the speaker at the sending-station.

The sender of the new photophone presents the important advantage that it does not emit any lateral rays of light—that is to say, the image of the source of light can only be perceived by an eye in or close to the optical axis of the sending-tube, so that the speech can be conveyed only to a distant receiving-tube 6 which is in line with the axis of the sending-tube 5. In a similar manner the receiver of the new photophone presents the advantage that owing to its small camera obscura 7 it does not receive any other rays of light but the beam of rays emanating from a

sending-tube 5 in line with its axis and passing through the narrow circular hole 41 of the camera obscura 7. Thereby an almost complete secrecy of the conversation is insured, which hitherto was not possible with the known photophones.

It is evident that if both photophones at the sending-station and at the receiving-station have two superposed tubes the sending-tube of the one photophone and the receiving-tube of the other photophone require to be above, while the receiving-tube of the former photophone and the sending-tube of the latter photophone require to be placed below. In other words, with the one photophone the sending-tube is above and the receiving-tube below, while with the other photophone the reverse is the case.

Where so preferred, the sending and the receiving tubes of a photophone may be placed side by side in a horizontal plane, so that the two photophones at the sending and the receiving stations may be made alike, as the sending-tube of the one photophone will be opposite to the receiving-tube of the other photophone, and vice versa. The elliptic mirror of each photophone may also be placed horizontally, and the two carbon pieces of the arc-lamp may be placed either horizontally or vertically or at any angle. I have shown the knurled wheel 23 as arranged to be turned by hand; but it may also be automatically turned by any known mechanism. The arc-lamp may be of any known and approved construction. The supporting-table 8, with the three legs 9 9, may be replaced by any convenient support.

Where so preferred, the sender, comprising the elliptic mirror 1, the plane mirror 2, the arc-lamp, the tube 5, and the mouthpiece 3, with the membrane 4 and the mirror 28, may be made separately and supported by a convenient table 8, while the receiver, comprising the tube 6 and the small camera obscura 7, may equally be made separately, supported by a convenient table.

The angle between the axes of the elliptic mirror and the sending-tube may be varied. The photophone may be varied in its construction without deviating from the spirit of the present invention.

What is claimed, and desired to be secured by Letters Patent, is—

1. In a system of photophony, the combination with a device emitting an intense, thin and very acute angled pencil of rays of light, of means for subjecting this pencil of rays to the action of the voice, a sending-telescope adapted to change the pencil of varied rays to a beam of nearly parallel rays passing through the space, a receiving-tube with a lens adapted to bend the rays of this beam toward the center, a small second camera obscura in the receiving-tube and having a narrow circular central hole in the focus of the

lens, a radiophone on the bottom of the small camera obscura and adapted to increase and decrease its electrical resistance under the action of the beam of bent and varied rays of light, a circuit connected with the radiophone, and a telephone in this circuit.

2. In a photophone, the combination of an elliptical mirror, a plane mirror covering the elliptical mirror and provided with a small hole in the axis of the elliptical mirror, a source of light in the focus of the elliptical mirror, means for subjecting the rays of light passing through the hole of the plane mirror to sound-waves, and means for transmitting the varying rays through space.

3. In a photophone the combination of an elliptic mirror, a plane mirror covering said elliptic mirror and provided with a small circular hole in the axis of said elliptic mirror, a source of light in the focus of said elliptic mirror, so that the rays of light emanating in all directions from said source of light are several times reflected by said elliptic mirror and said plane mirror, until they pass through the small hole of the latter in an intense, thin and very acute angled pencil, a mouthpiece having a vibrating and reflecting membrane standing at an angle to the axis of the elliptical mirror, and a telescope into which the pencil-rays are deflected.

4. In a photophone the combination of an elliptic mirror, a plane mirror covering said elliptic mirror and provided with a small circular hole in the axis of said elliptic mirror, an arc-lamp, the carbon pieces of which pass through holes in said elliptic mirror and are adapted to form the arc-light in the focus, so that the rays of light emanating in all directions from said arc-light are several times reflected by said elliptic mirror and said plane mirror, until they pass through the small hole of the latter in an intense, thin and very acute angled pencil, a mouthpiece arranged at an angle to the axis of the elliptical mirror and having a vibrating and reflecting membrane, and a telescope into which the pencil-rays are deflected.

5. In a sender of a photophone, the combination with an elliptic mirror, of a plane mirror covering said elliptic mirror and provided with a small circular hole in the axis of said elliptic mirror, a source of light in the focus of said elliptic mirror, so that the rays of light emanating in all directions from said source of light are several times reflected by said elliptic mirror and said plane mirror, until they pass through the small hole of the latter in an intense, thin and very acute angled pencil, a Bell's mouthpiece at an angle to the axis of said elliptic mirror and having a membrane which is adapted to vibrate under the action of the voice and to reflect the pencil of rays, a telescope adapted for changing the pencil of reflected and varied rays of light to a beam of nearly-parallel rays which

pass through the space, and means for supporting all said parts.

6. In a sender of a photophone, the combination with an elliptic mirror, of a plane mirror covering said elliptic mirror and provided with a small circular hole in the axis of said elliptic mirror an arc-lamp, the carbon pieces of which pass through holes in said elliptic mirror and are adapted to form the arc-light in the focus, so that the rays of light emanating in all directions from said arc-light are several times reflected by said elliptic mirror and said plane mirror, until they pass through the small hole of the latter in an intense, thin and very acute angled pencil, a Bell's mouthpiece at an angle to the axis of said elliptic mirror and having a membrane which is adapted to vibrate under the action of the voice and to reflect the pencil of rays, a telescope adapted for changing the pencil of reflected and varied rays of light to a beam of nearly-parallel rays which pass through the space, and means for supporting all said parts.

7. In a receiver of a photophone, the combination with a tube, of a bottom closing the one end of said tube, an object-glass closing the other end of said tube and adapted to bend a beam of rays of light toward the center, a small camera obscura longitudinally adjustable in said bottom and having a small circular hole in the focus of said object-glass, a radiophone in said small camera obscura and adapted to increase and decrease its electrical resistance under the action of the bent rays of light, a telephone, and a circuit connecting said radiophone with said telephone.

8. In a receiver of a photophone, the combination with a tube, of a bottom closing the one end of said tube, an object-glass closing the other end of said tube and adapted to bend a beam of rays of light toward the center, a small tube longitudinally movable in said bottom, a cover closing the internal end of said small tube and having a small central hole, a small bottom closing the external end of said small tube, means for adjusting said small tube in said bottom to bring the small central hole in said cover into the focus of said object-glass, a radiophone on the inside of said small bottom and adapted to increase and decrease its electrical resistance under the action of the bent rays of light, a telephone, and a circuit connecting said radiophone with said telephone.

9. In a receiver of a photophone, the combination with a tube, of a bottom closing the one end of said tube, an object-glass closing the other end of said tube and adapted to bend a beam of rays of light toward the center, a small tube longitudinally movable in said bottom, a cover closing the internal end of said small tube and having a small central hole, a small bottom closing the external end of said small tube, means for adjusting said small

tube in said bottom to bring the small central hole in said cover into the focus of said object-glass, a selenium cell on the inside of said small bottom and adapted to increase and decrease its electrical resistance under the action of the bent rays of light, a telephone, and a circuit connecting said selenium cell with said telephone.

10. In a photophone, the combination of an elliptical mirror, a plane mirror covering the elliptical mirror and having a small hole in the axis of the elliptical mirror, a source of light in the focus of the elliptical mirror, means for subjecting the rays of light passing through the hole of the plane mirror to sound-waves, means for transmitting the varying rays through space, a receiver having means for producing audible sounds, and a telephone connected with the sound-producer of the receiver.

11. In a photophone, the combination with an elliptic mirror, of a plane mirror covering said elliptic mirror and provided with a small circular hole in the axis of said elliptic mirror, a source of light in the focus of said elliptic mirror, so that the rays of light emanating in all directions from said source of light are several times reflected by said elliptic mirror and said plane mirror, until they pass through the small hole of the latter in an intense, thin and very acute angled pencil, a Bell's mouthpiece at an angle to the axis of said elliptic mirror and having a membrane which is adapted to vibrate under the action of the voice and to reflect the pencil of rays, a telescope adapted for changing the pencil of reflected and varied rays of light to a beam of nearly-parallel rays which pass through the space, a receiving-tube, a bottom closing the one end of said receiving-tube, an object-glass closing the other end of said receiving-tube and adapted to bend a beam of rays of light toward the center, a small camera obscura longitudinally adjustable in said bottom and having a small circular hole in the focus of said object-glass, a radiophone in said small camera obscura and adapted to increase and decrease its electrical resistance under the action of the bent rays of light, means for supporting all said parts, a telephone, and a circuit connecting said radiophone with said telephone.

12. In a photophone, the combination with an elliptic mirror, of a plane mirror covering said elliptic mirror and provided with a small circular hole in the axis of said elliptic mirror, an arc-lamp, the carbon pieces of which pass through holes in said elliptic mirror and are adapted to form the arc-light in the focus, so that the rays of light emanating in all directions from said arc-light are several times reflected by said elliptic mirror and said plane mirror, until they pass through the small hole of the latter in an intense, thin and very acute angled pencil, a Bell's mouthpiece at an angle to the axis of said elliptic mirror and having

a membrane which is adapted to vibrate under the action of the voice and to reflect the pencil of rays, a telescope adapted for changing the pencil of reflected and varied rays of light to a beam of nearly-parallel rays which pass through the space, a receiving-tube, a bottom closing the one end of said receiving-tube, an object-glass closing the other end of said receiving-tube and adapted to bend a beam of rays of light toward the center, a small camera obscura longitudinally adjustable in said bottom and having a small circular hole in the focus of said object-glass, a radiophone in said small camera obscura and adapted to in-

crease and decrease its electrical resistance under the action of the bent rays of light, means for supporting all said parts, a telephone, and a circuit connecting said radiophone with said telephone.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

BRUNO SAENGER.

*Administrator of the estate of Raimund
Wilhelm Hartmann, deceased.*

Witnesses:

HENRY HASPER,

WILLIAM MAYNER.

No. 799,555.

PATENTED SEPT. 12, 1905.

B. GATI.

TELEGRAPHY.

APPLICATION FILED MAY 9, 1904.

2 SHEETS—SHEET 1.

Fig. 1.

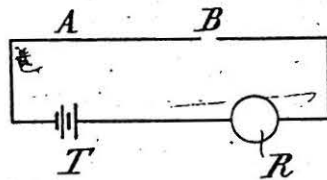


Fig. 3.

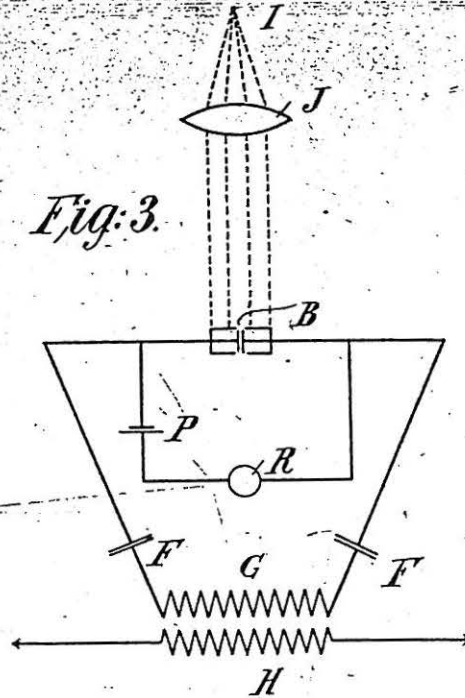
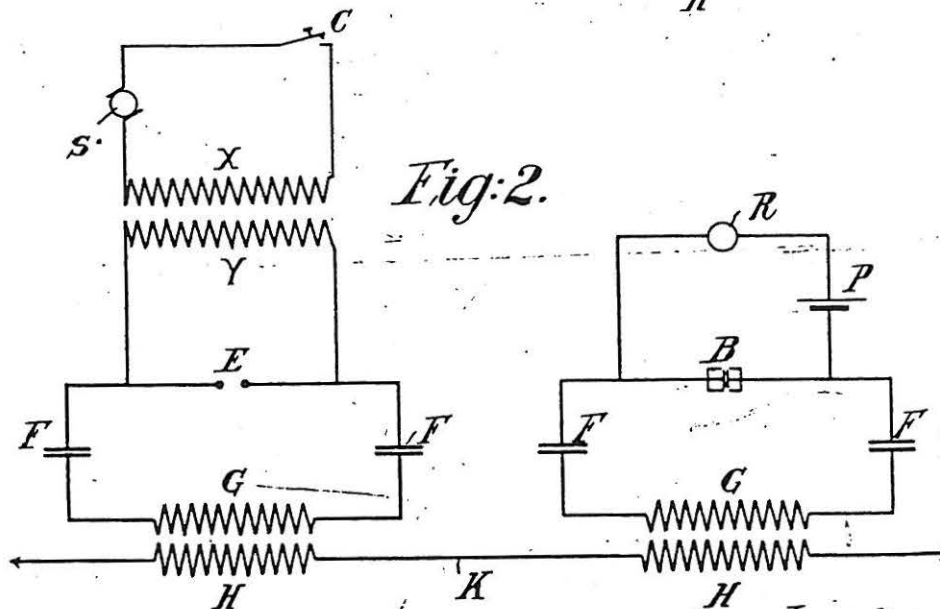


Fig. 2.



Witnesses
Edwin D. Barker
Elect. Engr.

Inventor
Bela Gati
per Herbert Seftin Jones
Attorney

No. 799,555.

PATENTED SEPT. 12, 1905.

B. GATI.
TELEGRAPHY.

APPLICATION FILED MAY 9, 1904.

2 SHEETS—SHEET 2.

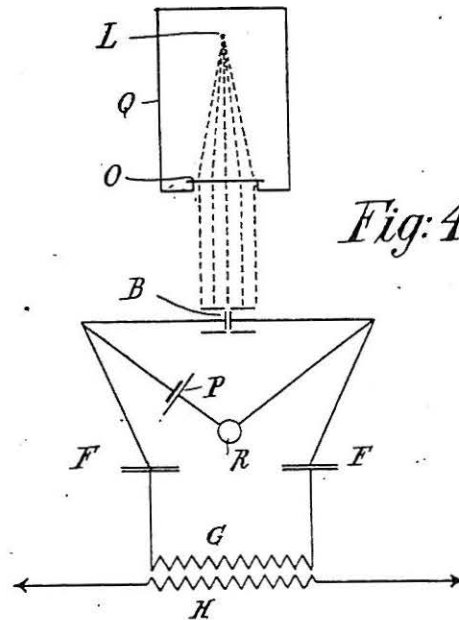


Fig. 4.

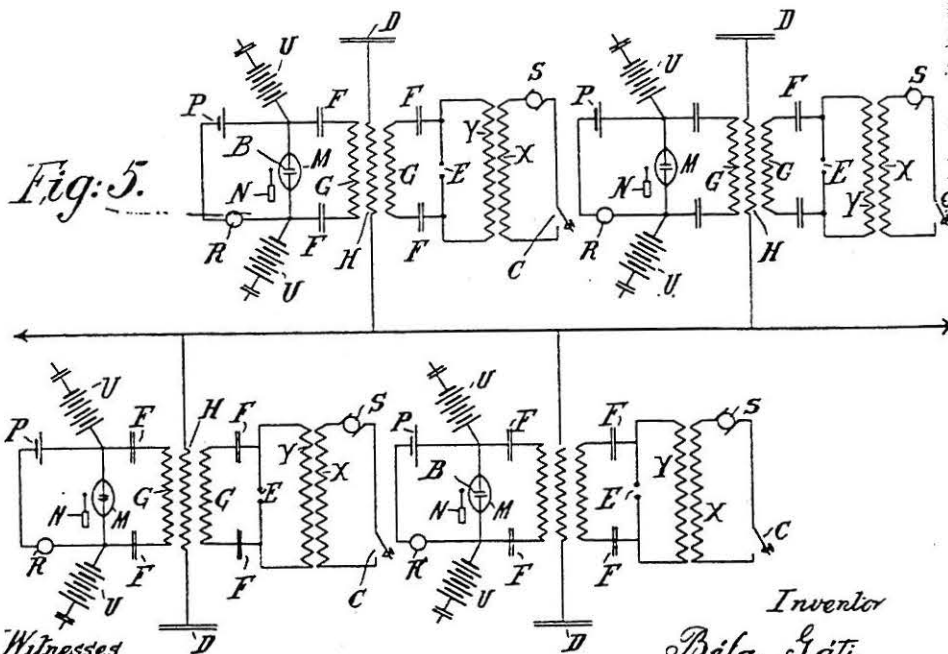


Fig. 5.

Witnesses
Edwin J. Bartlett
J. H. Green.

Inventor
Bela Gati

per Herbert Lepton Jones
Attorney

UNITED STATES PATENT OFFICE.

BÉLA GÁTI, OF BUDAPEST, AUSTRIA-HUNGARY.

TELEGRAPHY.

No. 799,555.

Specification of Letters Patent.

Patented Sept. 12, 1905.

Application filed May 9, 1904. Serial No. 207,107.

With whom it may concern:

Be it known that I, BÉLA GÁTI, electrical engineer, of Hotel Metropole, Budapest, Austria-Hungary, have invented Improvements in telegraphy, of which the following is a specification.

Existing telegraphic systems are, so to speak, exclusively based upon the magnetic action of the electric current. The variation of the current strength—that is, the increase thereof from zero to a certain value or the decrease thereof from a certain value to zero in a wire coil—causes the variation of the magnetism. By means of the magnetism mechanical devices are actuated, and thereby the signals are produced at the distant station. The requisite current strength, the corresponding magnetism, and the actuation of the mechanical devices are comparatively easy to obtain with simple telegraphy, but with multiplex telegraphy many complications arise, and in consequence thereof the permanent maintenance of any quadruplex system is difficult, while for cable transmission such systems can only be used with great difficulty. According to the present invention these difficulties are obviated by employing in place of the magnetic action of the current the ionizing action thereof. In order to render the means employed for this purpose intelligible, it is necessary to more particularly describe the phenomena based upon ionization. If a substance is resolved into its ions and positive ions travel in one direction and negative ions in another direction, it is said that the substance conducts electricity. With solid bodies the movement of the ions cannot be shown. With liquid bodies this is easier: but with gases the ion movements can be followed, as in the case of ion-rays, cathode-rays, anode-rays, &c. The resolution of a body into its ions can be brought about by a variety of causes, such as electric potential differences, light-waves, electromagnetic waves, ion-rays, cathode-rays, anode-rays, Röntgen-rays, N-rays, radium-light, ultra-violet light, chemical action, caloric action, &c. There is, so to speak, hardly any phenomenon under the influence of which a substance would not commence to be resolved into its ions. In the following I will consider the case in which any solid substance and a gas are so grouped that the solid substance is readily resolved into its ions, but the gas with difficulty.

In the accompanying drawings, Figure 1 is

a preliminary diagram. Fig. 2 shows diagrammatically a sending and a receiving station connected by line-wires for simple telegraphy. Figs. 3 and 4 show ways of ionizing the gases in the gap at the receiving-station. Fig. 5 shows four stations of a multiplex system connected to a single line-wire.

Referring to the diagram Fig. 1 of the drawings, the electric potential difference at the terminal of a current source T would begin to resolve the solid part of the circuit A into its ions, and in the circuit of the current source an electric current would ensue if the gas at the gap B were also resolved into its ions by any means. If, for example, the gas at B were subjected to the action of radium, the gas would be resolved into its ions and electricity would begin to flow in the circuit. It would, for example, put a relay R in action and by it any recording apparatus could be operated, so that if the radium were made to act during a longer or shorter time, corresponding to certain telegraphic symbols, the recording instrument on the receiver would record the corresponding symbols. Instead of radium or radio-active substance any other ionizing means can be employed, or two or more such may be employed in combination. In practical application several ionizing means are generally employed, and one of these depends regularly upon the electromagnetic wave.

Fig. 2 shows an arrangement for effecting telegraphy by the use of a gap in which the gases are made conducting by electromagnetic waves resulting from waves transmitted through a wire from a sending-station. S is any suitable source of alternating or oscillating currents. C is a key, and X the primary of an induction-coil in circuit with the source S through the key. The terminals of the secondary winding Y are connected to sparking points E. F F are condensers, connected on the one hand to the points E and on the other hand to the terminals of a coil G. H is a coil in the line-wire K, arranged to have waves induced in it by waves in G. At the receiving-station there are corresponding coils G H and condensers F F, the latter in this case being connected to the terminals of a gap B. A local circuit, including a battery P and a relay or indicating apparatus R, is also connected to the terminals of the gap. When the key C is depressed, an alternating current passes through coil X, exerting a high inductive action on the coil Y, and sparks are produced at E. Hence oscillations of cur-

rent of high frequency take place in G, causing waves in H, which pass in both directions along the line K. The coil H at the receiving-station is made to resonate with these waves, causing waves in the circuit G F B F at the receiving-station, whence oscillations are produced at the gap B, and the gases at the gap may thus be ionized, allowing a current to pass from battery P through signaling-relay R.

It is not difficult to show by the following calculations that for obtaining the coherer action (if only electromagnetic waves be employed as the ionizing means) very high speeds of vibration are required. According to Drude, the number of gas molecules in one cubic centimeter at 0° centigrade temperature and seven hundred and sixty millimeters barometric pressure amounts to 2.4×10^{19} . A calculation may be made with reference to the "Karoly" coherers, which have hitherto been considered the most sensitive. These coherers consist of two steel needles, which are crossed; the distance between them at the point of crossing being very small, usually from 0.1 to 0.0001 of a millimeter. (See *Mathematical and Physical Papers*, 1903, page 127, of the Mathematical and Physical Society of Budapest.) The volume of the gas between the two contacts of such a coherer may be taken to be $0.001 \times 0.001 \times 0.001$ cm. = 10^{-9} cm. Assuming there are 2.4×10^{10} molecules and that each molecule consists of one thousand positive and one thousand negative electrons, there have to be taken into account 2.4×10^{13} electrons. In order to establish an electric current, according to Drude, at least 1.2×10^5 molecules must be resolved into their ions, and consequently 2×10^8 electrons must be produced, for which purpose a wave with at least 10^8 vibrations will be necessary even if it be assumed that each wave separates at least one negative and one positive electron, while it is possible that a number of waves may pass through the gas without separating electrons. The length of the wave with the number of vibrations 10^8 with a wave speed of 3×10^{10} centimeters is 3×10^2 centimeters. It is therefore tolerably small. The propagation of such a wave could only be effected with certainty if with such lengths the electric factors of the conductors (such as resistance, dispersion, leakage, self-induction, and capacity) could be assumed to be stable, which is of course not possible. It is therefore necessary with the existing system of conductors to adopt longer waves. For this purpose it is necessary to employ other ionizing means than that of the electromagnetic wave alone. Electrical potential difference must be employed on account of the inclusion of the relay in the receiving-circuit. Of the other ionizing means, the ion-rays and the light-rays have proved to be the best. With caloric action the reduction of the gas molecules to their ions is very rapid,

and it can therefore hardly be used for this purpose. The simpler the ion-rays or light-rays are the more reliably can their action be regulated. Most kinds of radium-light are mixed lights, (ion-rays, Röntgen rays, &c.,) and consequently the adjustment for these is difficult. The stronger the secondary ionizing means is the greater can be the volume of gas employed. The distance apart of the terminals of the conducting part of the circuit can be made greater, and the disturbing effect of the caloric action can be reduced. With a greater distance the number of gas molecules will be greater, and more energy will be required for ionizing them. This can be remedied by reducing the number of gas molecules contained in the volume—i. e., by attenuating or partially exhausting the gas. If, for example, by the attenuation of the gas or by increasing the action of the ionizing means the effect is obtained that for producing the conduction of the current, for instance, only 10^4 ions need to be produced instead of 2×10^8 ions, then for producing this number electromagnetic waves of 10^4 vibrations can be used with certainty. The corresponding wave length will be about 3×10^6 centimeters, a length within which on the one hand the electric factors of the conductor are tolerably constant and on the other hand such vibrations can be produced more easily and with a less tension. In the apparatus used at the receiving-station there must therefore be used an additional ionizing means which is always acting on the gases in the gap B, but which, with the potential due to the battery for actuating the relay, is not sufficient to produce ionization of the gases at the gap unless aided by electromagnetic waves received from the line.

Fig. 3 shows how violet and ultraviolet light may be applied to the gases at the gap B for the purpose of assisting in the ionization. The rays of violet and ultraviolet light from a source at I—such, for example, as a mercury-vapor lamp, an arc-lamp, or a magnesium-burner—are condensed on the gap B by a quartz lens J and so act on the gases that the waves produced in the circuit G F B F by the waves coming from the line will be able to complete the ionization.

Fig. 4 shows how cathode-rays, Röntgen rays, or the like from a source at L can be caused to act on the gap through an aluminium plate O. A metallic casing Q may be used to prevent any electromagnetic waves from the source L from acting on the gases in the gap B. If radium or a radio-active substance is to be used as the additional ionizing means, it is simply necessary to bring that substance into the neighborhood of the gap B. Electric potential difference can also be used as the additional ionizing means, as is illustrated at each station in Fig. 5. (Explained below.) The potential difference may be produced between plates in the gap by batteries U, the outer ter-

minals of which are connected to condensers. The batteries U U have no circuit except through their insulation resistance, so that no appreciable current can flow from them across the gap. The batteries, in fact, act somewhat like charged condensers. The scientific reason for the ionizing action of the batteries so connected cannot be given; but it is a fact that the desired action is obtained, as has been experimentally proved.

If the gases at the gap are to be attenuated, they may be inclosed in tubes, as at M in Fig. 5, and vibrators of any known type (indicated diagrammatically at N) may be used for causing the terminals of the gap to vibrate. The use of vibrators is particularly desirable when one of the ionizing means is electrical potential difference acting between metallic terminals, because in such case after the cessation of the waves the gas might still remain conducting. Further, in consequence of the electric current passing through the gas at the gap ions of the adjacent conductors will probably become mixed with the gas ions, so that after the ionization has been started a less degree of energy will be required for its maintenance. Hence the vibrating of the contacts is desirable in this case in order, for instance, to increase the gap from 0.001 centimeter to 0.01 centimeter, whereby the current-circuit would be interrupted and the action of the conducting ions would be stopped. With carbon terminal electrodes such vibrating should not be necessary; but it should always be employed when metallic electrodes are used.

By the arrangements above mentioned simple telegraphy can be effected. For multiplex telegraphy it is necessary to use various frequencies of electromagnetic waves for communicating between the respective stations. Fig. 5 shows four complete stations I, II, III, and IV connected to a single line K. If station I transmits electromagnetic waves of a frequency of 10^4 and if the coil H of station III resonates to these waves, then signals can be transmitted from I to III and from III to I. The coils of the sets II and IV may be set to resonate to a different frequency of wave, (for instance 10^5), and the waves from stations I and III will then not affect them. In this way a large number of stations may be connected with one line over which they can all communicate without interference one with another. It is true that in addition to the main vibrations also higher vibrations will be produced in the coils; but as we are not bound to such narrow limits as in wireless telegraphy the number of vibrations can be chosen with much greater differences, and consequently the working will be more reliable. The sizes of the coils will vary according to the length of the conductors. In an article commencing on page 957 of the *Annalen der Physik* (Vol. 11, Series 4, 1903) it is

shown that there are two main vibrations, one principally dependent upon the conducting length of the coil and the other upon the wave length of the system comprising the circuits (I and II, for example) with the connecting-wire K. It depends mainly upon financial considerations to which of these the apparatus is to be adjusted. With short distances the wave length of the system can be the main value, while with greater distances the wave length due to the length of the conducting length of the coil may predominate. The existence of the circuits III and IV will, it is true, have a disturbing effect upon the calculations for circuits I and II; but the necessary corrections can always be made in advance, as will be well understood, by means of experiments carried out with suitably-diminished electrical factors, (resistance, leakage, self-induction, capacity.)

Capacities D may be connected with the lines for establishing the equilibrium which would be disturbed by connecting the wave-producing apparatus with the lines. Their values can be calculated from formulae which are known to physicists and are given, for instance, in the *Annalen der Physik*, (Vol. 11, Series 4, 1903,) in the article above referred to, (page 957 *et seq.*) The capacities D may be in connection with the earth, or if two line-wires are available one can be used, as D, or, again, in the case of cables the sheathing of the cable may supply the capacity, as will be well understood.

As with overland single lines the dispersions or leakage vary considerably, the system cannot be well applied to greater distances than with existing lines. It is, however, very advantageous for cables where the dispersion is small and constant. It is true that large dimensions are necessary and that, for instance, a coil for a cable of one thousand kilometers will occupy a considerable space; but if it be considered that the wave length does not depend very much upon the diameter of the wire and that consequently wires of 0.2 millimeters can be used it will be seen that the cost of the coils will be very small notwithstanding the large dimensions.

The gases at the gaps B can be replaced by non-conducting but ionizable liquid or solid bodies. In such cases, however, the adjustment is very difficult, because the laws relating to the ionization of such bodies are not nearly so well known as those relating to gases, although there are already some wave-indicators known the adjustment of which is easily made even when the material to be ionized is fluid. These can be employed, therefore, if desired, as coherers in the receiving-circuits.

What I claim is—

1. In a telegraphic system, apparatus comprising a coherer in which is a small gap with a fluid between the terminals thereof, a cir-

4
circuit in connection with the terminals of the
coherer including a source of electric current
and a relay; additional ionizing means adapted
to constantly act on the fluid in the gap
5 but with insufficient intensity to produce
ionization, and means whereby electric waves
can be made to act on the fluid in the gap for
producing ionization.

10 2. In a telegraphic system, the combination
with a line-wire, of a plurality of transmitting
instruments connected to said wire each
of said instruments including means for trans-
mitting electric waves of approximately a cer-
tain frequency through the wire, a plurality
15 of receiving instruments connected to said
wire each comprising a coil adapted to reso-

nate to electric waves of approximately a cer-
tain frequency, and a circuit including a
source of electric current, a relay, a gap with
a fluid between the terminals thereof, means 20
tending to ionize the fluid in the gap, and
means whereby the waves received from the
line are caused to act on the fluid in the gap
for producing ionization.

In testimony that I claim the foregoing as 25
my invention I have signed my name in pres-
ence of two subscribing witnesses.

BÉLA GÁTI.

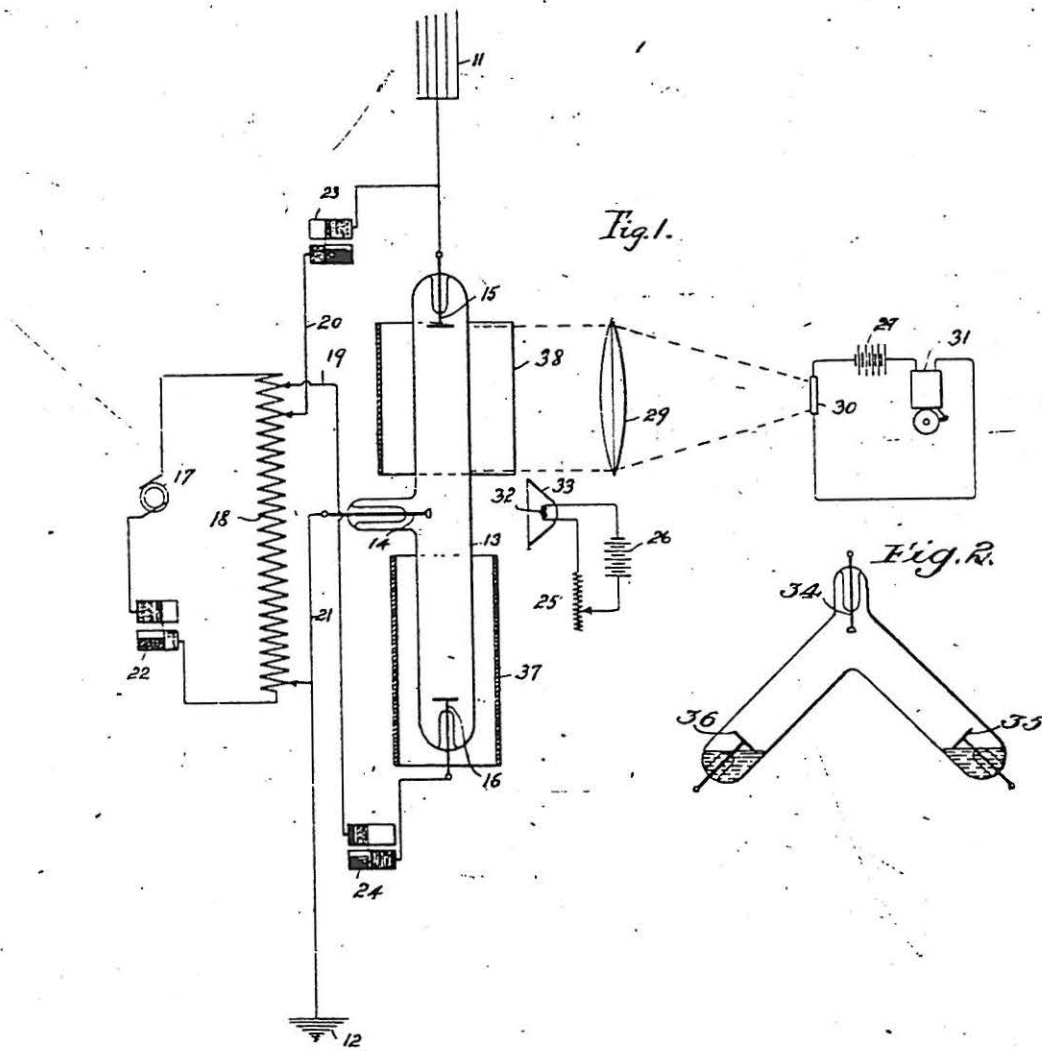
Witnesses:

LOUIS VANDOR,
ANDREW KELEMEN.

B. A. FESSENDEN.
ELECTRIC SIGNALING.
APPLICATION FILED FEB. 8, 1907.

915,280.

Patented Mar. 16, 1909.



Witnesses

F. P. Hambury
Jessie E. Bent

Inventor

Richard A. Fessenden

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF WASHINGTON, DISTRICT OF COLUMBIA.

ELECTRIC SIGNALING.

No. 915,280.

Specification of Letters Patent.

Patented March 16, 1909.

Application filed February 8, 1907. Serial No. 356,383.

To all whom it may concern:

Be it known that I, REGINALD A. FESSENDEN, a citizen of the United States, and a resident of Washington, in the District of Columbia, have invented certain new and useful Improvements in Electric Signaling, of which the following is a specification.

My invention relates to the art of electric signaling, and particularly to receivers for wireless telegraphy, its primary object being to provide a more reliable and sensitive means for receiving electric impulses, especially electro-magnetic waves, and producing signals thereby.

In the accompanying drawing Figure 1 is a diagram in partial section showing apparatus for carrying out my invention, and Fig 2 shows in section a modified form of the receiver tube.

Vacuum tubes heretofore used as receivers for wireless telegraphy have not been found sufficiently sensitive and positive in their action, and especially for feeble impulses. I have experimentally discovered that the defects may be overcome as by using an improved differential vacuum tube containing gases, especially those of the helium type; and also by using differentially acting circuits. The efficiency is further improved by an essential arrangement of the parts one form of which is hereinafter specified.

In Fig. 1 the antenna 11 may be grounded as at 12, or not, and may be connected to the conductor 19 in other modifications. It is preferably tuned by any of the means well known in this art and may be used either with a secondary receiving circuit or without it as here shown. Connected with the antenna is a so-called vacuum tube 13, which may be of any desired shape, and may contain any suitable gas such as hydrogen, nitrogen, helium, argon, neon, etc., the ones named of the helium group having been found especially advantageous. The tube is provided with terminals 14, 15, 16, of which intermediate terminal 14 is preferably made extremely small and composed of iridium. I provide a source of voltage 17, which may be either a continuous current source, or an alternating current source, and is here preferably shown as a high frequency alternator, having preferably a frequency approximately the same as the frequency of impulses to be received. It is connected with a potentiometer 18 and may have a variable inductance or resistance 22 also in circuit.

In this device one winding cylinder is metallic so as to short-circuit any number of turns of the wire desired. It will be understood that the outer ends of the coils on both cylinders are directly connected to the leads, and while on the insulating cylinder the whole length of wire is traversed, the metallic cylinder directly connects the initial point with the last turn of wire wound thereon. The conductors 19, 20 and 21 make adjustable contact with the potentiometer, and may contain variable resistances or inductances 23, 24 as shown. The terminals of the tube 13 may be heated by any suitable means as for example 14 is shown heated by coil 32 excited by battery 26 and having in circuit the variable resistance or inductance 25, the heat being projected by a reflector 33. A screen 37 may envelop the terminal 16 and a reflector 38 around the upper end of the tube is preferably used in order to direct the radiation through a lens 29, whence it impinges on selenium cell or bolometer 30 to thereby operate the indicating mechanism such as the bell 31 having battery 27 in circuit. Otherwise the signals caused by radiation from the upper end of the cell 13 may be read directly, or of course the bell may be replaced by a galvanometer.

In operation the potential between electrodes 14 and 15 is so arranged by means of the potentiometer that no current will pass between these terminals or only a slight and comparatively non-luminous one, while the greater current passes between 16 and 14. The potentials here are so adjusted that when electro-magnetic waves strike the antenna 11, the steady balance of current is disturbed in the differential vacuum tube 13, and the luminous column is caused to pass, either intermittently or steadily between terminals 14 and 15, which will effect a signal as above described.

In the construction of parts I prefer to make the terminals 15 and 16 of such material as iridium or aluminum and they may be covered with an oxid of calcium or its equivalents barium or strontium.

In Fig. 2 I have shown a different form of the tube, made in a Y shape, and the terminals may consist of mercury with central metallic projection as 35 or 36. In this case the mercury may contain a small percentage of metallic calcium or its equivalents or potassium or sodium with advantage.

The above described apparatus has been

found to act as a very reliable and steady receiver, it being a great advantage, among other things, to have the discharge diverted to an entirely new terminal and directly cause a signal by its incidental effects rather than by changes in the current being discharged passing through a detecting instrument.

Having thus described my invention and illustrated its use, what I claim as new and desire to secure by Letters Patent, is the following:

1. A receiver for electro-magnetic waves comprising an exhausted tube containing gas of the helium group.

2. A receiver for electro-magnetic waves comprising a discharge tube with several paths of discharge acting differentially and means for shifting the path of discharge therein by the waves received.

3. A receiver for electric signaling comprising a differentially acting discharge tube with several terminals, and connected differential governing circuits adapted to have their balance changed to shift the discharge path by the passage of signal impulses.

4. A receiver for wireless telegraphy comprising a discharge tube with several discharge paths therethrough, means operated by electro-magnetic waves to shift the path of discharge, and means independent of the tube circuit for effecting a signal by such shifting of the discharge path.

5. A receiver for wireless telegraphy comprising a discharge tube and means for exciting it, connected differential circuits adapted to have their balance disturbed by the passage of electro-magnetic waves to shift

the path of discharge in the tube, and means to observe such shifting of discharge.

6. The combination with a current source and discharge tube having a central terminal and two legs each provided with a terminal, of means actuated by electro-magnetic waves to shift the discharge from one leg to the other, and indicating means operated by said shifting of the discharge.

7. A receiver for electric signaling comprising an electric discharge tube, means to annul or balance off the effective discharge in a path therein, and means operated by the received impulses to disturb the balance and restore said discharge to produce a signal.

8. A receiver for electric signals comprising a discharge tube with several alternative paths of discharge, and means, comprising a receiving circuit operatively connected to a terminal of the discharge tube for shifting the path of the discharge therein on receipt of the transmitted impulses.

9. A receiver for electric impulses comprising a discharge tube with several alternative paths of discharge and means comprising a receiving circuit operatively connected to a terminal of the discharge tube for altering the normal potentials between the terminals and so causing the path of the discharge therein to be shifted on receipt of transmitted impulses.

Signed at Brant Rock in the county of Plymouth and State of Massachusetts this 6th day of February, A. D. 1907.

REGINALD A. FESSENDEN.

Witnesses:

JESSIE E. BENT,
ODELEINE DOLEVER.

R. A. FESSENDEN.
WIRELESS TELEGRAPHY.
APPLICATION FILED JAN. 14, 1907.

974,762.

Patented Nov. 1, 1910.

Fig. 1.

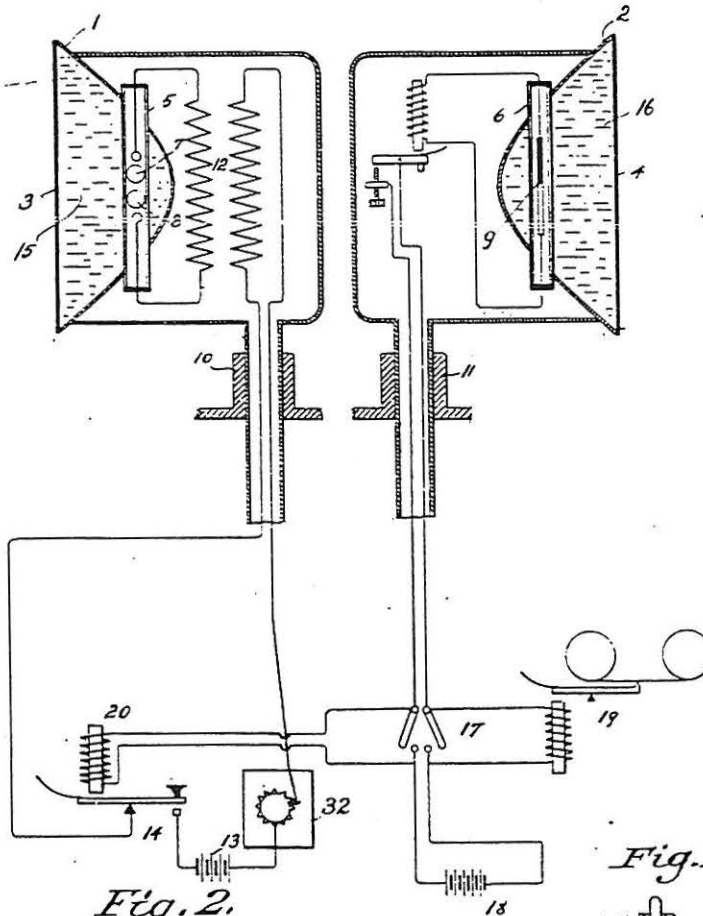
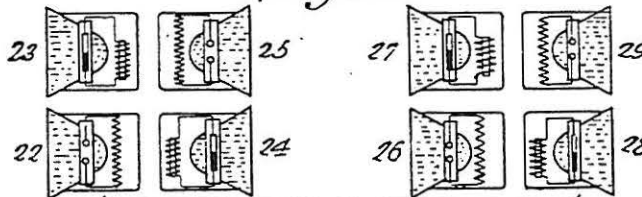


Fig. 1^a.



Fig. 2.



WITNESSES:

Jesse C. Best
Fritz P. Knechtel

INVENTOR.

Rogers A. Fessenden

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF WASHINGTON, DISTRICT OF COLUMBIA.

WIRELESS TELEGRAPHY.

974,762.

Specification of Letters Patent.

Patented Nov. 1, 1910.

Application filed January 14, 1907. Serial No. 352,212.

To all whom it may concern:

Be it known that I, REGINALD A. FESSENDEN, citizen of the United States, and resident of Washington, in the District of Columbia, have invented certain new and useful Improvements in Wireless Telegraphy, of which the following is a specification.

My invention relates to methods of relaying wireless telegraph messages, and more particularly to projectors for transmitting wireless messages in one direction.

In the accompanying drawings forming a part of this specification Figure 1 shows apparatus for carrying out my invention. Fig. 1^a shows the construction of a part. Fig. 2 shows the method of arranging the apparatus at different stations.

The object of the present invention is to permit of the relaying of wireless messages and for the operation by wireless telegraphy of a series of interconnecting stations such as is used on railway lines.

In Fig. 1, 1 and 2 are projectors preferably filled with a liquid of high specific inductive capacity 15, 16 such as water. 3 and 4 are hard rubber disks for retaining the water. Means for controlling the expansion of the water, etc., are not shown being obvious mechanical expedients. 5 and 6 are hard rubber tubes, 5 containing radiating conductors, including a discharge gap, 7 and 8, and 6 containing a receiver such as thermo-electric couple 9. 10 and 11 are swiveling supports for enabling the projectors to be turned in any direction. 12 is a transformer or induction coil. 13 is a source of voltage, 14 is a key. On depressing the key 14 sparks pass between the radiating conductors at 7 and 8 and electromagnetic waves issue from the projector. The presence of the medium 15, 16 causes a very intense emission of waves and also causes long waves to be transmitted in a straight line, as the wave length increases on passing out of the medium.

Any suitable means of generating the electromagnetic waves may be used as I do not confine myself to the method here shown. The insulating tube 5 may be filled with any desired gas and the composition of the discharge terminals suitably varied. For example with nitrogen gas I have found magnesium or alloys of magnesium and aluminum suitable for the terminals. Also alloys of aluminum or magnesium or zinc

of a receiver and a generator of electromagnetic waves, and automatic means to retransmit effects from one to the other, and a shield for protecting each of said apparatuses from the other, and means to shorten the wave length in the immediate vicinity of the receiver and generator.

with metallic calcium or as the wick for a wick electrode as at 7^a in Fig. 1^a. Pure iridium may be used for one electrode with advantage preferably in the form of a thin water cooled sheet. A calcium alloy may be used for the other electrode. These alloys are also efficient with other gases besides nitrogen. The receiver may also be used in a compressed gas. A wave chute may be applied to the edge of the projector.

17 is a switch, 18 a source of current as a local battery, 19 a recorder and 20 a relay magnet. On the receipt of waves by the receiver 9, the recorder operates, and the relay magnet 20 depresses the key 14 and causes the message to be retransmitted by the sending conductors 7 and 8. The projectors are made of metal, and as they face in opposite directions and the receiving and transmitting apparatus are inclosed in a metal sheath, they do not affect each other except through the relay magnet. Fig. 2 shows two stations equipped in this manner.

22, 23, 26, 29 show sending projectors and 23, 24, 27, 28 show receiving projectors. A message received on the receiver 23 is relayed and transmitted by the sending projector 25. It is again received by the receiving projector 27 and retransmitted by the sending projector 29 and so on.

What I claim is:

1. In wireless signaling the combination of a receiving apparatus and a transmitting apparatus, means for shielding the receiving apparatus from the action of the sending apparatus during the simultaneous operation of the sending and receiving apparatus, said means comprising a focusing device for receiving the waves and a focusing device for emitting the waves, both focusing devices being filled with a medium having a higher dielectric constant than air, so that the waves as emitted and received are of much shorter wave length than when traversing the space between the stations.

2. In wireless signaling, the combination of a receiving apparatus and sending apparatus and a relay for retransmission from one to the other, of shields protecting one apparatus from the action of the other during simultaneous operation of the two, said protecting means being adapted to change the wave length when, in the immediate neighborhood of the receiver and sender.

3. In wireless signaling, the combination

Signed at Brant Rock in the county of Plymouth and State of Massachusetts this 12th day of January A. D. 1907.

REGINALD A. FESSENDEN.

Witnesses:

JESSIE E. BENT,
ADELEINE WOLCOTT.

R. A. FESSENDEN.
METHOD OF AND APPARATUS FOR REPRODUCING IMPULSES.
APPLICATION FILED FEB. 9, 1914.

1,133,435.

Patented Mar. 30, 1915.

2 SHEETS—SHEET 1.

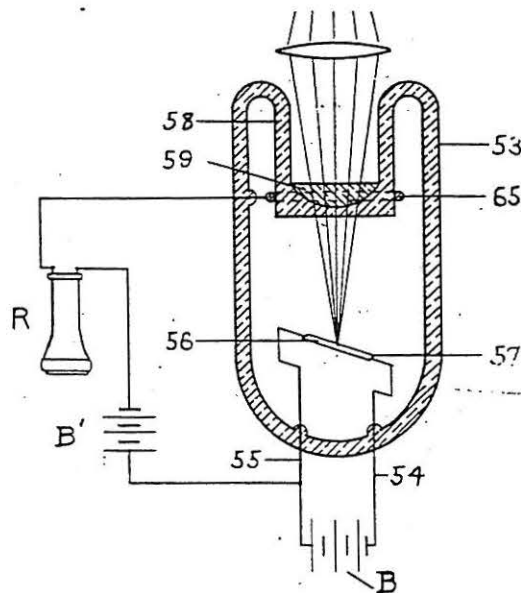


FIG. 1.

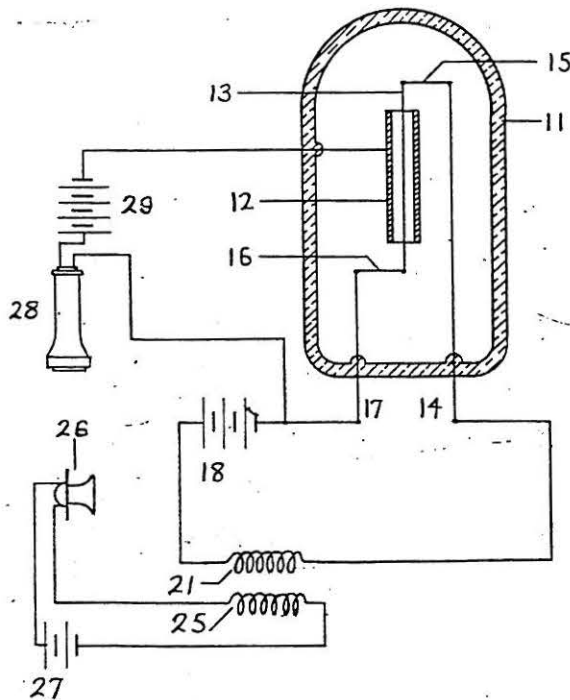


FIG. 2.

WITNESSES:
Patrick J. Conroy
E. B. Dombrowski

INVENTOR
Reginald A. Fessenden
BY *Brown & Woodworth*
ATTORNEYS

R. A. FESSENDEN.
METHOD OF AND APPARATUS FOR REPRODUCING IMPULSES.
APPLICATION FILED FEB. 9, 1914.

1,188,485.

Patented Mar. 30, 1915
3 SHEETS—SHEET 2.

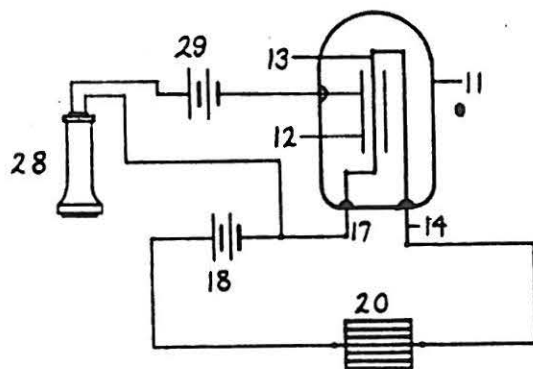


FIG. 3

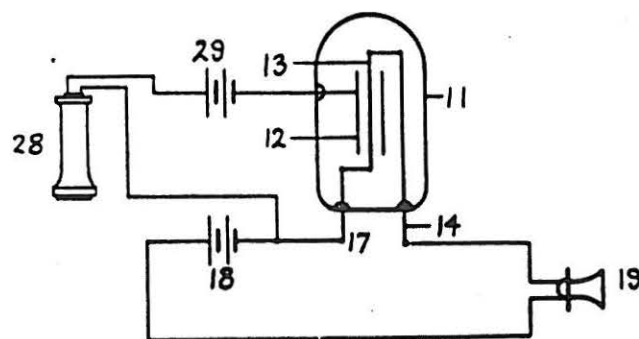


FIG. 4

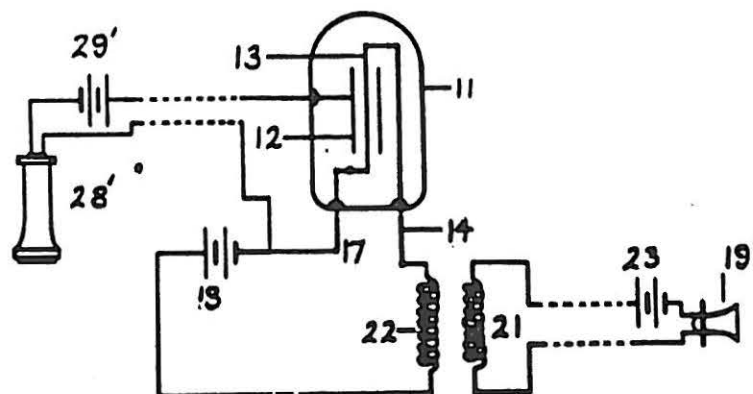


FIG. 5

WITNESSES:
Arthur J. Emery
E. W. Tomlinson

INVENTOR
Reginald A. Fessenden
BY
James W. Fessenden
ATTORNEY.

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF BROOKLINE, MASSACHUSETTS.

METHOD OF AND APPARATUS FOR REPRODUCING IMPULSES.

1,133,435.

Specification of Letters Patent.

Patented Mar. 30, 1915.

Application filed February 9, 1914. Serial No. 817,453.

To all whom it may concern:

Be it known that I, REGINALD A. FESSENDEN, a citizen of the United States, and a resident of Brookline, in the county of Norfolk and State of Massachusetts, have invented a new and useful Improvement in Methods of and Apparatus for Reproducing Impulses, of which the following is a specification.

My invention relates to the reproduction, therewith or without amplification and with or without change of form, of impulses, such for example, as sound impulses, electrical impulses, et cetera, and, although obviously of more general application, it may be used to reproduce and also to amplify by means of light and heat phonographically recorded sounds.

My method, broadly speaking, is based upon the fact, as more fully explained by me in a paper printed in the *Atrophysical Journal* for December, 1906, that if the cathode of a vacuum tube be heated, negative electricity is emitted therefrom. I have found that if the temperature of said cathode be varied, similar variations of considerable amplitude will be created in the electrical current flowing in a circuit, the terminals of which are connected respectively to the anode and cathode of said tube; and I have found also that when such temperature variations are made in accordance with impulses of light, heat, electricity, et cetera, the sounds reproduced by an electroresponsive device in series with said anode and cathode, may, by suitably proportioning the tubes and electrodes, be made to vary in accordance with the original sounds initiating such impulses of light, heat, electricity et cetera.

The drawings which accompany and form a part of this specification illustrate several forms of apparatus and arrangements of circuits whereby my improved method may be realized in practice; but my invention is broader than the particular apparatus shown, and may be practiced with a variety of devices and systems of circuits.

In the drawing, Figure 1 is a sectional view of a vacuum tube with its associated circuits shown in diagram, constructed and arranged in accordance with one embodiment of my invention. Fig. 2 is a similar view of a modification. Figs. 3, 4 and 5 are

diagrammatic views of other modifications of the system shown in Fig. 2.

In the particular drawings selected to illustrate the principle of my invention, 53 is a tube into which is sealed a smaller tube 58, flattened and polished to a plane surface at its lower end on its under side and rough-ground on its upper side. A piece of optical glass 59 having its upper surface plane and polished, is inserted as shown in the tube 58, and a suitable fluid such as Canada balsam is used to fill the space between the rough-ground or unground upper surface of the tube 58 and the lower surface of the glass piece 59. The tube 50 formed is then evacuated and constitutes a vacuum tube having a true optical window. While it will be understood that I do not limit myself specifically to this way of producing a vacuum tube having a true optical window, nevertheless I have found this procedure convenient for overcoming the difficulty that has heretofore existed in making such devices. Platinum wires 51, 55 are sealed into the tube and carry between them, preferably on a slant as shown, a conducting member, such for example as a piece of platinum foil 57, which may be provided with a thin coating 56 of a salt of calcium or barium, or other substance which has the property of readily giving out electrons when heated. The platinum foil constitutes one electrode of the vacuum tube, and the ring 65, which may also be of platinum, the other. The platinum foil 57 being heated by current from a suitable source of energy such as the battery B, a small current flows through the vacuum tube and through the external circuit, which includes the electroresponsive device R, herein shown as a telephone receiver, and the source of electrical energy B', herein shown as a battery, and which has its terminals connected with the electrodes of the vacuum tube.

The operation is as follows: When light is focused upon the platinum foil 57, the current flow through the tube and external circuit increases greatly and to an extent depending upon the amount of the light. Inasmuch as the current in the vacuum tube and external circuit varies in accordance with such variation in light and as the indication produced by the receiver R varies according to the current flowing through the same, said receiver will reproduce a phono-

60

65

70

75

80

85

90

95

100

105

110

graphic record, and if sufficient light is used, will amplify the same, if the light be caused to vary in accordance with said record in the manner shown in my application Serial No. 635,362, filed June 26, 1911, or in any other suitable manner.

In Fig. 2, 11 represents a vacuum tube, in which is located an anode 12 of conducting material, which wholly or partly surrounds the cathode 13 and preferably is in the form of a tube of any convenient diameter, but preferably relatively small, such for example, as one millimeter in diameter, although it may be as large as one inch in diameter. The conductors 14, 17 are sealed into the vacuum tube and support the cathode 13, preferably by means of spring portions 15, 16, to maintain the cathode in its proper position under very light tension. The cathode is shown in the present instance as consisting of a strip of very fine wire or foil of any suitable cathode material, such for example as tungsten, platinum, molybdenum, or the like, and the anode may be of the same or different material. A suitable source of electrical energy, such as the battery 18, is employed to heat the cathode to the desired temperature and such temperature may be varied by varying the current in the circuit containing the cathode by any suitable current-varying device, such, for example, as the telephone transmitter 20, which is inductively associated with the cathode circuit by means of the transformer 21, 25, and which is serially connected with a suitable source of electrical energy such as the battery 27; or by means of the telephone transmitter 19 in series with the cathode, as shown in Fig. 4; or by means of a bolometer or selenium cell 20 as shown in Fig. 3. By speaking into either transmitter, or by causing radiation such as light or heat to change the resistance of the device 20, current variations are produced in the circuit of the cathode and the temperature of the latter is varied, and such variations in temperature will be in accordance with the variations of the impulses of sound, light, or heat employed to vary the resistance of the telephone transmitter, selenium cell, or bolometer, respectively.

When the temperature of the cathode is varied in any of the ways above described, or in any other suitable way, the current flowing in the circuit containing the electro-responsive device 28, source of electrical energy, such as the battery 29, the anode 12, and the cathode 13, will be correspondingly varied and the electroresponsive device will reproduce such variations. It is desirable that the cathode should have small heat capacity so that it will respond to frequencies as high as those of the human voice, and it is also desirable to employ a tubular anode to conserve the heat developed by the pas-

sage of the current through the cathode, because thereby less energy is required to produce a given fluctuation in temperature, and the device is more responsive to rapid current variations. It will be understood of course that the impulse reproducing and amplifying device herein described is capable of use in many other relations, where it is desirable to amplify feeble electrical impulses, such for example, as those produced in telephone circuits, or in the production of alternating currents from direct currents, and it is especially useful as a telephone relay or repeater, in which relation it will require none of the more or less complicated circuitual arrangements to prevent "back-talking" or "howling." An example of the use of my invention as a telephone repeater is shown in Fig. 5, where 19' represents a telephone transmitter at one station and 28' a telephone receiver at a distant station, the vacuum tube and its associated circuits being located at a point intermediate of said stations. In this case, a battery 28 is serially connected with the transmitter 19' and the primary 21, and the cathode circuit includes the secondary 22 inductively connected with said primary, while the receiver 28' is connected in series with the battery 29' and the anode and cathode.

I claim:

1. The method of reproducing impulses which consists in heating the cathode of a vacuum tube, thereby establishing an electrical current in a circuit which includes the electrodes of said tube and an electroresponsive device, varying the temperature of said cathode by means of the impulses to be reproduced, thereby creating variations in the current established in said circuit, and causing said current variations to actuate said electro-responsive device, thereby reproducing said impulses.

2. In a device for reproducing impulses, a vacuum tube, a tubular anode therein, a cathode located within said anode, electrical means for heating said cathode, impulse-actuated means for varying the temperature of said cathode, a circuit including said anode and cathode, and a device in said circuit responsive to the changes of current resulting from such temperature variations.

3. In a device for reproducing impulses, a vacuum tube, a tubular anode, a cathode located within said anode, means for varying the temperature of said cathode in accordance with the impulses to be reproduced, a circuit including said anode and cathode, and a device and source of electrical energy associated with said circuit responsive to the changes of current resulting from such temperature variations.

4. In a device for reproducing impulses, a vacuum tube, a tubular anode therein, a cathode located within said anode, said cath-

ode having small heat capacity, electrical means for heating said cathode, a circuit including said anode and cathode, impulse-actuated means for varying the temperature of said cathode and a device in said circuit responsive to the changes of current resulting from such temperature variations.

5. In a device for reproducing impulses, a vacuum tube, a tubular anode, a cathode located within said anode, said cathode having small heat capacity, means for varying the temperature of said cathode in accordance with the impulses to be reproduced, a circuit including said anode and cathode and a device responsive to the changes of current resulting from such temperature variations and a source of electrical energy associated with said circuit.

6. In a device for reproducing impulses, a vacuum tube, a tubular anode therein, a cathode located within said anode, said cathode having small heat capacity, electrical means for heating said cathode, a circuit including said anode and cathode, impulse-actuated means for varying the temperature of said cathode, a device in said circuit responsive to the changes of current resulting from such temperature variations and a source of electrical energy in said circuit.

In testimony whereof, I have hereunto subscribed my name this 7th day of February, 1914.

REGINALD A. FESSENDEN.

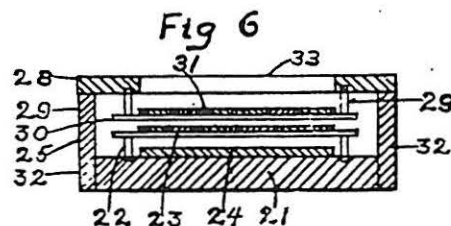
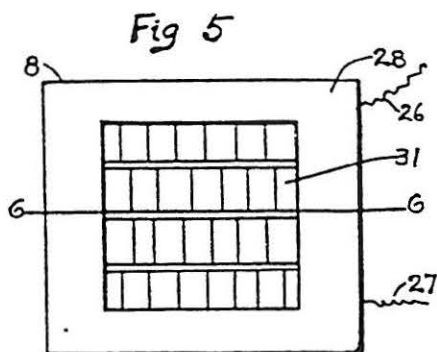
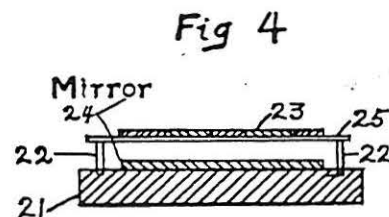
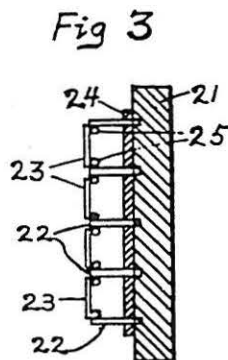
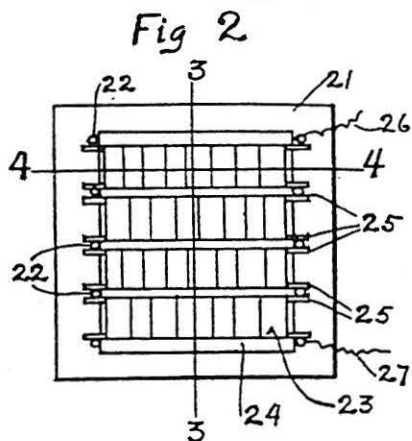
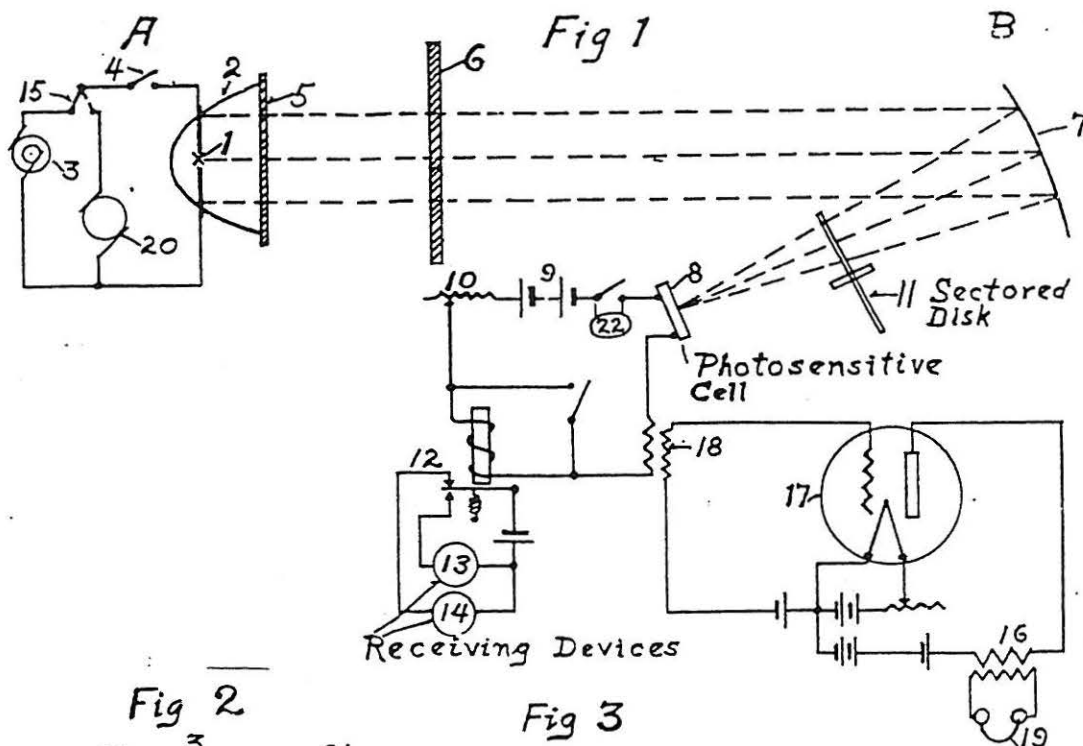
Witnesses:

GEO. K. WOODWORTH,
E. B. TOMLINSON.

W. W. COBLENTZ.
RADIOPHONE.
APPLICATION FILED OCT. 8, 1919.

1,345,586.

Patented July 6, 1920.



Inventor
W. W. Coblentz

UNITED STATES PATENT OFFICE.

WILLIAM W. COBLENTZ, OF WASHINGTON, DISTRICT OF COLUMBIA.

RADIOPHONE.

1,345,586.

Specification of Letters Patent.

Patented July 6, 1920.

Application filed October 8, 1919. Serial No. 329 365.

(FILED UNDER THE ACT OF MARCH 3, 1883. 22 STAT. L., 625.)

To all whom it may concern:

Be it known that I, WILLIAM W. COBLENTZ, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Radiophones, of which the following is a specification.

This application is made under the act of March 3, 1883, chapter 143, (U. S. Statute XXII, page 625), and the invention herein described and claimed may be used by the Government of the United States, or any of its officers or employees in the prosecution of work for the United States, or by any person in the United States without the payment of any royalty thereon.

The object of my invention is to provide a device whereby thermal radiant energy, especially infra-red or so-called heat rays, may be utilized as a means of communication.

Another object of my invention is to provide a means of varying the strength of the current in a charged electrical conductor by exposing my device to heat and light rays.

A further object of my invention is to provide an instrument of this nature which, although it is compact in form and rigid in construction, will be so sensitive to heat rays that it may be used to advantage in the most refined physical experiments.

It is well known that when selenium is exposed to light rays, its electrical conductivity is greatly increased; and this property has been utilized in a great many inventions. Such a substance is said to be photoelectrically sensitive. In the case of selenium, its sensitivity is confined practically to the visible rays. Moreover, its temperature co-efficient of resistance is negative so that a rise in temperature caused by absorption of radiant energy has the same effect as that produced by light rays in changing the electrical resistance.

I have found that the mineral, molybdenite, which is a sulfid of molybdenum (MoS_2) is very sensitive photoelectrically, so that its resistance is greatly decreased on exposure to radiant energy, especially when exposed to infra-red rays. In this respect, it differs greatly from selenium. Further, its temperature coefficient of electrical re-

sistance is negative so that the rise in temperature which results when it is exposed to heat rays also tends to decrease the electrical resistance.

Unlike selenium, the photoelectric action is quick in its response. Furthermore, I have found that the thin lamina of this substance can be soldered directly to copper wires by means of ordinary solder which insures good contact, thus eliminating the noise in the telephone which results from the fluctuations of the electric current caused by poor contacts between the photo-sensitive mineral and the metal electrodes.

A further useful physical property which I have found is that the photoelectric effect produced is an additive phenomenon, directly proportional to the area exposed. For example, maintaining the same electric current through the receivers, if the area of the receiving surface be doubled, the photoelectric current produced is doubled when the receiver is exposed to radiation. The utilization of this additive property enables one to produce a large photoelectric current by building up a large receiver as set forth in the herein described invention.

The foregoing physical properties are utilized in the device of my invention, producing the result that very small changes in electrical current may be distinguished by means of a galvanometer, telephone or other suitable indicating device in the circuit.

The photoelectric current may be amplified by means of an audion amplifier or by other well known devices recently invented.

Other objects of this invention will be apparent from the detailed description and from the drawings, in which—

Figure 1 represents diagrammatically an arrangement including my device, and suitable well known auxiliary apparatus which may be used in signaling, or for detecting the passage of a movable object between two given points.

Fig. 2 is a top plan view of one form of the receiving device of my invention.

Figs. 3 and 4 are sectional views taken on the lines 3—3 and 4—4 respectively of the embodiment illustrated in Fig. 2.

Fig. 5 is a top plan view of a modified form of receiving device; and

Fig. 6 is a sectional view taken on the line 6—6 of Fig. 5.

Similar reference characters refer to similar parts in all these figures.

Referring to Fig. 1, A represents a transmitting station consisting of a projector or reflector 2 containing any suitable source 1 of radiant energy, *e. g.*, a concentrated filament tungsten lamp or a carbon arc lamp supplied through switches 15 and 4 from a suitable source of energy as a source of direct current 20, or of alternating current 3. The arc lamp may be combined with suitable inductance and capacity to produce the so-called audible or speaking arc (see, for example, the patent to Hayes and Crani, No. 654,630, dated July 31, 1900), or a manometric flame may be used. If it is desired to employ invisible infra-red rays for secret signaling or for detecting the passage of a movable object across the path of an invisible beam of rays, the front of the reflector 1 is covered by means of a suitable screen 5 which absorbs the visible rays and transmits the invisible infra-red rays, *e. g.*, a deep ruby glass, or a gelatin film containing a suitable dye or asphaltum varnish.

At the receiving station, B, a suitable mirror 7 is used to concentrate the projected radiant energy upon the receiving device or detector 8 of my invention. This detector is connected in circuit with an adjustable resistance 10, electric battery 9, and a suitable current indicator 22, or a suitable relay 12, or an amplifier 17. Although any suitable amplifier may be used, I have here shown one of the thermionic type, having its input circuit coupled to the circuit of receiver 8 by a coupling coil 18 and its output circuit coupled to a pair of telephone receivers 19 by a coupling coil 16. The relay 12 may control a local circuit containing a receiving device or an indicator 13 which is energized when no radiant energy falls on detector 8, or may control a local circuit containing a device 14 which is energized when radiant energy falls on detector 8, or as shown, the relay 12 may have two sets of contacts and control both devices 13 and 14.

If the intensity of the source of radiation, 1, fluctuates periodically with a frequency within the range of audibility, for example, by using a "hissing" or "speaking" arc, or by using an alternating current to supply the source 1, the current through the receiver 8 will vary as a result of the fluctuation in intensity of the incident radiant energy, and a musical note of the same frequency will be produced in the telephone receivers 19. Such musical note may also be produced, when the source 1 does not fluctuate in intensity, by interposing at any point in the path of the projected beam of

radiant energy a rotating sectored disk 11, but because such a disk as ordinarily used will obstruct half of the rays, thus reducing the sensitivity by one half, it is desirable to vary the intensity at the transmitting station in the manner first described.

The system thus far described may be used for the transmission of signals by code by emitting long and short pulses of radiant energy, each of which will actuate the device 14 or the receiver 19, as desired. The emission at the transmitting station A may be controlled by the switch or key 4, or the source 1 may radiate continuously and the effective emission be controlled by interposing an opaque object, as 6, in the path of the emitted rays. This latter method of control immediately suggests the use of the system to detect the passage of an object between the stations A and B across the line joining them. If radiant energy is passing from A to B and an opaque object 6, as a ship, the periscope of a submarine or any other object, comes into the path of the projected rays, they are cut off and the indicator 13 will be actuated, as is obvious, or if the beam of radiant energy is fluctuating periodically, the indicator 13 will be actuated, or the musical note in the receiver 19 will cease so long as the opaque object remains in the path of the projected rays. As invisible infra-red rays may be used, this communication, or detection, may be carried on in secret.

Referring to Figs. 2, 3 and 4 which show in detail the construction of one form of the receiving device or detector 8 of Fig. 1, 21 is a support of any suitable insulating material; 22 are metal posts secured in this material; suitable conducting leads or wires, *e. g.*, copper, 25, are soldered to these posts 22; the thin laminae (say 0.15 mm. in thickness) of molybdenite 23 are soldered directly to the wires 25; and the lead wires 26 and 27 complete the circuit. It is, of course, to be understood that in building up a receiving surface from individual laminae of molybdenite, the number of pieces in a row and the number of rows (units) will be determined by the size of the material available and the surface required to obtain the sensitivity desired.

Furthermore, the manner of connecting these units, whether in series or in parallel, will be determined by the nature of the application of the device in practice, in connection with the auxiliary receiving apparatus to be employed in a given case.

Although I have mentioned that thin laminae 23 of molybdenite are used, this is not necessary, as thick pieces of material can also be used.

Figs. 3 and 4 are side and end view sections of the device shown in Fig. 2, showing a suitable mirror 24 for reflecting back any

of the rays which may be transmitted by the molybdenite.

Fig. 5 is a top view of a modified form of the receiving device 8 of Fig. 1, in which the top insulating support 28 is perforated by an opening 33 of sufficient size to expose the sensitive receiving surface 31, composed of a plurality of laminae of molybdenite, to the incident radiations.

Fig. 6, which is a sectional view of Fig. 5, shows the complete embodiment of my invention, assembled as it would be used to best advantage in actual practice so as to utilize to the maximum efficiency all the radiation falling upon the receiver. In this form, the construction of the parts 21, 22, 23, 24, 25, 26 and 27 is identical with that of the parts designated by the same numerals in Figs. 2, 3 and 4. In the form shown in Figs. 5 and 6, a second sensitive surface 31, of laminae of molybdenite, is placed in front of the sensitive surface 23. The laminae 31 are soldered to leads 30, which are in turn soldered to posts 29 secured in the insulating top 28, which has an opening 33 to allow the radiant energy to fall on the sensitive surface 31. The member 28 is held spaced from the support 21 by suitable sides 32. In this form of receiver, the radiant energy which is transmitted by the layer 31 is available to affect the layer 23, and if the layer 23 transmits any energy, it is reflected by the mirror 24, so that this form of receiving device utilizes to the maximum efficiency all the incident radiation.

In the description of this invention, I have mentioned molybdenite as the active agent in causing a change (decrease) in electrical resistance in the circuit because it is the most active substance yet found. I have obtained good results by using gold leaf mounted in exactly the same manner as the molybdenite. The front surface of the gold leaf was smoked to absorb the incident radiations. Gold leaf is not sensitive photo-electrically, so that the change (increase) in electrical resistance in the circuit is due to the rise in temperature of the gold leaf caused by absorption of radiant energy. Its heat capacity is so small that the amplitude of the temperature (hence, resistance and electric current) change is sufficient to produce an audible sound in the telephone.

In some cases, it may be found desirable to inclose the photo-sensitive cell 8 in a casing having a suitable aperture transparent to the radiations to be detected, so that the whole cell may be maintained at a suitable low temperature by any well known means.

Having thus described my invention, I claim:

1. A resistance unit variable by the action of radiant energy comprising molybdenite.

2. A resistance unit comprising two

spaced metallic leads and a material whose resistance is changed by the action of radiant energy bridging the space between said leads and soldered thereto.

3. A resistance unit variable by the action of radiant energy comprising a body of molybdenite and metallic leads soldered thereto.

4. A resistance unit comprising a material whose resistance is variable by the action of radiant energy and circuit leads therefor, said material being capable of being soldered directly to said leads, whereby the contact resistance between said leads and said material is rendered constant.

5. A resistance unit for controlling the flow of electric current in the input circuit of a thermionic amplifier comprising molybdenite.

6. In a radiophone, a thermionic amplifier having input and output circuits, and means inductively coupled to said input circuit for varying the current in said input circuit by the action of infra-red thermal radiation.

7. In combination, a thermionic amplifier having input and output circuits, and means associated with said input circuit for varying the current in said input circuit by the action of infra-red thermal radiation, said means comprising molybdenite.

8. Means for detecting the passage of a movable object between two points comprising a source for providing an invisible beam of infra-red radiations located at one of said points, and a receiving device responsive to said radiations located at the other of said points, whereby upon interruption of said radiations by said object, said receiving device will indicate the presence of said object.

9. Means for detecting the passage of a movable object between two points as set forth in claim 8 in which the intensity of the beam of infra-red radiations is periodically varied with a frequency within the range of audibility, so that a musical note is produced in a telephone receiver associated with the receiving device.

10. A device for varying the current in an electrical circuit comprising two spaced layers of material sensitive to radiant energy.

11. A device for varying the current in an electrical circuit comprising two spaced layers of material sensitive to radiant energy, one of said layers comprising molybdenite.

12. A device for controlling the current in an electrical circuit comprising two spaced layers of molybdenite.

13. A device for varying the current in an electrical circuit comprising a layer of material sensitive to radiant energy and a mirror behind said layer for reflecting back

to said layer the energy transmitted by said layer.

14. A device for controlling the current in an electrical circuit comprising a layer of molybdenite, and a mirror spaced from said layer.

15. A device for varying the current in an electrical circuit comprising two spaced layers of material sensitive to radiant energy and a mirror spaced from one of said layers.

16. A device for varying the current in an electrical circuit comprising two spaced layers of material sensitive to radiant energy, one of said layers comprising molybdenite, and a mirror spaced from both of said layers.

17. A device for controlling the current in an electrical circuit comprising two spaced layers of molybdenite, and a mirror spaced from both of said layers.

18. In a resistance unit variable by the action of radiant energy, an insulating support, posts mounted in said support, spaced conducting leads soldered to said posts, and material whose resistance is changed by the action of radiant energy soldered between said leads.

19. In a resistance unit variable by the action of radiant energy, an insulating support, posts mounted in said support, spaced

conducting leads soldered to said posts, and molybdenite soldered between said leads.

20. A current controlling unit variable by the action of infra-red radiations including a photoelectrically sensitive surface of molybdenite, said surface comprising a plurality of laminae soldered to copper leads.

21. In a device for detecting the presence of infra-red radiations, an element comprising a layer of molybdenum sulfid (MoS_2).

22. A detector of radiant energy of wave length shorter than that of the shortest Hertzian waves comprising molybdenite.

23. An electron discharge device having an input circuit including an impedance-varying element and a circuit including a photo-sensitive cell inductively coupled to said input circuit.

24. The method of detecting the passage of an object across a given line which consists in casting a beam of invisible radiant energy along said line and observing the changes in said beam caused by the passage of said object.

25. In a signaling system, a source of invisible radiant energy, means for controlling a beam of said energy in accordance with signals and means for translating said signals comprising molybdenite.

WILLIAM W. COBLENTZ.

Oct. 23, 1923.

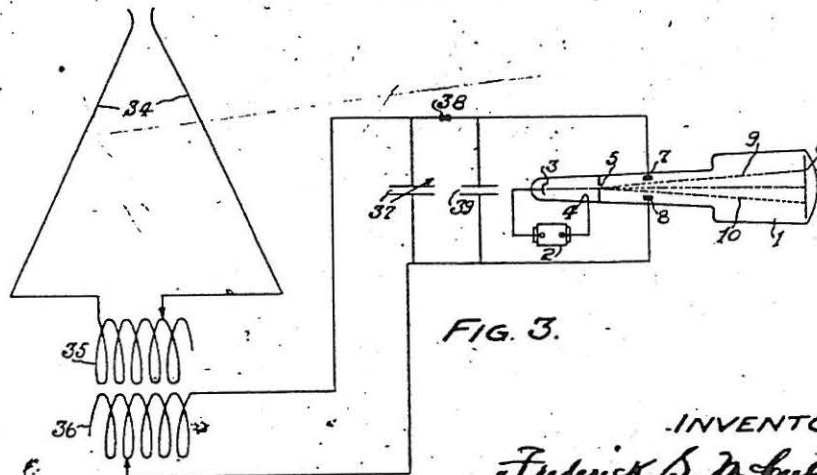
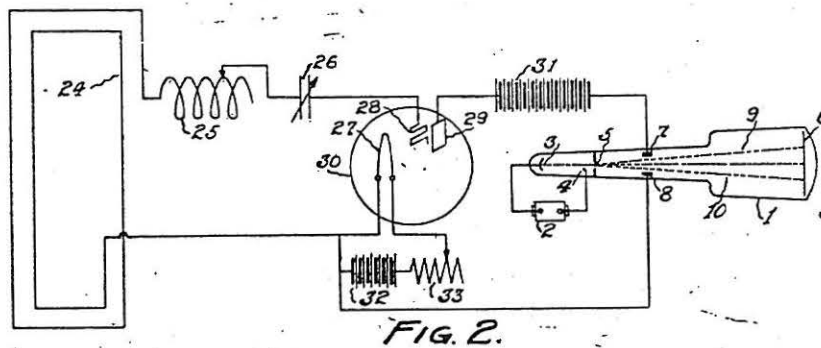
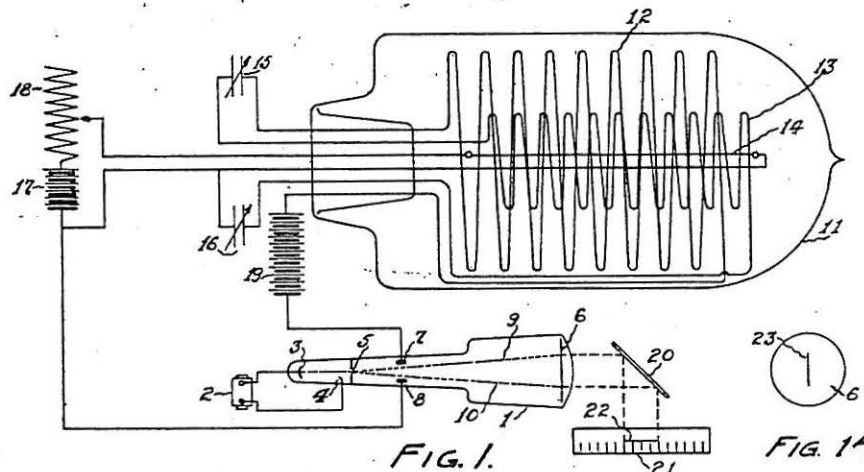
F. S. McCULLOUGH

1,471,406

RADIOTELEGRAPHY

Filed July 25, 1919

4 Sheets-Sheet 1



INVENTOR:

Frederick S. McCullough,

BY

Frederic, Merkel & Saywell,

ATTORNEY.

Oct. 23, 1923.

1,471,406

F. S. McCULLOUGH

RADIOTELEGRAPHY

Filed July 25, 1919

4 Sheets-Sheet 2

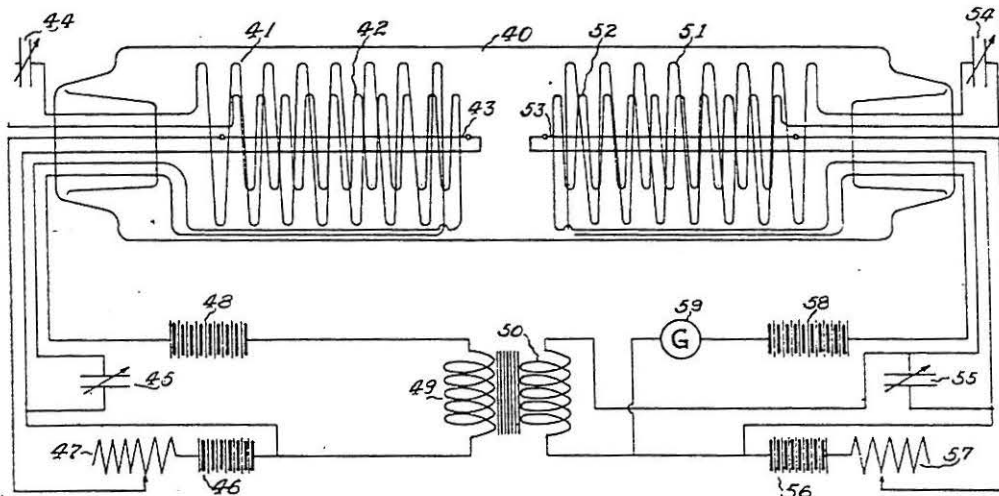


FIG. 4.

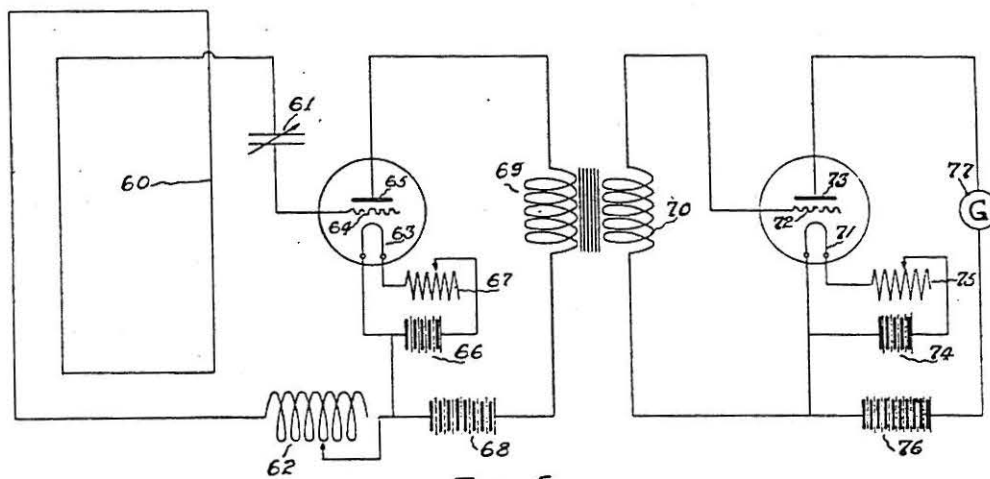


FIG. 5.

INVENTOR:

Frederick S. McCullough,

BY

Thorne, Mestel & Sargent,
ATTORNEYS.

Oct. 23, 1923.

F. S. McCULLOUGH

RADIOTELEGRAPHY

Filed July 25, 1919

1,471,406

4 Sheets-Sheet 3

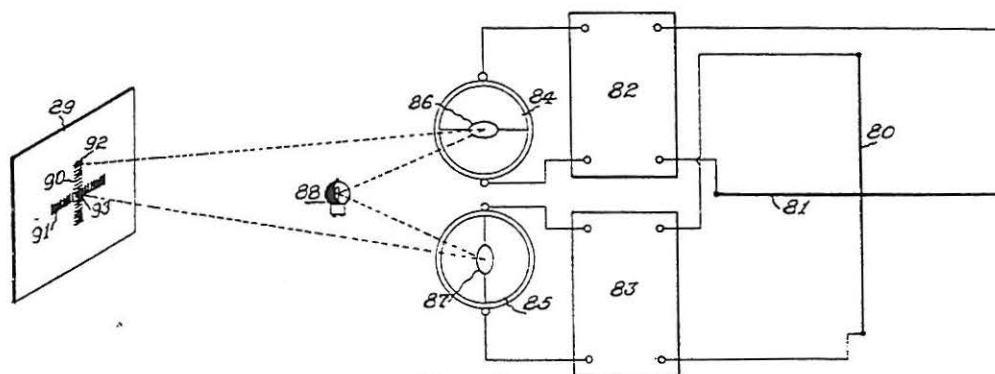


FIG. 6.

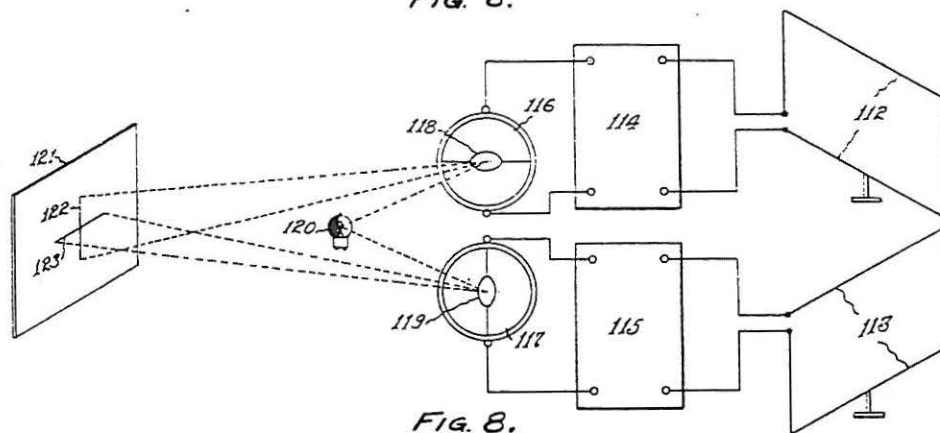


FIG. 8.

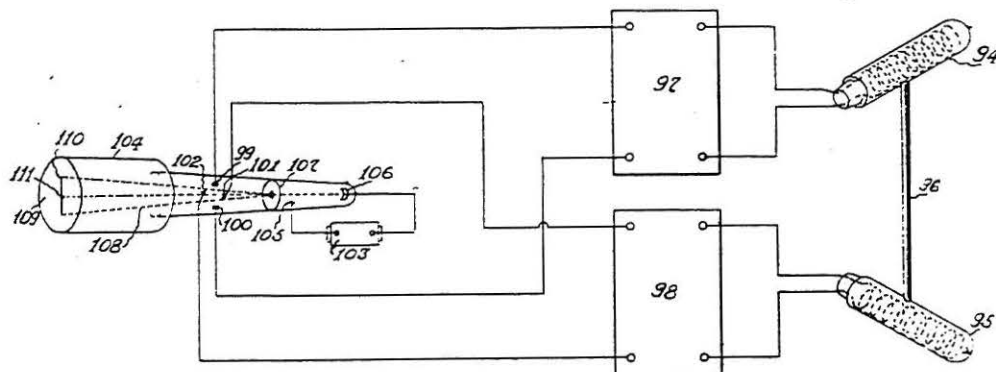


FIG. 7.

INVENTOR.
Frederick S. McCullough,
BY
Frederic M. Sigurd,
ATTORNEYS.

Oct. 23, 1923.

F. S. McCULLOUGH

1,471,406

RADIOTELEGRAPHY

Filed July 25, 1919

4 Sheets-Sheet 4

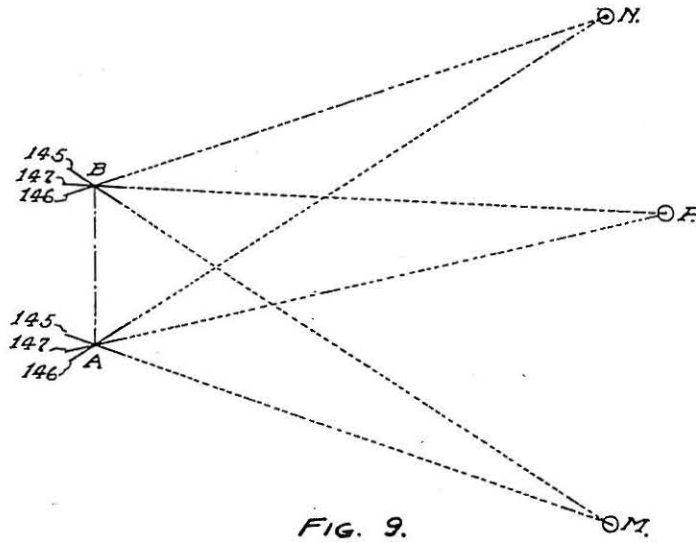


FIG. 9.

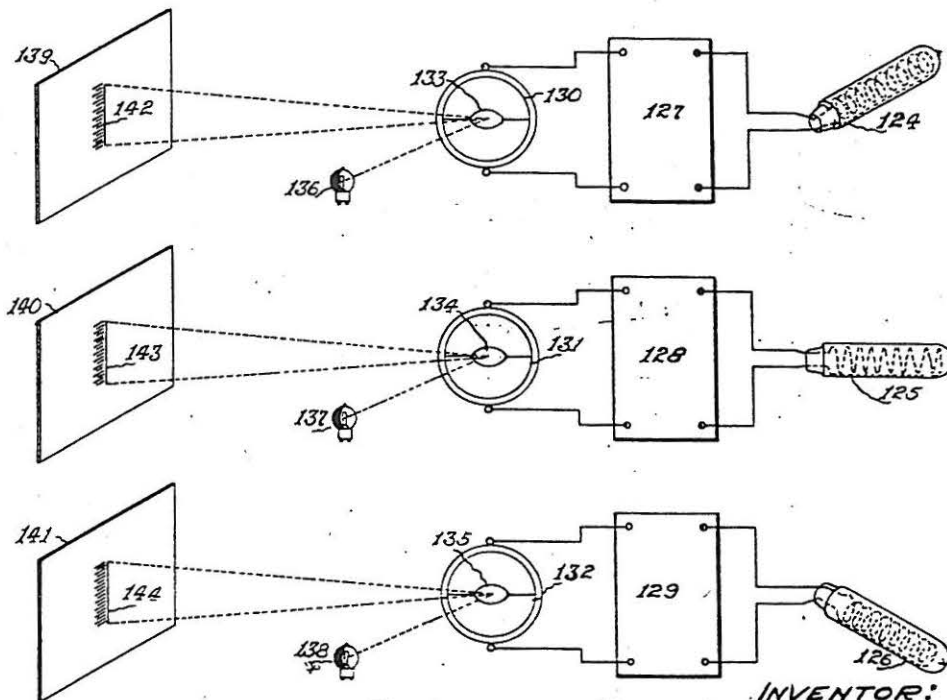


FIG. 10.

INVENTOR:
Frederick S. McCullough
BY
Freese, Markela, Saywell,
ATTORNEYS.

UNITED STATES PATENT OFFICE.

FREDERICK S. McCULLOUGH, OF CLEVELAND, OHIO, ASSIGNOR TO GLENN L. MARTIN, OF CLEVELAND, OHIO.

RADIOTELEGRAPHY.

Application filed July 25, 1919. Serial No. 313,161.

To all whom it may concern:

Be it known that I, FREDERICK S. McCULLOUGH, a citizen of the United States, resident of Cleveland, county of Cuyahoga, and State of Ohio, have invented new and useful Improvements in Radiotelegraphy, of which the following is a specification, the principle of the invention being herein explained and the best mode in which I have contemplated applying that principle, so as to distinguish it from other inventions.

My invention relates to systems of radio telegraphy and more particularly to systems for determining the direction of distant transmitting stations.

In the radio directional systems hitherto employed, the incoming electromagnetic waves have been received on antennae having special forms, generally in the shape of a closed loop, and the strength of the signals, with whatever form of detector that has been used, has been determined by the loudness of the sounds received in a telephone. This audible means of determining the direction of incoming radiant energy is more or less indefinite under any circumstances, and fails altogether where there are loud extraneous noises, as, for instance, on an aeroplane.

In view of these considerations, I have invented a system by which the strength of the received signals is shown visually, and the direction of maximum or minimum effect of the received electromagnetic waves, and hence the direction of the transmitting station, can be determined with great accuracy, and in spite of any amount of noise in the vicinity.

My invention also makes it easy to determine the direction of two or more distant transmitting stations simultaneously, and to determine the position of a moving receiving station, such as that on an aircraft or boat, at any moment.

The annexed drawings and the following description set forth in detail certain means embodying my invention, the disclosed means, however, constituting but one of various mechanical forms in which the principle of the invention may be employed.

In the accompanying drawings, which are largely diagrammatical, Figure 1 shows one form of my radio directional apparatus with cathode-ray tube indicating means.

Figure 1^a shows an end view of part of Figure 1.

Figure 2 shows a modified form of my invention, having a directional loop, with a vacuum-tube detector and a cathode-ray tube.

Figure 3 shows another modification of my invention, having a receiving antenna with a large loop, with a crystal detector and a cathode-ray tube.

Figure 4 shows a modification of my system, with means for amplifying the received oscillations, and with a sensitive galvanometer.

Figure 5 shows a modification of my system with a loop antenna, means for amplifying the received oscillations, and a galvanometer.

Figure 6 shows a modified form of my system, with two directional loop antennae.

Figure 7 shows a modification of my system, with two directional tube units.

Figure 8 shows a modified form of my invention for determining the direction of two transmitting stations simultaneously.

Figure 9 shows, diagrammatically, a method for determining the instantaneous position of a moving body, such as an aircraft or boat.

Figure 10 shows a modified form of my invention for determining the direction of three transmitting stations simultaneously.

In Figure 1, 1 is a cathode-ray tube; 2 is an induction or spark coil; 3 is a cathode, and 4 is an anode, both inside the tube and connected with the spark coil; rays are given off by the cathode, and are intercepted by the diaphragm 5, which permits only a beam or pencil of rays to pass through a small opening; 6 is a surface, such as a mica screen or other fluorescent surface, on which the beam of cathode rays impinges, making a bright spot when the beam is steady, and tracing a line of light when the beam moves. This screen is preferably transparent or translucent, so that the spot or line of light is visible on either side. This screen may have a scale marked on it, to measure the line of light. 7 and 8 are electrodes inside the tube and connected with the radio directional system; 9 and 10 are positions of the beam of cathode rays under the influence of electrodes 7 and 8; 11 is an evacuated tube; 12 is a directional coil

inside the evacuated tube; 13 is another directional coil inductively related to coil 12, with its axis parallel to, or coincident with that of 12, and also contained in the evacuated tube; 14 is a heated filament, or other source of ionization, also contained in the evacuated tube; 15 is a variable condenser connected with coils 12 and 13; 16 is a variable condenser connected with coil 13 and filament 14; 17 is a battery for heating filament 14; 18 is a variable resistance; and 19 is a battery for energizing the circuit containing the filament 14, coil 12 and the electrodes 7 and 8. 20 is a mirror, which reflects the spot or line of light from the surface or screen 6 to a scale 21, the line of light on the scale being shown at 22.

In Figure 1a, 6 is an end view of the screen in the cathode-ray tube, on which is shown a line of light, 23, formed when the beam of rays moves.

In Figure 2, 1 to 10, inclusive, are elements similar to those having the same numbers in Figure 1; 24 is a closed loop antenna; 25 is a variable inductance; and 26 is a variable condenser. The loop should have such characteristics and the electrical quantities of the circuits should have such values as will give the best results in each case. 27 is a filament; 28 is a grid and 29 is a plate, all three contained in a vacuum tube 30. 31 is the battery for the plate circuit; 32 is the battery for heating the filament 27; and 33 is a variable resistance in the filament circuit.

In Figure 3, 1 to 10, inclusive, are elements similar to those having the same numbers in Figures 1 and 2. 34 is a large directional antenna; 35 is the primary of an oscillation transformer, of which 36 is the secondary; 37 is a variable condenser in the secondary receiving circuit; 38, as shown, is a detector of the crystal type, but it may be a detector of any other suitable kind; 39 is a condenser.

In Figures 1, 2 and 3, instead of having the screen 6, the cathode rays may impinge upon the end surface of the tube as shown in Figure 7.

In Figure 4, 40 is an evacuated tube, 41 is a directional coil inside the tube, of the type shown in Figure 1; 42 is another directional coil inductively related to coil 41, with its axis parallel to, or coincident with that of 41, and also contained in the tube; 43 is a filament which can be heated, or other source of ionization; 44 is a variable condenser connected with coils 41 and 42; 45 is a variable condenser connected with coil 42 and filament 43; 46 is a battery for heating filament 43; 47 is a variable resistance for regulating the current in filament 43; 48 is a battery for energizing the circuit containing coil 41, filament 43 and the primary 49, of a transformer. 50 is the secondary of this

transformer. 51 and 52 are coils and 53 is a filament, or other source of ionization, contained in the tube 40, and similar, respectively, to coils 41 and 42 and filament 43. 54 and 55 are variable condensers. 56 is a battery and 57 a variable resistance, in circuit with filament 53. 58 is a battery for energizing the circuit containing coil 51, filament 53, and galvanometer 59, which latter indicates the strength of the received signals after amplification by the above-described system.

In Figure 5, 60 is a directional loop antenna; 61 is a variable condenser and 62 is a variable inductance. 63 is a filament; 64 is a grid; and 65 is a plate, all three contained in a vacuum tube or bulb; 66 is a battery for heating the filament 63; 67 is a resistance for regulating the current passing through the filament; 68 is a battery for supplying current to the plate circuit, which also comprises the primary, 69, of a transformer, the secondary of which is 70. 71 is a filament; 72 is a grid, and 73 a plate, all three contained in a vacuum tube. 74 is a battery for heating the filament 71, and 75 is a variable resistance for regulating the current through the filament. 76 is a battery in circuit with the filament 71, the plate 73, and the galvanometer 77, which latter indicates the strength of the received signals after amplification by the above receiving system.

In Figure 6, 80 and 81 represent directional loop antennae, whose position relative to each other is adjustable, but which are here shown at right angles to each other. Precautions should be taken to avoid mutual interference. 82 and 83 represent radio receiving apparatus such, for instance, as shown in Figures 1 to 5, but the details of which are omitted here for the sake of convenience. 84 and 85 are sensitive galvanometers of any suitable type. 86 and 87 are mirrors attached to the moving or indicating part of the galvanometers, 86 being shown with a horizontal suspension and 87 with a vertical suspension, for purposes of illustration. 88 is a light, or source of illumination, of any convenient kind, the reflections of which from the galvanometer mirrors indicate their movements. 89 is a screen on which the reflections of the light 88 are thrown. 90 and 91 are scales marked on the screen and here shown at right angles to each other; but the angle between these scales may be any found most suitable. 92 and 93 are spots of light, being the reflections of the light 88 from the galvanometer mirrors. When both mirrors are in their normal positions, that is to say, when no current is passing through the galvanometers, the spots of light will be at the zero point at the intersection of the scales, but when current flows through one or both

galvanometers, the spot of light corresponding to that galvanometer, will move away from the zero point along its respective scale. In this figure, the spot of light 92 from the galvanometer mirror 86 is shown at some distance from the zero point, while the spot of light 93 from the galvanometer mirror 87 is shown at the zero point.

In Figure 7, 94 and 95 are directional tube units on my system; 96 is an element, such as a rod, connecting these two tubes, by which they can be turned in any desired direction. The tubes can be set at any desired angle with each other, but are here shown at right angles. They should be far enough apart to avoid mutual interference. 97 and 98 represent radio receiving apparatus such, for instance, as shown in Figures 1 and 4. 99, 100, 101 and 102 are electrodes in a cathode-ray tube connected in pairs with the radio receiving apparatus 97 and 98. 103 is an induction or spark coil. 104 is a cathode ray tube. 105 is an anode and 106 is a cathode in the tube and connected with the spark coil. 107 is a diaphragm with a small opening which permits a beam or pencil of cathode rays to pass through. 108 represents the cathode rays which have passed through the diaphragm opening. 109 is the end surface of the tube, composed of such material as will show a spot or line of light where the beam of cathode rays impinges. It may also be a screen, composed of mica or some other suitable material, as shown in Figures 1, 2 and 3. 110 is a line of light produced by the movement of the beam of cathode rays. 111 is the spot of light produced when the beam of rays is at rest in its normal position. The varying electrification of the electrodes 99, 100, 101 and 102, caused by the varying amounts of radiant energy effectively received by the directional tubes 94 and 95, cause the beam of cathode-rays to move in one direction or the other from its normal position and so vary the form and dimensions of the lines of light on the screen 109.

In Figure 8, 112 and 113 are directional loop antennae which can be moved independently of each other, and which are far enough apart to prevent disturbing mutual interference. 114 and 115 represent radio receiving apparatus connected, respectively, with the directional loops 112 and 113, and which may be of any suitable kind such, for instance, as shown in Figures 1 to 5 inclusive. 116 and 117 are sensitive galvanometers of any suitable type. 118 and 119 are mirrors attached to the needles or other moving parts of the galvanometers, and suspended so that spots of light reflected from them will travel in different paths when shown on the screen 121. 120 is a light or source of illumination of any suitable kind, which is reflected from the galvanometer

mirrors onto the screen 121. 122 and 123 represent lines of light caused by the rapid movement to and fro of the galvanometer mirrors 118 and 119, respectively. This movement of the galvanometer mirrors is caused by the electromagnetic waves received on the loop antennae 112 and 113, respectively, as modified by the radio receiving apparatus 114 and 115. I may also use types of galvanometers such as those used in Figure 6, which have a steady deflection instead of a rapid vibration of the movable members.

In Figure 9, M and N represent transmitting stations whose position on the chart or map is fixed. A and B represent different positions of a movable receiving station on an aircraft, or boat, or other moving body. 145 and 146 are directional loop antennae, directional tubes or other apparatus which receives varying amounts of radiant energy depending upon its direction with reference to the transmitting station. When the moving body is in position A, these direction finders are turned until one gets the maximum effect (or the minimum effect), from one transmitting station and the other gets the maximum effect (or the minimum effect), from the second transmitting station. The direction of the transmitting stations from the moving body is thus determined at any instant and the exact position of the moving body can be at once fixed on the chart or map if the compass bearing of at least one of the transmitting stations is also known. After any interval of time, observations can again be made, and a second position of the moving body, such as at B, can be fixed. The course A-B and the distance traveled can then be readily ascertained.

In cases where neither the magnetic nor gyroscopic compass can be relied upon, and where the heavenly bodies are obscured so that it is impossible to find the compass bearing of either of two transmitting stations, the position of the moving body can nevertheless be determined by getting the direction of a third transmitting station, such as P, whose position on the map is fixed. The direction of P is determined by means of a third direction finder, such as 147, similar to 145 and 146, which is turned until the maximum effect (or the minimum effect) is obtained from station P, and the latter's direction is then noted simultaneously with the directions of the other two stations M and N. The position of the receiving station can then be found by calculation or with suitable instruments. To ascertain conveniently and quickly the position of the receiving station on the map or chart, suitable mathematical tables and mechanical aids can be used.

Figure 10 shows a system for obtaining

the directions of three transmitting stations simultaneously. 124, 125 and 126 are directional tubes, but there may also be used directional loop antennæ, or other direction finders which can be moved independently of each other and are far enough apart to avoid disturbing mutual interference. 127, 128 and 129 represent radio receiving apparatus of any suitable type, such as shown, for instance, in Figures 1 to 5, inclusive. 130, 131 and 132 are sensitive galvanometers of any suitable type. 133, 134 and 135 are mirrors attached to the movable indicating parts of these galvanometers, respectively. 136, 137 and 138 are lights of any suitable type, to be reflected from the galvanometer mirrors onto the screens 139, 140 and 141, respectively. 142, 143 and 144 are lines of light produced by the movement of the galvanometer mirrors, the extent of the deflection of the galvanometer mirrors being shown by scales on the screens. Instead of a line of light as here shown, caused by the rapid to and fro motion of the galvanometer needle or reed or other moving part, there may be a spot of light in a steady position produced by the steady deflection of the galvanometer mirror, where such a type of galvanometer is used.

In the forms of my invention shown in Figures 1, 4, 7 and 10, I employ directional receiving means which I have described fully in my co-pending application, Serial No. 308,978, filed July 7, 1919. In Figure 1 there is shown a single unit, in Figure 4 there are two units in the same evacuated tube, in Figure 7 there are shown two separate tubes, each of which may contain one or more units, and in Figure 10 there are shown three separate tubes, each of which may contain one or more units. I have found that when the planes of the coils in the tubes are in the direction of the transmitting station, or, in other words, when the axes of the coils are at right angles to a line joining the transmitting and receiving stations, the received signals are at a maximum. The tubes with the coils are therefore turned until the maximum effects are observed on the indicating apparatus, and the direction of the transmitting station is at once determined. Besides acting as direction finders, my tubes, with the accompanying apparatus, also perform the function of electrical wave or oscillation detectors.

In the forms of my invention shown in Figures 1, 2 and 3, the variations of the received current change the electrical condition of the terminals 7 and 8, and thereby cause deflections of the pencil or beam of cathode rays passing along the tube 1, through the diaphragm 5.

The rapidly-alternating variations in the electrification of the terminals 7 and 8 are

followed by movements of the pencil or rays. At the end of the tube the pencil of rays falls upon a mica screen or some other suitable surface, and when at rest, it makes a spot of light there. When under the influence of the alternating electrification of the terminals 7 and 8, the pencil or beam of rays moves to and fro, and traces a line of light on the screen. The greater the electrification of the terminals, the greater the amplitude of the movements of the beam of rays, and the longer the line which it traces on the screen.

As the electrification of the terminals depends upon the strength of the oscillations received on the directional system, the length of the line on the screen is a measure of the strength of the received oscillations, and therefore will show when the direction finder is in the position for maximum effect or for minimum effect. The direction of the transmitting station is thus readily and clearly determined.

In the form of my invention shown in Figure 7, I employ two direction-finding tubes, which are independent of each other. The energy received by the directional coils in one of them, 94, acting through the rest of the apparatus, indicated at 97, varies the electrical condition of the electrodes 99 and 100, which are 180 degrees apart, and so changes the direction of the beam of rays 108. When these changes follow each other rapidly, a line of light appears on the screen.

The energy received by the directional coils in the other tube, 95, acting through the rest of the radio apparatus indicated at 98, varies the electrical condition of the electrodes 101 and 102, which are 180 degrees apart, and 90 degrees from electrodes 99 and 100. These variations in electrodes 101 and 102 deflect the beam of rays at right angles to the deflections caused by electrodes 99 and 100. The resultant direction of the beam of rays will depend upon the relative strength of the electrification of the electrodes, and so will the form and dimensions of the figure of light traced on the screen 109. When the electrification of one pair of electrodes, for instance, 99 and 100, is at a maximum, and the electrification of the other pair, 101 and 102, is at a minimum, the beam of rays will vibrate in a plane through the electrodes 99 and 100, and a line of light, such as shown at 110, will be traced on the screen. This state of affairs will indicate that the tube 94 is receiving the maximum effect from the incoming radiant energy, and the tube 95 the minimum effect. As these tubes have been set so that the axes of their enclosed coils are at right angles to each other, the direction of the distant transmitting station is at once determined. By this system, any deviation from the maximum or minimum position

will be more quickly and certainly shown than when only one tube is used.

Instead of using two of my directional tubes with my cathode-ray indicator, I may employ two directional loop antennae, or two large directional antennae, in a similar manner to that shown with one directional loop and one large directional antenna, in Figures 2 and 3, respectively.

In the forms of my invention shown in Figures 4, 5, 6 and 8, sensitive galvanometers indicate the strength of the received signals. In some cases, it is preferable to amplify the received oscillations in order to cause the galvanometers to show great enough deflections, and I therefore provide amplifying means, as shown. In the form shown in Figure 4, the amplification is secured by two units of my directional-tube system, fully described in my said co-pending application, and in the form shown in Figure 5, the amplification is obtained by means of an ordinary vacuum tube amplifier. With some forms of galvanometer, such, for instance, as those having a vibrating reed capable of being tuned to a definite frequency, amplification is not essential, and need not be employed.

In the form of my invention shown in Figure 6, I employ two directional loops at right angles to each other, so that when one is in the position for maximum effect, the other is in the position for minimum effect. My indicating means consists of sensitive galvanometers, one of which is actuated, through suitable receiving apparatus, by the effective energy received by one of the loops, and the other one is actuated by the effective energy received by the other loop. For purposes of convenience I use a single screen for receiving the spots of light reflected from both galvanometer mirrors, and I dispose the mirrors so that the movements of the beams of light from them are in different planes, and can be clearly distinguished on the screen. I have here shown the spots of light moving at right angles to each other, but they may make any convenient angle. Instead of the directional loops I may use my direction-finding tubes arranged as shown in Figure 7. The arrangement shown in Figure 6 is particularly useful for the purpose of determining the direction of a single transmitting station more accurately than can be done with a single loop, but the loops can be adjustable so as to make any angle with each other and can then be used to determine the direction of two transmitting stations simultaneously, provided proper precautions are taken to avoid mutual interference between the loops.

In Figure 8 is shown a modification of my system, embodying a preferable arrangement for receiving electromagnetic waves from two transmitting stations simultaneously and

determining their respective directions. I use two separate directional loops, which can be adjusted independently of each other. Each one actuates a sensitive galvanometer or other suitable indicating apparatus, and the reflected light from these two galvanometer mirrors is thrown on the same screen. The galvanometer mirrors are so suspended that the beams of light from them move in different planes, and are shown in different lines on the screen. I may employ a form of galvanometer in which the light is reflected from a member which vibrates under the influence of the incoming currents or oscillations, so that the beam of light traces a line upon the screen, the length of this line indicating the strength of the received current, and hence the effective energy received in any position of the directional loop. Each receiving unit should preferably be tuned to the wave length of the transmitting station, and where a tuned vibrating reed is used in the galvanometer, this reed should be tuned to the spark or group frequency of its corresponding transmitting station. The loops should also be placed so as to avoid mutual interference with each other. In operating this system, the loops should be turned until the maximum deflection for each unit is observed on the screen. At this instant, the direction of the respective loops is noted, and, if necessary, transferred to a chart or map, and the position of the receiving station can be determined, as shown in Figure 9, provided the compass bearing of at least one of the transmitting stations is also determined at the same time by the direction finder. If, however, at the receiving station the magnetic compass and the gyroscopic compass or any other means of showing the compass bearing are not operative, and if the heavenly bodies are invisible, it will be necessary to know the direction of a third transmitting station in order to fix the position of the receiving station.

In Figure 10, I have shown the means for accomplishing this object. I there have three direction finding units, one for each of the transmitting stations. The direction finding member may be either one of my direction finding tubes, or a directional loop antenna, or any other suitable means. The indicating means may be either galvanometers, cathode-ray tubes, or other suitable means for showing the strength of the received energy visually. Each receiving system is preferably tuned to the wave length of its corresponding transmitting station, and where a tuned indicating apparatus is employed, the latter is also tuned to the spark or group frequency of the corresponding transmitting station. The directional tubes or loops and other receiving apparatus are so arranged as to avoid mutual interference.

The dimensions and characteristics of the

loops, coils and other apparatus, and the values of the electrical quantities of the various parts of my system are so chosen as to obtain the best results in each case. In general, I do not confine myself to the exact constructions and arrangements herein described, but I may also employ other means within the scope of my invention, but what I claim and desire to secure by Letters Patent is:

1. In a radio receiving system, the combination with directional receiving means enclosed in an evacuated tube, of a visual indicator of the strength of the received signals.
2. In a system for receiving radiant energy, the combination with detecting and di-

rectional receiving means enclosed in an evacuated vessel, of visual means for indicating the strength of the received signals.

3. In a radio receiving system, the combination with a plurality of evacuated tubes containing directional receiving coils, of visual means for indicating the effective radiant energy received on said coils.

4. A radio receiving system having two directional receiving units, each of said units consisting of coils and a filament contained in an evacuated tube, the axes of the two sets of said coils being at right angles to each other.

Signed by me, this 23rd day of July, 1919.
FREDERICK S. McCULLOUGH.

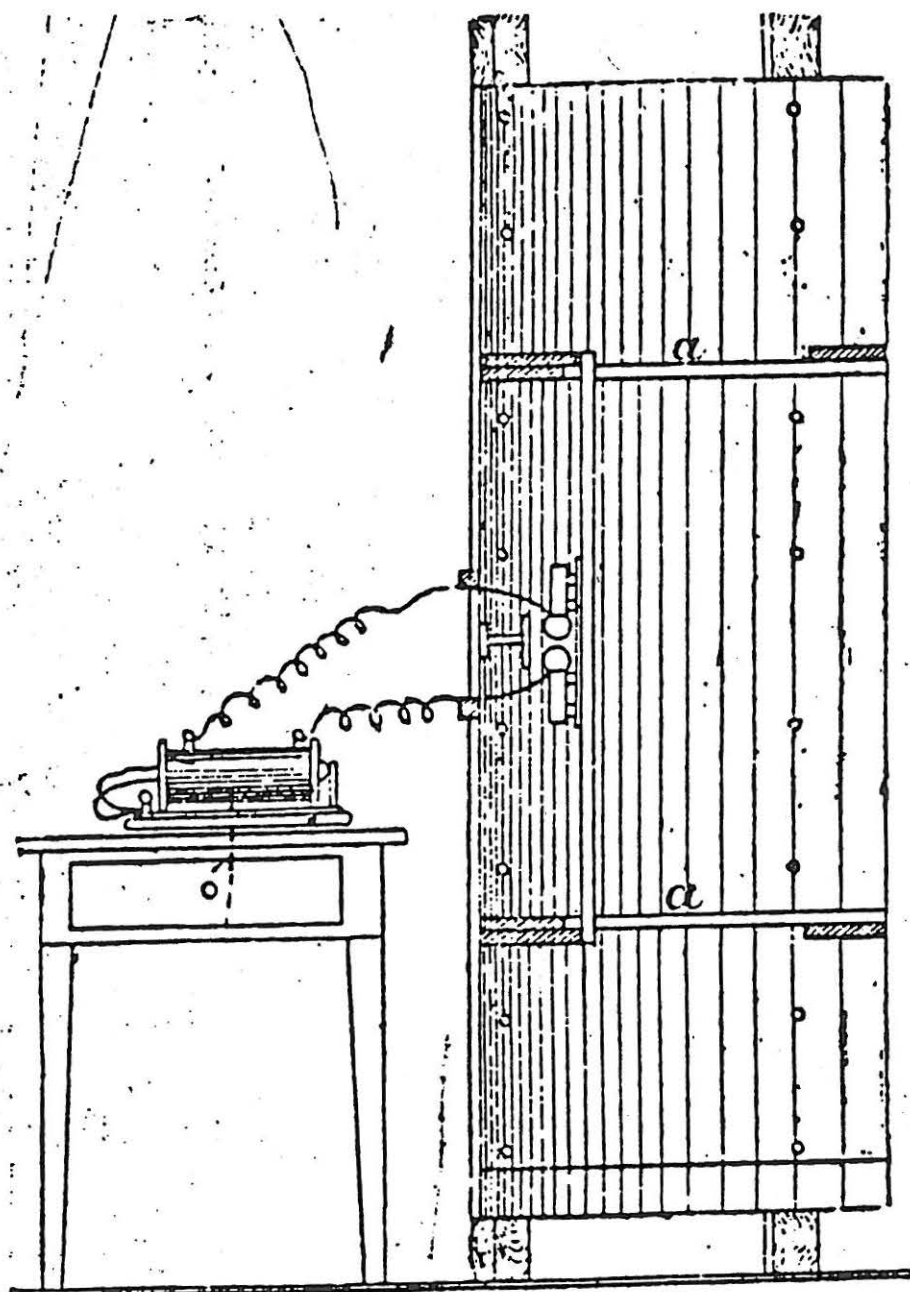
SECTION
3

RAY GENERATORS
AND
TRANSMITTERS

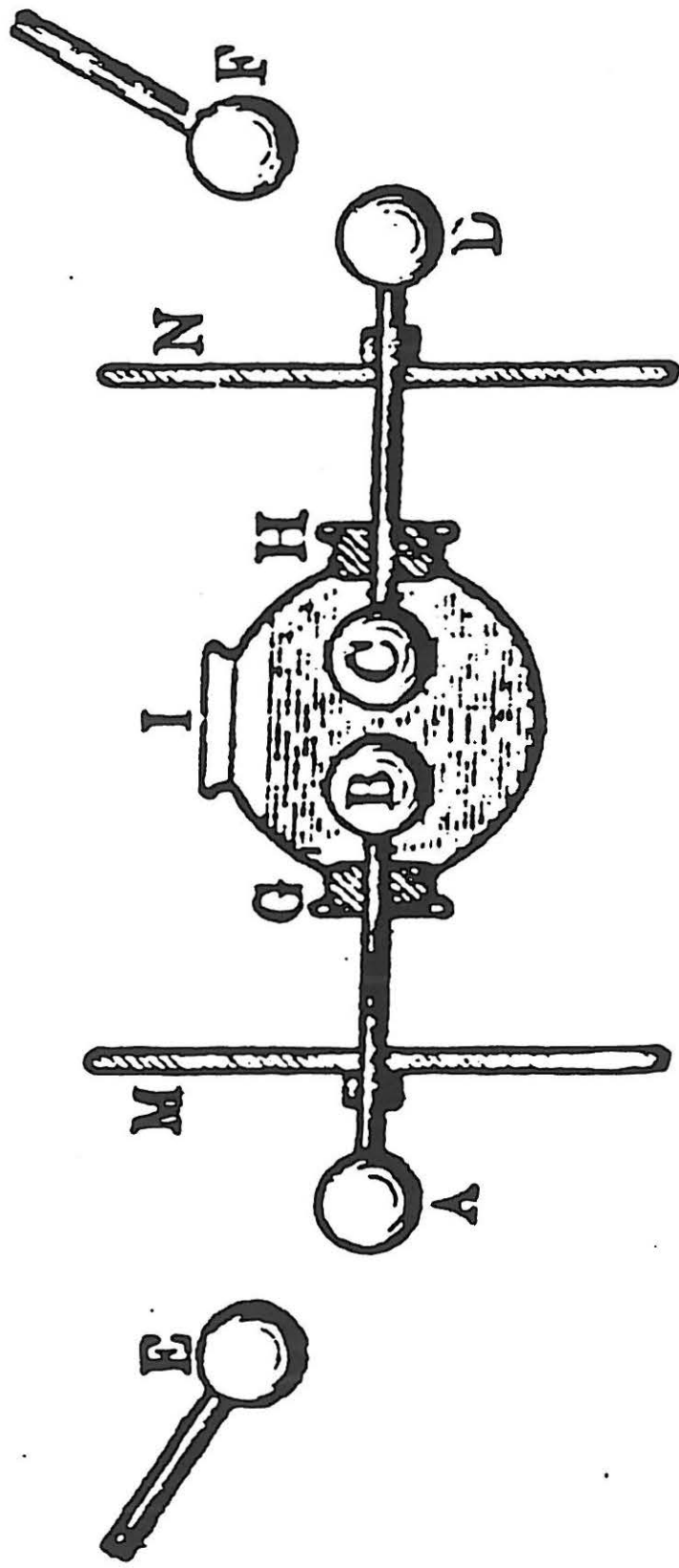




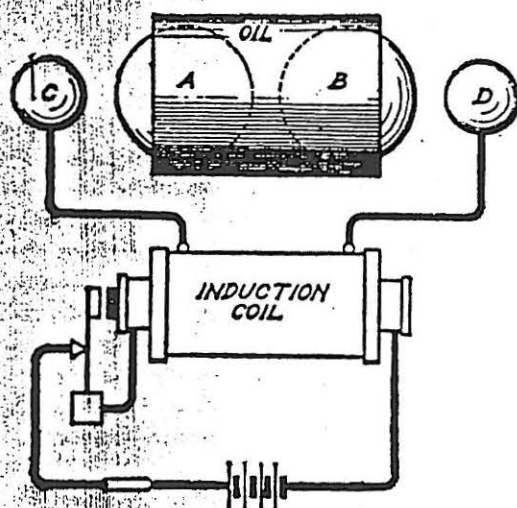
DR. HEINRICH HERTZ



HEINRICH HERTZ
UHF
BEAM TRANSMITTER



AUGUSTO RIGHI
OILBATH
UHF SPARK GENERATOR



Righi's oscillator.

From 1915 to his death, he devoted his researches to the theory of relativity, being one of the few physicists of that day who could understand Einstein's mathematics.

His principal scientific papers were: "The Optics of Electric Oscillations," 1897; "The Motion of Ions in the Electric Discharge," 1903; "Telegraphy without Wires" (in collaboration with B. Dessau), 1903; "The Modern Theory of Physical Phenomena," 1904; "On the Hypothesis of the Electrical Nature of Matter," 1907; "New Views of the Intimate Structure of Matter," 1910; "Radiating Matter and Magnetic Rays," 1910; "The New Physics," 1911; "Ionomagnetic Rotation," 1915; "Electro-Atomic Phenomena under the Action of Magnetism," 1918.

END

References:

Enciclopedia Italiana, 1936
Cyclopedia of Applied Electricity, 1911
 Florian Cajori, *History of Physics*

Il prof. Lodge [11] ideò un oscillatore costituito da un semplice conduttore isolato (per esempio sferico) A (fig. 64), sul quale due conduttori B, C comunicanti coi poli della sorgente elettrica producono due scintille in corrispondenza a punti diametralmente opposti. Le due cariche opposte acquistate così dal conduttore si neutralizzano dopo una serie di oscillazioni, cioè dopo che le cariche alla superficie si sono alternate regolarmente per un certo numero di volte. Lo stesso Lodge diede pure al conduttore A la forma di cilindro cavo (fig. 65), caricato internamente dalle scintille fornite dalle 'palline' B, C.

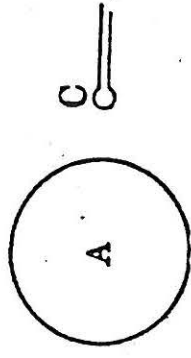


Fig. 64.

Questi oscillatori sono assai poco efficaci e lo prova il fatto che gli oscillatori a tre scintille, come quelli delle fig. 66, 67 e 68, che saranno descritti fra poco, diventano quasi inattivi, quando si mettono a contatto le due sfere che li costituiscono. Ora, così facendo, essi si trasformano in un oscillatore del tipo di quelli del Lodge.

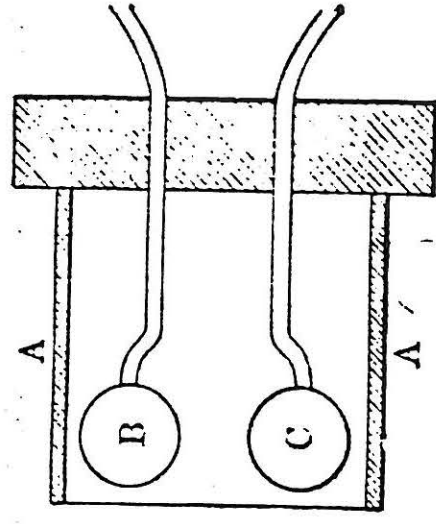


Fig. 65.

RIGHI

UHF WAVE TRANSMITTER

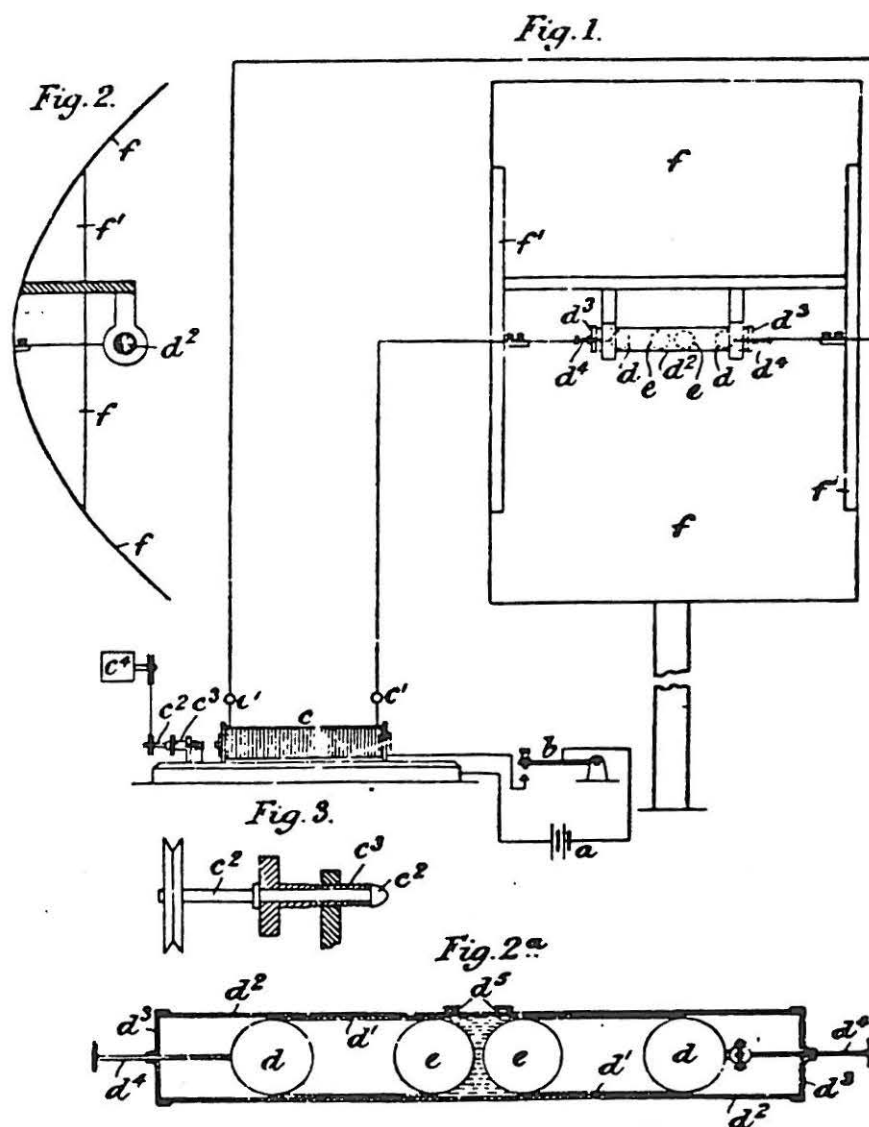
(No Model.)

3 Sheets—Sheet 1.

G. MARCONI.
TRANSMITTING ELECTRICAL SIGNALS

No. 586,193.

Patented July 13. 1897.



Witnesses
E. A. Rulloch
B. W. Miller

Guglielmo Marconi,
Inventor
By his Attorneys
Baldwin, Davidson & Wright

(No Model.)

3 Sheets—Sheet 2.

G. MARCONI.
TRANSMITTING ELECTRICAL SIGNALS.

No. 586,193.

Patented July 13, 1897.

Fig. 4.

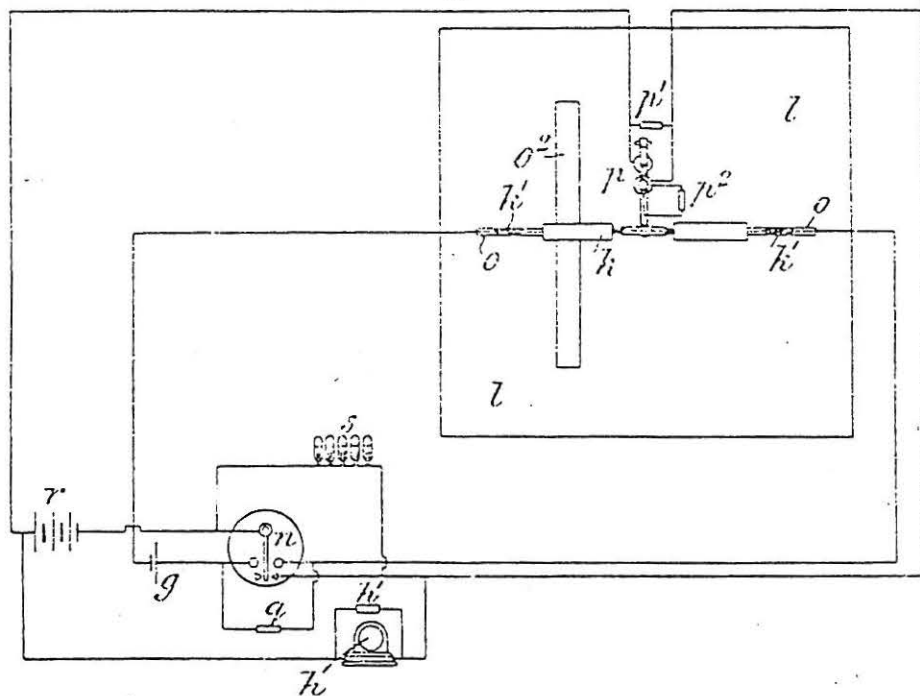


Fig. 5.



Fig. 6.



Fig. 7.

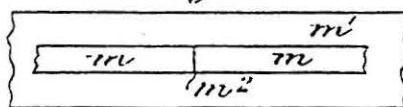


Fig. 8.



Witnesses

E. A. Balloch
B. W. Miller.

Guglielmo Marconi,
Inventor

By his Attorneys
Baldwin Davidson & Wright

(No Model.)

3 Sheets—Sheet 3.

G. MARCONI.
TRANSMITTING ELECTRICAL SIGNALS.
No. 586,193. Patented July 13, 1907.

Fig. 9.

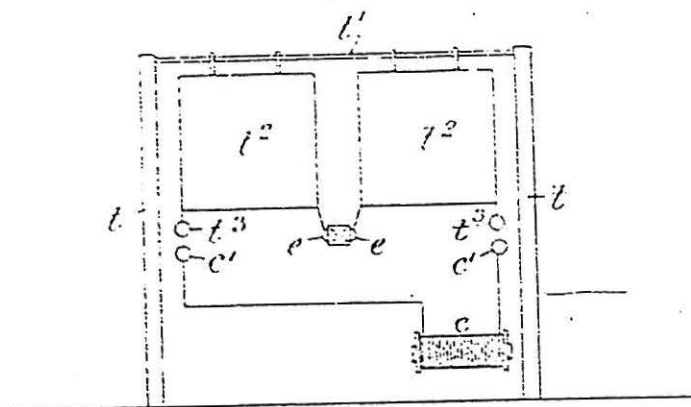


Fig. 10.

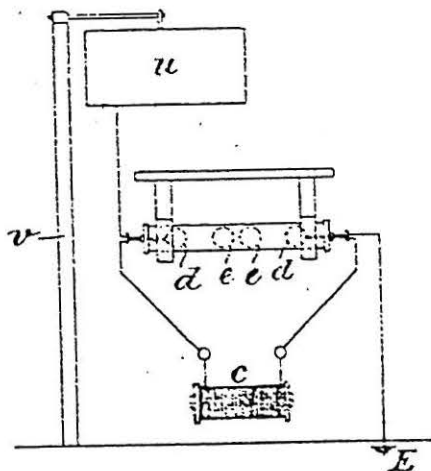
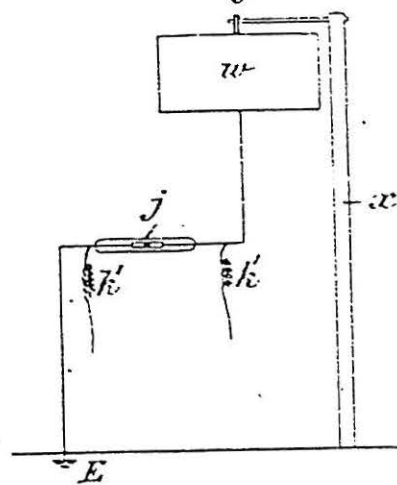


Fig. 11.



Witnesses

E. A. Bullock
B. W. Miller

Giuseppe Marconi
Inventor

By his Attorney
Baldwin, Davidson & Wright

UNITED STATES PATENT OFFICE.

REISSUED

GUGLIELMO MARCONI, OF LONDON, ENGLAND.

TRANSMITTING ELECTRICAL SIGNALS.

SPECIFICATION forming part of Letters Patent No. 586,193, dated July 13, 1897.

Application filed December 7, 1893. Serial No. 614,833. (No model.)

To all whom it may concern:

Be it known that I, GUGLIELMO MARCONI, student, a subject of the King of Italy, residing at 21 Burlington Road, London, in the county of Middlesex, England, have invented certain new and useful Improvements in Transmitting Electrical Impulses and Signals and in Apparatus Therefor, of which the following is a specification.

According to this invention electrical signals, actions, or manifestations are transmitted through the air, earth, or water by means of oscillations of high frequency, such as have been called the "Hertz rays" or "Hertz oscillations." Usually all line-wires are dispensed with. At the transmitting-station I employ a Ruhmkorff coil, having in its primary circuit a Morse key or other signaling instrument and at its poles appliances for producing the desired oscillations. The Ruhmkorff coil may, however, be replaced by any other source of high-tension electricity. When working with large amounts of energy, it is, however, better to keep the coil or transformer constantly working for the time during which one is transmitting, and instead of interrupting the current of the primary interrupting the discharge of the secondary. In this case the contacts of the key should be immersed in oil, as otherwise, owing to the length of the spark, the current will continue to pass after the contacts have been separated. At the receiving-station there is a local-battery circuit, containing any ordinary receiving instrument and an appliance for closing the circuit, the latter being actuated by the oscillations from the transmitting-station. When transmitting through the air and it is desired that the signal should only be sent in one direction, I place the oscillation-producer at the transmitting-station in the focus or focal line of a reflector directed to the receiving-station, and I place the circuit-closer at the receiving-station in a similar reflector directed toward the transmitting-station. When transmitting signals through the earth, I connect one end of the oscillation-producer and one end of the circuit-closer to earth and the other ends to similar plates, preferably electrically tuned with each other in the air and insulated from earth.

of the instruments at the transmitting-station when signaling through the air, and Fig. 2 is a vertical section of the transmitter. Fig. 2^a is a longitudinal section of the oscillator to a larger scale. Fig. 3 shows a detail on a larger scale. Fig. 4 is a diagrammatic front elevation of the instruments at the receiving-station. Fig. 5 is a full-sized view of the receiver. Fig. 6 shows a modification of the tube *j*. Fig. 7 shows the detector. Fig. 8 is a full-sized view of the liquid-resistance. Figs. 9 and 10 show modifications of the arrangements at the transmitting-station. Fig. 11 shows a modification of the arrangements at the receiving-station.

Referring now to Fig. 1, *a* is a battery, and *b* an ordinary Morse key closing the circuit through the primary of a Ruhmkorff coil *c*. The terminals *c'* of the secondary circuit of the coil are connected to two metallic balls *d* *d'*, fixed by heat or otherwise at the ends of tubes *d''* *d'''*, Fig. 2^a, of insulating material, such as ebonite or vulcanite. *e* *e'* are similar balls fixed in the other ends of the tubes *d''*. The tubes *d''* fit tightly in a similar tube *d'''*, having covers *d'''*, through which pass rods *d''''*, connecting the balls *d* to the conductors. One (or both) of the rods *d''''* is connected to the ball *d* by a ball-and-socket joint and has a screw-thread upon it working in a nut in the cover *d'''*. By turning the rod therefore the distance of the balls *e* apart can be adjusted. *d''''* are holes in the tube *d'''*, through which vaseline, oil, or like material is introduced into the space between the balls *e*.

The balls *d* and *e* are preferably of solid brass or copper, and the distance they should be apart depends on the quantity and electromotive force of the electricity employed, the effect increasing with the distance so long as the discharge passes freely. With a coil giving an ordinary eight-inch spark the distance between *e* and *e'* should be from one twenty-fifth to one-thirtieth of an inch and the distance between *d* and *e* about one and a half inches. *f* is a cylindrical parabolic reflector made by bending a metallic sheet, preferably of brass or copper, to form and fixing it to metallic or wooden ribs *f''*. Other conditions being equal the larger the ball's the greater is the distance at which it is pos-

balls of solid brass of four inches diameter, giving oscillations of ten inches length of wave.

The reflectors applied to the receiver and transmitter ought to be preferably in length and opening the double at least of the length of wave emitted from the oscillator.

If a very powerful source of electricity giving a very long spark be employed, it is preferable to divide the spark gap between the central balls of the oscillator into several smaller gaps in series. This may be done by introducing between the big balls smaller ones, (of about half an inch diameter,) held in position by ebonite frames.

I find that the regularity and power of the discharge of an ordinary Ruhmkorff coil with a trembler-break on its primary is greatly improved by causing one of the contacts of the vibrating break to revolve rapidly. I do this by having a revoluble central core c^2 , Fig. 3, in the ordinary screw c^1 , which is in communication with the platinum contacts. I cause the said central core with one of the platinum contacts attached to it to revolve by connecting it to a small electric motor c^4 . This motor can be worked by the same circuit that works the coil, or, if necessary, by a separate circuit. The connections are not shown in the drawings. By this means the platinum is kept smooth and any tendency to stick is removed. They last also much longer. At the receiving-station is a battery whose circuit includes an ordinary telegraphic instrument (or it may be a relay or other apparatus which it is desired to work from a distance) and a circuit-closer.

In Fig. 4, g is the battery, and h a telegraphic instrument on the derived circuit of a relay n .

The appliance I employ as a circuit-closer is shown full size at Fig. 5 and consists of a glass tube j , containing metallic powder or grains of metal j^1 , each end of the column of powder being connected to a metallic plate k of suitable length to cause the system to resonate electrically in unison with the electrical oscillations transmitted. The glass tube may be replaced in some cases by one of gutta-percha or like material. Two short pieces of thick silver wire j^2 of the same diameter as the internal diameter of the tube j , so as to fit tightly in it, are joined to two pieces of platinum wire j^3 . The tube is closed and sealed onto the platinum wires j^3 at both ends.

Many metals can be employed for producing the powder or filings j^1 ; but I prefer to use a mixture of two or more different metals. I find hard nickel to be the best metal, and I prefer to add to the nickel filings about ten percent. of hard-silver filings, which increase greatly the sensitiveness of the tube to electric oscillations. By increasing the proportion of silver powder or grains the sensitiveness of the tube also increases; but it is better for ordinary work not to have a tube of

enced by atmospheric or other electricity. The sensitiveness can also be increased by adding a very small amount of mercury to the filings and mixing up until the mercury is absorbed.

The mercury must not be in such a quantity as to clot or cake the filings. An almost imperceptible globule is sufficient for a tube. Instead of mixing the mercury with the powder one can obtain the same effects by slightly amalgamating the inner surfaces of the plugs which are to be in contact with the filings. Very little mercury must be used, just sufficient to brighten the surface of the metallic plugs without showing any free globules. The size of the tube and the distance between the two metallic stops may vary under certain limits. The greater the space allowed for the powder the larger and coarser ought to be the filings or grains.

I prefer to make my sensitive tubes of the following size: The tube j is one and one-half inches long and one-tenth or one-twelfth of an inch internal diameter. The length of the stops j^2 is about one-fifth of an inch, and the distance between the stops is about one-thirtieth of an inch. I find that the smaller the space between the stops in the tube the more sensitive it proves, but the space cannot under ordinary circumstances be excessively shortened without injuring the fidelity of the transmission.

The metallic powders ought not to be fine, but rather as coarse as can be produced by a large and rough file.

All the very fine powder ought to be removed by blowing or sifting.

The powder ought not to be compressed between the stops, but rather loose and in such a condition that when the tube is tapped the powder may be seen to move.

The tube must be sealed, but a vacuum inside it is not essential, except the slight vacuum which results from having heated it while sealing it. Care must also be taken not to heat the tube too much in the center when sealing it, as it would oxidize the surfaces of the silver stops and also the powder, which would diminish its sensitiveness. I use in sealing the tubes a hydrogen and air flame. A vacuum is, however, desirable, and I have used one of about one one-thousandth of an atmosphere, obtained by a mercury-pump. It is also necessary for the powder or grains to be dry and free from grease or dirt, and the files used in producing the same ought to be frequently washed and dried and used when warm.

If the tube has been well made, it should be sensitive to the induction of an ordinary electric bell when the same is working at one to two yards or more from the tube.

In order to keep the sensitive tube j in good working order, it is desirable, but not absolutely necessary, not to allow more than one milliamperes to flow through it when active. If a stronger current is necessary, several

the plugs, a circuit through the plugs and powder, a relay actuated by the circuit, and means actuated by the relay for shaking the powder.

39. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powders between the plugs, metallic plates connected to the plugs, choking-coils connected to the plugs, a circuit through the coils, plugs and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

40. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powder and mercury between the plugs, a circuit through the plugs and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

41. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powder and mercury between the plugs, metallic plates connected to the plugs, a circuit through the plugs and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

42. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powder and mercury between the plugs, metallic plates connected to the plugs, choking-coils connected to the plugs, a circuit through the coils, plugs and powder, a relay actuated by the circuit and means actuated by the relay for shaking the powder.

43. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving-station, an earth connection to one end of the contact an insulated conductor connected to the other end and a circuit through the contact.

44. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving-station, an earth connection to one end of the contact an insulated conductor connected to the other end, a circuit through the contact and means actuated by the circuit for shaking the contact.

45. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving-station, choking-coils connected to each end of the contact, an earth connection to one end of the imperfect contact an insulated conductor connected to the other end and a circuit through the coils and contact.

46. The combination of a spark-producer

at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving-station, choking-coils connected to each end of the contact, an earth connection to one end of the imperfect contact, an insulated conductor connected to the other end, a circuit through the coils and contact and means actuated by the circuit for shaking the contact.

47. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, an earth connection to one end of the powder, an insulated conductor connected to the other end and a circuit through the powder.

48. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, an earth connection to one end of the powder an insulated conductor connected to the other end, a circuit through the powder and means actuated by the circuit for shaking the powder.

49. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, choking-coils connected to each end of the powder, an earth connection to one end of the powder, an insulated conductor connected to the other end and a circuit through the coils and powder.

50. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, choking-coils connected to each end of the powder, an earth connection to one end of the powder, an insulated conductor connected to the other end, a circuit through the coils and powder and means actuated by the circuit for shaking the powder.

51. The combination of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, choking-coils and earth connection through condensers connected to each end of the powder, a circuit through the coils and powder and means actuated by the circuit for shaking the powder.

52. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, a circuit through the contact, an electric trembler shaking the contact, and means for preventing the self-induction of the trembler from affecting the contact.

tuned plates, but this arrangement is not quite as satisfactory as the single tube. It is necessary when using tubes of the type I have described not to insert in the circuit more than one cell of the Leclanché type, as a higher electromotive force than 1.5 volts is apt to pass a current through the tube even when no oscillations are transmitted. I can, however, construct tubes capable of working with a much higher electromotive force. Fig. 6 shows one of these tubes. In this tube instead of one space or gap filled with filings there are several spaces separated by sections of tight-fitting silver wire. A tube thus constructed, observing also the rules of construction of my tubes in general, will work satisfactorily if the electromotive force of the battery in circuit with the tube is equal to 1.2 volts multiplied by the number of gaps. With this tube also it is well not to allow a current of more than one milliampere to pass.

The tube *j* may be replaced by other forms of imperfect electrical contacts, but this is not desirable.

The plates *k* are of copper or aluminium or other metal, about half an inch or more broad, about one-fiftieth of an inch thick, and preferably of such a length as to be electrically tuned with the electric oscillations transmitted. The means I adopt for fixing the length of the plates is as follows: I stick a rectangular strip of tin-foil *m* (see Fig. 7) about twenty inches long (the length depends on the supposed length of wave that one is measuring) by means of a weak solution of gum onto a glass plate *m'*. Then by means of a very sharp penknife or point I cut across the middle of the tin-foil, leaving a mark of division *m''*. If this detector is held in the proximity (four or five yards) and parallel with the axis of the oscillator in action, it will show little sparks at *m''*. If the length of the pieces of tin-foil approximates to the length of wave emitted from the oscillator, the spark will take place between them at a certain distance from the transmitter, which is a maximum when they are of suitable length. By shortening or lengthening the strips, therefore, it is easy to find the length most appropriate to the length of wave emitted by the oscillator. It is desirable to try this detector in the focus or focal line of the reflector. The length so found is the proper length for the plates *k*, or rather these should be about half an inch shorter on account of the length of the sensitive tube *j*, connected between them.

l is a cylindrical parabolic reflector similar to that used at the transmitting-station.

The plates *k* may be in the form of tubes or even wires.

It is slightly advantageous for the focal distance of the reflector to be equal to one-fourth or three-fourths of the wave length of the oscillation transmitted.

When no oscillations are sent from the transmitting-station, the tube *j* does not conduct the current, and the local-battery circuit

is broken, but when the powder or tube is influenced by the electrical oscillations from the transmitter it conducts and closes the circuit. I find, however, that when once started the powder in the tube continues to conduct even when the oscillations from the transmitter have ceased, but if it be shaken or tapped the circuit is broken. A tube well prepared will instantly interrupt the current passing through it at the slightest tap, provided it is inserted in a circuit in which there is little self-induction and small electromotive force, such as a single cell, and where the effects of self-induction have been removed by one of the methods which I will presently describe.

The two plates *k* communicate with the local circuit through two very small coils *k'*, which I will call "choking-coils," formed by winding a few inches of very thin and insulated copper wire around a bit of iron wire about an inch and a half long. The object of these choking-coils is to prevent the high-frequency oscillation induced across these plates by the transmitter from dissipating itself by running along the local-battery wires which might weaken its effect on the sensitive tube *j*. These choking-coils may, however, be sometimes replaced by simple thin wires. They may also be connected directly to the tube *j*. The local circuit in which the sensitive tube *j* is inserted contains a sensitive relay *n*, preferably wound to a resistance of about twelve hundred ohms. This resistance need not be necessarily that of the relay, but may be the sum of the resistance of the relay and another additional resistance. The relay ought to be one possessing small self-induction.

The plates *k*, tube *j*, and coils *k'* are fastened by means of wire stitches *o'* to a thin glass tube *o*, preferably not longer than twelve inches, firmly fixed at one end to a strong piece of timber *o''*. This may be done by means of wood or ebonite grasping-screws.

I do the tapping automatically by the current started by the tube, employing a trembler *p* on the circuit of the relay *n* similar in construction to that of an electric bell, but having a shorter arm. The vibrator must be carefully adjusted. Preferably the blows should be directed slightly upward to prevent the filings from getting caked. In place of tapping the tube the powder can be disturbed by slightly moving outward and inward one or both of the stops *j'*, the trembler *p* being replaced by a small electromagnet (or magnets) whose armature is connected to the stop.

I ordinarily work the telegraphic receiver *k* (or other instruments) by a derivation, as shown, from the circuit which works the trembler *p*. They can also, however, be worked in series with the trembler. When working ordinary sounders or Morse apparatus, a special adjustment of the same is sometimes needed to enable one to obtain dots and dashes. Sometimes it is necessary to work the telegraphic instruments or relays from the back-stops of the first relay, as is done in

some systems of multiple telegraphy. Such adjustments are known to telegraphic experts.

By means of a tube with multiple gaps it is possible to work the trembler and also the signaling or other apparatus direct on the circuit which contains the tube, but I prefer when possible to work with the single-gap tube and the relay, as shown. With a sensitive and well-constructed trembler it is also possible to work the trembler with the single-gap tube in series with it without the relay.

In derivation on the terminals of the relay n is placed an ordinary platinoid resistance double-wound (or wound on the "bight," as it is sometimes termed) coil q of about four times the resistance of the relay, which prevents the self-induction of the winding of the relay from affecting the sensitive tube.

The circuit actuated by the relay contains an ordinary battery r of about twelve cells and the trembler p , the resistance of the winding of which should be about one thousand ohms, and the nucleus ought preferably to be of soft iron, hollow and split lengthwise, like most electromagnets used in telegraph instruments. In series or derivation from this circuit is inserted the telegraphic or other apparatus h which one may desire to work.

It is desirable that this instrument or apparatus, if on a derivation, should have a resistance equal to the resistance of the trembler p . A platinoid resistance h' of about five times the resistance of the instrument is inserted in derivation across the terminals of the instrument and connected as close to the same as possible. In derivation across the terminals of the trembler p is placed another platinoid resistance p' , also of about five times the resistance of the trembler. A similar resistance p'' is inserted in a circuit connecting the vibrating contacts of the trembler. In derivation across the terminals of the relay-circuit it is well to have a liquid resistance s , which is constituted of a series of tubes, one of which is shown full size in Fig. 8, filled with water acidulated with sulfuric acid. The number of these tubes in series across the said terminals ought to be about ten for a circuit of fifteen volts, so as to prevent, in consequence of their counter electromotive force, the current of the local battery from passing through them, but allowing the high-tension jerk of current generated at the opening of the circuit in the relay to pass smoothly across them without producing perturbing sparks at the movable contact of the relay. It is also necessary to insert a platinoid resistance in derivation on any apparatus one may be working on the local circuits. These resistances ought also to be inserted in derivation on the terminals of any resistance which may be apt to give self-induction.

I have hitherto only mentioned the use of cylindrical reflectors, but it is also possible to use ordinary concave reflectors, preferably parabolic, such as are used for projectors.

It is not essential to have a reflector at the transmitters and receivers, but in their absence the distance at which one can communicate is much smaller.

I find it convenient when transmitting across long distances to make use of the transmitter shown in Fig. 9.

There are two poles connected by a rope l' , to which are suspended by means of insulating suspenders two metallic plates f, f' , preferably in the form of cylinders closed at the top, connected to the spheres e (in oil or other dielectric, as before) and to the other balls f' in proximity to the spheres e' , in communication with the coil or transformer c . The balls f' are not absolutely necessary, as the plates f may be made to communicate with the coil or transformer by means of thin insulated wires. The receiver I adopt with this transmitter is similar to it, except that the spheres e are replaced by the sensitive tube j and plates k , while the spheres f are replaced by the choking-coils k' , in communication with the local circuit. It may be observed that, other conditions being equal, the larger the plates at the transmitter and receiver and the higher they are from earth and to a certain extent the farther apart they are the greater is the distance at which correspondence is possible.

When transmitting through the earth or water, I use a transmitter as shown in Fig. 10. I connect one of the spheres d to earth E , preferably by a thick wire, and the other to a plate or conductor u , suspended on a pole v and insulated from earth; or the spheres d may be omitted and one of the spheres e be connected to earth and the other to the plate or conductor u . At the receiving station, Fig. 11, I connect one terminal of the sensitive tube j to earth E , also by a thick wire, and the other to a plate or conductor w , preferably similar to u . The plate w may be suspended on a pole x and must be insulated from earth. The larger the plates of the receiver and transmitter and the higher from the earth the plates are suspended the greater is the distance at which it is possible to communicate. When using the last-described apparatus, it is not necessary to have the two instruments in view of each other, as it is of no consequence if they are separated by mountains or other obstacles. At the receiver it is possible to pick up the oscillations from the earth or water without having the plate w . This may be done by connecting the terminals of the sensitive tube j to two earths, preferably at a certain distance from each other and in a line with the direction from which the oscillations are coming. These connections must not be entirely conductive, but must contain a condenser of suitable capacity—say one square yard of surface. Balloons can also be used instead of plates on poles, provided they carry up a plate or are themselves made conductive by being covered with tin-foil. As the height to which they may be sent is great, the distance at which communication is possible be-

comes greatly multiplied. Kites may also be successfully employed if made conductive by means of tin-foil.

The apparatus above described is so sensitive that it is essential either that the transmitters and receivers at each station should be at a considerable distance from each other or that they should be screened from each other by stout metal plates. It is sufficient to have all the telegraphic apparatus in a metal box and any exposed part of the circuit of the receiver inclosed in metallic tubes which are in electrical communication with the box. (Of course the part of the apparatus which has to receive the radiation from the distant station must not be inclosed, but possibly screened from the local transmitter by means of metallic sheets.) When working through the earth or water, the local receiver must be switched out of circuit when the transmitter is at work and this may also be done when working through air.

What I claim is—

1. In a receiver for electrical oscillations the combination of an imperfect electrical contact, a circuit through the contact and means actuated by the circuit for shaking the contact.

2. In a receiver for electrical oscillations the combination of an imperfect electrical contact, metallic plates connected to it, a circuit through the contact and means actuated by the circuit for shaking the contact.

3. In a receiver for electrical oscillations the combination of an imperfect electrical contact, metallic plates connected to the contact, choking-coils connected to the contact, a circuit through the coils, and contact and means actuated by the circuit for shaking the contact.

4. In a receiver for electrical oscillations the combination of a tube containing metallic powder, a circuit through the powder and means actuated by the circuit for shaking the powder.

5. In a receiver for electrical oscillations the combination of a tube containing metallic powder, metallic plates connected to the powder, a circuit through the powder and means actuated by the circuit for shaking the powder.

6. In a receiver for electrical oscillations the combination of a tube containing metallic powder, metallic plates connected to the powder, choking-coils connected to the powder, a circuit through the coils and powder and means actuated by the circuit for shaking the powder.

7. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powders, a circuit through the powder, and means actuated by the circuit for shaking the powder.

8. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powders metallic plates con-

nected to the powder, a circuit through the powder and means actuated by the circuit for shaking the powder.

9. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powder, metallic plates connected to the powder, choking-coils connected to the powder, a circuit through the coils, and powder and means actuated by the circuit for shaking the powder.

10. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powder and mercury, a circuit through the powder and means actuated by the circuit for shaking the powder.

11. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powder and mercury, metallic plates connected to the powder, a circuit through the powder and means actuated by the circuit for shaking the powder.

12. In a receiver for electrical oscillations the combination of a tube containing a mixture of metallic powder and mercury, metallic plates connected to the powder, choking-coils connected to the powder, a circuit through the coils and powder and means actuated by the circuit for shaking the powder.

13. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, metallic powder between the plugs, a circuit through the plugs and powder and means actuated by the circuit for shaking the powder.

14. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, metallic powder between the plugs, metallic plates connected to them, a circuit through the plugs and powder and means actuated by the circuit for shaking the powder.

15. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, metallic powder between the plugs, metallic plates connected to the plugs, choking-coils connected to the plugs, a circuit through the coils and plugs and means actuated by the circuit for shaking the powder.

16. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powders between the plugs, a circuit through the plugs and powder and means actuated by the circuit for shaking the powder.

17. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powders between the plugs, metallic plates connected to the plugs, a circuit through the plugs and powder and means actuated by the circuit for shaking the powder.

18. In a receiver for electrical oscillations the combination of a tube, metallic plugs in the tube, a mixture of metallic powders between the plugs, metallic plates connected to the plugs, choking-coils connected to the

53. A receiver for electrical oscillatory impulses having a medium whose electrical resistance is altered by the received electrical oscillations, a trembler or shaker for acting upon the variable-resistance medium to restore it to its normal condition of electrical resistance, and means for controlling such trembler to cause it to act upon the variable-resistance medium to restore it to its normal condition after each reception of such oscillatory impulses.

54. A receiver for electrical oscillatory impulses having a medium whose electrical resistance is altered by the received electrical oscillations, a trembler or shaker for acting upon the variable-resistance medium to restore it to its normal condition of electrical resistance, means controlling such trembler to cause it to act upon the variable-resistance medium to restore it to its normal condition after each reception of such oscillatory impulses, and means for rendering manifest said electrical oscillatory impulses consecutively received, whereby defined signals may be given out by the receiver.

55. The combination of a transmitter capable of producing at will of the operator elec-

tric oscillatory impulses or rays, and a receiver responsive thereto having a variable-resistance medium whose resistance is altered by such received oscillatory impulses, means controlled by the received oscillations for restoring such medium to its normal condition after each reception of such oscillations, and means for rendering manifest the received oscillations, whereby signals sent from the transmitter may be received upon the receiver.

56. The combination of a transmitter capable of producing electrical oscillations or rays at the will of the operator, and a receiver located at a distance and having a conductor tuned to respond to such oscillations, a variable-resistance medium, in circuit with the conductor, whose resistance is altered by the received oscillations, means controlled by the received oscillations for restoring the resistance medium to its normal condition after each reception of such oscillations, and means for rendering the received oscillations manifest.

GUGLIELMO MARCONI.

Witnesses:

WILFRED CORPMAN,
FRED C. HARRIS.

No. 685,957.

Patented Nov. 5, 1901.

N. TESLA.

APPARATUS FOR THE UTILIZATION OF RADIANT ENERGY.

(Application filed Mar. 21, 1901.)

(No Model.)

Fig. 1

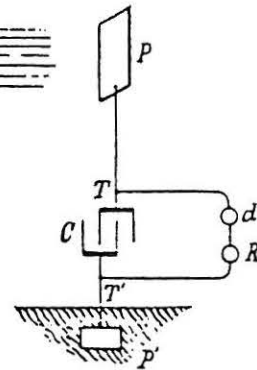


Fig. 2

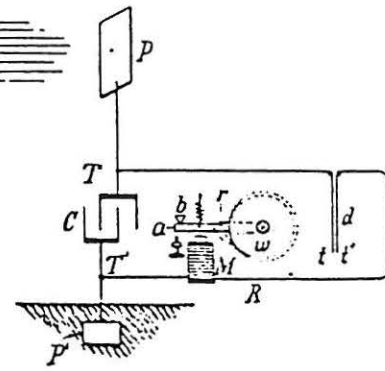


Fig. 3

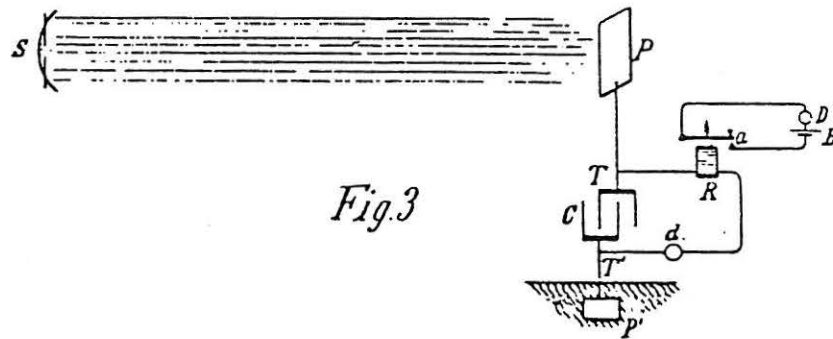
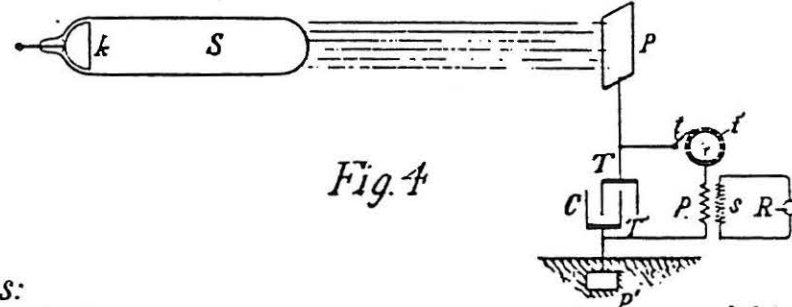


Fig. 4



Witnesses:

Harold P. Hitt
Wm. Leamon Dyer

Inventor

Nikola Tesla
by *Ken. Page & Cooke* Attys.

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

APPARATUS FOR THE UTILIZATION OF RADIANT ENERGY.

SPECIFICATION forming part of Letters Patent No. 685,957, dated November 5, 1901.

Application filed March 21, 1901. Serial No. 52,153. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city, county, and State of New York, have invented certain new and useful Improvements in Apparatus for the Utilization of Radiant Energy, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

It is well known that certain radiations—such as those of ultra-violet light, cathodic, Roentgen rays, or the like—possess the property of charging and discharging conductors of electricity, the discharge being particularly noticeable when the conductor upon which the rays impinge is negatively electrified. These radiations are generally considered to be ether vibrations of extremely small wave lengths, and in explanation of the phenomena noted it has been assumed by some authorities, that they ionize or render conducting the atmosphere through which they are propagated. My own experiments and observations, however, lead me to conclusions more in accord with the theory heretofore advanced by me that sources of such radiant energy throw off with great velocity minute particles of matter which are strongly electrified, and therefore capable of charging an electrical conductor, or, even if not so, may at any rate discharge an electrified conductor either by carrying off bodily its charge or otherwise.

My present application is based upon a discovery which I have made that when rays or radiations of the above kind are permitted to fall upon an insulated conducting-body connected to one of the terminals of a condenser while the other terminal of the same is made by independent means to receive or to carry away electricity a current flows into the condenser so long as the insulated body is exposed to the rays, and under the conditions hereinafter specified an indefinite accumulation of electrical energy in the condenser takes place. This energy after a suitable time interval, during which the rays are allowed to act, may manifest itself in a powerful discharge, which may be utilized for the

operation or control of mechanical or electrical devices or rendered useful in many other ways.

In applying my discovery I provide a condenser, preferably of considerable electrostatic capacity, and connect one of its terminals to an insulated metal plate or other conducting-body exposed to the rays or streams of radiant matter. It is very important, particularly in view of the fact that electrical energy is generally supplied at a very slow rate to the condenser, to construct the same with the greatest care. I use, by preference, the best quality of mica as dielectric, taking every possible precaution in insulating the armatures, so that the instrument may withstand great electrical pressures without leaking and may leave no perceptible electrification when discharging instantaneously. In practice I have found that the best results are obtained with condensers treated in the manner described in a patent granted to me February 23, 1897, No. 577,671. Obviously the above precautions should be the more rigorously observed the slower the rate of charging and the smaller the time interval during which the energy is allowed to accumulate in the condenser. The insulated plate or conducting-body should present as large a surface as practicable to the rays or streams of matter, I having ascertained that the amount of energy conveyed to it per unit of time is under otherwise identical conditions proportionate to the area exposed, or nearly so. Furthermore, the surface should be clean and preferably highly polished or amalgamated. The second terminal or armature of the condenser may be connected to one of the poles of a battery or other source of electricity or to any conducting body or object whatever of such properties or so conditioned that by its means electricity of the required sign will be supplied to the terminal. A simple way of supplying positive or negative electricity to the terminal is to connect the same either to an insulated conductor supported at some height in the atmosphere or to a grounded conductor, the former, as is well known, furnishing positive and the latter negative electricity. As the rays or supposed streams of mat-

ter generally convey a positive charge to the first condenser-terminal, which is connected to the plate or conductor above mentioned, I usually connect the second terminal of the condenser to the ground, this being the most convenient way of obtaining negative electricity, dispensing with the necessity of providing an artificial source. In order to utilize for any useful purpose the energy accumulated in the condenser, I furthermore connect to the terminals of the same a circuit including an instrument or apparatus which it is desired to operate and another instrument or device for alternately closing and opening the circuit. This latter may be any form of circuit-controller, with fixed or movable parts or electrodes, which may be actuated either by the stored energy or by independent means.

My discovery will be more fully understood from the following description and annexed drawings, to which reference is now made, and in which—

Figure 1 is a diagram showing the general arrangement of apparatus as usually employed. Fig. 2 is a similar diagram illustrating more in detail typical forms of the devices or elements used in practice, and Figs. 3 and 4 are diagrammatical representations of modified arrangements suitable for special purposes.

As illustrative of the manner in which the several parts or elements of the apparatus in one of its simplest forms are to be arranged and connected for useful operation, reference is made to Fig. 1, in which C is the condenser, P the insulated plate or conducting-body which is exposed to the rays, and P' another plate or conductor which is grounded, all being joined in series, as shown. The terminals T T' of the condenser are also connected to a circuit which includes a device R to be operated and a circuit-controlling device d of the character above referred to.

The apparatus being arranged as shown, it will be found that when the radiations of the sun or of any other source capable of producing the effects before described fall upon the plate P an accumulation of electrical energy in the condenser C will result. This phenomenon, I believe, is best explained as follows: The sun, as well as other sources of radiant energy, throws off minute particles of matter positively electrified, which, impinging upon the plate P, communicate continuously an electrical charge to the same. The opposite terminal of the condenser being connected to the ground, which may be considered as a vast reservoir of negative electricity, a feeble current flows continuously into the condenser, and inasmuch as these supposed particles are of an inconceivably small radius or curvature, and consequently charged to a relatively very high potential, this charging of the condenser may continue, as I have actually observed, almost indefinitely, even to the point of rupturing the dielectric. If the

device d be of such character that it will operate to close the circuit in which it is included when the potential in the condenser has reached a certain magnitude, the accumulated charge will pass through the circuit, which also includes the receiver R, and operate the latter.

In illustration of a particular form of apparatus which may be used in carrying out my discovery I now refer to Fig. 2. In this figure, which in the general arrangement of the elements is identical to Fig. 1, the device d is shown as composed of two very thin conducting-plates t t', placed in close proximity and very mobile, either by reason of extreme flexibility or owing to the character of their support. To improve their action, they should be inclosed in a receptacle, from which the air may be exhausted. The plates t t' are connected in series with a working circuit, including a suitable receiver, which in this case is shown as consisting of an electromagnet M, a movable armature a, a retractile spring b, and a ratchet-wheel w, provided with a spring-pawl r, which is pivoted to armature a, as illustrated. When the radiations of the sun or other radiant source fall upon plate P, a current flows into the condenser, as above explained, until the potential therein rises sufficiently to attract and bring into contact the two plates t t', and thereby close the circuit connected to the two condenser-terminals. This permits a flow of current which energizes the magnet M, causing it to draw down the armature a and impart a partial rotation to the ratchet-wheel w. As the current ceases the armature is retracted by the spring b, without, however, moving the wheel w. With the stoppage of the current the plates t t' cease to be attracted and separate, thus restoring the circuit to its original condition.

Fig. 3 shows a modified form of apparatus used in connection with an artificial source of radiant energy, which in this instance may be an arc emitting copiously ultra-violet rays. A suitable reflector may be provided for concentrating and directing the radiations. A magnet R and circuit-controller d are arranged as in the previous figures; but in the present case the former instead of performing itself the whole work only serves the purpose of alternately opening and closing a local circuit, containing a source of current B and a receiving or translating device D. The controller d, if desired, may consist of two fixed electrodes separated by a minute air-gap or weak dielectric film, which breaks down more or less suddenly when a definite difference of potential is reached at the terminals of the condenser and returns to its original state upon the passage of the discharge.

Still another modification is shown in Fig. 4, in which the source S of radiant energy is a special form of Roentgen tube devised by

me, having but one terminal k , generally of aluminium, in the form of half a sphere, with a plain polished surface on the front side, from which the streams are thrown off. It may be excited by attaching it to one of the terminals of any generator of sufficiently high electromotive force; but whatever apparatus be used it is important that the tube be exhausted to a high degree, as otherwise it might prove entirely ineffective. The working or discharge circuit connected to the terminals T T' of the condenser includes in this case the primary p of a transformer and a circuit-controller comprising a fixed terminal or brush l and a movable terminal l' in the shape of a wheel, with conducting and insulating segments, which may be rotated at an arbitrary speed by any suitable means. In inductive relation to the primary wire or coil p is a secondary s , usually of a much greater number of turns, to the ends of which is connected a receiver R . The terminals of the condenser being connected, as indicated, one to an insulated plate P and the other to a grounded plate P' , when the tube S is excited rays or streams of matter are emitted from the same, which convey a positive charge to the plate P and condenser-terminal T , while terminal T' is continuously receiving negative electricity from the plate P' . This, as before explained, results in an accumulation of electrical energy in the condenser, which goes on as long as the circuit including the primary p is interrupted. Whenever the circuit is closed owing to the rotation of the terminal l' , the stored energy is discharged through the primary p , this giving rise in the secondary s to induced currents, which operate the receiver R .

It is clear from what has been stated above that if the terminal T' is connected to a plate supplying positive instead of negative electricity the rays should convey negative electricity to plate P . The source S may be any form of Roentgen or Lenard tube; but it is obvious from the theory of action that in order to be very effective the electrical impulses exciting it should be wholly or at least preponderatingly of one sign. If ordinary symmetrical alternating currents are employed, provision should be made for allowing the rays to fall upon the plate P only during those periods when they are productive of the desired result. Evidently if the radiations of the source be stopped or intercepted or their intensity varied in any manner, as by periodically interrupting or rhythmically varying the current exciting the source, there will be corresponding changes in the action upon the receiver R , and thus signals may be transmitted and many other useful effects produced. Furthermore, it will be understood that any form of circuit-closer which will respond to or be set in operation when a predetermined amount of energy is stored in the condenser may be used in lieu of the device

energy, comprising a condenser, having one terminal connected to earth and the other to an elevated conducting-plate, which is adapted to receive the rays from a distant source of radiant energy, a local circuit connected with the condenser-terminals, a receiver therein, and a circuit-controller therefor which is

specifically described with reference to Fig. 2 and also that the special details of construction and arrangement of the several parts of the apparatus may be very greatly varied without departure from the invention.

Having described my invention, what I claim is—

1. An apparatus for utilizing radiant energy, comprising in combination a condenser, one armature of which is subjected to the action of rays or radiations, independent means for charging the other armature, a circuit and apparatus therein adapted to be operated or controlled by the discharge of the condenser, as set forth.

2. An apparatus for utilizing radiant energy, comprising in combination a condenser, one armature of which is subjected to the action of rays or radiations, independent means for charging the other armature, a local circuit connected with the condenser-terminals, a circuit-controller therein and means adapted to be operated or controlled by the discharge of the condenser when the local circuit is closed, as set forth.

3. An apparatus for utilizing radiant energy, comprising in combination a condenser, one terminal of which is subjected to the action of rays or radiations, independent means for charging the other armature, a local circuit connected with the condenser-terminals, a circuit-controller therein dependent for operation on a given rise of potential in the condenser, and devices operated by the discharge of the condenser when the local circuit is closed, as set forth.

4. An apparatus for utilizing radiant energy, comprising in combination a condenser, one terminal of which is subjected to the action of rays or radiations, and the other of which is connected with the ground, a circuit and apparatus therein adapted to be operated by the discharge of the accumulated energy in the condenser, as set forth.

5. An apparatus for utilizing radiant energy, comprising in combination a condenser, one terminal of which is subjected to the action of rays or radiations and the other of which is connected with the ground, a local circuit connected with the condenser-terminals, a circuit-controller therein and means adapted to be operated by the discharge of the condenser when the local circuit is closed, as set forth.

6. An apparatus for utilizing radiant energy, comprising in combination a condenser, one terminal of which is subjected to the action of rays or radiations and the other of which is connected with the ground, a local circuit connected with the condenser-terminals, a circuit-controller therein adapted to be operated by a given rise of potential in the condenser, and devices operated by the discharge of the condenser when the local circuit is closed, as set forth.

7. An apparatus for utilizing radiant energy, adapted to be operated by a given rise of potential in the condenser, as set forth.

NIKOLA TESLA.

Witnesses:

M. LAWSON DYER,
RICHARD DONOVAN.

No. 723,176.

PATENTED MAR. 17, 1903.

D. McF. MOORE..

APPARATUS FOR ELECTRIC CONTROL OF DEVICES AT A DISTANCE.

APPLICATION FILED DEC. 16, 1898.

NO MODEL.

Fig. 1.

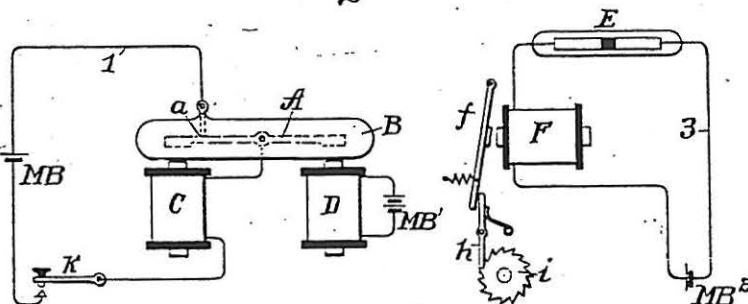
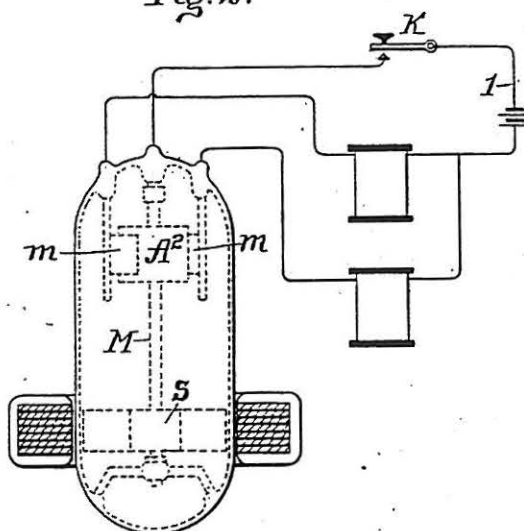


Fig. 2.



Witnesses:

Otto Greenberg
Ethel L. Lander.

Inventor

Daniel McFarlan Moore

By

H. Townsend
Attorney

UNITED STATES PATENT OFFICE.

DANIEL MCFARLAN MOORE, OF NEWARK, NEW JERSEY, ASSIGNOR TO THE MOORE ELECTRICAL COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

APPARATUS FOR ELECTRIC CONTROL OF DEVICES AT A DISTANCE.

SPECIFICATION forming part of Letters Patent No. 723,176, dated March 17, 1903.

Application filed December 16, 1898. Serial No. 699,423. (No model.)

To all whom it may concern:

Be it known that I, DANIEL MCFARLAN MOORE, a citizen of the United States, and a resident of Newark, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Apparatus for Electric Control of Devices at a Distance, of which the following is a specification.

My invention relates to those systems or apparatus in which electric control or operation of devices at a distance is effected without wires or conductors by "Hertzian" waves or oscillations generated under control at one point and propagated through space, reaching to another point, where they act upon a suitable coherer or receiver adapted to govern the condition of an electric circuit. When used for purposes of telegraphy, such a system is preferably termed a "Hertzian-wave" or "wireless" telegraph.

My invention or discovery relates more particularly to the manner of generating the waves or oscillations used in such a system of control or operation; the object being to improve the system by producing waves or oscillations of greater penetration or carrying power, thus enabling the control to be effected over longer distances than is possible with the apparatus and methods heretofore employed.

In previous apparatus the source of the waves has been a pair of metallic terminals or electrodes, across which a disruptive spark is maintained by electricity obtained from any suitable source—as, for instance, the secondary of an induction-coil. I have discovered that superior results may be obtained by using as the emitter or producer of the oscillations the electrodes or terminals of a circuit-interrupter operating in a vacuum to produce interruptions of a circuit of induction. For the best results the vacuum should be very high, so as to produce very abrupt changes of resistance in the circuit. A vacuum which is as nearly as may be an absolute vacuum is best suited to the practice of my invention. By "circuit of induction" I mean any circuit through which electric current flows from any suitable source of con-

tinuous, intermittent, pulsating, or alternating currents and which is adapted by its self-induction or by its induction upon a parallel circuit to generate electromotive forces at the point of separation.

By employing circuit-interrupters of the character hereinafter described, whereby an exceedingly high speed or rate of circuit interruption is obtained, I am enabled to secure very greatly improved results with electromotive forces or potentials of comparatively small amount, whereas heretofore in the art where a mechanical interrupter is employed the aim has been to secure a comparatively high potential by slowing down or retarding the rate of interruption of the circuit-interrupter in the primary of the induction-coil.

In my invention induction waves or oscillations are produced at the electrodes of a circuit-interrupter, and in this respect my invention differs materially from devices heretofore employed for the purpose, which involves the use of ball electrodes or surfaces or "capacity areas;" nor do I employ induction-coils and interrupters operating in the primary circuit while the secondary is connected to the electrodes of the emitter to maintain a spark.

At the receiving-point any proper or usual means for rendering the oscillations or waves sensible and for utilizing them to control an electric circuit may be employed. I may use the Branly coherer or any modification thereof or the form of instrument employed by Hertz for rendering such oscillations sensible and properly included in the electric circuit whose varying electric condition produces the desired operation directly or indirectly upon any translating device or device whose action is to be controlled.

Any circuit-interrupter of the character described in my Patent No. 548,127, dated October 15, 1895, may be used for the purposes of my invention, it being understood that in every case the interrupter-contacts are in a high vacuum and will operate to make and break a circuit of induction.

In the accompanying drawings I illustrate diagrammatically various forms of apparatus by which my invention may be practiced.

55

60

65

70

75

80

85

90

95

100

Figure 1 shows a form in which a vibrating interrupter is employed and in which the receiving apparatus comprises means for releasing a wheel instead of the usual telegraph-receiver which would be employed for wireless telegraphy. Fig. 2 shows a type of interrupter known as the "rotary" type.

In the accompanying drawings I have omitted to show the use of reflectors, which are sometimes employed for directing the oscillations toward the receiving-point, as also the means sometimes employed for adjusting the frequency of the oscillations or waves and the capacity areas which have been employed in some forms of wireless telegraphy, as these are all well known in the art. I would state, however, that it is desirable to arrange the electrodes of the emitter so that the radiations thereof will be best directed toward the receiving-point—that is to say, to arrange them with a view to the taking advantage of the fact that the radiations from an oscillator consisting of a pair of separated electrodes is greater in an equatorial than in the axial direction.

Referring now to the drawings, I show in Fig. 1 a circuit-interrupter capable of producing a very high rate of interruption—even as high as one hundred thousand times per minute. The interrupter is of the vibratory type, consisting of a circuit-closing lever A, mounted to work in a highly-exhausted receiver or inclosure B, preferably of glass and kept in vibration by an electromagnet C, whose pole is in close proximity to the armature of the lever A, but is preferably located outside the inclosure. The action of the electromagnet is to withdraw the armature or contact-lever A from connection with contact-point *a*, also within the inclosure, said lever and contact *a* forming the electrodes or terminals of a circuit of induction I, charged from any suitable source of energy M B and preferably including the coil C, whose self-inductive effects may be added to those which naturally belong to the circuit. The retractor for the armature-lever, which constantly tends to keep the circuit of induction closed, consists of an electromagnet D, exerting a constant influence upon an armature attached to the lever A, as shown. For this purpose the electromagnet D may be charged from any suitable source of electric energy M B'. In the circuit I is any key or circuit controller K, by which the operation of the apparatus may be controlled to vary or interrupt the production of the Hertzian waves or oscillations, though other means may obviously be employed for this purpose. At every interruption of circuit produced by the electromagnet C said magnet by that interruption loses its own power and electromagnet D immediately acts to restore the circuit, the operation being repeated at a very high rate. The degree of exhaustion in the receptacle B, as before stated, should be very high. Discharges of the circuit of induction across

the interval between the contacts of the interrupter within the vacuum set up the waves or oscillations which operate the receiver. Said contacts become in substance the terminals of an emitter, although it is to be understood that in the normal operation of the device there is nothing in the nature of a disruptive spark across said terminals such as has been heretofore employed in the art where there is a breaking through of an air-gap. At the receiving-point, E typifies a coherer or device included in the circuit 3 and operating, as well understood in the art, to vary the resistance thereof. The circuit 3 may include any local source of energy M I', the flow of energy from which is varied by the said coherer, the usual effect being, as well understood, that when the transmitted oscillations impinge upon the coherer, the resistance is lowered, to be restored by the rearrangement of the particles in said coherer by mechanical means or otherwise.

In the application of my invention herein shown the circuit 3 includes an electromagnet F, whose power increases under the effect of the oscillations or waves upon the coherer, and which may thereby be made to act more strongly upon an armature-lever *f*, and thereby disengage the pawl or detent *h*, which normally detains a wheel *i*. These parts are to be taken as merely typical of any mechanism for controlling mechanical or other power, and, as will be well understood, there may be substituted for them any other device whose action is to be controlled—as, for instance, a telegraph apparatus.

In the modification of my invention illustrated in Fig. 2 I show as a circuit-interrupter for generating the oscillations a rotary form of interrupter, the parts being inclosed in a sealed receiver and consisting of the shaft M, carrying circuit-breaking wheel A', which forms one terminal of the circuit of induction, while the brushes *m m*, bearing thereon, form opposite terminals of branches of said circuit of induction and interrupt the same in alternation. Rotation of the shaft M is produced by rotation of the magnetic field set up around the receptacle in the plane of a suitable armature S, secured to the shaft M, the organization being practically one which is described in my prior patent, No. 604,685, dated May 24, 1898. In this case, as before, the contacts of the interrupter operate as electrodes of an emitter whence the Hertzian waves or oscillations originate.

What I claim as my invention is—

1. In a Hertzian-wave or wireless-telegraph apparatus, an emitter or radiator consisting of electrodes or terminals of a circuit-interrupter operating in a high vacuum to interrupt a circuit of induction, combined with means such as a key or circuit for controlling a propagation of the waves or oscillations as and for the purpose described.

2. In a wireless apparatus for electric control or operation of devices at a distance by

Hertzian waves or oscillations, an emitter or radiator consisting of electrodes or terminals of a circuit-interrupter operating in a high vacuum to interrupt a circuit having self-induction, and means for controlling the operation of said emitter, as and for the purpose described.

3. In an apparatus for electric control or operation of devices at a distance by the wireless system, an emitter or radiator consisting of contacts or electrodes of a circuit-interrupter operating in a high vacuum to interrupt a charged electric circuit, combined with means for controlling the operation of said emitter or radiator, as and for the purpose described.

4. In a Hertzian-wave wireless-telegraph apparatus, electrodes or terminals of a circuit-interrupter operating in a high vacuum to interrupt a circuit of self-induction, combined

with means for controlling the propagation of the Hertzian waves or oscillations produced by the said interrupter as and for the purpose described.

5. In a system of wireless electric control or operation by Hertzian waves or oscillations, a source of radiation consisting essentially of electric contacts included within a vacuum and forming the poles of a charged electric circuit, combined with means for separating said contacts to propagate waves or oscillations suitable for operating on the distant apparatus, as and for the purpose described.

Signed at New York, in the county of New York and State of New York, this 10th day of December, A. D. 1898.

DANIEL MCFARLAN MOORE.

Witnesses:

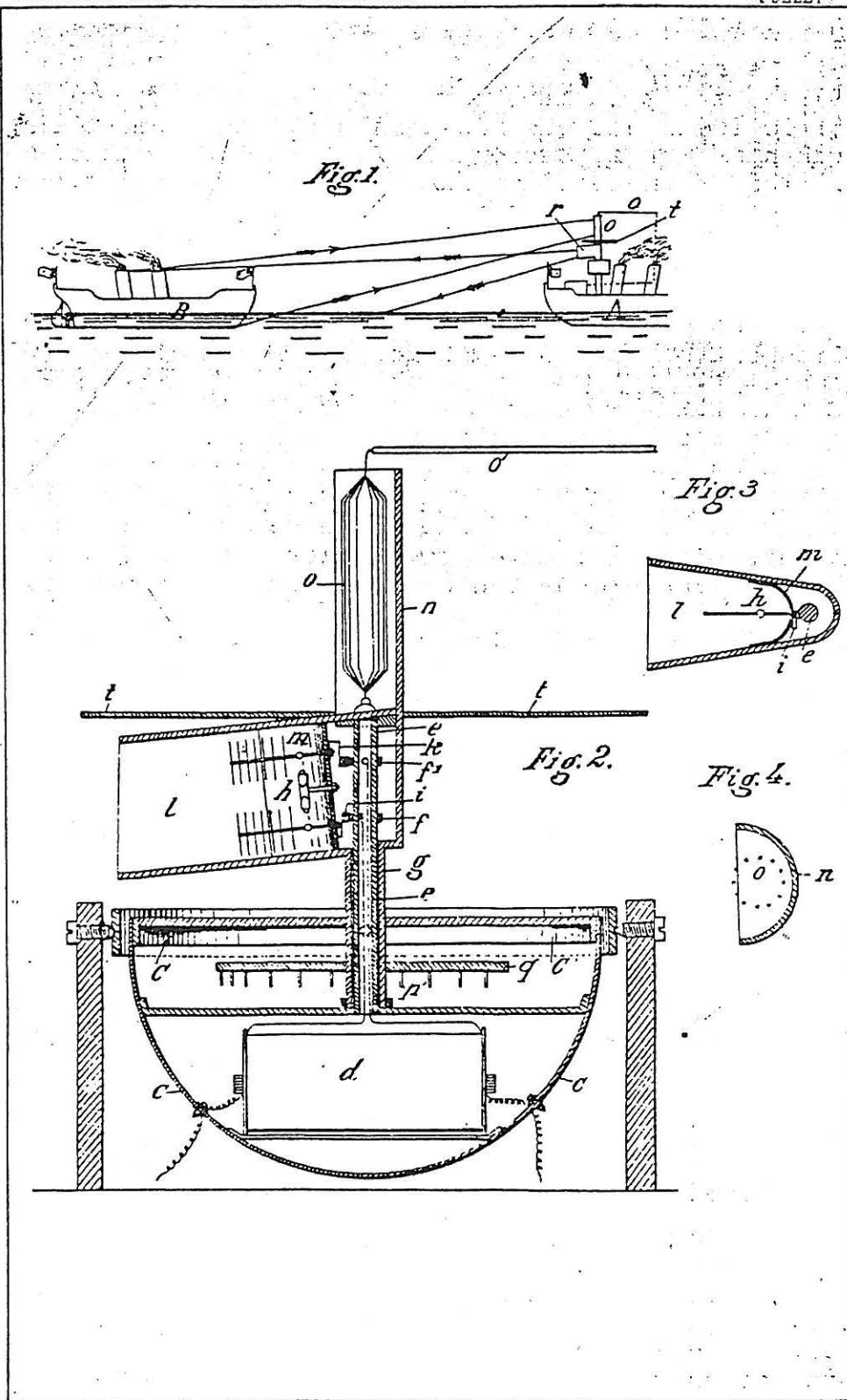
WM. H. CAPEL,

CLARENCE B. SHULTZ.

EARLY UHF RADAR DEVICE

A.D. 1904. JUNE 10. N^o. 13,170.
HULSMEYER'S COMPLETE SPECIFICATION.

(1 SHEET)



[This Drawing is a reproduction of the Original on a reduced scale]

Malby & Sons Photo-Litho

Fig. 1.3

Figs. 1 to 4 of Hulsmeyer's 1904 UK patent

The searchlight detection and location system has some similarities to a radar surveillance system, viz:

- a) the use of electromagnetic radiation and a powerful radiation source;
- b) the utilisation of means to focus the radiation in a narrow beam to increase the radiation flux in a given direction and hence increase the detection range of the system;
- c) the employment of a mounting which allows the beam to be swept over a given region and which enables the bearing of an object to be determined;
- d) the incorporation of a sub-system within the overall system, able to detect and track a given target.

The major disadvantage of the utilisation of searchlights, which meant a capital ship using them revealed its position to an enemy, was quickly realised. Again it was found that if searchlights were mounted well above the waterline on masts it was possible for torpedo boats to pass under the beams and be undetected. Solutions were soon forthcoming to counter both these system deficiencies: it is interesting to note that similar situations arose when radar systems were introduced.

1.3 CHRISTIAN HULSMEYER

Hulsmeyer, an engineer working in Dusseldorf, Germany, was the first person to patent a method and apparatus which essentially replaced the searchlight system by a system using non-visible electro-magnetic radiation. His first British patent [9] on this method was applied for on 10th June 1904 and had the title: 'Hertzian-wave projecting and receiving apparatus adapted to indicate or give warning of the presence of a metallic body, such as a ship or a train, in the line of such waves.' Later in 1904 Hulsmeyer made an application for a second patent [10] and this bore the title: 'Improvement in Hertzian-wave projecting and receiving apparatus for treating the position of distant metal objects.'

Neither of these patents indicates why the inventor wished to advance his ideas but it is highly likely that he wanted to produce an anti-collision detection and location system, which would be operative when searchlights were not capable of being used, that is in misty or foggy conditions.

Figs. 1 to 4 of Hulsmeyer's first patent show the principle of application and the apparatus of his invention. The equipment consisted of a transmitter (e, h, i, l, m) and a receiver (n, o) mounted 'similarly to a compass box, so that they are maintained by the action of gravity in an approximately vertical position'. A metal partition or guard 'obviated any possibility of waves passing direct from the transmitter to the receiver', vide Fig.1.3.

Early in 1934 this equipment was used for microwave propagation tests for the French Navy. 10km range was typical, although telephony across the English Channel was subsequently achieved [1], using larger reflectors. It seems that Henri Gutton recognised the effects of reflection from terrain and other obstructions because he proposed the use of the system as an 'obstacle detector' and filed a patent application [3] on 20th July 1934. This essentially constituted a c.w. radar system, using separate transmit and receive antennas.

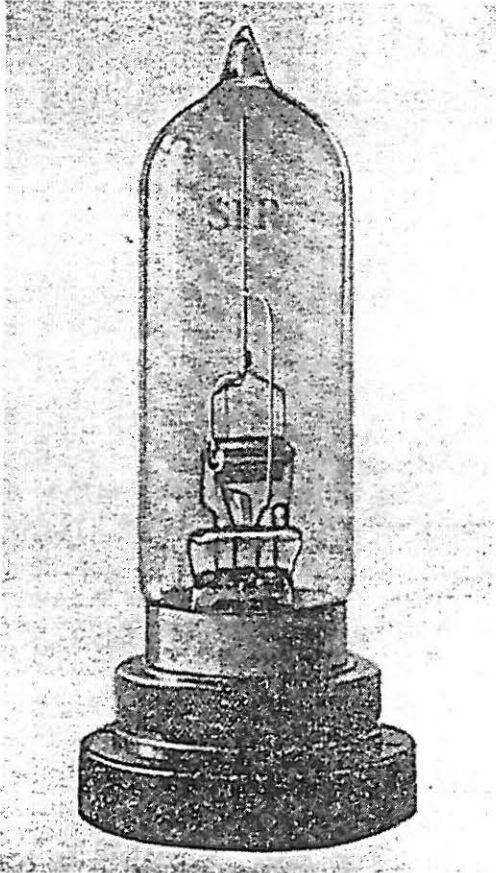


Fig. 4.1 The type UC 16 valve used by Gutton in 1935

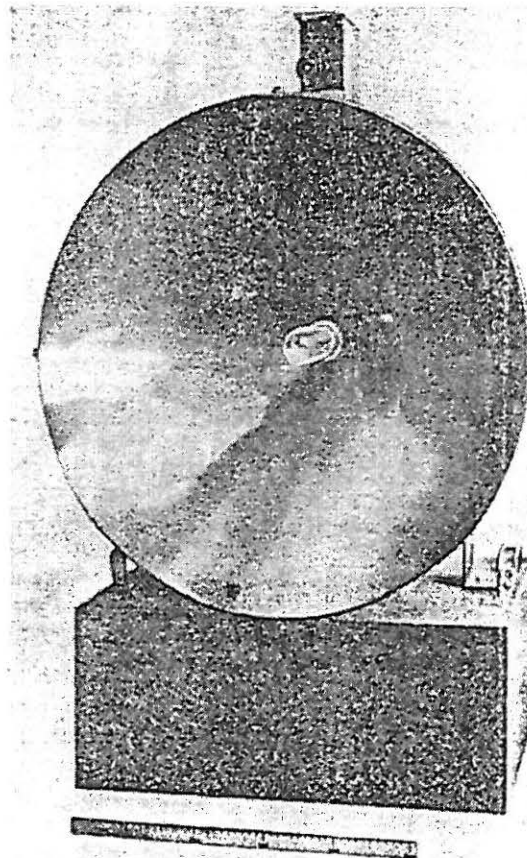


Fig. 4.2 The UC 16 placed at the focus of a parabolic mirror

An opportunity for exploitation presented itself when in January 1935 the owners of the liner 'Normandie', then still being completed, requested that the ship be equipped with the new system. Preliminary sea trials [1,4] were carried out on the cargo ship 'Oregon' using a pair of reflectors, one fore and the other aft, directed sideways as the ship steamed up the Channel. Reflections from the coast were detected, and some from ships at a few kilometres, but breakthrough from transmitter to receiver, and sea reflections, were troublesome. Other tests gave similar results; promising, but not fully satisfactory. It was decided to build a radar specially for the 'Normandie' (Fig.4.3.).

H. F. SHARTZER.
ELECTRIC GUN.
APPLICATION FILED JUNE 13, 1917.

1,284,155.

Patented Nov. 5, 1918.

Fig. 1.

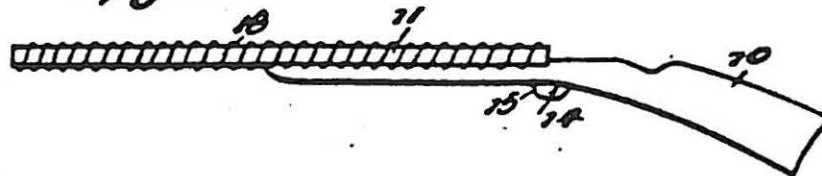
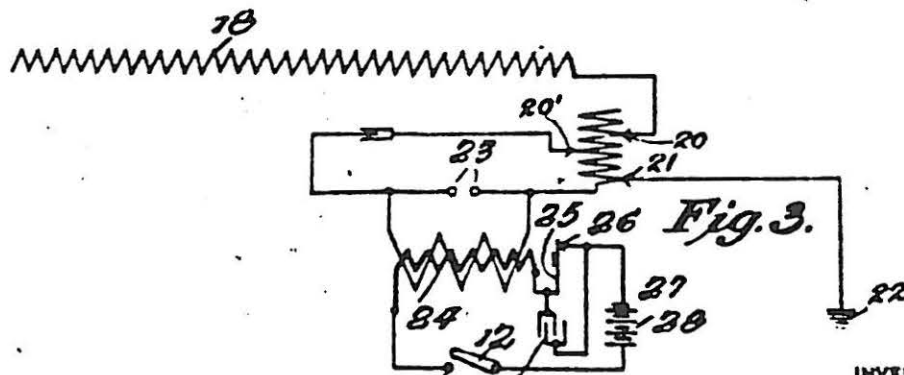
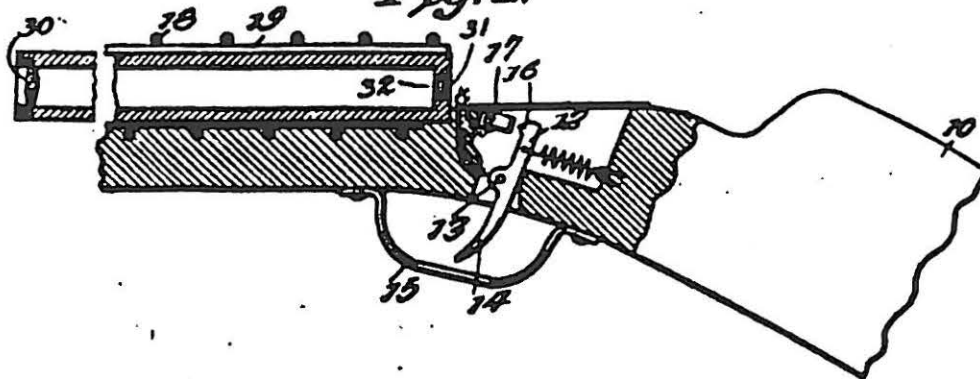


Fig. 2.



WITNESSES

James F. Brown,
H. W. Zaman

INVENTOR

Henry F. Shartzer,

BY

Richard A. Owen,

ATTORNEY

UNITED STATES PATENT OFFICE.

HENRY F. SHARTZER, OF LEITCHFIELD, KENTUCKY.

ELECTRIC GUN.

1,284,155.

Specification of Letters Patent.

Patented Nov. 5, 1918.

Application filed June 13, 1917. Serial No. 174,536.

To all whom it may concern:

Be it known that I, HENRY F. SHARTZER, a citizen of the United States, residing at Leitchfield, in the county of Grayson and State of Kentucky, have invented certain new and useful Improvements in Electric Guns, of which the following is a specification.

This invention has relation to radio energy apparatus, with special reference to the embodiment therein of what might be termed an electric rifle, and has for an object to provide a device for directing Hertzian waves in any direction desired whereby to energize apparatus located at a distance and adapted to receive the waves to release explosives or the like for military purposes.

Another object of the invention is to provide apparatus for the purpose above set forth in the nature of and having the appearance of a rifle whereby the same may be aimed and Hertzian waves projected therefrom in the direction pointed out by the rifle for the purpose above set forth.

Another object of the invention is to provide an apparatus in the nature of a rifle including a barrel having a bore and embodying a magnifying lens mounted in the muzzle whereby to direct and concentrate a ray upon a distant point.

In addition to the foregoing my invention comprehends improvements in the details of construction and arrangement of the parts to be hereinafter more fully described and particularly set forth in the appended claims.

In the accompanying drawings in which similar and corresponding parts are designated by the same characters of reference throughout the several views in which they appear:

Figure 1, is a view in side elevation of an apparatus constructed in accordance with my invention.

Fig. 2, is a fragmentary view thereof in section, illustrating in detail the essential parts, and

Fig. 3, is a diagrammatic view illustrating auxiliary apparatus and the method of electrically connecting the same with my invention.

With reference to the drawings, 10 indicates the stock of a rifle of conventional configuration and 11 the barrel which may be of steel and formed with a bore which may be

continued from end to end or may be closed at the rear end as illustrated in Fig. 2.

A recess is formed in the stock adjacent the rear end of the barrel to receive a switch mechanism, which comprises a lever 12 fulcrumed as at 13 within the recess provided with a trigger portion 14 which extends without the recess and beneath the rifle within a trigger guard 15. The other portion of the lever extending within the recess and in a direction opposite the direction of extension of the trigger portion is formed with a sharpened terminal 16 adapted to engage a spring contact finger 17 mounted upon one of the inner walls of the recess.

A coil of bare copper or aluminum wire 18 is wound around the barrel of the device from one end to the other, being held in spaced relation from the barrel, however, by means of strips of insulating material 19. The rear terminal of the coil 18 is connected to one sliding contact 20 of a transformer while the other sliding contact 21 is grounded as at 22. The terminal of the transformer is then connected to one of the spherical members 23 which are disposed in close relation to permit a spark to jump therebetween while the other spherical member is connected to a sliding contact 20' of the transformer by means of a conductor having a low capacity condenser interposed therein. The primary coil 24 is connected at one terminal to the contact finger 17 of the trip mechanism located within the rifle, while the other terminal of the primary is connected to a vibrating contact 25. Said contact is adapted for intermittent engagement with a stationary contact 26 placed in communication by means of a conductor 27 with the lever 12 of the aforesaid switch mechanism. A source of current 28 is also interposed in said conductor 27. To increase the efficiency of operation of the induction coil a condenser 29 may be connected across the vibrating contact 25 and stationary contact 26 as indicated in Fig. 3.

In operation the rifle is directed toward the object intended to be affected by the Hertzian waves, and at the proper moment the trigger 14 is drawn so as to complete the circuit through the primary of the induction coil whereby a high tension current is induced in the secondary with the result that Hertzian waves emanate from the coil 18. It has been my experience that with a coil

surrounding the metallic barrel such as I have herein disclosed, the waves will be directed in a particular abundance along a line coincident with the axis of the said coil

18. While waves will of course be radiated in a direction at right angles to the axis of the coils, and from every convolution thereof, the waves will be emanated more abundantly in an axial direction relatively to the coil. The object of my invention is therefore, to provide a device whereby the waves may be directed in particular toward some apparatus located at a distance and designed especially to be affected and energized by Hertzian waves. To this end the apparatus, for military purposes may be in the nature of a mine or other container of high explosives, having associated therewith a receiving apparatus for Hertzian waves, which may include a sensitive projector, grounded so as to complete the circuit through the ground 22; a sensitive relay actuable by current passing through the projector, and an electric fuse in a circuit which may be energized by operation of the relay, together with any other apparatus that may be necessary to effect the object desired. Since receiving apparatus, of the nature above stated are well known in the art, it is not thought necessary to describe any particular type of apparatus in detail.

A magnifying lens 30 of the best quality obtainable is fitted in the muzzle of the barrel. It has been my experience that with this arrangement, a ray generated by the high tension current will be concentrated at a distant point or at the focal distance of the lens, and that intense heat will be generated at the said focal point of concentration. The end of the barrel opposite that end provided with the lens 30 may be formed with a reduced aperture 31 and a concave lens fitted in said opening of a focal distance adapted, in conjunction with the focal strength of the lens 30 to form a telescope whereby the object at which the rifle is pointed may be enlarged and rendered more distinct thereby facilitating the use of the instrument, without affecting the capacity of the lens 30 to concentrate the wireless waves. It is to be

noted that inasmuch as the lens 30 is rather small in diameter in order that it may be fitted in the end of an ordinary size gun barrel or of a barrel slightly larger, it will be necessary to generate wireless waves of relatively short lengths in order that a beam of rays of sufficient concentration may be refracted, and directed in the manner desired. To this end a transformer and low capacity condenser are used, although it will be understood that any form of wireless wave generating apparatus capable of producing a short wave length will be amply sufficient and operable for the purposes of my invention.

While I have illustrated and described my invention with some degree of particularity, I realize that in practice various alterations thereover may be made, and I therefore desire to reserve the right and privilege of changing the form of the details of construction or otherwise altering the arrangement of the correlative parts without departing from the spirit of the invention, or the scope of the appended claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. An apparatus for directing wireless waves including a rifle stock, a steel tubular barrel mounted thereon, a coil of wire wrapped spirally around the barrel with the convolutions spaced therefrom, a switch mechanism mounted on the stock, and means for generating high-frequency oscillatory currents of short wave lengths for transmission through the coil.

2. An apparatus for directing and transmitting rays of energy including a hollow steel core, a magnifying lens fitted into one end of the core, a coil of wire wrapped spirally around the core, and means for generating wireless waves of short lengths for transmission through the coil.

In testimony whereof I affix my signature in presence of two witnesses.

HENRY F. SHARTZER.

Witnesses:

E. T. SHREWSBURY,
J. MORGAN BERRY.

J. HETTINGER.

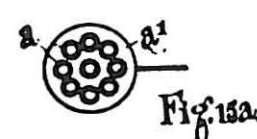
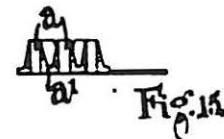
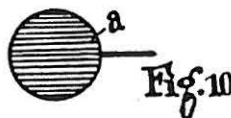
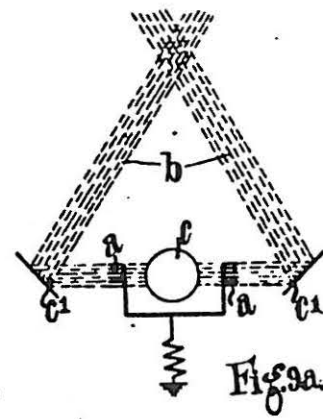
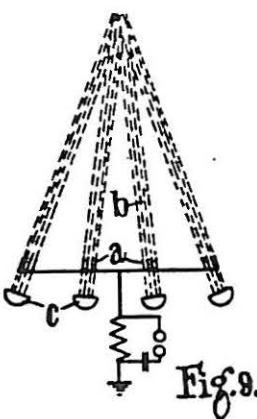
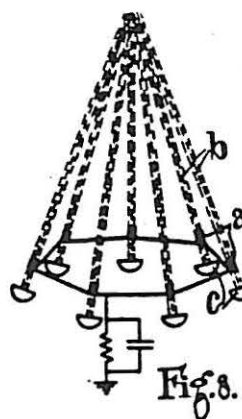
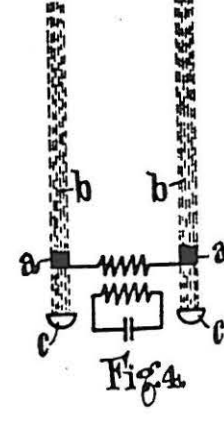
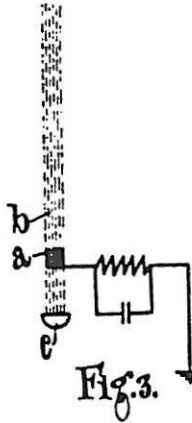
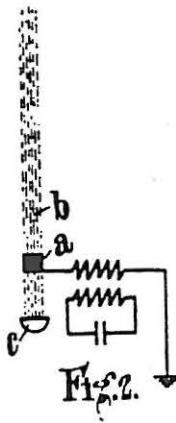
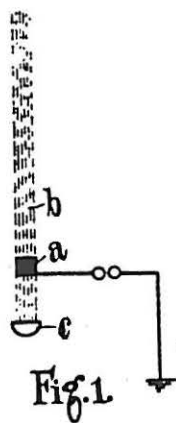
AERIAL CONDUCTOR FOR WIRELESS SIGNALING AND OTHER PURPOSES.

APPLICATION FILED JUNE 4, 1919.

Patented July 8, 1919.

4 SHEETS—SHEET 1.

1,309,031.



John Hettinger Inventor
by *Robt. B. Litch* Attorney

J. HETTINGER.

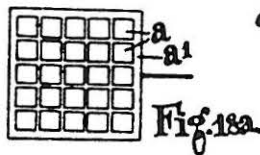
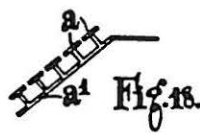
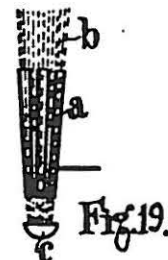
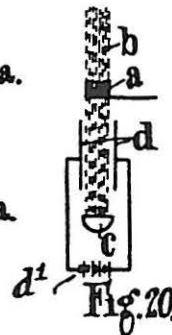
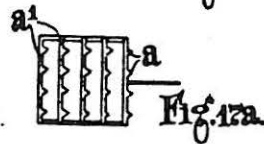
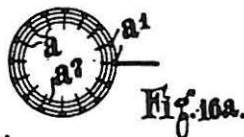
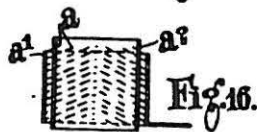
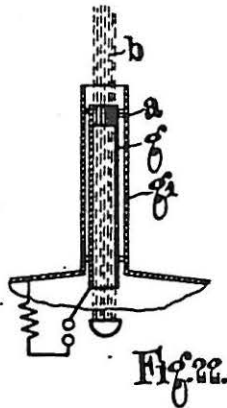
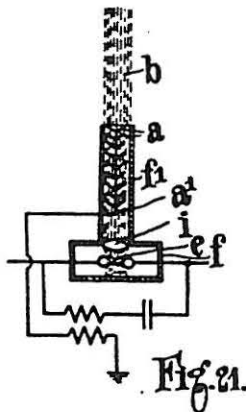
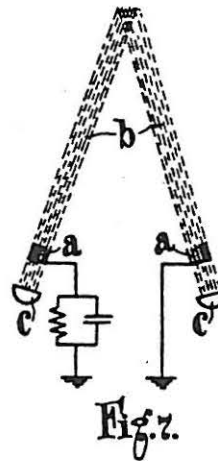
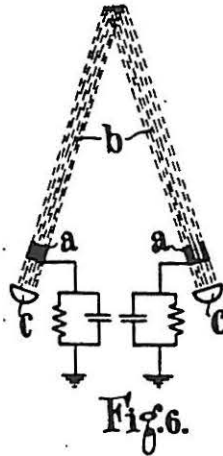
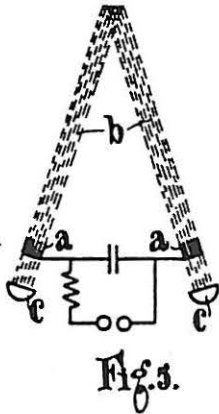
AERIAL CONDUCTOR FOR WIRELESS SIGNALING AND OTHER PURPOSES.

APPLICATION FILED JUNE 4, 1917.

Patented July 8, 1919.

4 SHEETS—SHEET 2.

1,309,031.



John Hettinger Inventor
by Paul R. R. R. R.
Attorney

J. HETTINGER.

AERIAL CONDUCTOR FOR WIRELESS SIGNALING AND OTHER PURPOSES.

APPLICATION FILED JUNE 4, 1917.

Patented July 8, 1919.

4 SHEETS—SHEET 3.

1,309,031.

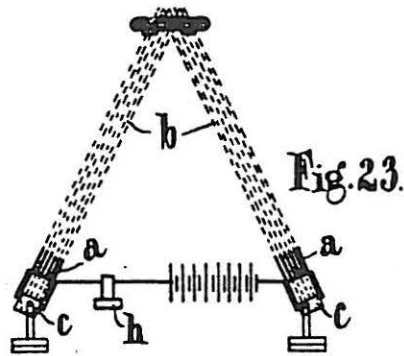


Fig. 23.

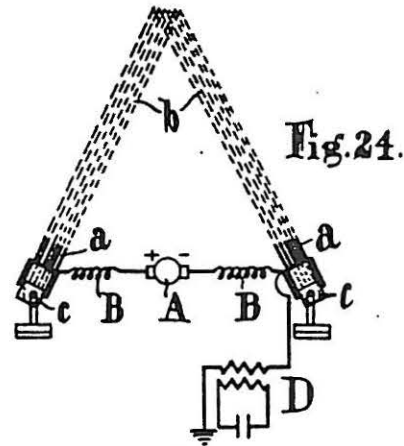


Fig. 24.

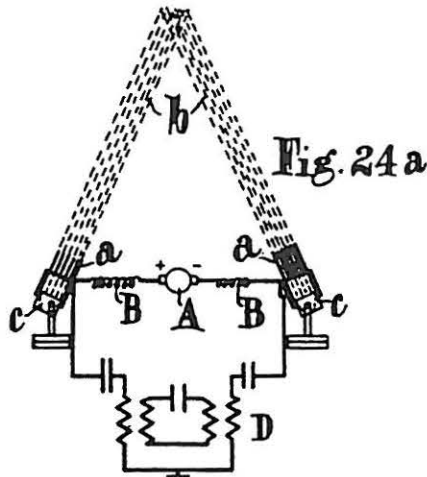


Fig. 24a

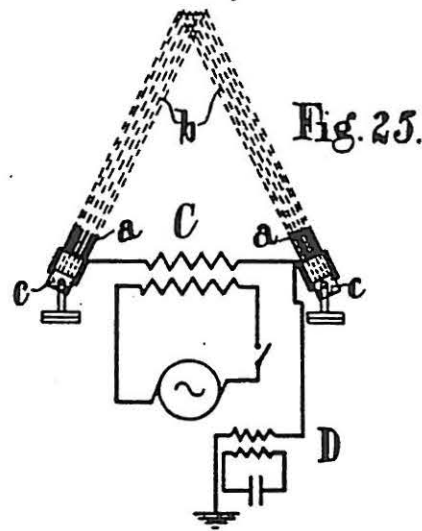


Fig. 25.

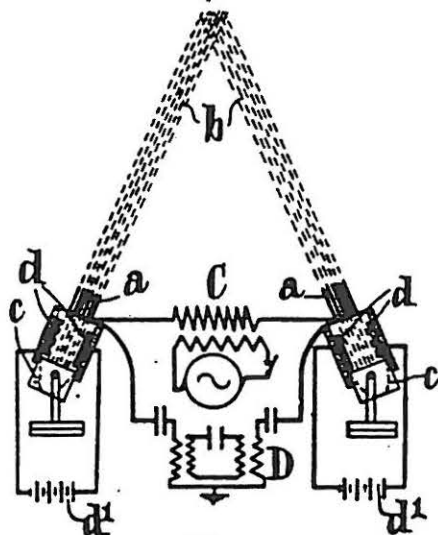


Fig. 25a

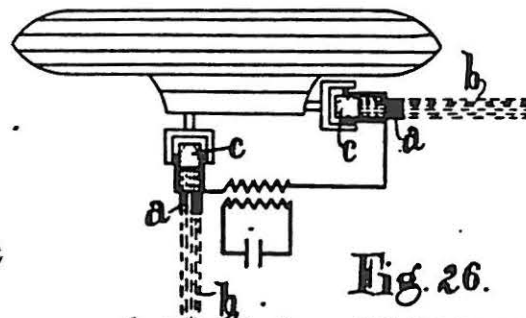


Fig. 26.

John Hettinger, INVENTOR
BY *Rich. Paul Smith*
ATTORNEY

J. HETTINGER.

AERIAL CONDUCTOR FOR WIRELESS SIGNALING AND OTHER PURPOSES.

APPLICATION FILED JUNE 4, 1917.

Patented July 8, 1919.

4 SHEETS—SHEET 4.

1,309,031.

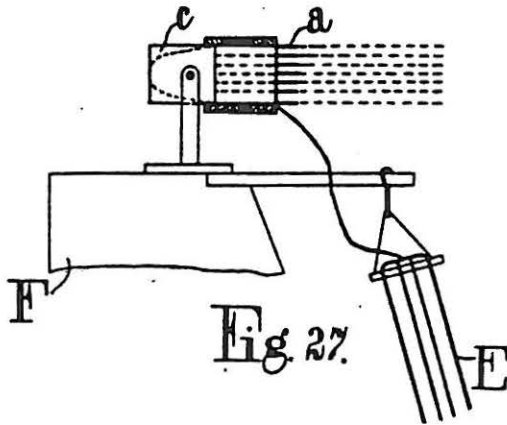


Fig. 27.

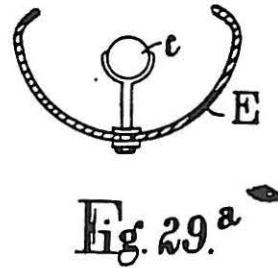


Fig. 29a.

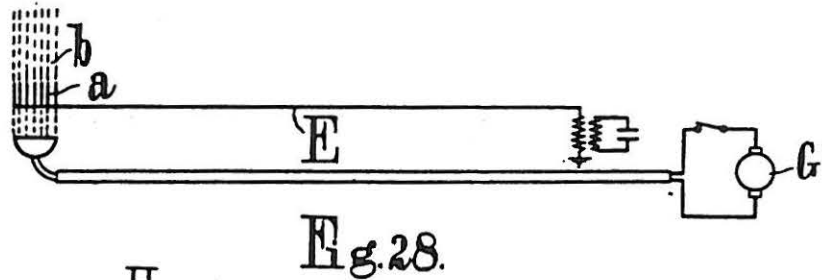


Fig. 28.

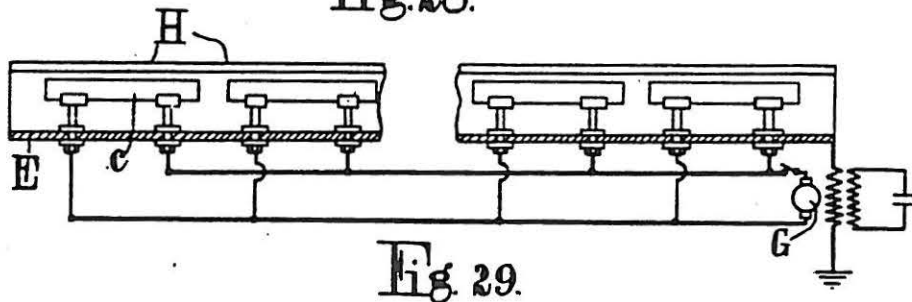


Fig. 29.

John Hettinger, INVENTOR
BY *Reich, Ruten, & Co.*
ATTORNEY

UNITED STATES PATENT OFFICE.

JOHN HETTINGER, OF STREATHAM, LONDON, ENGLAND.

AERIAL CONDUCTOR FOR WIRELESS SIGNALING AND OTHER PURPOSES.

1,309,031.

Specification of Letters Patent.

Patented July 8, 1919.

Application filed June 4, 1917. Serial No. 172,792.

To all whom it may concern:

Be it known that I, JOHN HETTINGER, a subject of the King of Great Britain and Ireland, residing at 31 Ribblesdale road, Streatham, London, S. W., 16, England, have invented certain new and useful Improvements in and Relating to Aerial Conductors for Wireless Signaling and other Purposes, of which the following is a specification.

This invention relates to an improved method of propagating electric energy at a distance without connecting wires and of collecting such energy, the invention being more particularly intended for use in wireless telegraphy and telephony but generally useful also for other purposes, such as the production of electric disturbances at a distance, for instance in or from airships or flying machines, the explosion of bombs or mines, etc.

The main object of the invention is to provide a substitute for transmitting and receiving aerials which does not require any high or elevated supporting means, other objects of the invention being hereinafter more particularly referred to in connection with the various applications of the fundamental idea.

The invention broadly consists in the utilization of a long beam of ionized or ionizing medium—such as a searchlight beam of ultra-violet rays produced by means of a suitable electric arc or mercury vapor lamp—as a substitute for a long conductor of electricity, which may be led thereto in the form of continuous currents or of impulses or alternating currents of low or high frequency and of low or high potential, according to the particular application and purpose of the electric circuit in which said long beam is included.

The invention also consists in the utilization of the long beam of ionized or ionizing medium as a transmitting or receiving aerial for wireless telegraphy and telephony, hereinafter referred to as the "ionized beam aerial".

The invention also consists in the arrangements of ionized beam aerials and long ionized conductors as hereinafter more particularly referred to by way of example.

I wish it to be understood that the present invention does not include the method of wireless signaling in which a beam of light or ultra-violet rays is utilized for changing

the electrical conductivity of a selenium cell, nor the method in which the beam of light produced by a spark discharge or by another source of ultra-violet rays is utilized to cause a discharge through another distant spark gap, the method according to the present invention differing from these well known methods, mainly in that according to the present invention electricity is actually conveyed to and propagated through the beam employed, the beam actually forming part of an electric circuit.

In order that the essence of the invention may be better understood, it may be advisable to explain some of the phenomena on which the invention is based a little more specifically.

According to the invention, a portion of the atmosphere is continuously ionized along a beam so as to render it more conductive than the remaining portion thereof, and a good electrical connection is established between the said beam and the metallic portion of the electric circuit in which the beam is substituted for another long conductor. In view of the fact that the air along the beam is not inclosed but is in actual contact with the remaining part of the atmosphere, there is a certain amount of diffusion with the consequence that the surrounding atmosphere in the immediate neighborhood of the beam is also rendered conductive to a less extent, the conductivity decreasing continuously and quickly along circles concentric with the beam, also gradually decreasing from its electrical connection in the direction of the beam facing away from its source; further, owing to the fact that the air is free to move about, ionized particles of air will, in the case of winds, be shifted from the position they occupy in the path of the beam so that the actual form of the conductive zone will be altered to a certain extent at various points thereof. The effect of these various causes is that, although ionization is continuously maintained along a predetermined line, viz., along the beam, the substitute conductor is not to be supposed to have the actual form of the beam, but a form depending upon the circumstances above referred to, the line of comparatively strongest conductivity being in the center of the beam, with small deviations therefrom in the case of moderate movements of air. The substitute conductor according to the invention, when used as an

aerial for signaling purposes may therefore be compared to an elevated conductor of large surface in electrical connection with a metallic circuit, the other end of which is earthed. The potential imparted to the electrical connection with the beam, tries to equalize itself along the beam conductor as above defined, and the whole system thus absorbs a large amount of energy as compared with the energy that could be imparted thereto without the ionized beam. In the latter case, all the lines of electric force would be bent toward the earth practically immediately after leaving the outer end of the metallic circuit. In the arrangement according to the present invention, however, a current will flow along the lines of least resistance, viz., upward within the beam and immediately around the same, more particularly along the center of the beam, and there will be lines of force which will start bending downward toward the earth at a much higher point than in the case without an ionized beam. While the amount of current actually flowing through the beam may be small and decrease continuously toward the upper end of the beam, it is to be remembered that this is not material in the case of an aerial, it being known that the current flowing through the aerial, and more particularly through the upper part thereof, may be small as long as the potential is high in the upper part thereof, and the current large at its earthing point. The electrical connection of the ionized beam with a point of high potential and the absorption of great energy by such a beam insures the fulfilment of these conditions.

In the accompanying drawings which illustrate diagrammatically and by way of example various arrangements and details for carrying the invention into effect:—

Figures 1, 2, 3, 4, 5, 6, 7, 8, 9 and 9^a illustrate various arrangements of aerials.

Figs. 10, 11, 12, 13, 13^a, 14, 14^a, 15, 15^a, 16, 16^a, 17, 17^a, 18, 18^a and 19 illustrate various forms of electrical beam connections.

Fig. 20 shows a detail.

Fig. 21 illustrates a modification wherein the source of oscillations is also used as the source of the beam.

Fig. 22 shows the form of application of the invention to submarines, and

Fig. 23 illustrates one form of application of the invention to the detection of aircraft in space.

Figs. 24, 24^a, 25, 25^a, 26, 27, 28, 29 and 29^a illustrate different modifications for carrying the invention into effect.

According to one arrangement, the one end of a spark gap, (see Fig. 1), of the secondary of an oscillation transformer, (see Fig. 2), or of a self-induction coil or condenser (see Fig. 3), forming part of an oscillatory circuit is connected at *a* with the

ionized beam aerial *b*, which may be produced at *c* as hereinbefore referred to, the other end thereof being connected to earth or its equivalent, or with another ionized beam aerial which is parallel to the first ionized beam aerial, (see Fig. 4), intersects the latter at any desired height from the earth, (see Fig. 5), or has any other suitable position relatively thereto, the sources of the beams being arranged at any desired distance apart from each other.

According to a modification, (see Fig. 6), two intersecting ionized beam aerials are associated with two separate oscillatory circuits respectively, while according to another modification, (see Fig. 7), the second intersecting ionized beam aerial is earthed but is not connected to an oscillatory circuit except through the first ionized beam aerial, which may also be earthed.

By combining together a plurality of ionized beams any well known construction of aerial may easily be built up, such as aerials of the umbrella, (see Fig. 8), of the multiple parallel, (see Fig. 9), of the triangular directive (see Figs. 5 to 7), or of any other type in which a number of wires have hitherto been connected together in an open or closed circuit aerial. The plurality of ionized beam aerials may be produced from one single source by using reflectors. Such an arrangement is illustrated in Fig. 9^a in which the source *c* of the beam is arranged to throw the beams *b* on reflectors *c'* which reflect the same in such directions as to intersect with one another where required.

The connection between the metallic portions of the electric circuits and the ionized beam aerials is preferably effected by means which are known to facilitate the discharge of electricity, such as rods with pointed ends, etc. The connecting rods or plates may be arranged within the ionized beam parallel or at any suitable angle thereto and may be replaced by or be used in conjunction with a metal cylinder or truncated cone in touch with and surrounding the beam. The connection with the ionized beam may also be effected by means of wire gauze or by a perforated metal plate or superposed plates arranged across the beam, or by metal reflectors suitably inclined relatively to the source of the beam or in any other suitable manner.

Figs. 10 to 18^a illustrate various beam connections which are subdivided for the purpose of obtaining the best results.

The connection illustrated in Fig. 16 consists of a grid *a* comprising a series of parallel wires, the connection shown in Fig. 11 of a piece of wire gauze *a*, while the connection shown in Fig. 12 comprises a series of grids or pieces of wire gauze *a* as shown in Figs. 10 and 11 superposed upon one another and electrically connected together.

The connection illustrated in Figs. 13 and 13^a

13^a consists of a series of concentric cylinders *a* electrically connected together, the connection shown in Figs. 14 and 14^a of a series of pointed rods *a* supported on bars *a*¹ electrically connected together, and the connection illustrated in Figs. 15 and 15^a of a perforated plate *a*¹ provided with tubular extensions *a*.

According to another modification illustrated in Figs. 16 and 16^a, the connection may consist of several series of pointed metal pieces *a* supported on rods *a*¹ and penetrating into the interior of a cylinder of insulating material *a*², the pointed ends being preferably inclined in the forward direction of the beam passing through the cylinder.

According to a further modification illustrated in Figs. 17 and 17^a, the connection may consist of a series of metallic plates *a*¹ provided with serrations *a*, the pointed ends of which are preferably directed in the forward direction of the beam, which is split up by the plates *a*¹.

Figs. 18 and 18^a illustrate a reflecting connection consisting of a metallic plate *a*¹ carrying a plurality of small metallic surfaces *a* by which the beam is reflected in the required direction.

A further form of electrical connection is illustrated in Fig. 19: the same consists of a bank of metal tubes *a* of small diameter, the diameter preferably increasing toward the ends of the tubes facing away from the source of the beam.

It is known that when certain metals are charged, more particularly with negative electricity, they have the property of becoming discharged under the action of light, and it has been ascertained that this discharge is due to ultra-violet and other rays, and to be dependent upon the state of the surface of the metal. This property of certain metals is generally referred to as a photo-electric effect. As a small length of the beam *b* lies between the electrical connection *a* and the source *c* of the beam, use may be made of the photo-electric property possessed by certain metals, and not by other metals, or substances, to prevent a discharge of electricity from the electrical connection *a* toward the source *c* of the beam, or to reduce it as much as possible and at the same time assist the discharge from the electrical connection *a* in a direction away from the source of the beam. With this object in view, the photo-electric effect above referred to, has to be assisted in every respect on the surface of the connection facing away from the source of the beam, while

the same has to be prevented from taking place, or reduced as much as possible on the surface facing the source of the beam; for instance, the surface of the gauzes or perforated plates facing away from the source may be highly polished, while the opposite

surface may be covered with a material which is not transparent with respect to ultra-violet rays. The same object may also be attained by making the connection by means of a metal which is little sensitive with regard to the photo-electric phenomenon, such as copper, provided on the surface facing away from the source of the beam with a covering of metal which is very sensitive with respect to that phenomenon, such as rubidium or an alloy of potassium or sodium.

The discharge of electricity from the electrical connection *a* toward the source of the beam may also be prevented, or greatly diminished, by removing or greatly reducing the conductivity of the beam between its source and the electrical beam connection by causing a direct alternating or oscillating current to flow across the beam in the part thereof lying between the source of the beam and the electrical connection. This flow of current may be produced by means of an electric field, for instance, as shown in Fig. 20 (see also Fig. 25^a), the two plates *d* of a condenser being connected to the two poles of a source *d*¹ of constant potential which may be replaced by an alternating current supply circuit of low or high frequency, which may belong to the transmitting system.

For the production of the beam, use may be made of any ordinary search-light, in which an arc lamp or mercury vapor lamp is employed, care being however taken to prevent the absorption of the ultra-violet rays by substituting quartz for all transparent parts usually employed in search-lights.

The spark or arc producing the oscillations may also be employed for producing the beam. In Fig. 21 illustrating such an arrangement by way of example, a spark gap *e* is inclosed in a cylinder of insulating material *f* having an extension *f*¹ which is open at its outer end to allow the passage of the beam to the exterior and the electrical connection is effected by a series of pointed metal pieces *a* carried on a support *a*¹ electrically connected with the secondary of an oscillation transformer which is earthed. A quartz lens *i* may also be arranged in the path of the beam.

The high frequency currents or impulses supplied to the transmitting ionized beam aerial or collected by the receiving ionized beam aerial may be superposed upon an alternating electric field of low frequency or upon a continuous electric field of high potential.

This modification is illustrated, by way of example, in Figs. 24 and 24^a in connection with a continuous electric field, and in Figs. 25 and 25^a in connection with an alternating electric field.

Referring to Figs. 24 and 25, the continu-

ous or alternating field of low frequency is set up by connecting the two poles of a high voltage continuous current machine A through the inductive resistances BB, or the two terminals of the secondary C of an ordinary transformer (not a high frequency oscillation transformer) to two electrical beam connections *aa*, respectively, one of which is directly connected to the oscillatory system D, as hereinbefore referred to in connection with Fig. 2, while the other beam connection is not directly connected to the oscillatory system, and is placed in an ionized beam arranged to intersect the beam in which the beam connection first referred to is placed. Referring to Figs. 24^a and 25^a, the same differ from Figs. 24 and 25, respectively, in that both beam connections are directly connected to the oscillatory system.

In the application of the invention to wireless signaling to and from aircraft, use is preferably made on the aircraft of one ionized beam aerial directed downward so that it may strike the earth, a telegraph wire, the rail of a train, or other conductor, and of another ionized beam aerial which is substantially parallel to the earth, thereby forming a directive aerial. (See Fig. 26).

The aerial according to the present invention, may be used in conjunction with any wireless aerial of known construction—for instance it may be movably connected with the top end of the usual elevated aerial thereby forming a directive aerial of the horizontal type. Fig. 27 illustrates such an arrangement in which the source *c* of the beam, together with the electrical beam connection *a*, which is mounted in an insulated manner on the casing of the source *c* and is electrically connected with the top of the aerial E, is mounted on a high support in a well known manner so that it may be turned in a horizontal plane as well as in a vertical plane.

Attempts have hitherto been made to transmit wireless signals over long distances by means of horizontal aeri-als of short height, but such attempts have not hitherto led to any practical results; such results may however be obtained by combining this kind of aeri-als with the ionized beam aeri-als according to the present invention, for instance, as shown in Fig. 28, by leading the free end of the horizontal metallic aerial E into the ionized beam by means of a beam connection *a*, the source of the beam receiving its energy from a source of current G; or by arranging said metallic aerial in a plane of ultra-violet or equivalent rays directed upward. The latter arrangement is preferably carried out as shown in Figs. 29 and 29^a, by using as the metallic horizontal aerial, a long strip E of zinc or other metal which is sensitive with regard to the photo-electric phenomenon, and is bent trans-

versely to form a trough, the ionized aerial *b* being produced by a plurality of mercury vapor lamps *c* of tubular shape suitably supported in the concave part of the metallic trough and being directed upward in a plane containing the metallic aerial. The mercury vapor lamps receive the current from the source of energy G.

The invention is also well adapted for use on submarines, and Fig. 22 illustrates by way of example a transmitting arrangement used in connection therewith. The electrical connection *a* is attached to the upper part of a metal tube *g* which is arranged within a periscope or like tube *g'* and forms with the latter a condenser included in an oscillatory circuit. The system is earthed through the body of the submarine. The periscope mirror (not shown) which may be used to reflect the beam in any desired direction must be made of metal or the glass used in ordinary mirrors must be replaced by quartz. The receiving apparatus may be connected up to the beam aerial in a similar manner.

A long ionized beam at a transmitting station connected to a source of continuous or ordinary alternating currents and ordinary transmitting apparatus may be used in combination with a similar beam at a receiving station connected to a receiver, for the purpose of telegraphic or telephonic communication, the circuit being completed through earth and through the upper ionized layers of the atmosphere, and the electrical beam connections being effected as hereinbefore referred to.

A further application of the ionized beam aeri-als consists in their utilization for detecting the passage of aircraft through the space. For this purpose a suitable sensitive current indicator or detector, for instance a telephone *h*, is inserted in a connection between the bases of two beam aeri-als, the latter intersecting each other at a variable point by changing the directions of the beams in a well known manner, and the beams forming, together with the metallic part of the arrangement, an electric circuit, the current through which is changed by the passage of the aircraft. (See Fig. 23).

I wish it to be understood that the various arrangements and details hereinbefore referred to for carrying the invention into effect may be varied without in any way departing from the spirit and scope of the invention, and that the invention is not limited to the applications hereinbefore specifically mentioned. I also wish it to be understood that although I have assumed that the conductivity of the beam is due to an effect of ionization, in accordance with the present day theory, the invention is independent of any such theory and includes all means by which a long beam of a gaseous medium can be made conductive.

What I claim is:--

1. Substitute means for long conductors of electricity forming part of an electric circuit comprising means for ionizing the atmosphere along a long beam, and means for electrically connecting said ionized beam to the electric circuit, as set forth.

2. In combination an electric circuit through which electric energy is supplied, means for ionizing the atmosphere along a long beam and means for electrically connecting said ionized beam to the said electric circuit, as set forth.

3. Substitute means for long conductors of electricity forming part of an electric circuit comprising a source of ultra-violet rays arranged to ionize the atmosphere along a long beam and means for electrically connecting said ionized beam to the electric circuit, as set forth.

4. In combination an electric circuit through which electric energy is supplied, a source of ultra-violet rays arranged to ionize the atmosphere along a long beam, and means for electrically connecting said ionized beam to the said electric circuit, as set forth.

5. Aerials for wireless signaling comprising means for ionizing the atmosphere along a long beam and electrically connecting means inserted in said ionized beam, as set forth.

6. Aerials for wireless signaling comprising a source of ultra-violet rays arranged to ionize the atmosphere along a long beam and electrically connecting means inserted in said ionized beam, as set forth.

7. Aerials for wireless signaling comprising a plurality of ionized beams of the atmosphere, means for ionizing said beams, and electrically connecting means inserted in said ionized beams, as set forth.

8. Aerials for wireless signaling comprising a plurality of ionized beams of the atmosphere arranged to intersect each other, means for ionizing said beams, and electrically connecting means inserted in said ionized beams, as set forth.

9. Substitute means for long conductors of electricity forming part of an electric circuit, comprising means for ionizing the atmosphere along a long beam, and means for electrically connecting said ionized beam to the electric circuit, and for facilitating the discharge of electricity in the direction of the beam facing away from the means producing the ionization, as set forth.

10. Substitute means for long conductors of electricity forming part of an electric circuit comprising a source of ultra-violet rays for ionizing the atmosphere along a long beam, means for electrically connecting said ionized beam to the electric circuit, the latter means being such as to facilitate the discharge of electricity in the direction

of the beam facing away from the means producing the ionization, and means for preventing a photo-electric effect on the surface of the electrically connecting means which is facing the source of the ultra-violet rays, as set forth.

11. Aerials for wireless signaling comprising means for ionizing the atmosphere along a long beam and electrically connecting means inserted in said ionized beam, the latter means being such as to facilitate the discharge of electricity in the direction of the beam facing away from the means producing the ionization, as set forth.

12. Aerials for wireless signaling comprising means for ionizing the atmosphere along a long beam, electrically connecting means inserted in said ionized beam, the latter means being such as to facilitate the discharge of electricity in the direction of the beam facing away from the means producing the ionization, and means for preventing a photo-electric effect on the surface of the electrically connecting means which is facing the source of ultra-violet rays, as set forth.

13. Substitute means for long conductors of electricity forming part of an electric circuit, comprising means for ionizing the atmosphere along a long beam, and subdivided means for electrically connecting said ionized beam to the electric circuit, whereby the discharge of electricity into the beam is facilitated, as set forth.

14. Aerials for wireless signaling comprising means for ionizing the atmosphere along a long beam, and subdivided electrically connecting means inserted in said ionized beam, whereby the discharge of electricity is facilitated, as set forth.

15. Substitute means for long conductors of electricity forming part of an electric circuit, comprising means for ionizing the atmosphere along a long beam, means for electrically connecting said ionized beam to the electric circuit, the latter means being such as to facilitate the discharge of electricity in the direction of the beam facing away from the means producing the ionization, and means for destroying the electrical conductivity of the beam between said electrically connecting means and the ionizing means, as set forth.

16. Aerials for wireless signaling comprising means for ionizing the atmosphere along a long beam, electrically connecting means inserted in said ionizing beam, the latter means being such as to facilitate the discharge of electricity in the direction of the beam facing away from the means producing the ionization, and means for destroying the electrical conductivity of the beam between the electrically connecting means and the ionizing means, as set forth.

17. In combination an electric circuit

through which the electric energy is supplied in the form of high frequency currents, means for ionizing the atmosphere along a long beam, means for electrically connecting said ionized beam to the said electric circuit, and separate means for superposing an electric field of high potential on the beam, as set forth.

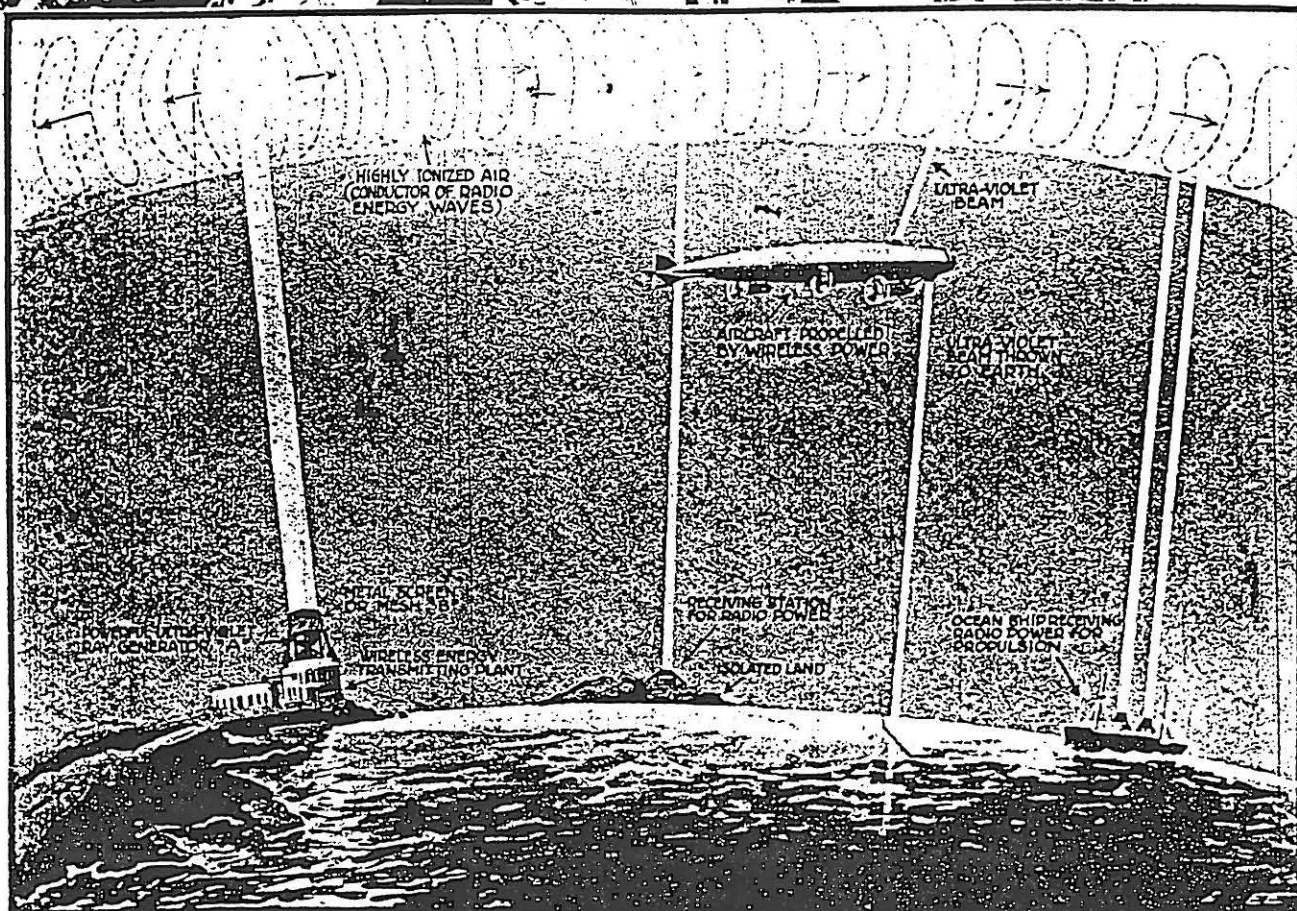
18. Aerials for wireless signaling comprising means for ionizing the atmosphere along a long beam, a high frequency circuit, means for electrically connecting said high frequency circuit to the ionized beam, a second

means for ionizing the atmosphere along a long beam, a second high voltage circuit, and means for electrically connecting said second high voltage circuit to the two ionized beams, as set forth.

19. Aerials for wireless signaling comprising in combination an ionized beam aerial and a metallic aerial, as set forth.

In testimony whereof I have signed my name to this specification.

JOHN HETTINGER.



Showing the Wireless Transmission of Power by Means of Ionized Searchlight Beams. Powerful Tesla Currents of High Potential and Frequency Are Imprest on the Ionized Beams and Received from Similar Beams as Shown.

Wireless Transmission of Power Now Possible

By THOMAS W. BENSON

RECENT developments tend to fulfill the old, old dream of power transmission without wires. For years men have labored in vain to transmit power without wires and thus solve a myriad of transportation problems, such as propelling aircraft, etc., without having to include a source of power in their construction. It makes one's head almost reel to think of the possibilities in such an achievement and now the dream promises to come true.

By one bold stroke an English genius, Mr. John Hettinger, has unthinkingly opened up the way to transportation as other nations, the way has before our very eyes, but we were all too blind to see it.

While working on a means for

transmitting radio waves without material aerials, Mr. Hettinger hit upon the idea of using ionized light beams as elevated conductors. Obviously simple when one thinks of it.

It is a well-known fact that an ionized gas is a conductor; in fact, the conductivity

of a gas is a measure of its ionization. Furthermore, it is possible to ionize a gas by means of a stream of ultra violet rays. Working with these facts, Mr. Hettinger devised means to utilize them for radio transmission in the following manner.

As shown in Fig. 1, a source of ultra violet rays, an arc or mercury vapor lamp, A, is arranged to throw a beam of ionizing rays vertically.

These rays result in an ionized stream of air that acts as a conductor for the surrounding un-ionized air being practically a perfect insulator by making contact with this ionized beam.

The perfect insulator that this ionized beam loses its ionizing power

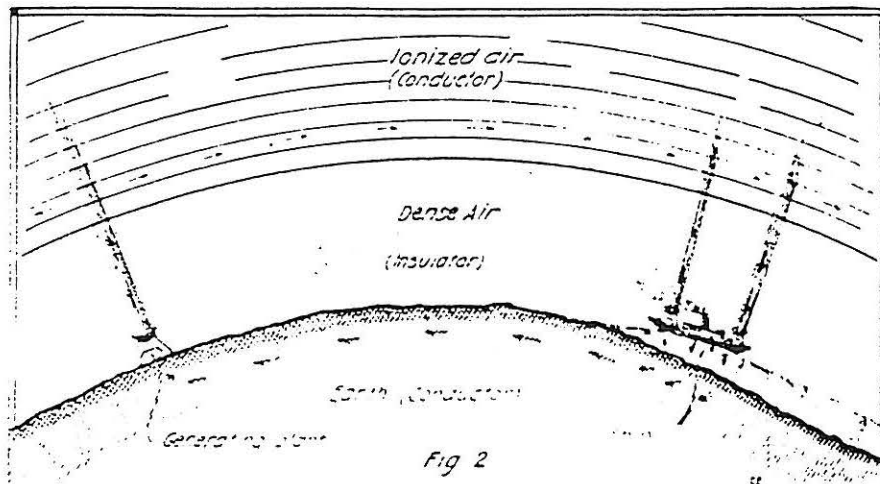


Diagram of the Author's Scheme for the Wireless Transmission of Power Thru Ionized Light Beams and the Upper Ionized Strata of the Atmosphere.

As the distance from the source increases, therefore the effective height of such an arrangement is determined by the intensity of the ray generator. So much for the idea as applied to radio communication.

But let us consider further. In studying the spectrum we find that the sunlight on reaching the earth contains few ultra violet rays of shorter wavelengths than 3,000 Angstrom units, yet we are able to generate much shorter rays with an arc light. It is unreasonable to assume that shorter waves do not leave the sun, and in view of the fact that it has been determined that the upper stratum of our atmosphere is ionized, it is accepted that the shorter rays are absorbed to cause this ionization.

It will now be apparent that a very good condition exists for the transmission of energy without wires. As shown in Fig. 2, we have the earth, a good conductor, surrounded with a blanket of insulating air about ten miles thick, beyond which, up to about a hundred miles, the air is highly rarefied and kept in a state of ionization by light from the sun and stars.

Hence, we have two good conductors separated by several miles of atmosphere, practically a perfect insulator, an ideal arrangement for our purposes. We have but to connect a source of current to the earth and to the ionized strata of air and energy can be transmitted entirely around the earth without wires. The energy could be utilized in any part of the earth by merely connecting to the pair of conductors.

This condition has been recognized for some time, but the difficulty lies in making connections to the upper layer of conducting atmosphere. It is hardly practical to construct towers six or seven miles high for the purpose, then again the energy could not be utilized without using a similar structure at the point of reception, which makes this scheme hardly feasible for aircraft or moving vehicles.

Return then to the ionized stream for radio aeriads. We can easily construct arcs that will throw a beam ten or twenty miles. Then why not make connection to that upper stratum with an ionized stream of air? Wonderful in its simplicity.

In Fig. 2 the writer attempts to portray a generating station embodying these principles. In the main building will be housed the generating units for supplying the current to the arc and the primary of the high voltage apparatus for transmission of energy. Supported on the roof of this structure will be a monstrous arc lamp

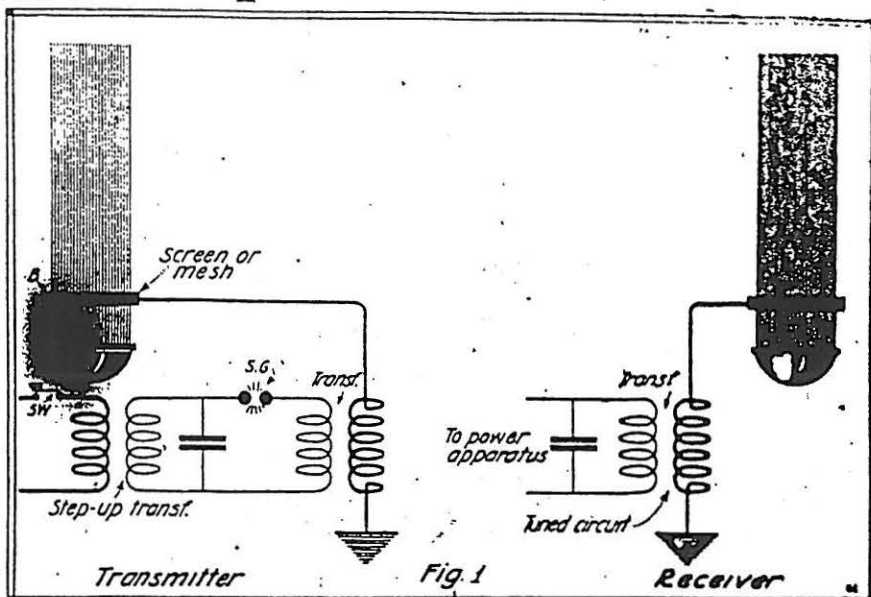


Diagram Showing the Transmitting and Receiving Circuits for the Transmission and Reception of Electric Power by Wireless.

capable of throwing a stream of ultra violet rays for at least ten miles. In this beam is supported a conducting screen to make connection to the conducting stream of ionized air. The insulation of these parts present no great difficulties to modern engineering.

The building will also house a huge step-up transformer, a set of high voltage condensers, a spark-gap either of the rotary or quenched type and a huge oscillation transformer or Tesla coil. These instruments are connected in the usual manner and tuned so that the inductance in the circuit and the capacity formed by the earth and ionized upper strata will have a well defined oscillation period.

By these means the whole earth will become an electrified body, energy to be drawn at any point by simply making metallic connection to the earth and pointing a beam of light vertically, a screen being used to take the energy that will flow down the beam. An inductance coil being necessary in the circuit to insure resonance with the transmitter at the receiving set. After

once started, the receiving energy can be used to keep the arc going.

Ships will have an arc and reflector mounted on the masts, aeroplanes have two arcs, one on top, the other below, and so on.

This scheme will not interfere with present short range transmission, it being hardly practical for each home to have an arc on the roof when one arc would serve for a town and several for a large city.

Rather its benefit will lie in the utilization of water falls far from civilization, now unused on account of difficulties in transmitting the power hundreds or thousands of miles.

Aside from the transmission of power other advantages may accrue. Will such a stress between the earth and upper air strata reduce the presence of dust particles in the atmosphere? Or, again, cause the immediate condensation of fogs and moisture in the air to give us perfectly cloudless days? Perhaps it will become simply a matter of changing the frequency or voltage of the current to cause rain or to prevent it.

Then the question of effect on radio communication: will it make our present sets obsolete, a transmitter of the future being connected directly to the power set and acting by superimposing different frequencies on the power frequency? Or will radio-telephony work hand in hand with the power system, the voice currents being impressed on the power circuit and filtered out at the receiver?

There are a thousand and one things such an arrangement might effect. Will trees and vegetation increase in growth as experiments in electrical culture would indicate? What effect would such stresses have on germs and bacilli? Their numbers will be decreased by the destructive effects of the ultra-violet light. Will man grow to an unsuspected height and become uniformly healthier due to the electrical treatment he would be constantly undergoing?

And so on—conjecture is without bounds, but the scheme is practical to all appearances; it requires but some financial genius to give it a trial.

And to think it all was within reach such a short time ago! Had Tesla but put a gigantic arc on top of the tower of his experimental station in Long Island accurate data would be at hand now—were it but even a promise it would mean another step towards the final mastery of all matter by man.

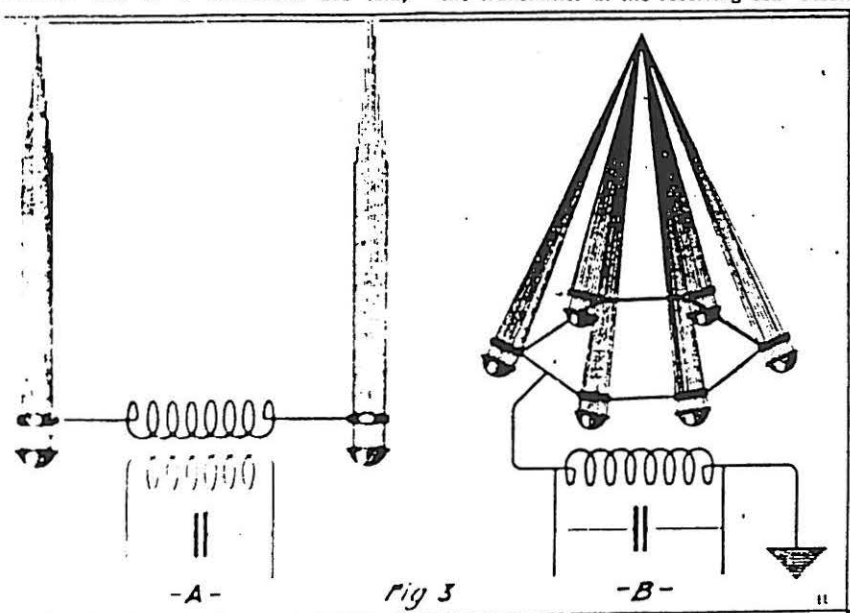


Fig 3

Two Optional Forms of Wireless Antennae Formed of Searchlight Beams—Ionized Atmospheric Streams.

F. S. McCULLOUGH.
 APPARATUS FOR DIRECTIVE TRANSMISSION OF ELECTROMAGNETIC WAVES.
 APPLICATION FILED OCT. 30, 1916.

1,403,700.

Patented Jan. 17, 1922.

2 SHEETS—SHEET 1.

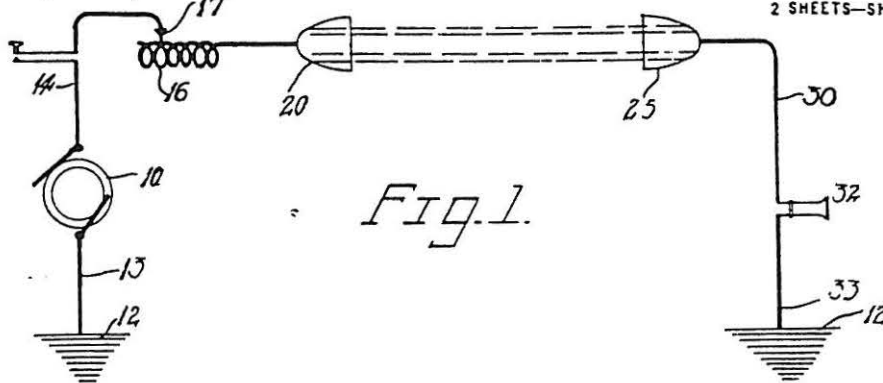


Fig. 1.

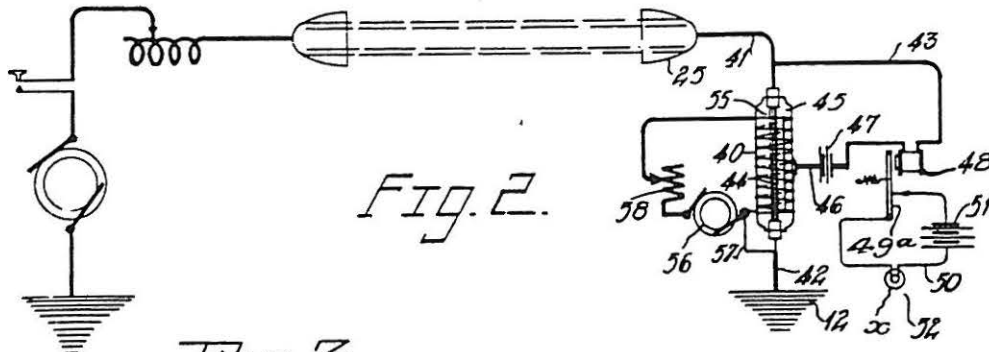


Fig. 2.

Fig. 3.

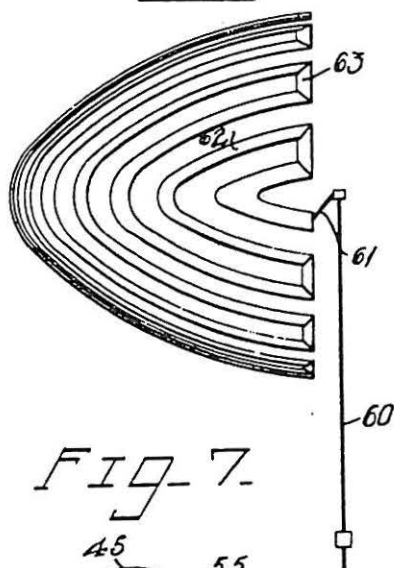


Fig. 7.

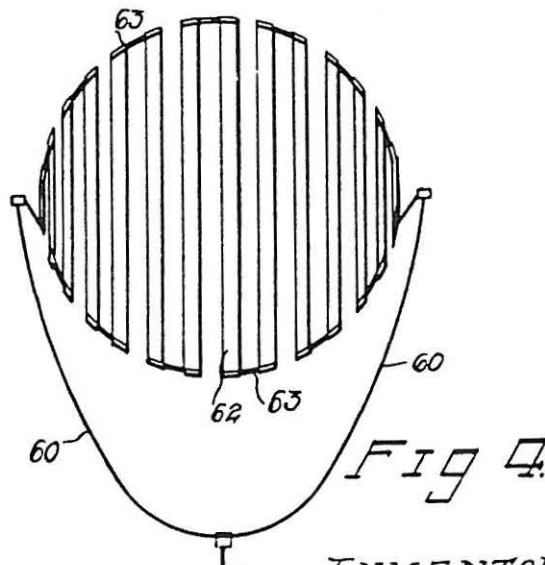
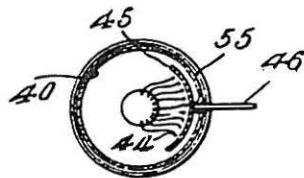


Fig. 4.

INVENTOR,
 FREDERICK S. McCULLOUGH
 BY
 Bates and Macklin ATT'YS

F. S. McCULLOUGH.
 APPARATUS FOR DIRECTIVE TRANSMISSION OF ELECTROMAGNETIC WAVES.
 APPLICATION FILED OCT. 30, 1916.

1,403,700.

Patented Jan. 17, 1922.
 2 SHEETS--SHEET 2.

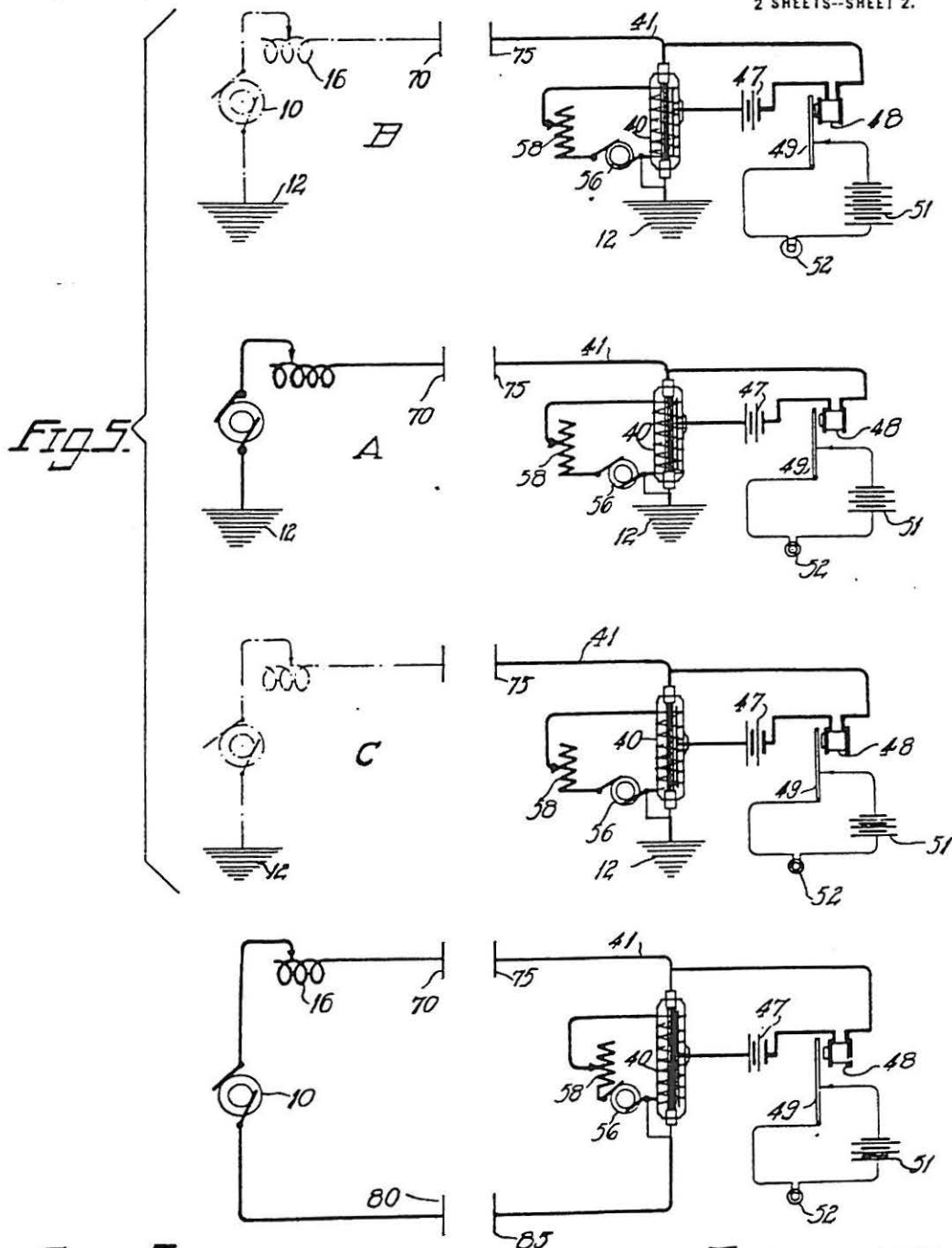


Fig. 6.

INVENTOR,
 FREDERICK S. McCULLOUGH
 BY Bates and Macklin,
 ATT'YS.

UNITED STATES PATENT OFFICE.

FREDERICK S. McCULLOUGH, OF CLEVELAND, OHIO. ASSIGNOR TO GLENN L. MARTIN,
OF CLEVELAND, OHIO.

APPARATUS FOR DIRECTIVE TRANSMISSION OF ELECTROMAGNETIC WAVES.

1,403,700.

Specification of Letters Patent. Patented Jan. 17, 1922.

Application filed October 30, 1916. Serial No. 128,375.

To all whom it may concern:

Be it known that I, FREDERICK S. McCULLOUGH, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented a certain new and useful Improvement in Apparatus for Directive Transmission of Electromagnetic Waves, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings.

This invention relates to an improved system of transmission of electro-magnetic waves for purposes of wireless communication, signaling, etc. The general object is to increase the efficiency of and to simplify such apparatus.

A more specific object of this invention is to so construct the apparatus that it may be effectively used for actuating selectively one or more of a plurality of receiving devices by directive transmission of electromagnetic waves from one or more transmitting apparatus. The invention is particularly useful for signaling successively individual members of a series of receiving devices the transmitting device being so arranged as to travel in a pathway leading past said receiving devices.

Another specific object of the invention is to arrange the apparatus that it may be well adapted for use in a system including a plurality of receiving members located at intervals along a trackway or guideway and in close proximity thereto, while a coacting transmitting device may communicate selectively with the receiving devices as it is moved along the trackway or guideway past the same.

The manner of accomplishing the above and other objects of my invention is set forth in the following description which refers to the drawings illustrating a preferred embodiment thereof. The essential characteristics of the present invention are set forth in the claims.

I have shown, in the drawings, illustrations of my invention in diagrammatic form, in order that it may be more readily understood, as it is apparent that those skilled in the art may readily embody the invention with proper mechanical devices corresponding to the diagrammatic illustrations.

In the drawings, Fig. 1 is a diagrammatic view illustrating a simple form of trans-

mission and receiving apparatus; Fig. 2 is a similar view showing a modified form of receiving apparatus; Figs. 3 and 4 are a side elevation and a front elevation respectively, of a particular form of parabolic-shaped capacity members; Fig. 5 is a view showing a series of receiving station and a transmission device coacting therewith and adapted to travel in parallel relation thereto. In this figure the transmitting device is illustrated in solid lines in the intermediate position, and in dot and dash lines in the other positions coacting with other receiving stations. Fig. 6 illustrates a slightly modified form of transmitting and receiving stations adapted to be used in a similar manner. Fig. 7 is a cross-section on an enlarged scale of the tube 40 showing the wire 55 in heating contact with the glass.

Referring to Fig. 1, 10 indicates a suitable high frequency generator which is illustrative of any means for generating electro-magnetic waves of high frequency. One pole of this generator is shown as connected to the ground 12 by a wire 13. From the other pole a wire 14 leads to a coil 16 providing a variable inductance, the contact 17 being movable along the same. This inductance is shown as connected with a capacity member indicated at 20, which is preferably of the form shown in Figs. 3 and 4, and which will be later more specifically described.

By arranging the capacity member 20 or the induction portion 16, or both, so that they may be adjusted, they may be brought into proper proportion to the desired wave length. The frequency of the generator may be varied by changing its speed.

At 25 is indicated a receiving capacity similar to the transmitting capacity 20 and connected by a wire 30 with a suitable receiver indicated at 32, and connected to the ground 12 by a wire 33. The telephone at 32 is merely symbolical of any suitable receiving apparatus, and its diaphragm is not intended to vibrate at radio frequencies.

Referring to Fig. 2 and Fig. 7, in which is illustrated an apparatus more particularly adapted for relay signaling by directive transmission of electromagnetic waves, the transmitting device is substantially the same as shown in Fig. 1, while the receiving device is shown as comprising the receiving capacity 25 and a hot cathode tube 40 hav-

ing connections 41 and 42 leading from the capacity to the cathode tube and thence to the ground respectively. Within this tube are a plurality of minute wires 44. Mounted adjacent the same is plate 45 connected by a separate wire 46 with a source of current 47 leading through a magnetic relay 48, wire 43, and thence to the wire 41. The relay 48 is shown as actuating an armature 49 governing an independent circuit 50 having a source of current 51 and controlling a signal indicated at 52, which may represent any indicating device, shown for example, as any electric light bulb.

The tube 40 is practically evacuated, but may contain a residuum of an inert gas, such as nitrogen. The coil of wire, 55, surrounds this tube and is connected with the high frequency alternating current generator 56. In circuit with the generator and the coil is the variable resistance 58, for regulating the current in the circuit. The frequency of the generator 56 may be varied by changing its speed. A branch circuit, 57, runs to the wire 42.

The rapidly alternating electrification or changing of the currents in the coil 55 causes the latter to become heated. This heated coil surrounding and substantially in contact with the glass tube or globe, causes the latter to become heated as the result of radiation and conduction of such heat. The filament or wires 44 are heated by the charge effect placed upon the capacity member 25, which creates current flowing through wires 44 in connection with the ground 12, making a complete circuit through the transmitter and receiver. In this manner, therefore, it will be understood that a maximum emission of electrons is obtained.

The frequency of generator 56 should be the same as that of generator 10 at the transmitting station, and a rapidly oscillating field is created in the tube, within the coil 55. Under these circumstances, when the waves from the transmitting station are received at the receiving station on the receiving capacity 25, and the oscillations are transmitted by the wire 41 to the wire or wires 44 in the tube, the flow of electrons between the wire or wires 44 and the plate 45 is increased to an extent sufficient to permit a flow of current in the circuit including the battery 47 and relay 48 great enough to operate the relay 48, so that current will flow in the circuit containing the indicating device 52, and cause the latter to give a signal.

The parabolic capacity device, illustrated particularly in Figs. 3 and 4, is shown as made up of a continuous flat metal surface warped into the shape of a parabolic reflector. This flat surface preferably comprises a thin ribbon of metal connected at each end to conductors 60 and bent re-

peatedly upon itself in a tortuous path, forming a series of loops 62 each connected at one end with the loop nearer the wire 60 and at the other end with the loop next away from that wire, as indicated at 63, and each of these ribbons lying in an imaginary surface of the reflector. This disposition of the conductor also reduces the inductance to a minimum.

A capacity such as just described has been found by experiment to be very sensitive and effective when used with a receiving apparatus.

In carrying out the specific object of actuating a plurality of receiving devices by directive transmission of electro-magnetic waves from a station having its capacity traveling in a pathway in parallel relation to the capacities of the receiving devices and without interference, I have arranged the system shown in Fig. 5 in which the generator 10, inductance 16 and ground 12 are illustrated substantially as in Fig. 1 and in which the capacity 70 may be of any desired shape or form.

The capacities 75 are adapted to receive impulses from the directive capacity 70 only when the capacity 70 is in proximity or position substantially opposite one of the capacities 75.

In this Fig. 5 the directive transmission device is adapted to be moved along a pathway and as it comes into the position marked A, which is shown in solid lines, it communicates with the receiving station directly opposite. The positions B and C indicate the sending device in position to transmit impulses to the corresponding receiving stations.

In the arrangement shown in Fig. 5, one terminal of the electro-magnetic generator means is connected with the ground which, furnishing a conductor, renders necessary only one set of capacity members. However, in Fig. 6 is shown a slightly modified arrangement in which the generator 10 has its one terminal connected with the capacity member 70, as above described, while the other terminal is connected with a capacity 80 adapted to receive impulses from a capacity member 85 when the capacity members are brought into the relative positions illustrated in this figure. This particular arrangement is useful in instances where grounding the circuit would tend to misdirect the same, as the capacity member may be made more truly selective if operative only when both capacities are brought into close proximity, as illustrated.

The arrangement of the system just described is particularly useful, for example, in signaling systems for elevators and the like.

The capacity members 70, 75, 80 and are diagrammatically illustrated as f

plates, but, in instances where the distance between the capacity members is comparatively great, capacity members such as illustrated in Figs. 3 and 4 may be used with advantage, as the waves might then be directed toward a particular station which would receive sufficient energy, by reason of the directing action of such a capacity member, to actuate its receiving device while those toward which the capacity member is not directed would receive no impulses sufficient to register.

From the foregoing description it will be seen that I have provided a system and apparatus for wireless transmission, capable of selectively communicating from one or more stations to any of a series of stations and that when the distance between the stations is appreciable, the directive capacity member herein described will function very usefully in controlling the selection of the receiving station.

Having thus described my invention, what I claim is:

1. In a system of wireless transmission, the combination of means for generating electro-magnetic waves, a directive capacity member associated with said means and comprising a conductive flat ribbon bent upon itself in a succession of loops and arranged in the form of a parabolic reflector.

2. In a wireless signaling apparatus, a means for receiving or projecting electro-magnetic waves, comprising a capacity member, made up of a flat conducting element which is oblong in cross section and arranged edge to edge in courses spaced apart.

3. A capacity member for use in a wireless transmission system, consisting of a conductor convoluted into the form of a skeleton paraboloid.

4. A capacity member for use in a wireless transmission system, consisting of a conductor convoluted into the form of a skeleton paraboloid, the conductor being elongated in cross section in the direction of the parabolic surface.

5. A capacity member for use in a wireless transmission system, comprising a skeleton paraboloid consisting of a substantially flat metallic ribbon convoluted into parallel strips with the edges adjacent but separated.

6. In a wireless system, an element consisting of a continuous thin, flat conductor, oblong in cross-section, disposed edge to edge in a series of adjacent courses, said conductor being bent back upon itself in a parabolic surface.

7. In a wireless system, an element consisting of a continuous thin, flat conductor, oblong in cross-section, disposed edge to edge in a series of adjacent courses, the adjacent courses running in opposite directions, in a parabolic surface.

8. In a wireless system, an element consisting of a continuous thin, flat conductor, oblong in cross-section, so disposed in a parabolic surface, as to increase its capacitance and reduce its inductance.

In testimony whereof, I hereunto affix my signature.

FREDERICK S. McCULLOUGH.

Aug. 12, 1924.

C. RENO

1,504,974

SYSTEM FOR TRANSMITTING ENERGY WITHOUT WIRES

Filed March 1, 1920

6 Sheets-Sheet 1

Fig. 1.

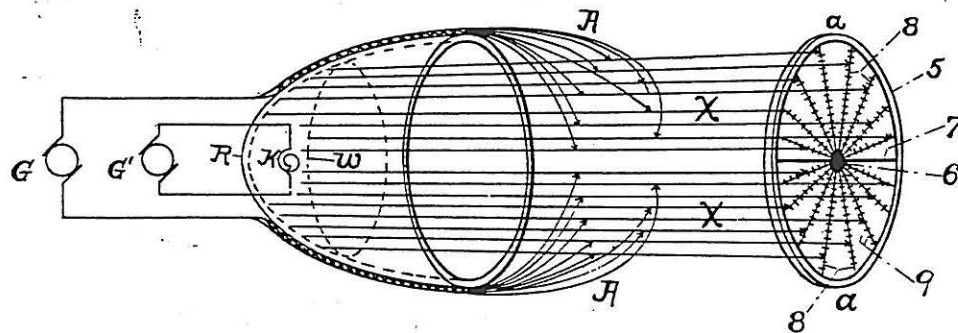
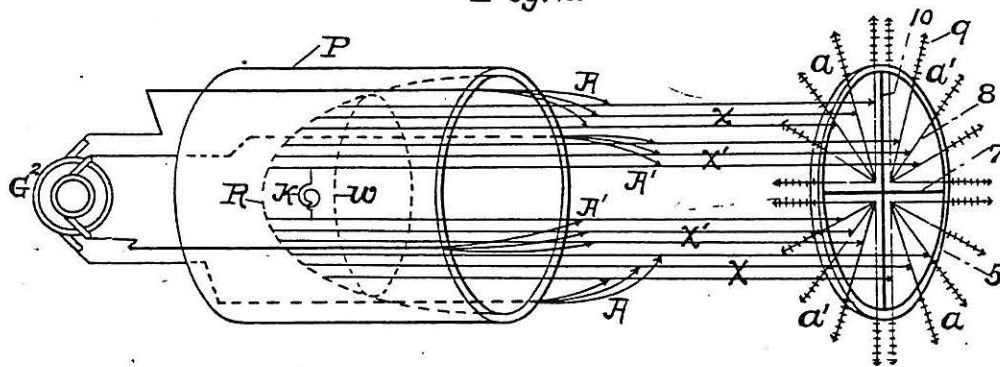


Fig. 2.



INVENTOR
Conrad Reno.

Aug. 12, 1924.

1,504,974

C. RENO

SYSTEM FOR TRANSMITTING ENERGY WITHOUT WIRES

Filed March 1, 1920

6 Sheets-Sheet 3

Fig. 5.

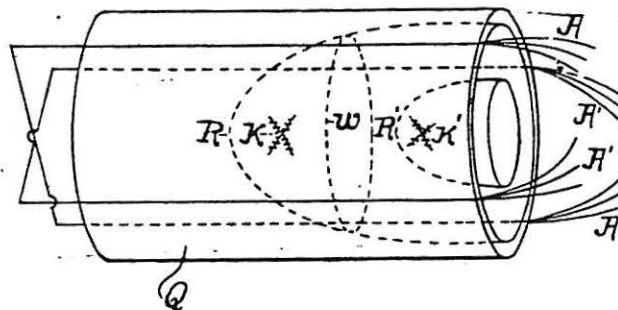


Fig. 6.

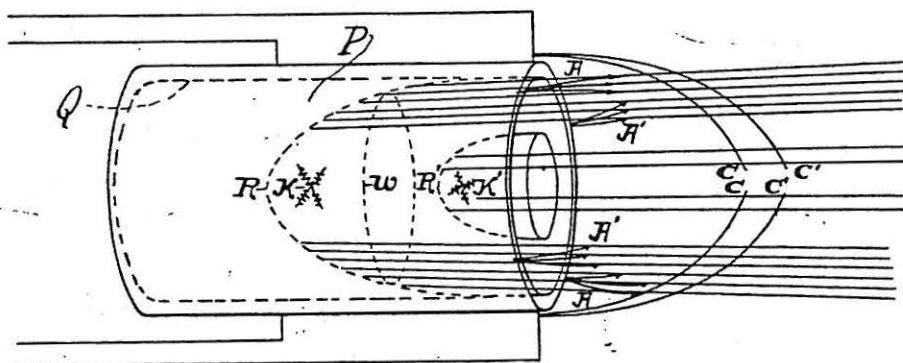
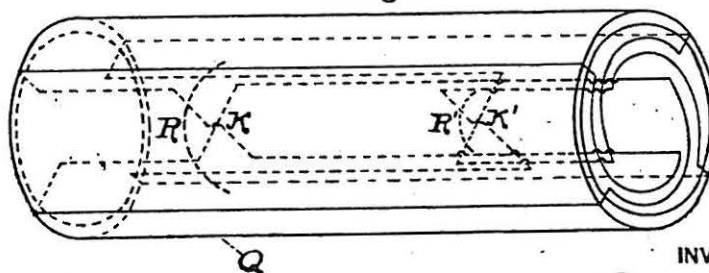


Fig. 6a.



INVENTOR

Comes Reno.

Aug. 12, 1924.

C. RENO

1,504,974

SYSTEM FOR TRANSMITTING ENERGY WITHOUT WIRES

Filed March 1, 1920

6 Sheets-Sheet 2

Fig. 3.

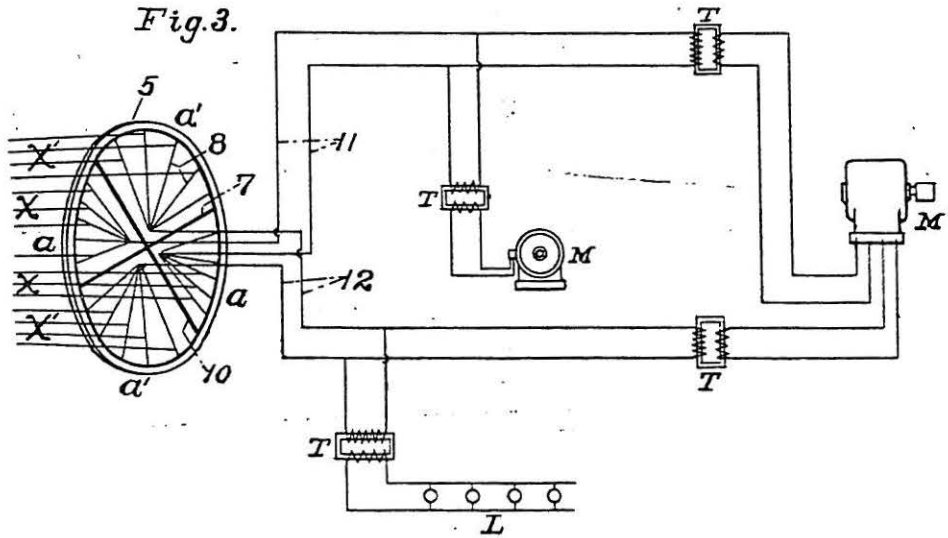
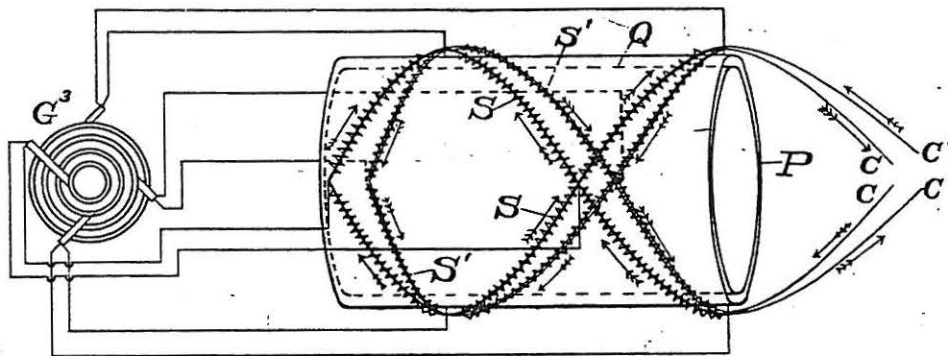


Fig. 4.



INVENTOR

Comad. Reno

Aug. 12, 1924.

1,504,974

C. RENO

SYSTEM FOR TRANSMITTING ENERGY WITHOUT WIRES

Filed March 1, 1920 6 Sheets-Sheet 4

Fig. 7.

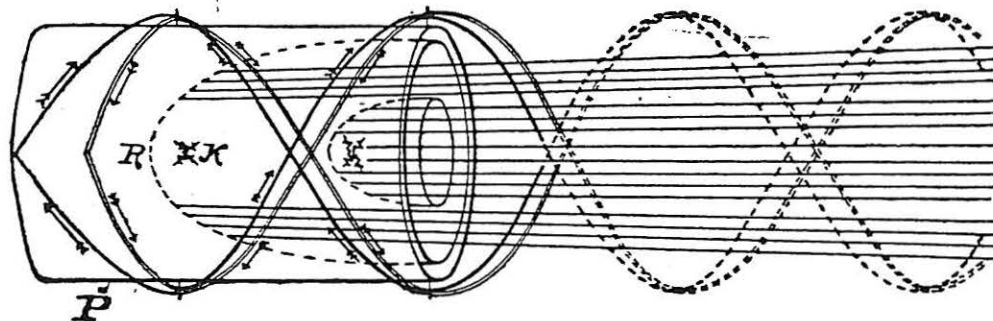
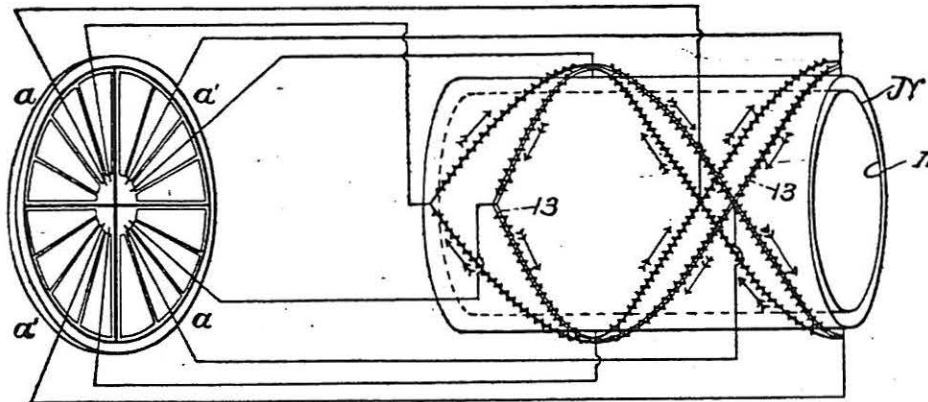


Fig. 8.



INVENTOR

Conrad Reno

Aug. 12, 1924.

C. RENO

1,504,974

SYSTEM FOR TRANSMITTING ENERGY WITHOUT WIRES

Filed March 1, 1920

6 Sheets-Sheet 5

Fig. 9.

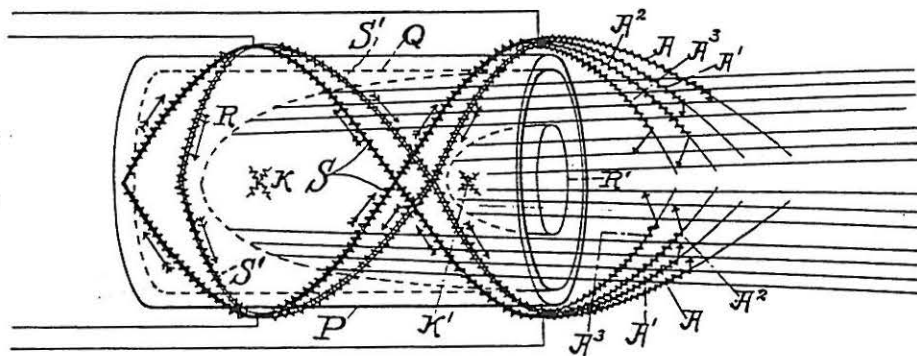
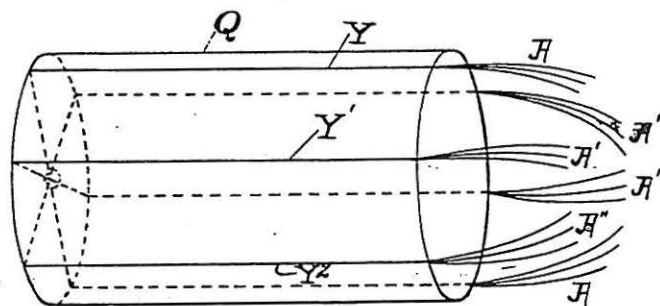


Fig. 10.



INVENTOR

Conrad Reno.

Aug. 12, 1924.

C. RENO

1,504,974

SYSTEM FOR TRANSMITTING ENERGY WITHOUT WIRES

Filed March 1, 1920

6 Sheets-Sheet 6

Fig. 11.

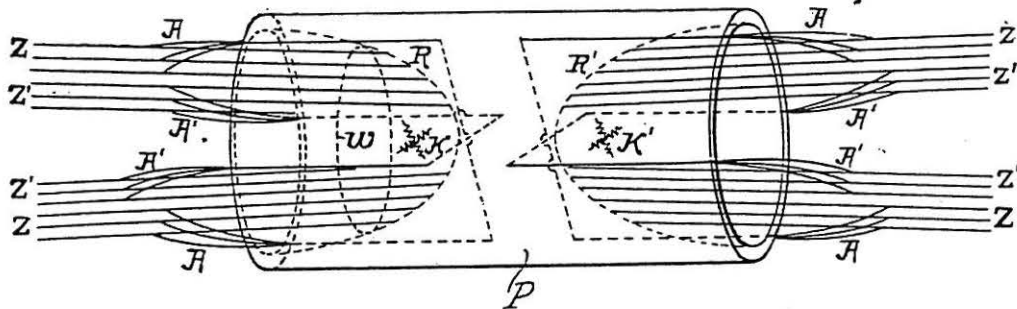
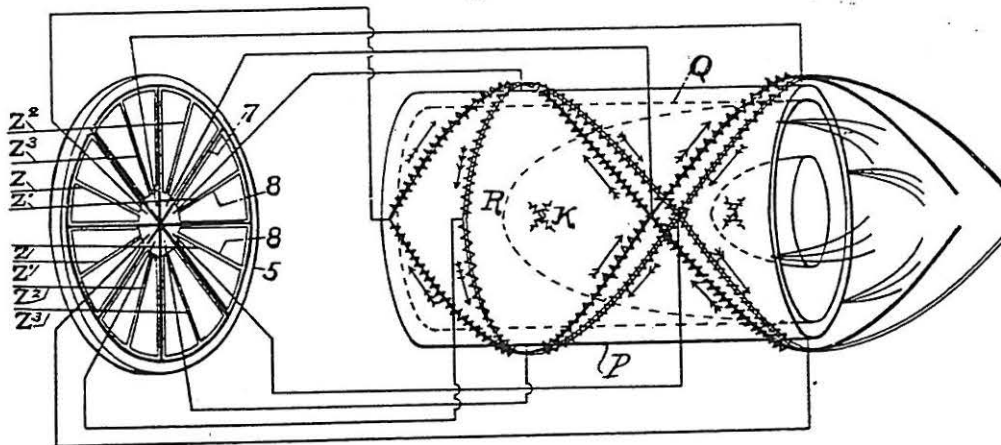


Fig.12.



INVENTOR

Conrad Reno.

UNITED STATES PATENT OFFICE.

CONRAD RENO, OF SPRINGFIELD, MASSACHUSETTS.

SYSTEM FOR TRANSMITTING ENERGY WITHOUT WIRES.

Application filed March 1, 1920. Serial No. 362,283.

To all whom it may concern:

Be it known that I, CONRAD RENO, a citizen of the United States, residing at Springfield, in the county of Hampden and Commonwealth of Massachusetts, have invented an Improved System for Transmitting Energy Without Wires, of which the following is a specification.

My invention relates chiefly to a new method of, and apparatus for, transmitting electromagnetic energy in a confined path in any desired direction through the air, the water and other non-metallic substances, without the directive aid, or agency, of connecting wires or metallic conductors of any kind.

The main object of my invention is the directive wireless transmission of energy. I attain this object by causing the energy to flow in the concentrated form of a stream or current, which can be transmitted in any desired direction along a wireless-and-metallic circuit, or system of circuits, which connect the transmitting apparatus with the utilizing apparatus. The energy is localized within the narrow confines of the wireless-and-metallic circuit, or system of circuits, like water flowing through a pipe, and does not spread out over a wide wave-front. The energy flows in stream-like form in contradistinction to the usual spreading wave-like form of the wireless flow of energy. My method of wireless transmission of energy may be described as the "stream method," to distinguish it from the usual wave method of wireless transmission of energy.

Another object of my invention is to gather and receive energy transmitted by wireless means, and to pass the energy on by metallic conductors to suitable utilizing apparatus, such as relays, controllers, amplifiers, retransmitting apparatus, motors, lamps, and the like. This object is attained by the aid and agency of a new form of receiving antenna, described herein, which may be placed in operative relation with a beam or cable, or system of wireless conductors and with the metallic conductors of the utilizing apparatus, so as to establish a complete wireless-and-metallic circuit for each phase of alternating current, when such current is supplied to the beam or cable, or system of wireless conductors; and also to establish a complete wireless-and-metal-

lic circuit for direct current, when direct current is supplied to the beam or cable, or system of wireless conductors.

The wireless-and-metallic circuit, or system of circuits, may be established entirely in the air, or partly in the air and partly in water or in the earth. Both-way sets of wireless conductors, for transmitting energy both out to the utilizing apparatus and back to the transmitting apparatus, may be located in the beam; or a one-way set of wireless conductors may be located in the beam, and the other-way set may be located outside of the beam.

Each wireless-and-metallic circuit is a divided circuit with many branches or divisions beginning at the transmitter-generator and ending at the utilizing apparatus. A divided circuit is known to reduce the total resistance, impedance and reluctance. Other devices and means for reducing the resistance, impedance and reluctance will be stated later.

When electrical connection is made by two sets of wireless conductors, wherever located, with the metallic conductors of the transmitter-generator at one end of the line and with the metallic conductors of the relay or other form of utilizing apparatus at the other end of the line, a complete wireless-and-metallic circuit will be established, capable of transmitting energy in the form of a stream.

Other objects and advantages will appear in the following description and in the accompanying drawings, in which:

Fig. 1 is a diagrammatical view illustrative of the X-ray type of transmitter-generator, designed for the use of either direct current or single phase alternating current;

Fig. 2 is a diagrammatical view illustrative of a transmitter-generator of the X-ray type designed for the use of two-phase alternating current;

Fig. 3 is a diagrammatical view of a receiving and utilizing apparatus for use with the transmitter-generator shown in Fig. 2;

Fig. 4 is a diagrammatical view of the primary of a transmitter-generator of the dynamo type, for use in practicing the Z-ray or ultra X-ray method of wireless transmission of energy;

Fig. 5 is a diagrammatical view of the secondary of the same apparatus;

Fig. 6 is a diagrammatical view combining the members separately shown in Figs. 4 and 5;

Fig. 6^a shows a method of producing a beam of wireless conductors through heating the cathodes by induction currents;

Fig. 7 is a diagrammatical view of a transmitter-generator of the solenoid variety of the Z-ray type and illustrative of the operation;

Fig. 8 is a diagrammatic view of the closed spiral iron-core variety of apparatus, wound for four-phase current, which may be used as the primary for a transmitter-generator, or as the primary for a relay, or re-transmitter-generator. The four phase primary windings are connected to one form of my receiving antenna;

Fig. 9 is a diagrammatical view of a transmitter-generator of the transformer variety; for use in practicing the Z-ray method of wireless transmission of energy;

Fig. 10 is a diagrammatical view of a secondary member of a transmitter-generator of the three-phase type;

Fig. 11 is a diagrammatical view of the secondary of a "double barreled" transmitter generator for producing two beams of Z-ray wireless conductors and two streams of energy in opposite directions; and

Fig. 12 is a diagrammatical view of a re-transmitter-generator designed to receive the energy from one receiving antenna and relay it to another receiving antenna.

In carrying out my methods of transmitting, receiving, and utilizing energy, I may, of course, employ various forms of apparatus and devices. In order to illustrate my method, I have shown two main types of apparatus, namely, the X-ray type and the Z-ray or ultra X-ray type.

The X-ray type of apparatus generates a beam of X-rays, and what I term X-ray wireless conductors, by the means described later. The Z-ray type of apparatus generates a beam of ultra X-rays, which I term Z-rays, and also a beam of Z-ray wireless conductors. Another type of apparatus is the ultra-violet-ray type, which generates a beam of ultra-violet rays and ultra-violet-ray wireless conductors.

The X-ray, Z-ray and ultra-violet-ray types of apparatus may each be divided and subdivided into varieties and modifications, some of which are described herein under the descriptive titles of "dynamo", "transformer", "solenoid", "closed spiral core", "magnetic amplifier", and "spirally revolving magnetic field" apparatus and devices. Also many different combinations of these types, varieties and modifications may be employed to fit the exigencies of particular cases, in the practice of the stream method of transmitting energy without wires.

In the operation of the X-ray and ultra-

violet-ray devices, a stream of electrons is pumped through the wireless-and-metallic circuit to the relay or other type of utilizing apparatus at high pressure, and flows back to the transmitter-generator at low pressure, when these pieces of apparatus are properly connected into the wireless-and-metallic circuit. In the operation of the Z-ray device, a stream of electromagnetons is pumped through the wireless-and-metallic circuit, including the windings of the relay or other type of utilizing apparatus, at high pressure, and flows back to the transmitter-generator at low pressure. This operation is repeated over and over again whenever these pieces of apparatus are properly connected into the wireless-and-metallic circuit.

Referring to Fig. 1: the X-ray type of transmitter generator, designed for the use of either direct current, or single phase alternating current, will be described. A A are a pair of transmitting antennae, which connect with the pair of X-ray wireless conductors marked X X, which in turn connect with the pair of receiving antennae marked a a.

R is a parabolic reflector; K is a spiral coil of tungsten wire or filament, located at the focus of said reflector R; G' is a generator connected with the spiral coil of tungsten, employed to heat the tungsten to incandescence, thus forming a prolific source of electrons, which are violently discharged against the interior walls of the reflector R, and generate the pair of X-ray wireless conductors marked X X; w is a "window" or thin partition wall in the reflector R and forms with the latter a chamber which is partially air-exhausted; G is a generator supplying current to the wireless-and-metallic circuit through the pair of transmitting antennae marked A A.

The receiving antenna shown in Fig. 1 consists of two segments, a a, insulated from each other and from the ground, forming a pair of segments. This pair of segments is adjusted across the pair of wireless conductors as shown in Fig. 1, in such a manner that the outgoing current will flow through one segment and the incoming current will flow through the other segment of the pair.

The particular antenna shown in Fig. 1 includes a circular band 5, a central hub 6, and a diametrical bar 7, which connects the hub and band; all the elements 5, 6 and 7 being of insulating material. From the hub 6 there radiate a series of metallic rods 8, each of which has a series of strips or cross-pieces 9 of tin foil, copper or the like, which connect with the wireless conductors X, and gather the current flowing in the wireless-and-metallic circuits. These rods 8 above the bar 7 constitute one of the segments of the antenna, and the rods 8 below the bar

7 constitute the other segment of the pair of segments referred to above.

Referring to Fig. 2, wherein is shown a transmitter-generator designed for the use of two-phase alternating current, the metallic conductors from the two-phase generator G^2 extend to the parabolic reflector R , as above explained, and terminate each with a series of transmitting antennae. The metallic conductors A for phase 1 current are, of course, located diametrically opposite each other, and so also are the metallic conductors A' for phase 2; the conductors for phase 2 being disposed at right angles to those for phase 1. In this instance, the reflector R is shown as located within sleeve P . The receiving antenna, as before, includes a circular ring 5 divided diametrically by a bar 7, and in addition again divided by a second bar 10 at right angles to bar 7; all such elements being of insulating material. The rods 8 are substantially the same as described above except that they extend beyond the periphery of ring 5. The bars 7 and 10 divide the antenna into four segments arranged in pairs a, a and a', a' .

The transmitting antennae A, A are supplied with phase 1 current, and the transmitting antennae A', A' are supplied with phase 2 current. A beam of two pairs of X-ray wireless conductors is projected from the parabolic reflector R , and these wireless conductors X, X' connect both with the transmitting antennae A, A' and with the receiving antennae a, a' , thus forming complete wireless-and-metallic circuits. The wireless-and-metallic circuit which carries phase 1 current is indicated by the letters $A X a X A$, and the wireless-and-metallic circuit which carries phase 2 current is indicated by the letters $A' X' a' X' A'$. These two-phase currents are then led to motors, incandescent lamps, or other types of utilizing apparatus, as shown in Fig. 3.

In Fig. 3 I have shown how a receiving antenna, such as that shown in Fig. 2, for example, may be connected to various types of utilizing apparatus. Thus, the rods 8 of the segments a, a are connected to metallic conductors 11, and the rods 8 of the segments a', a' are connected to metallic conductors 12. The wires 11 carry phase 1 current, and the wires 12 carry phase 2 current. When a high voltage generator is used, as is often advisable, step-down transformers marked T may be employed for one phase or for both or all phases. M is a single-phase motor; M' is a two-phase motor, and L is a string of lamps.

A feature of my invention is to construct and maintain wireless-and-metallic circuits between the transmitting apparatus and the apparatus for utilizing the energy. My so-called wireless conductors connect the metallic conductors of the transmitting an-

tenna with the metallic conductors of the receiving antenna, and the latter conductors are connected with the metallic conductors of the utilizing apparatus, thus forming one or more complete wireless-and-metallic circuits through which the energy flows in a confined path or narrow channel in any desired direction.

Another feature of my invention is to produce a beam of X-rays, which rays are known to construct lines of conductivity in the air, the water, and in other substances through which the rays pass. X-rays constitute one species of my wireless conductors. X-rays are known to be produced by the sudden stoppage of swiftly moving electrons; and it is also known that when tungsten (among other metals) is heated to incandescence, a copious supply of electrons will be liberated therefrom and discharged at high speed; that when a moving electron is brought to a sudden stop by impact with a hard substance, it gives rise to an X-ray, which is reflected from the surface of the reflector at the same angle at which the moving electron strikes that surface, the angle of reflection being equal to the angle of incidence, as in the case of light. Upon these familiar principles I produce a beam of X-rays by placing a source of electrons, such as an electrically heated tungsten-wire spiral, at the focus of a parabolic reflector. X-rays are further known to travel in straight lines, and to penetrate water a considerable distance, and to penetrate air a greater distance, and to act upon the photographic plate, and to take "shadow pictures."

Another feature of my invention is to produce a beam of Z-rays or ultra X-rays, which constitute a second species of my wireless conductors. Z-rays are ultra X-rays, and are produced by the sudden stoppage of swiftly moving electromagnetons, or electromagnetic units, composed of electrons "saturated" with magnetic energy, as explained more fully elsewhere. A beam of Z-rays is produced by superposing a moving magnetic field, preferably a spirally revolving magnetic field, upon the streams of electrons discharged from a hot cathode at the focus of a parabolic reflector. Since electromagnetons possess higher kinetic energy than an equal number of electrons moving at equal velocity, it follows that the Z-rays generated by the sudden stoppage of swiftly moving electromagnetons will be endowed with greater penetrating power than the X-rays generated by the sudden stoppage of electrons moving at the same speed, and the beam of wireless conductors which is generated by the Z-ray beam will extend to a greater distance from the transmitter-generator than will the beam of wireless conductors which is generated by the beam of X-rays. Another advantage of superpos-

ing the spirally revolving magnetic field upon the electrons discharged from a hot cathode at the focus of the parabolic reflector is that the electromagnetons are more advantageously distributed over the inner surface of the parabolic reflector, so that the rays produced by their sudden stoppage will form a denser and more symmetrical beam of rays, whereby a denser and more symmetrical beam of wireless conductors will be constructed in the desired portion of space.

The density of the beam of wireless conductors depends upon the number of electrons discharged from the hot cathode. When a very dense beam is desired, it may be produced by employing the method of two cathodes heated by polyphase currents, as shown in Fig. 6^a, and explained elsewhere herein.

Another advantage of the Z-ray method of producing a beam of wireless conductors is that the superposed moving magnetic field renders it unnecessary to employ a high vacuum, or to exhaust the air at all, in the chamber or barrel containing the source of the electron streams. A rotating magnetic field may be used for this purpose, but I prefer to use the spirally revolving magnetic field, for the reasons stated.

The electromotive force generated in a circuit by means of the spirally revolving magnetic field is distributed over a space of three dimensions, whereas the electromotive force generated by the rotating magnetic field is distributed over a space of only two dimensions.

The feature of generating distributed electromotive force by the use of the spirally revolving magnetic field is obviously applicable generally to all kinds of conductors, whether wireless or metallic.

Various forms of antenna are shown in the drawings, and may be used either with the X-ray type or with the Z-ray type of transmitting and utilizing apparatus.

The transmitting antenna consists preferably of copper wires extending beyond the open end (or ends) of the transmitter-generator, toward the wireless conductors and intercepting or connecting with the wireless conductors, as indicated in Figures 1, 2, 6, 9, and 11.

The receiving antenna consists preferably of a wheel-like structure divided into one pair of segments, a a , or into two pairs of segments, a a and a' a' , or into three (or more) pairs of segments. Each segment consists of metallic conductors and is insulated from all other segments, and each pair of segments is preferably so arranged and placed across the beam of wireless conductors as to receive a particular phase of current, when the current is alternating current, and, when direct current is used, each pair of segments is so adjusted as to receive

and pass the outgoing current through one segment and the incoming or return current through the other segment of each pair of segments. When two-phase current is used, I prefer two pairs of segments, a a and a' a' , as shown in Figures 2 and 8. When four-phase current is used, four pairs of segments may be employed, as indicated in Fig. 12, or two pairs may be employed, as indicated in Fig. 8. When three-phase current is used I prefer to employ three pairs of segments, each pair being so adjusted and placed across the beam of rays as to receive and to permit to pass through a particular phase of current. In the preferred case the short axis of the antenna should coincide as near as may be feasible with the long or major axis of the beam of rays. The metallic conductors of each pair of segments are connected with the metallic conductors or windings of the utilizing apparatus, such as motors, electric lights, etc., as shown in Figures 3, 8 and 12.

When direct current is supplied to my beam of wireless conductors, a section consisting of one-half of the wireless conductors will carry outgoing current to the receiving and utilizing apparatus, and the other section of the wireless conductors will carry the return or incoming current back to the transmitter-generator. For direct current, the receiving antenna consists preferably of two equal-sized segments forming a pair of segments, adjusted at right angles to the beam of wireless conductors, so that one segment will receive the outgoing current and the other segment will receive the return or incoming current.

When single-phase alternating current is supplied to my system of wireless conductors, one-half of such conductors will carry the outgoing current and the other half will carry the incoming or return current. Of course, when the alternating current changes direction, the half of the wireless conductors which previously carried the outgoing current will now carry the return or incoming current, and vice versa. The receiving antenna for single-phase current, as well as for direct current, consists preferably of one pair of segments whose centers are displaced from each other one hundred and eighty degrees in a circular antenna, which is placed across the system so that its short axis will coincide approximately with the major axis of the system.

When polyphase current is supplied to my system of wireless conductors, the various phases are supplied at different transverse points or sections of the system, corresponding to the number of phases supplied. Thus when two-phase current is supplied to the system, it is supplied to four sections of the system whose centers are displaced ninety degrees from each other.

The receiving antenna consists preferably of two pairs of segments, the centers of each pair being one hundred and eighty degrees removed from each other, when two-phase current is used.

When three-phase current is supplied to my system of wireless conductors, it is supplied to sections of the system whose centers are displaced by sixty degrees, thus dividing the system into three pairs of sections, corresponding to the three pairs of segments of the receiving antenna. That is to say phase 1 current is supplied to one pair of sections of the system and flows back and forth through said pair of sections and through one pair of segments in the receiving antenna, which segments are so arranged and adjusted as to receive this particular phase of current. Phase 2 current is supplied to a second pair of sections and flows back and forth through this second pair of sections, and back and forth through a second pair of segments in the receiving antenna, said segments being so arranged and adjusted as to receive this particular phase of current. Phase 3 current is supplied to a third pair of sections and flows back and forth through this third pair of sections, and back and forth through a third pair of segments in the receiving antenna, said pair of segments being so arranged and adjusted as to receive this particular phase of current. Metallic conductors are employed to carry the three-phase current from the receiving antenna to the three-phase motor and other apparatus designed for three-phase current.

This method of transmitting polyphase currents consists in providing a system or cable, of wireless-and-metallic circuits, and supplying to said system or cable at different transverse sections the various phases of alternating current, and providing at the receiving station an antenna divided into a suitable number of relatively insulated segments, each pair of segments being so adjusted and arranged as to receive a particular phase of the current and to pass it on to utilizing apparatus by metallic conductors connected therewith.

In more general terms the stream method of transmitting energy consists in establishing a wireless-and-metallic circuit between the transmitting apparatus and the utilizing apparatus and in applying electromotive force across said circuit to produce a stream of electrons (electric energy), or in superposing a moving magnetic field, preferably a spirally revolving magnetic field, upon said circuit, thereby producing a stream of electromagnetons (electromagnetic energy).

A leading feature of my Z-ray method of directive wireless transmission of energy is the production of a spirally revolving magnetic field by means of polyphase alter-

nating currents having phase displacements equal to the spiral displacements in position of the various windings or coils. To produce such a spirally revolving magnetic field I may use two or more iron cores arranged in spirals and preferably doubled back upon themselves so as to interlink and cross each other and themselves at angles equal to the phase-angles or phase-differences of the currents used in producing the spirally moving magnetic field. Thus when the currents have phase-differences of ninety degrees, the iron cores interlink and cross each other at angles of ninety degrees. When the currents have phase-differences of one hundred and twenty degrees, the iron cores interlink and cross at an angle of one hundred and twenty degrees.

In the solenoid variety of the Z-ray type of my transmitter-generator the ends of these iron cores are carried out beyond the body of the apparatus, so as to surround my beam or system of wireless conductors which connect with the metallic conductors of the secondary apparatus in my transmitter-generator. My wireless conductors are wireless extensions of these metallic conductors. The action of this apparatus is to project a beam or system of wireless conductors in the desired direction, and to connect these wireless conductors with the metallic conductors of both the transmitting and receiving apparatus, and to produce and superpose upon such wireless-and-metallic circuits a spirally revolving magnetic field, whereby electromotive forces are induced and currents produced in such wireless-and-metallic circuits.

The X-ray method of wireless transmission of energy has been described in connection with Figures 1, 2, and 3. Figures 4 to 12, relate to my Z-ray method of wireless transmission, reception and utilization of energy, the preferred method, and will next be described.

Fig. 4 represents the dynamo form of primary of the transmitter-generator used with my Z-ray method of wireless transmission of energy. G^3 is a four-phase generator supplying four-phase currents to the four windings of the spiral solenoids marked S S and S' S', and C C and C' C' are the iron cores thereof, which intersect each other at right angles. The phase windings are arranged like those of an induction motor. The iron ends C C and C' C' of the solenoids S S and S' S', are not wound for current, and extend out beyond the cylindrical framework P of the apparatus at the front end. The function of these four-phase windings and currents is to produce four-phase fluxes in time-and-space quadrature with one another, as in the four-phase induction motor; and the currents should be caused to flow in the like relative directions as in the four-phase induction motor. When the iron cores

of the solenoids are thus wound and supplied with four-phase currents, spirally shifting magnetic poles will be produced in each solenoid, which poles move in the directions indicated by the arrows in Figures 4, 7 and 8. Moreover, by reason of my arrangement, two streams of spirally moving magnetic fluxes will be projected from the iron ends of the solenoids S S and S' S' into the space surrounding my beam of wireless conductors, and the poles of "polarizations" produced by the combinations of these projected four-phase fluxes will also shift spirally around said beam, as shown in Fig. 7.

The apparatus just described in Fig. 4 is the primary only of the transmitter-generator, and is used with a secondary Q, such as is separately shown in Fig. 5, the two constituents or members being separately shown for the sake of clearness. The primary and secondary members are shown combined in Fig. 6, although much of the detail has been omitted for the sake of clearness. In Fig. 6 the apparatus is shown in operation, producing a spirally revolving magnetic field, and developing a beam of Z-ray wireless conductors.

I have shown four-phase currents and circuits merely to illustrate my method of and apparatus for producing a spirally revolving magnetic field, and transmitting the energy to a distance from its source. But polyphase currents with any convenient number of phases may be used with a suitable number of electrical circuits, which are spirally displaced in position from each other by a position angle equal to the phase angle of the polyphase currents. In general terms, the apparatus comprises a plurality of solenoids, spirally arranged, whose iron cores intersect and extend beyond the points of intersection, and a plurality of electrical coils supplied with polyphase currents, said coils being spirally displaced in position from each other around said spiral iron cores by a position angle equal to the phase-angle of the polyphase currents employed.

Also in general terms, the method consists in providing a plurality of spirally arranged electrical circuits excited by polyphase electromotive forces displaced in time-phase from each other by a phase-angle equal to the position angle of the coils of the circuits.

The spiral movement of the magnetic poles, produced by winding the iron cores, C C and C' C', with four-phase windings and supplying these windings with four-phase currents, is indicated by the arrows in Figures 4, 7 and 8. By this arrangement I produce a spirally revolving magnetic field, by means of which the electrons are converted into electromagnetons and Z-rays are

generated, and electric currents are produced by induction in my wireless-and-metallic circuits. The poles of this magnetic field shift spirally around the secondary metallic conductors and around the beam of Z-ray wireless conductors, and thereby induce currents in these conductors and in the wireless-and-metallic circuits, between the transmitting and utilizing apparatus.

The result of this arrangement is to produce a spirally moving stream of magnetism, which is analogous to the rotating stream or state of magnetism of the induction motor, with the important difference that my spirally moving stream of magnetism is projected out into space through the ends of the solenoids, S S and S' S'.

My transmitter-generator may be likened to an electro-magnetic pump, in that it drives or pumps streams of electromagnetic energy around the circuits. Streams of electrons are driven along the lines of my metallic and wireless conductors, by the X-ray type and ultra violet ray type of apparatus, and streams of electromagnetons are driven or pumped through the circuit or system of circuits by the Z-ray type of apparatus.

The wireless-and-metallic circuit may be likened to an electromagnetic pipe-line in that it affords a narrow and confined channel for the flow of electromagnetic energy, and prevents the energy from spreading out over a wide expanse. This pipe-line is porous in the sense that free electrons and electrons which are dislodged from their mother atoms and energized by the beam of rays and by the other means and devices disclosed herein, are driven from one part of the pipe-line into another part of the pipe-line and are all urged to flow through the wireless-and-metallic circuit. The quantity of energy flowing in the circuit is thus increased at various points, by the agency of some kind of distributed electromagnetic motive force.

Fig. 6^a illustrates a method of heating the cathodes K and K' electrically by polyphase currents, which are induced in the secondary conductors by a moving magnetic field, preferably by a spirally revolving magnetic field. In Fig. 6^a each cathode consists of two tungsten wires which cross each other at the focus of the reflector R, but are not in metallic contact with each other. Each of the four tungsten wires of the two cathodes is placed in circuit with one of the copper conductors of the secondary. With four of said copper conductors displaced by ninety degrees and carrying four-phase currents, the two cathodes may be heated to incandescence, and will liberate and discharge a copious supply of electrons. The cathodes may be heated, however, in any suitable manner. In Fig. 1 the cathode K is heated by conduction current from a generator.

The sources of electrons may consist of any metal which can be heated to a high temperature without melting, such as tungsten, or tantalum, and the like.

Many of the existing types of electrical machines, such as motors and electric lamps, can be operated by the energy transmitted by my methods of wireless transmission of energy. The electromagnetic energy transmitted by my stream method can also be converted into mechanical energy by means of my spirally revolving-field motor and other forms of apparatus which are especially designed for utilizing my spirally revolving magnetic field, such as my re-transmitter-generator, illustrated in Fig. 12, to be later described.

Fig. 8 represents in diagram-form the primary for the closed spiral iron-core variety of transmitter-generator, with connections to my receiving antenna through the primary windings. The iron cores of the primary are spirally arranged on a hollow cylindrical frame N, as already described in the case of my solenoid transmitter-generator, except that their ends do not project, but are welded together so as to make a continuous iron circuit with small magnetic leakage, in place of the large magnetic leakage at the ends of the solenoids in the solenoid variety of apparatus. In the dynamo variety of transmitting and re-transmitting apparatus, relative motion between the primary and secondary members is permitted, and either member (or both members) may be driven by mechanical power or energy. The dynamo converts this mechanical energy nearly quantitatively into electromagnetic energy. The apparatus has a large and variable reactance. Self-excitation of the dynamo variety of my transmitter-generator and re-transmitter-generator by armature reaction at speed can be explained by the fact that the counter electromotive force of self-induction is not wattless or in quadrature with the current, but contains an energy component of reactance, as in the case of the reaction generator. Negative power components of reactance exist in my wireless-and-metallic circuit, as in the case of a metallic oscillating-current circuit. The inductive reactance, as well as the condensive reactance, do not represent wattless electromotive forces, but introduce power components of negative sign into the circuit.

Fig. 9 represents the transformer type of my transmitter-generator in action, sending out two pairs of wireless conductors. S S and S' S' are two solenoids wound in spirals around a cylindrical framework P, and intersecting each other at right angles. The solenoids afford four primary coils arranged as in my dynamo type of apparatus, shown in Fig. 4, and these four coils are supplied

with four-phase currents, whereby a spirally revolving magnetic field is produced. There are also four secondary coils wound upon the two solenoids, marked A, A', A'', and A''', whose ends constitute my transmitting antennae and connect with the wireless conductors as shown. R is a large parabolic reflector, with a hot cathode K, located at its focus; and R' is a small parabolic reflector, with another hot cathode K', located at its focus. These hot cathodes are the sources of electrons, most of which are discharged against the walls of the reflectors and generate or originate Z-rays.

Fig. 10 is a diagrammatic representation of the secondary for a three-phase system, consisting of three copper loops Y, Y', Y'', extending longitudinally around a cylindrical framework Q, with their ends projecting beyond the cylinder, and constituting the transmitting antennae, marked respectively A A, A' A', and A'' A''. These loops are equally displaced from one another, and are insulated from each other.

Fig. 11 represents a double-barrelled secondary, projecting two beams of Z-ray wireless conductors in opposite directions. There are two reflectors, R and R', facing in opposite directions, and there are two sets of antennae, A A and A' A'. K and K' are sources of electrons, heated by electric current.

Fig. 12 shows my re-transmitted-generator of the solenoid variety, with the primary windings connected with the four pairs of segments of a receiving antenna for four-phase currents. The four pairs of segments of the receiving antenna connect with the four phases of the alternating current carried by the Z-ray wireless conductors. By means of this apparatus, which is like my transmitter-generator, streams of energy can be transmitted either in the same direction as that of the original stream of energy or in any other direction. Long-distance wireless transmission of energy in large quantities thus becomes feasible by the aid of my invention.

My stream of energy consists of two chief kinds or varieties of stream, which may be described as, first, the electric stream, composed of electrons (or electricity) flowing along my beam or cable of X-ray wireless conductors; and, second, the electromagnetic stream, composed of electromagnetons flowing along my beam or cable of Z-ray wireless conductors.

Moving electrons are known to be endowed with kinetic energy, and to possess "mass." The kinetic energy of my stream of electrons, or electric stream, is therefore equal to the product of half the mass of the electrons into the square of the velocity; or, in symbols,

W equals $\frac{1}{2} m v^2$,

where W is the kinetic energy, m is the mass, and v is the velocity.

5 The kinetic energy of my electromagnetic stream is greater than that of the electric stream, it seems, though I am unable to say how much greater it is. Moving mag-
netic poles and moving polarizations of
10 space possess velocity (v), and they act as if they also possessed mass (m), and momentum or inertia; for instance, in the poly-
phase induction motor where the rotor is set in motion by, and revolves in the same
15 direction as. the rotating magnetic poles. The same conclusion may be reached, how-
ever, namely, that my electromagnetic stream possesses greater kinetic energy than
20 my electric stream, by saying that a larger number of electrons are driven or pumped
into my circuits and set in stream-like motion by my distributed electromotive forces and
my spirally revolving magnetic field than by
25 a spirally revolving magnetic field.

The kinetic energy developed by my apparatus is considerable even when both the primary and secondary members are fixed in position and without relative motion.
30 In the dynamo variety of my transmitter-generator, where relative motion between these two members is permitted, the kinetic energy developed may be increased by driving the secondary member of the trans-
mitter-generator in the opposite direction
35 to that of the revolving magnetic field, or by driving the primary member in the same direction as that of the revolving magnetic field. The kinetic energy developed may
40 be still further increased by driving both members in these respective directions at the same time.

The frequency of the apparatus is also increased by driving one member or both
45 members in the directions stated immediately above in this specification.

What I claim is:—

1. A system for transmitting energy without wires comprising a source of electric
50 current, a pair of symmetrically disposed parabolic conductors connected to said source of electric current, utilizing apparatus at a distance therefrom, a pair of sym-
metrically disposed segmented conductors
55 connected to said utilizing apparatus, a pair of ultra X-ray wireless conductors extending the whole distance between said pairs of spaced conductors, and means for electrically connecting said pair of wireless con-
60 ductors to said pair of parabolic conductors at one end of the circuit and to said pair of segmented conductors at the other end of the circuit.

2. The method of closing an otherwise
65 open electric circuit between spaced metal-

lic conductors consisting in electrically connecting said spaced metallic conductors by an ultra X-ray wireless conductor extending the whole distance between said spaced metallic conductors.

3. A system for generating and transmitting energy comprising a closed wireless-metallic electric current, means for producing a spirally revolving magnetic field, and means for applying said magnetic field
75 across said electric circuit.

4. A system for transmitting energy comprising a polyphase alternator, a spiral-core transforming apparatus whose primary member is connected to said alternator and is adapted for producing a spirally revolving magnetic field, a secondary member in inductive relation to said spirally revolving magnetic field, receiving-utilizing apparatus at a distance therefrom adapted for receiving and utilizing alternating currents, means for producing a plurality of ultra X-ray wireless conductors, one pair for each phase of alternating current, and means for electrically connecting said wireless conductors to said secondary member at one end of the circuit and to said receiving-utilizing apparatus at the other end of the circuit.

5. Means for producing an ultra X-ray
95 wireless conductor comprising a parabolic reflecting surface adapted for converting a stream of impinging electrons into a beam of X-rays, an incandescent filamentary spiral coil at the focus of said parabolic reflecting surface adapted for discharging a
100 stream of electrons against said surface, a partially air-exhausted chamber enclosing said coil and said stream of electrons, means for producing a spirally revolving magnetic field, and means for superimposing said
105 magnetic field in such manner that the magnetic flux will pass through said parabolic reflecting surface and will be substantially parallel to the direction of said stream of
110 electrons.

6. The method of producing a beam of ultra X-rays consisting in discharging a stream of electrons from the focus of a parabolic reflecting surface against said surface, and in exposing said stream of electrons to the action of a spirally revolving magnetic field in such manner that the magnetic flux will be substantially parallel to the direction of said stream of electrons and will pass through said parabolic reflecting surface.

7. The method of producing the wireless element of a wireless-metallic circuit which consists in discharging a stream of electrons from the focus of a parabolic reflecting surface against said surface in a partial vacuum, and in exposing said electron stream to the action of a spirally revolving magnetic field in such manner that the mag-
130

netic flux will be substantially parallel to the direction of said electron stream and will pass through said parabolic reflecting surface.

8. Means for producing a beam of ultra X-rays comprising a parabolic reflecting surface adapted for converting a stream of impinging electrons into a beam of X-rays, a source of electrons at the focus of said surface adapted for discharging a stream of electrons toward said surface, a partially air-exhausted chamber enclosing said source and said stream, means for producing a spirally revolving magnetic field, and means for superimposing said magnetic field thereon in such manner that its flux will pass through said surface and will be substantially parallel to the direction of said stream of electrons.

9. Means for producing a pair of ultra X-ray wireless conductors comprising a pair of parabolic reflecting surfaces having a common focus and adapted for converting a pair of electron streams impinging thereon into a pair of X-ray beams, a source or sources of electrons located at said focus adapted for discharging a pair of electron streams toward said pair of reflecting surfaces, and means for focusing and concentrating each and every electron stream into an intense and confined stream of electrons comprising a spirally revolving magnetic field which is applied in such manner that its flux will be substantially parallel to the direction of each and every electron stream and will pass through each and every parabolic reflecting surface.

10. The method of generating and transmitting electric current consisting in exposing a closed wireless-metallic circuit or system of such circuits to the action of a spirally revolving magnetic field.

11. Means for producing the wireless element of a system of closed wireless-metallic circuits comprising a plurality of parabolic reflectors, a source of electrons at the focus of each reflector adapted for discharging at least one definite stream of electrons against at least one definite segment of each reflector, a sealed chamber enclosing each source of electrons and each stream of electrons, and means for focusing and concentrating each electron stream upon a segment of the suitable parabolic reflector comprising a spirally revolving magnetic field whose flux is substantially parallel to the direction of each and every electron stream and passes through each and every parabolic reflecting segment.

12. Means for producing the wireless element of a system of closed wireless-metallic circuits comprising, for each pair of wireless conductors desired, a pair of parabolic reflecting surfaces having a common focus, an electron-discharging material located at said

focus, means for producing a spirally revolving magnetic field, and means for superimposing said magnetic field thereon in such manner that the magnetic flux will pass through each and every pair of parabolic reflecting surfaces and through the major portion of the electron discharge at less than a right angle.

13. The method of transmitting alternating current through a closed and confined wireless-metallic circuit, or system of such circuits, which consists in the displacement of separate and distinct wireless conductors in space by a position angle equal to the phase angle of the current supplied.

14. In the wireless transmission of alternating current means for producing a system of confined wireless conductors comprising, for each phase of alternating current, a pair of parabolic reflecting surfaces having a common focus and adapted for producing a pair of X-ray beams, a source of electrons at the focus of each reflecting surface adapted for discharging a definite stream of electrons toward each particular reflecting surface, and means for displacing the different streams of electrons from one another by a position angle equal to the phase-angle of the alternating current supplied.

15. In combination a plurality of relatively insulated parabolic conducting segments, symmetrically spaced, a receiving antenna at a distance therefrom consisting of an equal number of relatively insulated conducting segments, likewise spaced, means for producing a plurality of confined X-ray wireless conductors, means for connecting said wireless conductors and the suitable segments into a closed and confined wireless-metallic circuit or system of such circuits, and means for producing and applying a spirally revolving magnetic field.

16. In a system for transmitting electric energy through closed and confined wireless-and-metallic circuits, the method of endowing electrons with motion along the conductors of said circuits which consists in exposing each circuit to the action of a spirally revolving magnetic field.

17. In combination a transmitting-generating apparatus, a receiving-utilizing apparatus at a distance therefrom, means for establishing a closed and confined-path wireless-and-metallic electrical circuit or system of such circuits connecting said apparatuses, means for generating electromotive forces distributed over two dimensions of space, and means for applying said distributed voltage across each circuit.

18. In combination a transmitting-generating apparatus, a receiving-utilizing apparatus at a distance therefrom, means for establishing a closed and confined wireless-and-metallic electrical circuit or system of such circuits connecting said apparatuses,

means for generating electromotive forces distributed over three dimensions of space, and means for applying said distributed electromotive forces across each and every circuit.

19. Means for generating electromotive forces distributed over three dimensions of space comprising means for producing a spirally revolving magnetic field.

20. Means for producing a spirally revolving magnetic field comprising a spiral-core apparatus provided with circuit-coils supplied with polyphase alternating currents, said coils being displaced upon said core by a position angle equal to the phase-angle of said currents.

21. In combination a spiral-core transmitting-generating apparatus provided with metallic primary and secondary circuits adapted for the production of a spirally revolving magnetic field and for generating electromotive forces in its metallic secondary conductors, a metallic receiving antenna at a distance therefrom adapted for receiving alternating current transmitted to it through a system of confined wireless conductors, and means for producing a system of confined wireless conductors extending the whole distance between and electrically connected both to the metallic secondary conductors of said transmitting-generating apparatus and to the metallic conductors of said receiving antenna at symmetrically spaced points.

22. A system of closed wireless-and-metallic electrical circuits for transmitting alternating current comprising two sets of metallic conductors at opposite ends of each circuit which are displaced from each other by a position angle equal to the phase angle of the impressed alternating electromotive force, and two sets of confined wireless conductors on opposite sides of each circuit which are likewise displaced from each other, and means for electrically connecting said metallic conductors and said wireless conductors to each other so as to establish a closed and confined-path wireless-and-metallic electrical circuit for each and every phase of electromotive force impressed upon said system.

23. In combination a source of current, a pair of metallic transmitting antennae connected to said source of current, a pair of metallic receiving antennae at a distance therefrom connected to the metallic conductors of a selected utilizing apparatus, and means for producing a pair of separate wireless conducting sections extending lengthwise, so located as to make electrical connection with both pairs of said metallic transmitting and receiving antennae.

24. In combination an alternator, a pair of metallic transmitting antennae connected to said alternator, a pair of metallic

receiving antennae at a distance therefrom connected to the metallic conductors of a selected utilizing apparatus and a pair of distinct ultra X-ray wireless conductors so located as to make electrical connection with said apparatuses.

25. In combination two parabolic reflectors opening in opposite directions having coinciding major axes, an electron-discharging cathode at the focus of each reflector adapted to the discharge of streams of electrons against predetermined segments of each reflector, and means for producing a spirally revolving magnetic field transversely to the major axes of said reflectors.

26. In combination a plurality of parabolic reflectors, an electron-discharging substance at the focus of each reflector adapted for the discharge of at least one stream of electrons, and means for producing a spirally revolving magnetic field transversely to the major axes of said reflectors.

27. In combination spaced metallic conductors, two parabolic reflectors having an electron-discharging substance at the focus of each reflector, means for the production of two beams of wireless conductors extending the entire distance between said metallic conductors, means for electrically connecting said beams to said metallic conductors and for establishing a closed and confined-path wireless-and-metallic circuit, or system of such circuit, between said metallic conductors, means for producing a spirally revolving magnetic field and for superposing said field upon the aforesaid in such manner that the magnetic lines of said field will cut the conductors of each circuit in the course of revolution.

28. A system for generating and transmitting polyphase alternating currents comprising means for establishing at least two closed and confined wireless-and-metallic electrical circuits arranged in quadrature position, means for producing a spirally revolving magnetic field, means for superposing said magnetic field upon said circuits in such manner that the revolving magnetic lines of the field will cut the conductors of each circuit, and means for increasing the rate of cutting between said magnetic lines and said conductors.

29. A closed wireless-and-metallic electrical circuit comprising a transmitting-generating apparatus, a receiving-utilizing apparatus at a distance therefrom, an X-ray wireless conductor extending the entire distance between and electrically connecting half of the metallic terminal conductors of each of said apparatuses, and means for electrically connecting the other half of the metallic terminal conductors of each of said apparatuses to a conducting medium other than said wireless conductor.

30. A system for transmitting alternating

current energy consisting of a system of wireless-and-metallic circuits comprising two sets of wireless conductors on opposite sides of each circuit, and of two sets of metallic conductors at opposite ends of each circuit, for each and every phase of alternating current supplied to the system, which wireless conductors and metallic conductors are so located with respect to each other as to make electrical connection, and to form a wireless-and-metallic circuit for each and every phase of alternating current supplied to the system.

31. In combination a pair of metallic transmitting antennæ, a pair of metallic receiving antennæ at a distance therefrom, means for producing a wireless element divided into a pair of conducting sections on opposite sides of said wireless element, and means for so locating said conducting sections as to make electrical connection with both pairs of said metallic antennæ.

32. In combination symmetrically spaced metallic transmitting antennæ adapted for making electrical connection with symmetrically spaced conducting sections in a wireless element, symmetrically spaced metallic receiving antennæ at a distance therefrom likewise adapted for making electrical connection with said conducting sections, means for producing a wireless element divided into symmetrically spaced conducting sections, and means for so locating said conducting sections as to make electrical connection with said metallic transmitting and receiving antennæ.

33. In combination a source of electric current, a pair of metallic transmitting antennæ connected thereto, a non-conducting parabolic reflector furnished with a pair of electrical conducting segments, means for producing a pair of confined wireless conductors and for connecting them to said pair of metallic conducting segments at the transmitting end of the circuit, a receiving-utilizing apparatus at a distance therefrom, and means for electrically connecting thereto the same pair of confined wireless conductors.

34. Wireless-and-metallic circuits for connecting an alternating-current transmitter-generator with utilizing apparatus, comprising, for each phase of alternating current, a pair of metallic transmitting antennæ, and for each phase of alternating current, a pair of metallic receiving antennæ, and for each phase of alternating current, a pair of wireless conductors connecting said transmitting and receiving antennæ, and for each phase of alternating current, a pair of metallic conductors or windings of the utilizing apparatus designed for use with that particular phase of alternating current and connected to a pair of said receiving antennæ, thus forming

a complete wireless-and-metallic circuit for each and every phase of alternating current.

35. A chain of wireless-metallic electric circuits comprising a plurality of such circuits linked together and electrically connected from beginning to end of the chain, each circuit being inductively connected to the adjacent circuit or circuits, so that electric current can be transmitted a long distance through a plurality of electric circuits from one part of the chain to another part thereof.

36. In the wireless transmission of energy by alternating current, for each and every phase of alternating current, a pair of metallic transmitting antennæ, consisting of two sets of copper wires, each pair of transmitting antennæ connecting with a pair of wireless conductors extending to and connecting with a pair of metallic conductors of the receiving antennæ, which latter are connected to the pair of metallic conductors of the utilizing apparatus designed for use with that particular phase of alternating current.

37. A receiving antenna divided into one pair of relatively insulated segments for each and every phase of alternating current supplied to the system, consisting of a circular frame-work having conducting segments extending from near the center to the circumference, the base of the circular frame-work being insulated from the ground, and the whole apparatus adapted to be placed in operative relation with a system of wireless-and-metallic circuits so that each pair of segments will receive a particular phase of current and conduct that phase of current to the particular circuit in the utilizing apparatus designed to receive said phase of current and to convert it into useful work.

38. In the wireless transmission of current, receiving antenna divided into a pair of relatively insulated segments, one segment being located across a beam of wireless conductors in such a manner as to receive the outgoing current and the other segment being so placed across the beam of wireless conductors as to receive the incoming current, flowing through a pair of said wireless conductors or flowing through a plurality of pairs of said wireless conductors.

39. A receiving antenna comprising a structure with metallic spokes and pendants, or cross-pieces, divided into one pair of relatively insulated segments, the structure being mounted so as to permit it to turn on its short axis or axle, in operative relation with a system of wireless-and-metallic circuits carrying current, said receiving antenna being insulated from the earth.

40. Apparatus for receiving alternating energy transmitted by wireless conductors comprising a structure the surface of which

is divided into relatively insulated segments containing metallic conductors, with one pair of segments for each and every phase of alternating energy flowing through said receiving apparatus, located in operative relation with a system of wireless-and-metallic circuits carrying current, said receiving apparatus being insulated from the earth.

41. Apparatus for receiving and utilizing energy transmitted by wireless means comprising a hollow structure the surface of which is divided into a suitable number of metallic segments insulated from each other and from the earth located in operative relation with a system of wireless-and-metallic circuits carrying current, and a solid structure located within said hollow structure with an air-space between the two members, which are so mounted as to permit relative motion between the members, said outer member corresponding to the primary of an induction motor, and said inner member corresponding to the secondary of an induction motor.

42. In combination symmetrically spaced metallic transmitting antennae, means for connecting opposite antennae into a closed and confined wireless-and-metallic circuit or system of such circuits, means for producing a spirally revolving magnetic field, and means for applying said field across each circuit.

43. In combination a segmented wireless receiving antenna, means for connecting opposite segments of said receiving antenna into a closed and confined wireless-and-metallic circuit or system of such circuits, means for producing a spirally revolving magnetic field, and means for applying said field across each circuit.

44. The method of relaying energy without wires which consists in spirally twisting magnetic lines of energy around the wireless conductors of a closed and confined wireless-and-metallic electrical circuit, or system of such circuits, in such manner that said magnetic lines will cut said wireless conductors in the process of twisting.

45. The method of relaying energy which consists in spirally twisting closed streams of polyphase magnetic energy around the wireless conductors of a closed and confined-path wireless-and-metallic electrical circuit, or system of such circuits, in such manner that said streams will cut said wireless conductors at a distance from the sources of said streams.

46. The combination with a wireless receiving apparatus of a wireless-and-metallic circuit connecting the receiving station with a transmitting station, and containing a source of distributed electromotive force, namely a spirally revolving magnetic field applied across said wireless-and-metallic circuit.

47. In combination, a spiral iron-core, metallic primary windings for said spiral iron-core, which are connected with an alternator, metallic secondary conductors in inductive relation to said primary windings, utilizing apparatus at a distance therefrom, and wireless conductors which are so located as to make electrical connection with said utilizing apparatus and with said metallic secondary conductors, thus forming a complete wireless-and-metallic circuit, or system of circuits.

48. In combination, a spiral iron-core primary wound for polyphase current, adapted to producing a spirally revolving magnetic field, a secondary apparatus so mounted with reference to the primary apparatus as to permit relative motion between the two members, means for driving one member and producing a spirally revolving magnetic field, thus inducing electromotive force in the metallic secondary conductors, utilizing apparatus at a distance therefrom, and wireless conductors which are so located as to make electrical connection with said utilizing apparatus and with said metallic secondary conductors, thus forming a complete wireless-and-metallic circuit or system of circuits.

49. In combination a wireless element divided into a pair of wireless conducting sections extending lengthwise, a pair of metallic transmitting antennae and means for electrically connecting them to said pair of wireless conducting sections, a pair of metallic receiving antennae at a distance from said metallic transmitting antennae, and means for electrically connecting said receiving antennae to the same pair of wireless conducting sections.

50. In combination with a wireless element divided into a system of wireless conducting sections extending lengthwise, a pair of metallic transmitting antennae for each and every pair of wireless conducting sections and means for electrically connecting the same, a pair of metallic receiving antennae at a distance therefrom for each and every pair of wireless conducting sections and means for electrically connecting each pair of metallic receiving antennae to the corresponding pair of wireless conducting sections.

51. Apparatus for relaying and re-transmitting energy comprising a plurality of spirally arranged iron cores wound with primary coils for polyphase currents which coils are spirally displaced around said iron cores by a position angle equal to the phase angle of the polyphase currents, the ends of the iron cores projecting beyond the primary coils, and the terminals of the primary coils being connected to the receiving apparatus at the relaying station, and comprising metallic secondary conductors in inductive rela-

tion to said primary circuits, and a system of wireless conductors extending from the relay to the next receiving station, the terminals of said metallic secondary conductors
5 projecting into the space occupied by said system of wireless conductors and intercepting said wireless conductors, thus forming wireless-and-metallic circuits between the relay and the next receiving station.

- 10 52. Means for relaying and re-transmitting energy comprising means for establishing a system of closed and confined wireless-and-metallic electrical circuits connecting the relaying station with the next receiving
15 station, means for producing a spirally revolving magnetic field, and means for applying said field across each and every electrical circuit.

- 20 53. In the wireless transmission of alternating-current energy, a metallic receiving

antennæ insulated from the earth, comprising for each and every phase of electromotive force, a pair of conducting members diametrically opposite each other and insulated from each other and from
25 every other member, adapted to gather alternating-current energy and connected into a system of wireless-and-metallic circuits in such manner as to afford a wireless-and-metallic circuit for each and every phase of
30 electromotive force applied across the system.

54. The method of producing a spirally revolving magnetic field which consists in supplying polyphase currents to winding
35 coils which are displaced upon a spiral cone by a position angle equal to the phase angle of the currents supplied.

CONRAD RENO.

CONRAD RENO, 73, DIES IN FLORIDA; WAS INVENTOR

Former Springfield Resident
Leaves Wife in This City;
Was Interested in
Politics.

DAYTONA BEACH, Fla., May 7—
(AP) Conrad Reno, 73, Peoples Party
candidate for President in the 1932
campaign and one of the leading par-
ticipants in the Theodore Roosevelt
progressive revolt against the Repub-
lican party in 1912, died here today.

His widow, who lives in Springfield,
Mass., and a brother, J. W. Reno, New
York city, survive him.

Reno was the inventor of the
"stream" method and beam system of
wireless transmission of energy, the
regenerative levitation motor, and was
the discoverer of the spirally revolv-
ing magnetic field.

Conrad Reno, who was best known
in Springfield because of his political
leanings, had been a resident of this
city, with quarters at the Oaks Hotel,
until several years ago when he went
south to spend most of his time there-
after. His political headquarters were
in Springfield in 1928 when he was a
candidate for President as well as in
1932.

Mr. Reno was one of the compara-
tively few Springfield men to rate a
biographical sketch in Who's Who
each year. Several inches of space
were required to relate all his accom-
plishments.

Conrad Reno married Susan M.
Eustis, daughter of Rev. William T.
Eustis of this city on April 13, 1887.
He was an inventor, author and
lawyer.

CONRAD RENO DEAD; FORMER LOCAL MAN

Was Candidate of People's
Party For President in
1932—Also Inventor

Conrad Reno, 73, for many years a
resident of this city, and candidate of
the People's party for President in
1932, died Sunday at Daytona Beach,
Fla. He had long been active in politics
and was the inventor of several de-
vices which attracted much attention.
While a resident here he made his
headquarters at the Oaks hotel. He
leaves a widow who was Susan M.
Eustis, daughter of Rev William T.
Eustis and a brother, J. W. Reno of
New York city.

Mr Reno's best known political ad-
venture was his role in the Progres-
sive revolt led by the late Theodore
Roosevelt in 1912. He has been for
years a resident of the Oaks hotel and
his research into political and eco-
nomic questions brought him into
contact, personal and otherwise, with
many leaders throughout the country.
In 1928, he organized the American
Home party and was its presidential
candidate, while last year the People's
party gave him the nomination.
Neither party, of course, gained suf-
ficient popular support to even have
its vote tabulated in the newspapers,
although there were scattered votes
for the party and Mr Reno in all
parts of the country.

Besides being active in politics in
his own way, Mr Reno was known
as an author, inventor and lawyer.
He was particularly well known for
the "stream" method and beam sys-
tem of transmitting energy, and dis-
covered the spirally revolving mag-
netic field.

March 17, 1925.

E. F. HENNELLY

1,530,364

AMPLIFIER

Filed June 26, 1922

Fig. 1.

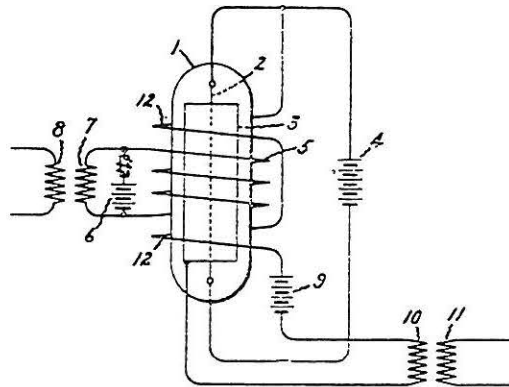


Fig. 2.

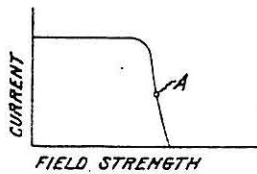
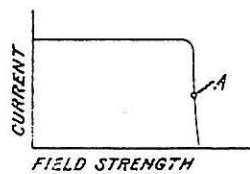


Fig. 3.



Inventor:
Edward F. Hennelly,
by *Alfred H. Davis*
His Attorney.

UNITED STATES PATENT OFFICE.

EDWARD F. HENNELLY, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

AMPLIFIER.

Application filed June 26, 1922. Serial No. 570,966.

To all whom it may concern,

Be it known that I, EDWARD F. HENNELLY, a citizen of the United States, residing in Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Amplifiers, of which the following is a specification.

My present invention relates to amplifiers and more particularly to amplifiers of the magnetron type such as are fully described in a paper entitled "The magnetron" by Albert W. Hull, published in the September, 1921, number of the Journal of the American Institute of Electrical Engineers, page 715.

The object of my invention is to provide means whereby the degree of amplification which may be obtained with devices of the magnetron type may be greatly increased.

By the term "magnetron" as used in this specification and the claims which follow, I intend to designate a device utilizing an electron stream the flow of which is controlled by means of a magnetic field.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation will best be understood by reference to the following description taken in connection with the accompanying drawing, in which Fig. 1 shows diagrammatically a circuit arrangement whereby my invention may be carried into effect, and Figs. 2 and 3 are characteristic curves illustrating the relation between the magnetic field strength and the current in a magnetron.

As illustrated in Fig. 1, the magnetron comprises an evacuated receptacle 1, containing the filamentary cathode 2 which is surrounded by a cylindrical anode 3. The source of current 4 provides heating current for the cathode. A polarizing field for the magnetron may be provided by means of coil 5 surrounding the receptacle 1 which is supplied with current of the proper value for producing a magnetizing field of the desired strength from a source of current 6. Currents which are to be amplified may also be supplied to the coil 5 from the secondary 7 of the transformer, primary 8 of which is

connected with the source of current to be amplified. The output circuit of the magnetron which is connected between the cathode 2 and the anode 3 includes a source of current 9 and primary winding 10 of a transformer by means of which amplified currents are supplied to a utilization circuit or to additional amplifiers by means of the secondary winding 11. The output circuit of the magnetron also includes the coil 12 which surrounds the receptacle 1.

In the operation of the system described the coil 12 is so wound that the magnetic field produced thereby opposes the polarizing magnetic field produced by the coil 5. The curve of Fig. 2 is a typical characteristic curve showing the relation between magnetic field strength and current in the magnetron. The degree of amplification which may be obtained depends upon the slope of the vertical part of this curve. In the normal operation of the magnetron as an amplifier the polarizing field winding is made of sufficient strength to hold the current through the magnetron at some value, as, for example, the value indicated by the point A on the curve along the vertical portion of the curve. When the additional magnetic field supplied by the current in the output circuit as illustrated and described is provided, the characteristic curve will take the form shown in Fig. 3; that is, the slope of the vertical part of the curve will be made much steeper and the degree of amplification which may be obtained will therefore be much greater. In this case the value of the polarizing field required to maintain the value of the magnetron current at the point A will be slightly larger, other factors being equal, than in the case illustrated in Fig. 2, this difference being equal to the strength of the field furnished by the coils 12. In the case illustrated in Fig. 3, an increase in the field produced by coil 5 will produce a consequent decrease in the magnetron current and this in turn will cause a decrease in the field produced by coil 12 which will result in further decrease of the magnetron current. The result of this conjoint action of the fields produced in coils 5 and 12 results in the steepening of the characteristic curve as indicated in Fig. 3.

While I have shown and described the

simplest embodiment of my invention, it will be apparent that many modifications in the circuit arrangements as well as in the form of magnetron employed may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. In an amplifying system, a magnetron having means for producing a polarizing magnetic field, input and output circuits and a coil in said output circuit connected in such a way that it produces a magnetizing field which normally opposes the polarizing magnetic field.

2. In an amplifying system, a magnetron having means for producing a polarizing magnetic field, input and output circuits and a coil in said output circuit connected in such a way that it produces a magnetizing field which normally opposes the polarizing magnetic field and which varies in accord-

ance with variations in current supplied to the input circuit.

3. The method of operating a magnetron having input and output circuits which consists in producing a polarizing magnetic field in the magnetron and producing by means of current in the output circuit a magnetic field which opposes the polarizing magnetic field.

4. The method of operating a magnetron having input and output circuits which consists in producing a polarizing magnetic field in the magnetron, supplying a current to be amplified to the input circuit and producing by means of current in the output circuit a magnetic field which opposes the polarizing field and which varies in accordance with variations in the current supplied to the input circuit.

In witness whereof, I have hereunto set my hand this 23rd day of June, 1922.

EDWARD F. HENNELLY.

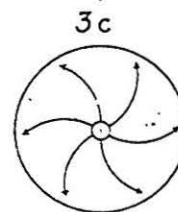
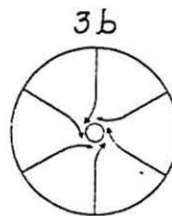
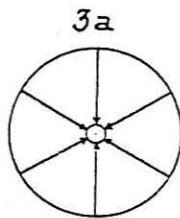
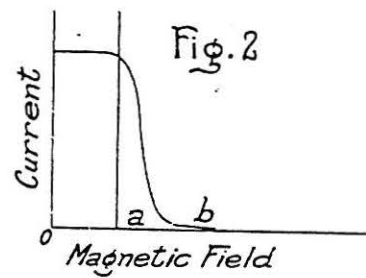
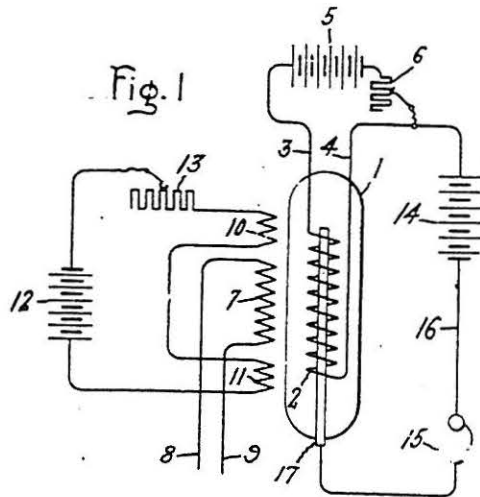
April 21, 1925.

E. F. W. ALEXANDERSON

1,535,082

ELECTRON DISCHARGE DEVICE

Original Filed Sept. 28, 1920



Inventor:
Ernst F. W. Alexanderson,
by *Alfred G. Davis*
His Attorney.

UNITED STATES PATENT OFFICE.

ERNST F. W. ALEXANDERSON, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, OF NEW YORK, N. Y.

ELECTRON-DISCHARGE DEVICE.

Application filed September 28, 1920. Serial No. 413,337. Renewed March 12, 1923.

To all whom it may concern:

Be it known that I, ERNST F. W. ALEXANDERSON, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Electron-Discharge Devices, of which the following is a specification.

The present invention comprises a novel electron discharge device which is particularly adapted to the controlling and amplifying of electrical currents.

Heretofore electron discharge devices have been constructed in which the transmitted current was subject to the control of a variable magnetic field. In these devices the cathode was axially arranged within the anode, preferably being substantially equidistant from the anode at all points along its length.

I have discovered that an even more sensitive device can be constructed by locating the anode centrally with respect to the cathode, and preferably spacing the electrodes symmetrically.

I have illustrated diagrammatically in Fig. 1 a form of apparatus embodying my invention; Fig. 2 is a diagram illustrating an electrical characteristic of my device, and Figs. 3^a, 3^b and 3^c illustrate visually electron flow under various conditions as an aid to explain my invention.

The device shown in Fig. 1 is adapted for use as an amplifier for weak electrical currents, for example, radio signals. It comprises an elongated glass envelope 1 containing a centrally located elongated or rod-like anode 17 and a helical cathode 2 symmetrically surrounding the anode. The cathode 2 is preferably although not necessarily equidistant from the anode 17 at all points along its length and in general I prefer to arrange the electrodes in devices embodying my invention in circular symmetry with respect to each other.

The cathode 2 is adapted to emit electrons independently of the passage of current across the space between the electrodes; for example, in the case illustrated in the figure the cathode consists of refractory material, preferably tungsten, connected by conductors 3, 4, to a suitable source of electric energy represented by an electric battery 5. A regulable resistance 6 is provided to control the heating current. The

anode 17 may also consist of tungsten and various other metals may also be used. The space within the envelope is evacuated and the parts of the device are deprived of gas to such an extent that the electron discharge can occur therein without material gas ionization. A slight amount of gas ionization will do no harm, but it should not be so high as to make the electrons uncontrollable by a magnetic field. Some suitable means for generating a variable magnetic field is provided, as, for example, a coil 7 which has been diagrammatically shown adjacent to the discharge tube, but which, as in devices of this type, will ordinarily surround the tube. This coil 7 is connected to the source of weak variable current which is to be amplified, as represented in this case by the conductors 8, 9.

There is also provided some means for generating a polarizing electric field, as represented by coils 10 and 11, connected in series to a source of direct current such as a battery 12 in circuit with a variable resistance 13. In circuit with the electrodes 2 and 17 are included a suitable source of direct current as represented by the battery 14 and a suitable indicating device such as a telephone receiver 15.

When no exterior magnetic field is applied to an electron discharge device having an anode centrally located with respect to the cathode the electrons in general tend to move in direct paths from the cathode to the anode, as shown in Fig. 3^a. When a magnetic field is generated substantially parallel to the cathode, the electrons are deflected out of a direct path. With a central location of the cathode in prior devices the path of the electrons tend to become curved as shown in Fig. 3^b. When the magnetic field is increased sufficiently the electrons eventually travel in a long spiral path about the cathode on their way to the anode and finally when the field strength is increased sufficiently electrons will fail to reach the anode by reason of this deflection.

In a device having a centrally located anode the electrons flowing inwardly from the surrounding cathode to the anode when deflected by a magnetic field as shown in Fig. 3^c, are caused to travel in a general direction tangentially to the anode and tend to form orbits about the anode. As the centrifugal force of the mass of electrons

works in the same direction as the magnetic field in a device having a centrally located anode, such a device is much more sensitive to variations of the magnetic field than a device having the cathode located within the anode. In the latter case the magnetic field must be strong enough to overcome the centrifugal force of the electrons in their circular path. The relation between the magnetic field tending to deflect the electrons and the current transmitted by the device is indicated by the diagram constituting Fig. 2, the values of the magnetic field being plotted as abscissae and the corresponding field values as ordinates for a given cathode temperature. As the strength of the magnetic field is increased from zero the current remains substantially constant until the magnetic field reaches a value represented as *oa* on the abscissae. A further increase of field strength causes a rapid reduction of current until at a field strength of *ob* current has fallen substantially to zero.

The magnetic field necessary to produce a decrease in current, in other words, the value *oa* will be less in a device embodying my invention than in devices heretofore constructed having a centrally located cathode. In practice the strength of the polarizing magnetic field is adjusted at some value between *oa* and *ob*. Consequently when the variable magnetic field of the coil 7 is superimposed upon the polarizing field an increase or decrease of conductivity of the device occurs. For example when the variable magnetic field produced by the coil 7 tends to assist the polarizing field generated by the coils 10 and 11, the current in the circuit 16 tends to decrease, and conversely, when the magnetic field of the coil opposes the polarizing field the current in the circuit 16 increases. Therefore, a variable current in the circuit 8, produces a corresponding amplified variable current in the circuit 16 which can be used in any desired manner, as in a telephone receiver 15.

What I claim as new and desire to secure by Letters Patent of the United States, is.—

1. In combination, an electron discharge device adapted to operate independently of gas ionization comprising the combination of an anode, an electron-emitting cathode arranged about said anode and magnetic means arranged to oppose the passage of electrons from said cathode to said anode.

2. In combination, an electron discharge device comprising an evacuated envelope, an electron-emitting cathode and an anode inclosed by said cathode and having a major

axis extending in the direction of the major axis of said cathode and means for producing a magnetic field parallel to the axis of symmetry of said electrodes for controlling the flow of electrons from said cathode to said anode.

3. An electron discharge device comprising the combination of electrodes contained in an evacuated space, the cathode comprising a coiled conductor, the anode being located substantially centrally within said coiled conductor, and means for generating a magnetic field substantially parallel to the axis of said cathode.

4. An electron discharge device comprising the combination of an elongated anode, a helical cathode symmetrically spaced about said anode, means for heating said cathode, an enclosing evacuated envelope and magnetic means for controlling an electrical discharge between said electrodes.

5. An electron discharge apparatus comprising the combination of an elongated electrode, a helical electrode spaced about the same, means for conducting an electric current through said helix, a sealed evacuated envelope enclosing said electrodes, a load circuit connected to said electrodes, and a magnetic winding located to generate a magnetic field substantially parallel to the axis of said helix.

6. An electron discharge device comprising in combination an evacuated envelope, an elongated anode, a filamentary cathode symmetrically spaced about said anode, and means for generating a magnetic field substantially parallel to the axis of said cathode.

7. An electron discharge device comprising in combination an evacuated envelope, an elongated anode, a helically coiled cathode symmetrically arranged about said anode, means for heating said cathode to a temperature sufficiently high to emit electrons, magnetic means for producing a field which will deflect electrons out of a direct path between said electrodes, means for varying said field, and a load circuit connected to said electrodes.

8. An electron discharge apparatus comprising the combination of an anode, an electron-emitting cathode arranged about said anode, an enclosing evacuated envelope, an output circuit connected thereto, magnetic means for generating a field opposing the passage of electrons from said cathode to said anode and input means for varying said field.

In witness whereof, I have hereunto set my hand this 27th day of September, 1920.

ERNST F. W. ALEXANDERSON.

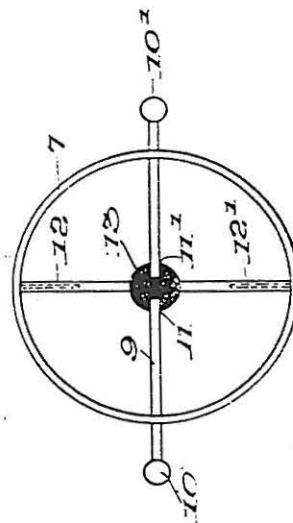
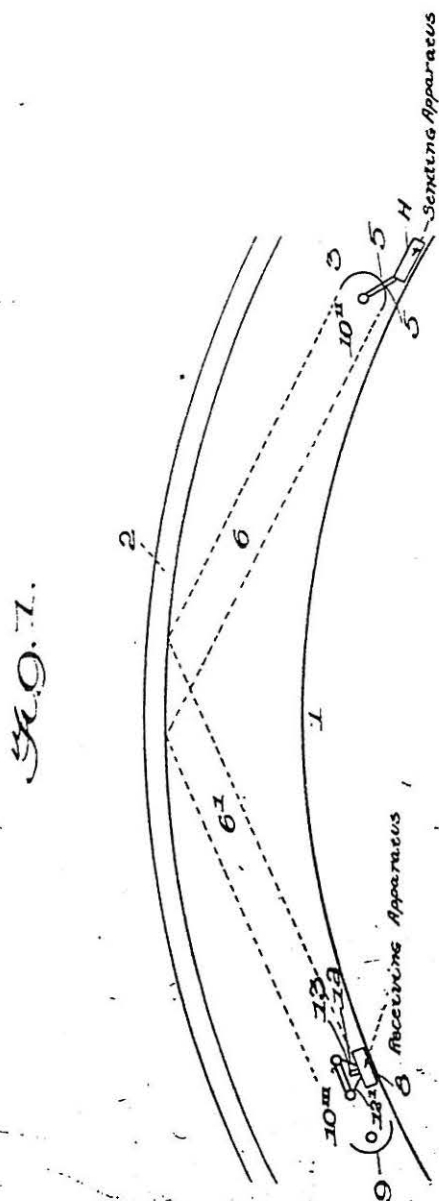
Feb. 8, 1927.

1,617,242

R. A. FESSENDEN

WIRELESS TRANSMISSION AND RECEPTION

Filed Oct. 13, 1924



Inventor
Reginald A. Fessenden

Cushman Report on Daily

Altos de

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF CHESTNUT HILL, MASSACHUSETTS.

WIRELESS TRANSMISSION AND RECEPTION.

Application filed October 13, 1924. Serial No. 743,265.

My invention relates to the wireless transmission and reception of energy, and more particularly to wireless signaling; and still more particularly to increased efficiency in transmission and freedom from disturbances in reception and increased selectivity and range; and more especially in wireless telephony and broadcasting.

It has for its object increased efficiency, freedom from disturbances, increased selectivity and range, and convenience in operation and cheapness.

Figures 1 and 2 shew, partly diagrammatically, apparatus adapted for carrying out my invention. Fig. 1 shews how the waves are transmitted and received; and Fig. 2 shews a reception device in more detail.

This invention relates to further developments along the lines of applicant's previous patents, U. S. 956,489—June 21st, 1906; 974,762—Jan. 14th, 1907; 1,015,881—Dec. 19th, 1906; British 2955, 1908; and others.

Heretofore in the practice of the art of wireless signaling it has been the practice to use for transmission and reception waves having their electric component perpendicular, or in a plane perpendicular to the earth's surface. The reason for this is that if the antennae wires are placed parallel to the earth there will be substantially no radiation in a plane at right angles to the antenna and to the earth's surface; in fact the antenna then acts as a directional antenna in a plane containing the antenna and at right angles to the earth's surface. This is well known and is shewn in applicant's German Patent 225,256—Jan. 14th, 1907; and the methods therein shewn are used extensively and known as the wireless compass.

So far as applicant knows no attempt has been made to use waves having their electrical component parallel to the earth with the exception of British Patent 2955, 1908 referred to above; and this, while operating well for its limited purpose, was very wasteful of power and had but short range. The experience of others has no doubt been similar.

But during the course of some experiments during the late war it occurred to applicant that it would be of interest to see if a beam of waves having its electrical component parallel to the earth's surface

would act differently. On trying the experiment it was found that the previous excessive absorption no longer occurred, especially when the reflector was so tilted that the beam of waves was slightly inclined away from the earth's surface, as shewn in Fig. 1; where the electrical component is perpendicular to the plane of the paper. In fact the transmission was found to be much better than with the usual way, in which the electrical component is parallel to the plane of the paper, in Fig. 1.

It was found that it was not necessary that the beam should be inclined away from the earth's surface, as if the reflector was slowly tilted nodes of alternate large range and small range were found to occur, especially if a sheet of copper were laid on the ground beneath and in front of the reflector.

It was also found that the effect was somewhat better, on many occasions considerably so, if continuous waves were used. It was also found that the effect of atmospheric and other disturbances was reduced very greatly, and at times entirely. It was also found that the beam of waves so emitted was not absorbed to the same extent by the Heavyside layer, (for explanation of evidence of the existence of this layer see Electrical Review, London, May 11th and 18th, 1906; Trans. Amer. Inst. Elec. Eng. July, 1908; Electrician, London, Dec. 19th, 1919; Popular Radio, November, 1923) the turning of the plane of polarization through a right angle from that hitherto used appearing to greatly diminish the absorption and reflection losses and scattering. And the fact that other stations operated with the plane of polarization perpendicular to the earth, greatly diminished their disturbing effect on the receiving station of the present system, which is arranged to receive waves transmitted with the plane of polarization, i. e. the plane of the electrical component of the waves, substantially parallel to the earth's surface, or approximately so. There were also other advantages.

In Fig. 1, 1 is the surface of the earth, 10'' a short antenna end-on, which may be of the type shewn in applicant's projector patents referred to above, or of other form, as well known in the art, or of the type shewn at 10, 10', Fig. 2. The source of oscillations is shewn at 4, and 5, 5' are the leads thereto from the antenna.

The reflector 3, may be either of the para-

holic spherical or cylindrical forms, according to the lateral dispersion desired and range. It may be made of a sheet of copper or other conductor, or of parallel wires, as well known in the art. The wave-length and size of antenna, which lies horizontally to the earth's surface, will preferably be small compared with the dimensions of the reflector when it is desired to send a concentrated beam. By the term "small wave length" is meant wave length small compared with that standard in the art, or, in other words, substantially as disclosed in applicant's companion application, Serial No. 532,489, filed Jan. 28, 1922, where the wave length is disclosed as above one meter and below fifty meters. This application is a continuation-in-part of said application, Serial No. 532,489.

Means for generating waves of short wave length are well known in the art, e. g. as shewn in applicant's patents referred to above, and in applicant's application Ser. No. 532,489, applicant's Patents 793,777; 923,963; et al; applicant's papers in Nature and elsewhere; and have been used successfully by himself and by others. See Electrician, London, May 19th, 1922, for production of 3 meter waves with applicant's compressed gap transmitter and Austin's paper in Bureau of Standards technical publications, May, 1907, on one of applicant's compressed gas gaps loaned the Bureau for purposes of tests. Also the DeForest three electrode hot cathode tube, as is well known in the art. Also the hot cathode oscillator tube of applicant, shewn in applicant's specification, Ser. No. 423,185, filed Nov. 10th, 1920. This, which is a development of applicant's former types, shewn in U. S. application 222,301, Aug. 26th, 1904, and U. S. Patents 915,280 and 1,133,435, is peculiarly adapted to the production of short wave lengths, for with very short wave lengths the extremely high frequency currents flowing in the hot cathode are confined much more to the surface than with the usual frequencies, and hence the efficiency is much increased as much less cathode has to be heated, i. e. much less of the mass of the cathode or much less conductor, and the response is better. Moreover, by making nodes in the cathode conductor and placing the anode in suitable position opposite one of the nodes, or more than one, the antenna itself which radiates the waves may be constituted of a short section of a heated wire or hollow cylinder which also acts as cathode. Or it may be an extension of such wire or operatively connected thereto. In this way very short waves may be efficiently produced, and also efficiently radiated. This last described method and apparatus is not claimed in the present application.

The reflector is preferably tilted slightly

away from the plane of the earth's surface, as shewn, though, as stated above, it may be tilted down to be parallel to it, especially if a sheet of conducting material is placed in front of it or beneath it, as described above.

If the distance is short, there will be no reflection from the Heavyside layer as the waves will not reach that high. With long transmission the waves it is believed, see experiments referred to above, are reflected as shewn.

At the receiving end a small horizontal antenna, as shewn at 10, 10', Fig. 2, may be used. Or, as shewn in Fig. 1, a loop antenna, suitably tuned and with capacity, as is well known in the art, described for example in applicant's German Patent 225,256; Jan. 14th, 1907; and elsewhere. This is shewn more in detail in Fig. 2. The loop is supported in any suitable way, normally in a horizontal plane, by the leads 12, 12' of stiff wire, attached to the insulating support 13, so that the loop 7 may be rotated and tilted in any desired way. The receiving apparatus 8 may be of any of the well known types, such as are used or are suitable for receiving the waves of the type used, i. e. wireless waves, of short length, preferably.

In place of the loop 7 a receiving reflector, preferably similar to 3, may be used; the receiving antenna may be similar to 10, 10' of Fig. 2, and the leads 11, 11' attached to a receiving apparatus like 8.

The loop 7 used as receiving apparatus as shewn in Fig. 1, has the advantage for some purposes that it will receive from all directions in the earth's horizontal plane and at the same time not be responsive to disturbances coming from overhead. It may also be used to cut out any particular set of disturbing influences by conjoining with it the short horizontal antenna 10, 10' as shown in Fig. 2; which is preferably formed of a pair of knobs 10, 10' and a pair of rods, 9, 9'. When used for antenna in conjunction with a reflector, as shewn at 3, 10'', Fig. 1, the knobs may be omitted, as they slightly increase the size of the reflector necessary for equal definition of beam.

This method of horizontal plane polarization has many advantages as described above. It is especially valuable in broadcasting, as powerful stations near by may use, the one horizontal, and the other vertical, polarization, and listeners-in near by may use the oppositely polarized receiving sets. I. e. a receiver using a vertically polarized antenna apparatus of the usual type will not be substantially interfered with by a high powered horizontally polarized sending station. It also enables those using loop reception to listen in simultaneously to all directions while still enjoying freedom from

static, and hence is especially suitable for marine work and inter-subscriber communication and the like. And at the same time, by the use of the method shewn in applicant's Patents, e. g. 727,329, Mar. 14th, 1903; 752,895, Mar. 14th, 1903; et al. may operate directionally.

Where the horizontal loop or coil antenna, as i. e. of the type described, and shewn at 10 7, Figs. 1 and 2, is used for emitting waves as in broadcasting, the coil or loop is preferably placed on the top of a high pole and at a distance from absorbing bodies which might act as above described, prejudicially, in the case of the projector described above.

What I claim is:—

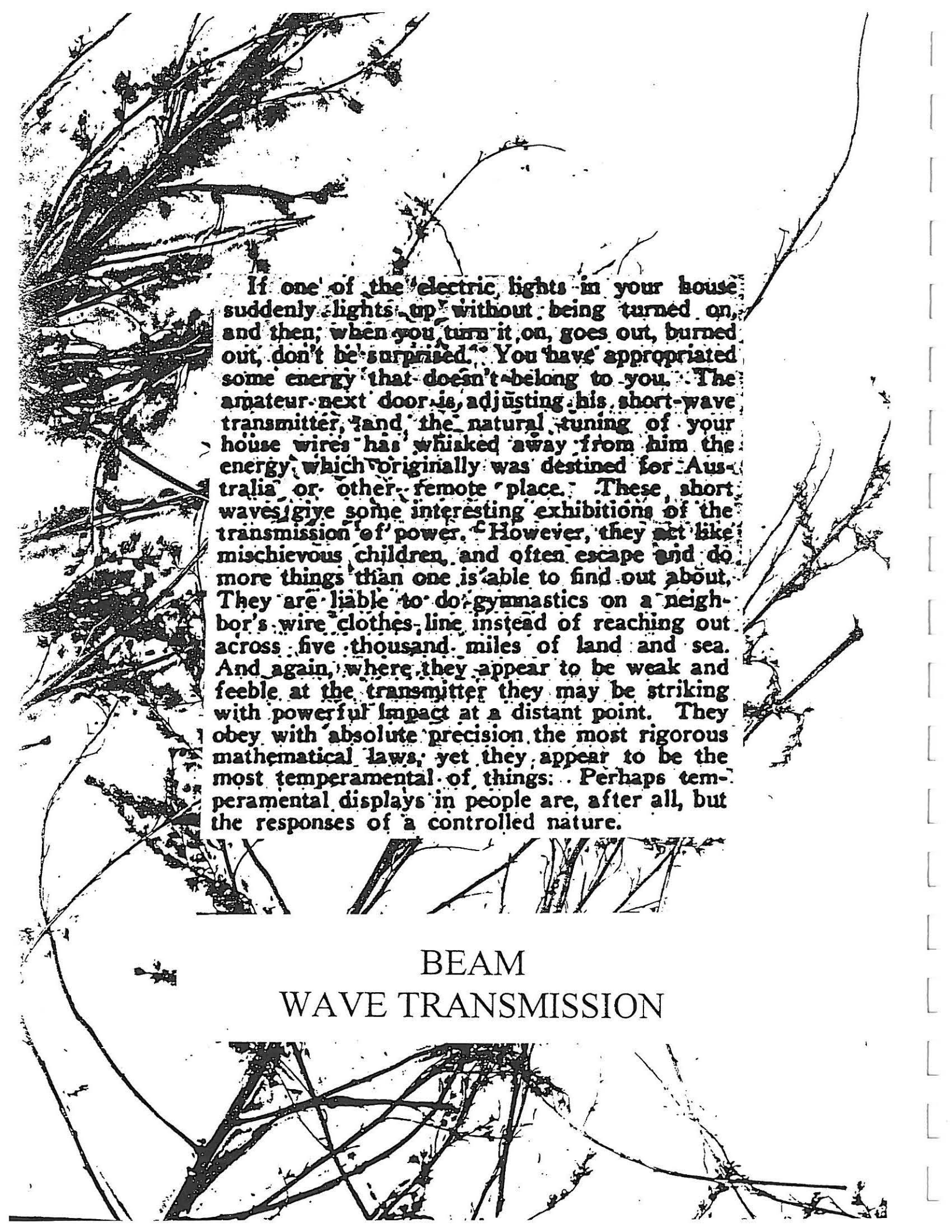
20 1. In wireless signaling, the method of increasing the reliability of operation and diminishing errors and disturbance, which comprises transmitting the wireless signals by horizontally polarized waves projected from the sending station at an angle sub-

stantially inclined to the plane of the earth's surface at said sending station. 25

2. In wireless signaling, the method of increasing the reliability of operations and eliminating errors and disturbance, which comprises receiving horizontally polarized waves at the receiving station at an angle 30 substantially inclined to the plane of the earth's surface at said receiving station.

3. In wireless signaling, the method of increasing the reliability of operation and diminishing errors and disturbance, which 35 comprises transmitting the wireless signals by horizontally polarized waves projected from the sending station at an angle substantially inclined to the plane of the earth's surface at said sending station and receiving 40 said horizontally polarized waves at the receiving station at an angle substantially inclined to the plane of the earth's surface at said receiving station.

REGINALD A. FESSENDEN.



If one of the electric lights in your house suddenly lights up without being turned on, and then, when you turn it on, goes out, burned out, don't be surprised. You have appropriated some energy that doesn't belong to you. The amateur next door is adjusting his short-wave transmitter, and the natural tuning of your house wires has whisked away from him the energy which originally was destined for Australia or other remote place. These short waves give some interesting exhibitions of the transmission of power. However, they act like mischievous children, and often escape and do more things than one is able to find out about. They are liable to do gymnastics on a neighbor's wire clothes-line instead of reaching out across five thousand miles of land and sea. And again, where they appear to be weak and feeble at the transmitter they may be striking with powerful impact at a distant point. They obey with absolute precision the most rigorous mathematical laws, yet they appear to be the most temperamental of things. Perhaps temperamental displays in people are, after all, but the responses of a controlled nature.

BEAM WAVE TRANSMISSION

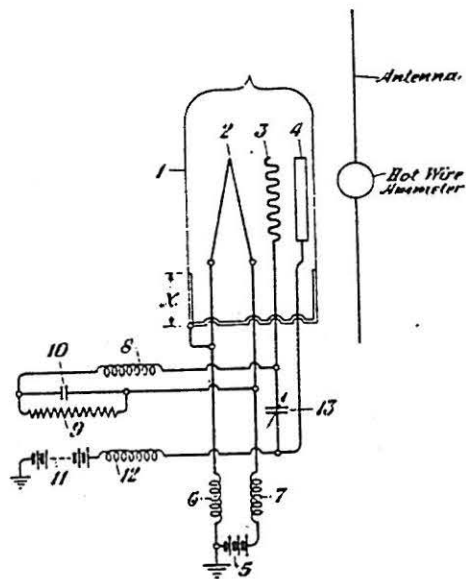
Jan. 24, 1928.

1,656,987

R. S. OHL

ULTRAHIGH FREQUENCY GENERATOR

Filed Dec. 24, 1924



INVENTOR
R. S. OHL

BY
[Signature]

Patented Jan. 24, 1928.

1,656,987

UNITED STATES PATENT OFFICE.

RUSSELL S. OHL, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

ULTRAHIGH-FREQUENCY GENERATOR.

Application filed December 24, 1924. Serial No. 757,926.

This invention relates to high frequency generators and particularly to a generator of the vacuum tube type designed for the production of ultra-high frequencies.

Generators of the vacuum tube type have been used in many fields of electrical work. Such generators are characterized by a coupling between the output and the input circuits of the vacuum tube by which sufficient energy is fed back from the output circuit to the input circuit to maintain the production of oscillations. The vacuum tube generators of the prior art have been satisfactory where the frequency requirements have not been very high; that is to say, not above 5,000 kilocycles. With the improvements being rapidly made in radio signaling, particularly along the lines of directional control, it is desirable to produce oscillations of relatively short wave length, for example, of the order of magnitude of 5 meters or less.

This invention resides in a vacuum tube generator capable of producing ultra-high frequency oscillations. By the term "ultra-high frequency" is meant a frequency higher than 5,000,000 cycles per second.

The invention will be apparent from the following description when read in connection with the attached drawing showing schematically a form of embodiment of the invention.

In the drawing, the vacuum tube 1 is of the well known three-electrode type comprising a filament 2, a grid 3 and a plate 4. For the purpose of carrying out this invention the tube employed in the generating circuit should have low internal loss at the frequencies of oscillation. The filament 2 is connected with the source of filament-heating current 5, one pole of which is grounded. The connection between the source 5 and the filament includes the choke coils 6 and 7 which should be so proportioned as to have extremely high impedance at the oscillating frequency. The grid 3 is connected with one of the filament leads, the connection including a high frequency choke coil 8, a resistance 9 and a condenser 10, the said resistance serving as the grid leak. The plate 4 is connected with the positive pole of the source 11 of plate potential, the negative

is a variable condenser 13 which determines the frequency of oscillation of the circuit. The base of the vacuum tube, namely, the part designated *a* supporting the glass container, which base coacts with a receptacle to hold the tube in correct position, should, in effect, be connected to ground in order to avoid the dissipation of the high frequency energy through its capacity to ground. The possibility of such dissipation will be apparent when it is considered that the base, consisting of a relatively large mass of metal, is in close juxtaposition to the space in which the high frequency oscillations are being set up and has, also, fairly large capacity to ground. A preferred method of grounding the base consists in connecting it with the filament-heating circuit between said filament and a choke coil, for example, 6, so that the choke coil acts in the same manner with respect to the base as to the filament circuit. The leads to the cathode and the grid should have as low inductance and capacity as practicable in the construction of vacuum tubes.

The radiating element of a vacuum tube generator of the type described consists of a rod of copper or similar metal of such diameter as to cause the rod to remain in a fixed position without appreciable vibration. Such a rod should be ungrounded and its length should be one-half the length of the generated wave. The rod should be placed in close juxtaposition to the source of oscillations and should have a thermammeter inserted midway between the ends of the rod. As thus placed the rod will absorb most of the power output of the vacuum tube generator when the resonant circuit of the tube is attuned to the natural period of the rod.

The manner in which the circuit functions to produce the ultra-high frequency oscillations is as follows: The grounded source of plate potential 11, which for example, may be of the order of magnitude of 1,000 volts, will cause a flow of current from the plate 4 to the filament 2 and to ground through the source 5. This source of plate potential 11 will also apply a charge to the condenser 13 which will produce a positive

leak 9. It will be apparent therefore that there will be a charge and discharge of the condenser 13, and the rate of charge and discharge will depend upon the magnitude of the condenser and of the constants of the tube. The connecting circuits do not appreciably affect the rate of oscillation because the choke coils 6, 7, 8 and 12 have been so chosen as to prevent the passage of high frequency currents through the circuits in which the coils are placed. The oscillations produced within the tube will be transferred to the antenna and radiated therefrom. The connection of the base x of the tube to the grounded lead of the filament heating circuit, which lead includes the high frequency choke coil 6, prevents the dissipation of energy through the base.

As an indication of the magnitudes of the various parts, it may be stated that in a generator producing a wave of 5 meters the condenser 13 was variable up to the maximum capacity of 150 mmf.; the condenser 10 had a capacity of .001 mf.; the resistance 9 was of 5,000 ohms; the tube was of 51 watts capacity; the source 5 was of 10 volts and the

source 11 was 1,000 volts. With such an arrangement it was found that the power output efficiency was comparable with that of a vacuum tube generator producing much lower frequencies.

While this invention has been disclosed as embodied in a particular form it is to be understood that it is capable of embodiment in other forms without departing from the spirit and scope of the appended claim.

What is claimed is:

A generator of ultra-high frequency oscillations, comprising a vacuum tube having a plate, a grid and a filament, an evacuated vessel enclosing such electrodes and having a metallic base supporting said vessel, a condenser coupling between said plate and grid, a grounded source of plate potential, a grounded source of filament-heating current, and a connection between the said metallic base and the grounded side of the source of filament-heating current.

In testimony whereof, I have signed my name to this specification this 23rd day of December, 1924.

RUSSELL S. OHL.

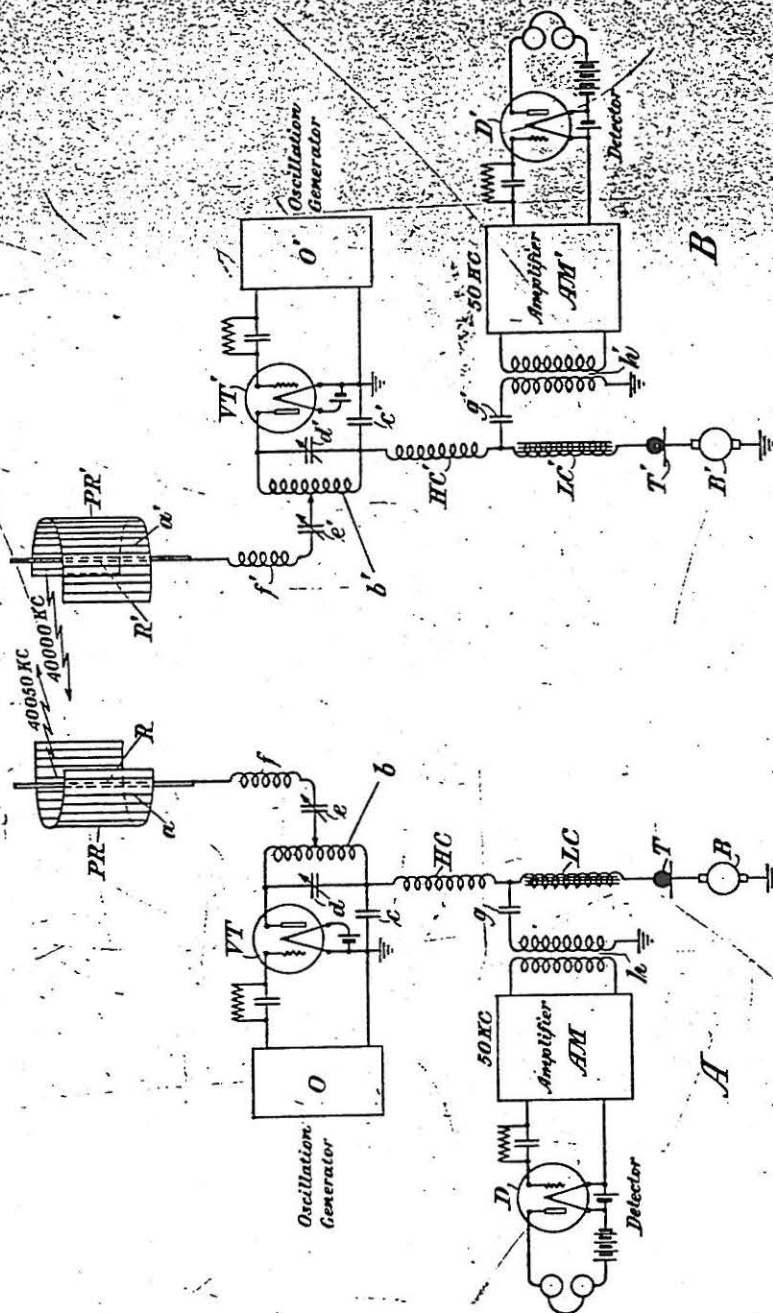
Nov. 12, 1929.

R. S. OHL

1,735,053

RADIO SIGNALING SYSTEM

Filed Sept. 23, 1925



INVENTOR
R. S. Ohl
BY. *gr 406*
ATTORNEY

UNITED STATES PATENT OFFICE

RUSSELL S. OHL, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

RADIO SIGNALING SYSTEM

Application filed September 23, 1925. Serial No. 58,164.

This invention relates to short wave signaling systems.

It has been found desirable in short wave signaling systems to use a beam of waves for the transmission and reception of signals. In order to set up a beam of waves a parabolic reflector may be employed therefore, the parabolic reflector consisting of a plurality of elements arranged on a parabolic surface around a transmitting or receiving aerial as a focus, each element being tuned to the frequency of the aerial. The length of each element is preferably about half a wave length, but the length may be made greater or less than this by including either a condenser or an inductance therein.

But when a parabolic reflector is used for the transmission of a beam of waves, it is customary to employ another parabolic reflector for the reception of a similar beam of waves. Such reflectors are large and expensive, and it therefore seems necessary to provide a system whereby a single reflector may be employed for both the transmission and reception of a beam of waves.

Accordingly, it is an object of this invention to provide a pair of parabolic reflectors, one at each station, each being suitable for both the transmission and reception of a polarized beam of waves.

While the nature of this invention will be pointed out with particularity in the appended claim, the invention itself, both as to its objects and features, will be more clearly understood from the detailed description hereinafter following when read in connection with the accompanying drawing representing one embodiment of the invention. The apparatus at the two stations shown in the drawing are similar and therefore the same reference characters have been employed in connection with each station, except that at one of the stations the reference characters are primed.

Referring to the drawing, two stations A and B are shown. At station A there is a parabolic reflector PR consisting of a plurality of elements a all arranged on a parabolic surface around an aerial R, sometimes called a resonator. An oscillation generator

O is shown in the drawing for generating a very high frequency, for example, 20,025 kilocycles, the frequency being constant within very narrow limits. This may be a piezo-electric oscillator, or a vacuum tube oscillator controlled as to frequency by means of a piezo-electric device, or a low frequency oscillator having connected thereto in tandem a plurality of harmonic generators, or frequency multipliers, so as to change the low frequency oscillations to high frequency oscillations.

A harmonic generator, or a frequency multiplier, is connected to the oscillation generator O including a vacuum tube VT having an input circuit and an output circuit. The output circuit of this vacuum tube includes the anode and cathode of the vacuum tube VT, the inductance b and condenser c . A variable condenser d is employed for tuning the output circuit of the vacuum tube VT to any frequency, preferably a harmonic of the frequency in the input circuit thereof, for example, 40,050 kilocycles. Another variable condenser e and an inductance f are connected to the output circuit of the vacuum tube VT for impressing the frequency of the output circuit on the aerial R.

The reference character T represents a device which is employed for superimposing signals on a high frequency current supplied to the aerial R. This device may be a microphone, an alternator, or any device capable of transmitting signals which may be superimposed on a high frequency current. A source of potential B supplies the necessary space current to the anode of the vacuum tube VT. Current from the source of potential B flows through choke coils LC and HC and the inductance b , the choke coil HC being employed for preventing the transmission of frequencies of 40,000 kilocycles or more, and the choke coil LC being employed for preventing the transmission of a frequency of 50 kilocycles. However, current of a frequency of 50 kilocycles passes through the condenser g and is impressed on the primary winding of the transformer h . Due to the coupling existing between the primary and secondary windings of the transformer

h, this current is also impressed on the secondary winding thereof, and thereafter upon the input circuit of an amplifier AM. This amplifier AM may be any amplifier well known in the art, preferably a vacuum tube amplifier.

The output circuit of this amplifier is connected to a detector D which has a receiving device connected in the output circuit thereof. This receiving device receives the signals which are superimposed on the current of the frequency of 50 kilocycles which are detected by D.

The apparatus at station B is similar to the apparatus at station A, the reference characters for the apparatus at station B being the same as the reference characters at station A except that they are primed.

The arrangements of this invention operate in the following manner:

The oscillation generator O transmits a high frequency, for example, 20,025 kilocycles, to the input circuit of the vacuum tube VT. The output circuit of this vacuum tube is tuned by the variable condenser *d* to a harmonic of the frequency in the input circuit, for example, 40,050 kilocycles. For the transmission of signals from the station A to the station B the transmitter T transmits signals through the choke coils LC and HC, and these signals are superimposed on the high frequency current in the output circuit of the vacuum tube VT. This high frequency current, modulated in accordance with the signals, is then transmitted through the condenser *e* and inductance *f* to the aerial R. By virtue of the relation of the elements of the parabolic reflector PR to the aerial R, a beam of polarized waves of the frequency of 40,050 kilocycles modulated in accordance with signals is transmitted from station A to the parabolic reflector at station B.

This beam of polarized waves strikes the inner surface of the parabolic reflector PR' at station B. Thus, this beam of high frequency waves modulated in accordance with signals is transmitted by the aerial R' at station B to the output circuit of the vacuum tube VT' through the inductance *f'* and the condenser *e'*. There are also impressed on the output circuit of the vacuum tube VT' the oscillations of a harmonic of the frequency of the oscillation generator O'. The frequency of this harmonic may be 40,000 kilocycles.

Thus the high frequency oscillations, for example, 40,050 kilocycles, received at station B, modulated in accordance with signals, and the oscillations of the frequency of the harmonic of the oscillation generator O', for example, 40,000 kilocycles, beat in the output circuit of the vacuum tube VT' to produce, among other frequencies, a difference frequency, for example, 50 kilocycles. This difference frequency, for example, 50 kilocycles,

is impressed on the primary winding of the transformer *k'*, the choke coil HC opposing the flow of current of the frequency of 40,000 kilocycles, or of higher frequencies, and the choke coil LC' opposing the flow of current of the frequency of 50 kilocycles in order to permit this latter frequency to be transmitted to the primary winding of the transformer *k'*. This difference frequency, or intermediate frequency, also has the signals transmitted from station A impressed thereon and is amplified by the amplifier AM'. After amplification by the amplifier AM' this frequency is transmitted to the detector D' so that the signals may be derived therefrom.

Similarly, signals from the transmitter T' superimposed on the locally generated high frequency, for example, 40,000 kilocycles, are transmitted by the parabolic reflector PR' at station B to the parabolic reflector PR at station A. This high frequency upon which signals are superimposed is beaten with the high frequency generated at the station A in the output circuit of the vacuum tube VT at station A, for example, 40,050 kilocycles, so that an intermediate frequency, for example, 50 kilocycles, results which is amplified by the amplifier AM and impressed on the detector D after being amplified by the amplifier AM so that the signals may be derived therefrom.

It will be understood that in the arrangements of this invention, as disclosed, signals cannot be transmitted simultaneously from station A and station B by reason of the fact that there will be intermodulation of the signals and neither signal will be understood. But the invention is not so limited, for arrangements may be provided to permit the simultaneous transmission and reception of signals between two or more stations without intermodulation.

It will be understood that the frequencies referred to herein are merely illustrative and that other frequencies may be employed in practice as conditions necessitate.

While the invention has been disclosed in one particular embodiment which is deemed desirable, it is to be understood that it is capable of embodiment in other and varied organizations without departing from the spirit and scope of the invention as defined in the appended claim.

What is claimed is:

A system for signaling between two stations, in which each station includes, in combination, a low frequency oscillator, a vacuum tube system having a grid circuit and a plate circuit, said vacuum tube system being employed for locally producing a predetermined harmonic of the current of said oscillator of a frequency suitable for transmission through space, a source of voice frequency signals connected to the plate circuit of the vacuum tube system and modulating

the high frequency oscillations derived therefrom, a parabolic reflector coupled to the plate circuit of the vacuum tube system, said parabolic reflector being employed for transmitting as a polarized beam said high frequency oscillations modulated by said voice frequency signals, said parabolic reflector also receiving from a distant station a similar polarized beam of different high frequency oscillations modulated by voice frequency signals, said received high frequency oscillations modulated by voice frequency signals and said locally generated high frequency oscillations produced by the vacuum tube system being beaten together in the plate circuit of the vacuum tube system so as to produce oscillations of an intermediate frequency well above the range of audibility and which is modulated by the received voice frequency signals, means for amplifying the intermediate frequency and its modulated voice frequency signals, and means for detecting said received voice frequency signals.

In testimony whereof, I have signed my name to this specification this 21st day of September, 1925.

RUSSELL S. OHL.

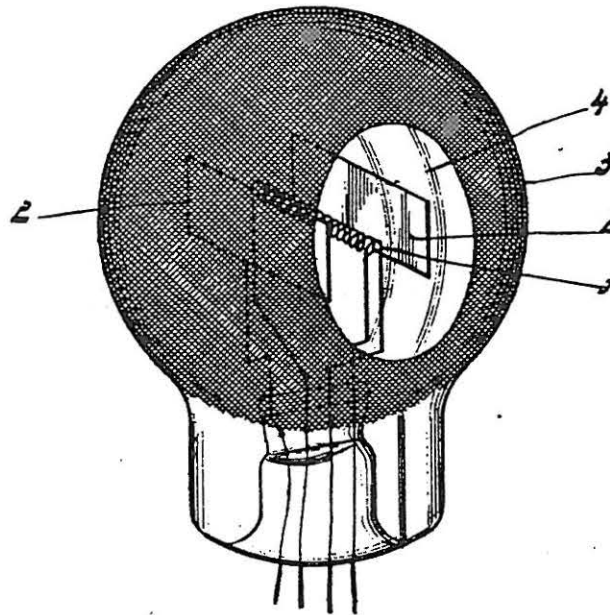
March 13, 1934.

G. ZECHER

1,951,116

ELECTRIC DISCHARGE TUBE FOR THE EMISSION OF RAYS OF LIGHT

Filed Dec. 12, 1930



Inventor.

Gustav Zecher
By *Chas. B. Hennon.*
Att'y.

UNITED STATES PATENT OFFICE

1,951,116

ELECTRIC DISCHARGE TUBE FOR THE
EMISSION OF RAYS OF LIGHTGustav Zecher, Eindhoven, Netherlands, assignor,
by mesne assignments, to General Electric Com-
pany, a corporation of New YorkApplication December 12, 1930, Serial No. 501,973
In the Netherlands February 12, 1930

5 Claims. (Cl. 250-35)

When use is made of electric discharge tubes for emitting light rays, for example ultraviolet rays, it is often desirable to throw the rays in a determined direction. For example, if a discharge tube emitting ultraviolet rays is utilized for the irradiation of an object with ultraviolet light, it is advisable to concentrate the ultraviolet rays on this object owing to which the active effect of the irradiation is enhanced while other objects in the neighbourhood of the discharge tube are exposed as little as possible to the action of the ultraviolet rays.

It has therefore previously been proposed to surround such a discharge tube partly with a reflector whereby the rays emerging from the tube are reflected as a concentrated beam of light.

The invention relates to an electric discharge tube suitable for the emission of light rays and it has for its object such a discharge tube constructed in such manner that concentration of the rays generated is obtained in a very simple manner.

In an electric discharge tube according to the invention, part of the inner side of the wall of the tube is provided with a mirror which forces the rays produced in the discharge tube to pass to the outside through that portion of the wall which is not covered by the mirror so that a concentrated beam of light is obtained. The discharge tube occupies less space than the installation with a reflector utilized before while due to the fact that the rays are reflected within the tube, they will be less absorbed.

For generating ultraviolet rays use is frequently made of a mercury vapour discharge. The mirror is made in this case of a material which reflects ultraviolet rays, for example of chromium, nickel or aluminium, and which preferably does not amalgamate with mercury.

In order that the invention may be more readily understood and more easily carried into effect, it will be explained more fully with reference to the accompanying drawing which represents, by way of example, a discharge tube according to the invention.

The discharge tube represented in the drawing serves to generate ultraviolet rays and comprises an incandescent cathode 1 and two anodes 2 while it is filled with a quantity of gas, for example of argon, under a pressure, for example, of some millimetres, some mercury vapour being added to the said gas. The wall 3 of the discharge tube consists of a material transparent to the ultraviolet rays generated in the mercury va-

ing mercury vapor, said container being adapted to transmit ultra-violet radiations and being covered, in part, internally with a mirror of nickel to reflect said ultra-violet radiations.

5. An ultra-violet generating electric discharge device comprising a container, electrodes sealed

pour discharge, for example of quartz or one of the well known ultraviolet transmitting glasses.

The inner side of the wall of the bulb of the discharge tube is coated with a reflecting mirror. This mirror consists of a material which is not harmfully attacked by the gas or the vapour in which the discharge is produced. Besides, this material has been so chosen that it reflects the ultra-violet rays. For example, chromium may be used for this purpose. This metal does not form an amalgam with mercury. In the mirror is left an opening 4 through which the ultraviolet rays produced in the tube can pass to the outside. A concentrated beam of rays is the result thereof, which as above set forth may be of great importance. Due to the fact that the rays are reflected within the discharge tube, the absorption of the rays by the material of the wall of the tube is very slight, which is favourable for the efficiency of the tube.

The chromium mirror may be provided in the tube, for example by evaporating, before the electrodes are introduced into the tube, a chromium or chrome-nickel wire in the exhausted bulb during which operation the window 4 is screened, for example with the aid of a mica plate.

What I claim is:

1. An ultra-violet generating electric discharge device comprising a container, electrodes sealed therein, a gaseous atmosphere therein comprising mercury vapor, said container being adapted to transmit ultra-violet radiations and being covered, in part, internally with a mirror adapted to reflect said ultra-violet radiations, said mirror being of metal inert with respect to said gaseous atmosphere.

2. An ultra-violet generating electric discharge device comprising a container, electrodes sealed therein, a gaseous atmosphere therein compressing mercury vapor, said container being adapted to transmit ultra-violet radiations and being covered, in part, internally with a mirror of chromium to reflect said ultra-violet radiations.

3. An electric discharge device comprising a container, electrodes sealed therein, a gaseous atmosphere therein comprising mercury vapor, said container being adapted to transmit light radiations and being covered, in part, internally with a mirror adapted to reflect said light radiations, said mirror consisting of a metal of low atomic weight and inert with respect to the gaseous atmosphere.

4. An ultra-violet generating electric discharge device comprising a container, electrodes sealed therein, a gaseous atmosphere therein comprising mercury vapor, said container being adapted to transmit ultra-violet radiations and being covered, in part, internally with a mirror of aluminium to reflect said ultra-violet radiations.

GUSTAV ZECHER.

Aug. 31, 1937.

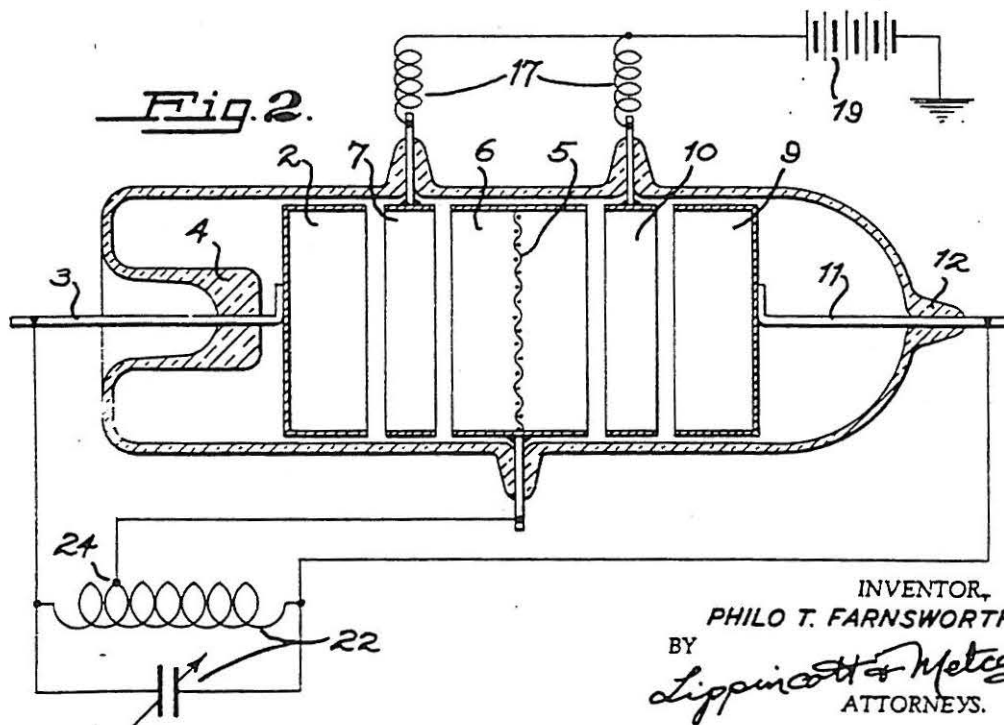
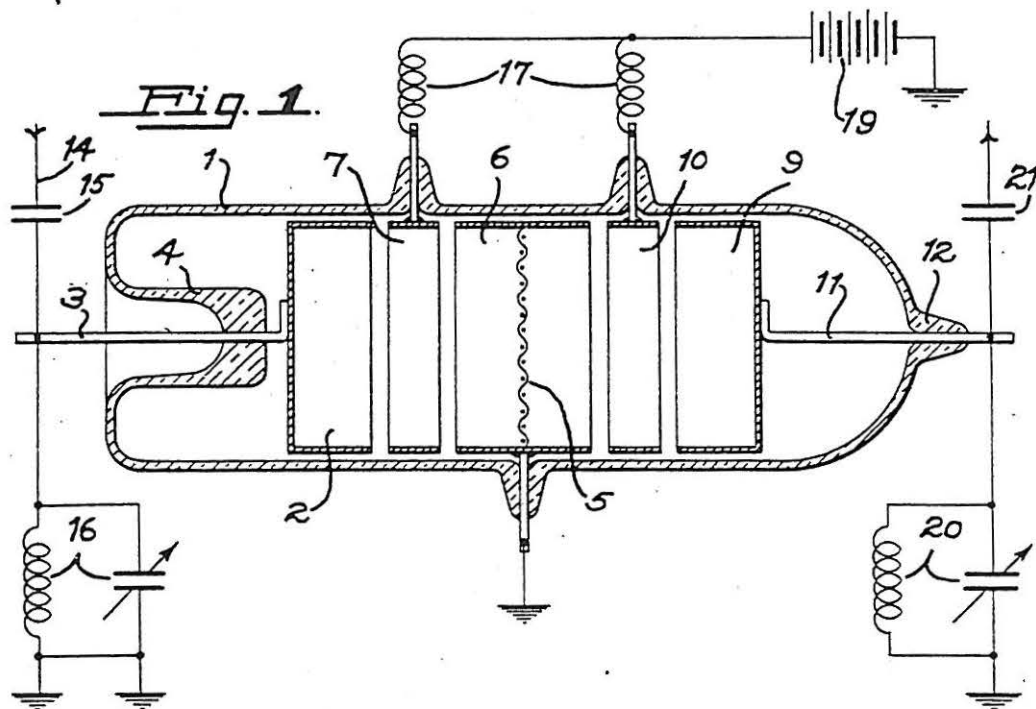
P. T. FARNSWORTH

2,091,439

MULTIFACTOR OSCILLATOR AND AMPLIFIER

Filed Feb. 24, 1936

2 Sheets-Sheet 1



INVENTOR,
PHILO T. FARNSWORTH.
BY
Lippincott & Metcalf
ATTORNEYS.

Aug. 31, 1937.

P. T. FARNSWORTH

2,091,439

MULTIPACTOR OSCILLATOR AND AMPLIFIER

Filed Feb. 24, 1936

2 Sheets-Sheet 2

Fig. 3.

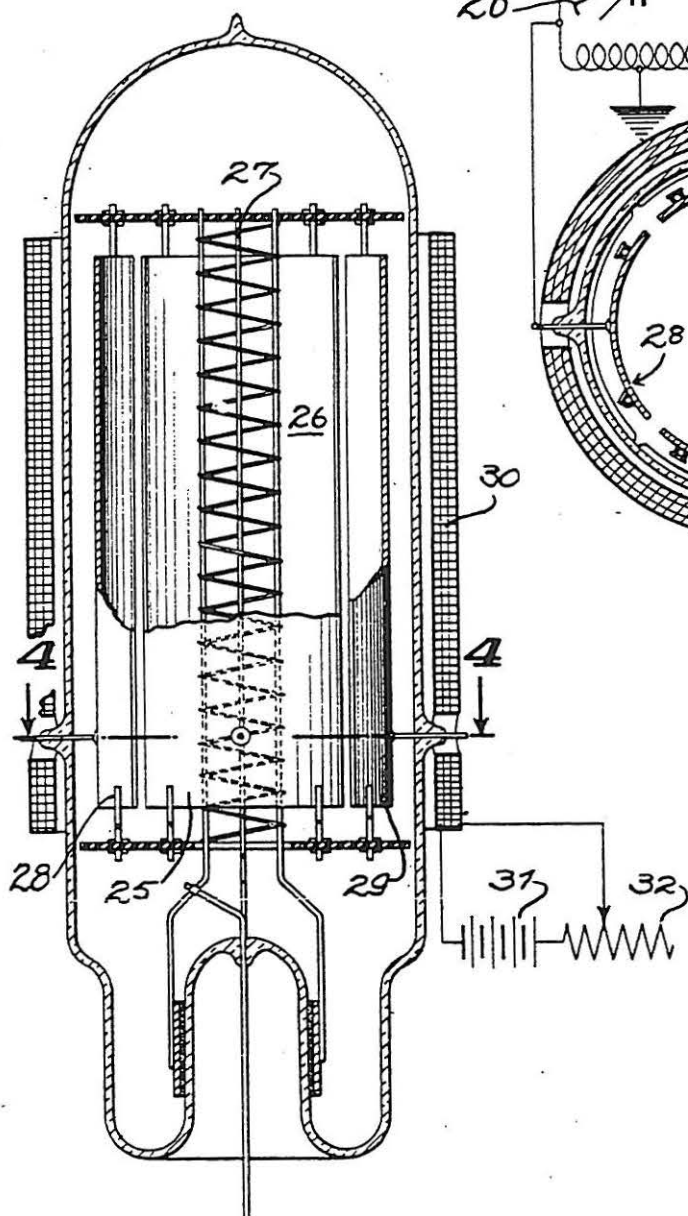
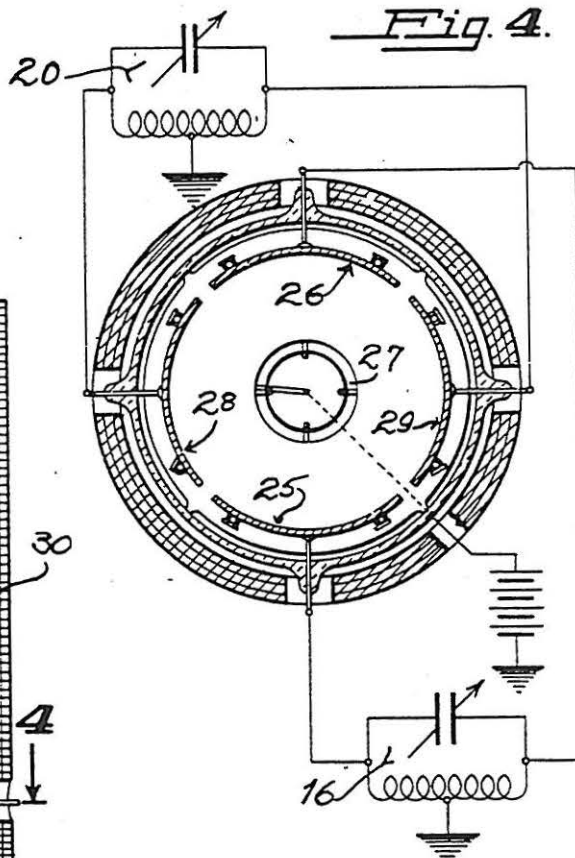


Fig. 4.



INVENTOR,

PHILO T. FARNSWORTH.

BY

Lippincott & Metcalf

ATTORNEYS.

UNITED STATES PATENT OFFICE

2,091,439

MULTIPLIER OSCILLATOR AND AMPLIFIER

Philo T. Farnsworth, San Francisco, Calif., assignor to Farnsworth Television Incorporated, San Francisco, Calif., a corporation of California

Application February 24, 1936, Serial No. 65,465

19 Claims. (Cl. 250-27)

My invention relates to a multiplier oscillator and amplifier, and more particularly to a means and method of utilizing secondary emission for the production of electron multiplication.

This device operates broadly on the principles set forth in my prior application, Serial No. 692,585, filed October 7, 1933, for an "Electron multiplying device", and my prior application, Serial No. 706,965, filed January 17, 1934, for "Methods of electron multiplication".

The present application deals with a multiplier structure and method of operation where multiplication and collection are separated. The present device is, in common with the previous types of multipliers described by me, capable of producing amplification by electron multiplication, and by proper connection can be made to generate self-sustaining oscillations.

The primary object of this invention is to provide an improved means and method of abstracting power from a multiplier.

Other objects of my invention are: To provide an oscillator which will convert direct current energy at extremely high efficiency; to provide an oscillator of the high vacuum type which is not subject to the instability and inconsistencies which such phenomena introduce; to provide an oscillator and amplifier which has no heated electrode of the thermionic type, and which is correspondingly free of the difficulties and complications introduced by cathode heating surfaces; to provide an electron multiplier structure which is capable of generating self-sustained oscillations and which may be readily modulated; to provide a means and method of operating a combined multiplier and output structure having a common cathode; to provide a means and method of creating an oscillating cloud of electrons, and a means and method of absorbing power from this cloud; and to provide a simple and efficient multiplier tube.

My invention possesses numerous other objects and features of advantage, some of which, together with the foregoing, will be set forth in the following description of specific apparatus embodying and utilizing my novel method. It is therefore to be understood that my method is applicable to other apparatus, and that I do not limit myself, in any way, to the apparatus of the present application, as I may adopt various other apparatus embodiments, utilizing the method, within the scope of the appended claims.

Referring to the drawings:

Figure 1 is a diagrammatic sectional view, to-

gether with a multiplier circuit, of a preferred form embodying my invention.

Figure 2 is a sectional view and circuit diagram embodying the tube shown in Figure 1, connected to be a self-oscillator.

Figure 3 is a view, partly in section and partly in elevation, of a multiplier structure utilizing four electrodes describing a cylinder around the central anode.

Figure 4 is a sectional view taken as indicated by the line 4-4 in Figure 3, together with an operating circuit attached thereto.

The operation of my electron multiplier or multiplier, as I desire to call my device, depends upon the transference of energy between an oscillating cloud of electrons and an oscillating E. M. F., usually established between a pair of opposed cathodes, treated or otherwise capable of producing secondary electrons at a ratio greater than unity when impacted by the oscillating electron cloud. If the energy transfer be from the oscillating E. M. F. to the electron cloud, the electrons strike the cathodes and give rise to the secondary electron multiplication phenomena. If, on the other hand, energy is absorbed from the oscillating cloud of electrons, the oscillating field between the cathodes is intensified, and the tube may sustain oscillations in the cathode circuit.

The present invention concerns a device where both of these phenomena are produced in differing but adjacent structures, electrons being passed, preferably through a common cathode, from one to the other.

Considering then, first, the condition where energy is transferred from the applied E. M. F. to the electron cloud. I find that when the period of the oscillating cloud of electrons is close to the resonant frequency of a circuit connecting the cathodes, that the tube acts as a highly efficient electron multiplier and, in many cases, will self-oscillate if energy is withdrawn from the multiplier structure and used, at least in part, to supply the oscillating E. M. F. applied to the cathodes, energy in this case, of course, being supplied from a D. C. source applied to an anode preferably positioned between the two cathodes.

When the period of the oscillating cloud of electrons is close to the resonant frequency of the circuit connecting the cathodes, it is found, experimentally, that the tube generates oscillations which are largely determined by the resonant frequency of the tuned circuit.

The impressed R. F. initiates, by the multi-

cation process, a cloud of electrons of the proper phase to absorb energy from the oscillations. This cloud of electrons would oscillate by itself at approximately the same frequency as that of the circuit, except for the fact that the R. F. itself accelerates the cloud and makes the trip across the tube less than a half period of the tuned circuit. The mere fact that the electrons are speeded up insures that they strike the cathode. The returning group of electrons also make the trip in slightly less than one-half cycle. The result is that the fastest electrons very rapidly get out of phase with the potential. The electron distribution in the cloud, however, reshapes itself at each half period because the rate of multiplication is large compared to the amount of phase shift.

The process results, however, in electrons being fed from the multiplication phase into the opposite phase wherein an electron is decelerated rather than accelerated by the R. F. Electrons in this phase do not strike the cathodes at all, but continue to oscillate between them, delivering energy to the external circuit as they are slowed down by the R. F. If the probability of an electron striking the anode is sufficiently small, equilibrium current results when the electrons are fed from the multiplying phase into the energy-giving phase at the same rate as the electrons are multiplied at the cathode, and electrons of the energy-giving phase never strike the cathode until they have given substantially all their energy to the oscillating circuit.

I may desire, however, as in the present case, not to abstract power directly from the multiplier structure, but to utilize directly a portion of the oscillating cloud of electrons in another structure closely associated with the first, and withdraw the multiplied output from the second structure.

My invention may be more fully understood by direct reference to the drawings, which show an improved type of multiplier structure connected, in Figure 1, as a direct electron multiplier.

The tube itself comprises a conventional type of multiplier, as hitherto described and claimed by me in the applications referred to above, comprising a pair of opposed cathodes, one of which, preferably the end electrode in an envelope 1, is in the form of a cup-shaped cathode 2, the interior of the cup facing the remainder of the structure.

The cup-shaped cathode 2 may be mounted in any convenient manner, such as on a lead 3 passing through a reentrant stem 4 in the end of the tube.

The opposing cathode may conveniently be located at approximately the midpoint of the tube, and comprises a screen cathode 5 extending across the tube and preferably positioned within a cathode cylinder 6.

Between the two cathodes is positioned a multiplier anode 7, preferably in the form of a cylinder whose walls are in the same projected surface as determined by the walls of the cup 2 and the cylinder 6.

The interior of the cathode cup 2 and the surface of the cathode screen 5 are preferably sensitized so that they will emit secondaries at a ratio greater than unity, when impacted, and this sensitization, which is performed in order that the highest possible ratio may be obtained, may be accomplished by forming the cathodes of silver, oxidizing the silver, and depositing caesium thereon, for example. Such a surface makes a

very efficient secondary emissive surface, with ratios as high as one primary to six secondaries, when impacted at the proper velocity, but I do not wish to be limited to such a formed surface as even untreated nickel has been found to have an emission ratio greater than unity; and any surface, formed or unformed, having such a ratio will be satisfactory, although, of course, multiplication can be accomplished with a lesser number of impacts with the materials having higher ratios.

At the opposite end of the envelope 1 is positioned what may be called a collector cathode cup 9. This cup may be identical in form and shape with the multiplier cathode 2, and between the collector cathode cup 9 and the central cathode cylinder 6 is positioned a second anode 10, identical with the first anode 7.

I prefer to position all five electrodes so that they shall be symmetrical, with the spacing between cathodes 2 and 5 equal to the spacing between cathodes 5 and 9.

Collector cathode 9 is supported on a lead 11 passing through a seal 12 in the end of the tube. Collector cathode 9, however, differs from multiplier cathode 2 in that its inner surface is preferably of a nature that it will not emit secondaries, at least secondary emission will be reduced to a minimum; and I have found that a carbonized nickel surface in this position will prevent, to a large extent, secondary emission.

After the electrodes have been assembled as described, the tube is, of course, baked out, degassed, evacuated, and the surfaces formed on cathodes 2 and 5.

For multiplication, the tube is connected as shown in Figure 1. On the multiplier end radio frequency is fed into the input connection 14 through a blocking condenser 15, to cathode 2 through lead 3, and cathode 2 is connected through a tunable resonant circuit 16 to the screen cathode 5 through suitable ground connections. Anodes 7 and 10 are connected together through separate radio frequency chokes 17 to a D. C. anode source 19, the opposite end of which is also grounded, the positive end of this source being connected to the anodes.

The collector cathode 9 is connected through an output resonant circuit 20 to ground, and the output may be taken from this cathode through blocking condenser 21. All that is necessary to set the tube into oscillation is to energize the anodes 7 and 10, as there will be, in the space between cathodes 2 and 5, a sufficient number of free electrons which are accelerated toward one or both of the cathodes by the potential of the anode, to strike thereon and cause the initiation of secondary emission.

If, then, a radio frequency is applied between the cathodes 2 and 5 and controlled by means of the tuned circuit 16, and the time of flight of the electrons between cathodes 2 and 5 is adjusted by means of placing upon the anode 7 the proper potential so that the time of flight corresponds to the period of the input, oscillations of the electrons between the two cathodes will occur and repeated impacts with the cathodes will take place with the release of secondary electrons at each impact.

Inasmuch as the field between the cathodes is so arranged either by the construction of the cathodes, as shown, or by an external electric field, as has been pointed out in my prior cited applications, certain definite members of traversals will take place before collection by anode 7

occurs, and a definite multiplication factor will be reached before equilibrium current is arrived at in the tube. Thus, there will occur within the multiplier end of the tube, electron multiplication; and I prefer, with this type of tube, to so adjust the constants on the two cathodes and the anode of the multiplier structure, that a maximum equilibrium current is reached.

The structure just described, however, differs from previous multiplier structures in that the central cathode 5 is apertured. This means that at each time the electron cloud reaches the plane of cathode 5, a certain number of electrons impact and create secondaries which are used to continue the multiplication process, but others of the electrons pass directly through the aperture in cathode 5 and enter the output structure comprising cathode 5, anode 10 and cathode 9.

In this structure, however, conditions are different. The output cathode 9 has been treated to prevent secondary emission, and if cathode 9 is connected to cathode 5 through a tuned circuit 20, the electrons passing through the central cathode 5 will oscillate back and forth between cathodes 9 and 5, and energy will be absorbed from them as they oscillate between cathodes 9 and 5; in other words, in the output structure, energy is being absorbed from the electrons.

The advantage gained in taking energy out of the tube in this manner is that phase shift of the oscillating electrons in the output structure is unimportant. In other words, any electrons in the output portion of the tube which get out of phase, and therefore are in a position to absorb energy from the oscillations, strike the cathodes and are absorbed by them, and as the potential on the anodes in each portion of the tube can be adjusted so that the electron oscillation frequency coincides with that of the tuned circuits and with the E. M. F. to be amplified, both structures operate completely in phase.

It will be understood, of course, that the output structure does, in no sense, create electron multiplication; it is in effect a multiplier structure with the exception that the cathode 9 absorbs all electrons striking it, and will not release secondaries. In other words, by using symmetrical structure operating in phase, I have separated multiplication and output. I create the oscillation of the electron cloud and supply power to it, in one structure, with multiplication; and I absorb power from the cloud, without multiplication, in the other structure.

I have thus eliminated the necessity within the multiplier structure of developing a large out-of-phase component, in order that power be absorbed from the cloud. In other words, it is necessary, as above explained, in order to create an output from the ordinary multiplier, to absorb power from a component of the electron cloud which is out of phase with the multiplying cloud. In this case only enough power is absorbed to continue multiplication.

Such an arrangement leads to a high conversion efficiency, and also leads to a high efficiency self-oscillator. For example, I have shown a circuit in Figure 2 where the output cathode 9 is coupled to the input cathode 2 through a common tuned circuit 22, an intermediate tap 24 being taken from the inductance of the tuned circuit to the central apertured cathode 5. Such a connection causes self-oscillation of the multiplier structure comprising cathodes 2 and 5 and anode 1, with additional power being absorbed in

the output structure comprising cathodes 5 and 9 together with anode 10. This power is fed back to the input structure, and thus the E. M. F. is regeneratively amplified and an extremely efficient oscillator results.

Another structural embodiment utilizing my method of electron collection is shown in Figures 3 and 4. In this tube, opposed multiplying cathodes 25 and 26 are connected through the tunable resonant circuit 15. Cathodes 25 and 26 are sensitized, as were cathodes 2 and 5, for secondary emission, and in this case the anode is a central spiral 27.

Output cathodes 28 and 29 are also positioned in opposed relation, the four cathodes 25, 26, 28 and 29 being positioned to form a cylinder, each cathode, however, being electrically separated, and output cathodes 28 and 29 are also connected by tunable resonant circuit 20. Output cathodes do not emit secondaries and may be of carbonized nickel, as explained above for output cathode 9. The anode 27 is supplied with a positive potential from the anode battery 19.

I also prefer to provide, preferably by means of a focusing coil 30 energized by focusing source 31 under the control of a resistor 32, a feeble magnetic field in the tube with the lines of force axial, so that there will be a progression of the electron oscillation paths in the direction from multiplier cathodes to output cathodes. For example, when radio frequency is applied between the multiplier cathodes 25 and 26, either from a driver or by causing the two multiplying cathodes to become a self-oscillatory structure, the electrons of the proper phase for multiplication tend to oscillate so that they are traveling along the center line connecting the multiplying cathodes, and the electrons oscillating in the phase to give up their energy to the output circuit 20 tend to swing around at right angles to the multiplier cathodes. The application of the magnetic field effectively prevents the output electrons from swinging around, so that they are absorbing power. There is therefore, due to this field, a continuous drift of multiplying electrons over to the output cathodes 28 and 29, where they are collected after giving up their energy to the output circuit.

The main advantage of this type of structure over the structure heretofore described is that all of the current built up by multiplication is eventually converted into oscillating power, thus resulting in a very high efficiency.

Other circuits utilizing the means and method herein described will readily suggest themselves to those skilled in the art, the circuits shown being in the nature of examples only.

I claim:

1. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, means for diverting a portion of said cloud into a space apart from that bounded by said surfaces, and means for absorbing power from said diverted portion within said space.

2. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, one of said surfaces being apertured to allow a portion of said

cloud to pass therethrough at the time of each impact, and means for absorbing power from the electrons passing through said apertures.

3. An electron multiplier comprising a pair of
5 opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, means for divid-
10 ing said cloud at the plane of one of said surfaces, means for abstracting one of the divided portions from the space bounded by said surfaces, and means for absorbing power from the abstracted portion.

15 4. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create re-
20 peated multiplying impacts therewith, means for dividing said cloud at the plane of one of said surfaces means for abstracting one of the divided portions from the space bounded by said surfaces, means for absorbing power from the abstracted
25 portion, and a work circuit for utilizing the power obtained.

5. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary
30 electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, means for dividing said cloud at the plane of one of said
35 surfaces, means for abstracting one of the divided portions from the space bounded by said surfaces, means for absorbing power from the abstracted portion, a work circuit for utilizing the power obtained, and means for feeding energy from said
work circuit into said oscillating cloud.

40 6. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated
45 multiplying impacts therewith, means for dividing said cloud at the plane of one of said surfaces, means for abstracting one of the divided portions from the space bounded by said surfaces, means for absorbing power from the abstracted portion,
50 a work circuit for utilizing the power obtained, and means for utilizing a portion of the energy in said work circuit to cause continued oscillation of said cloud.

7. An electron multiplier comprising a pair of
55 opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, means for dividing
60 said cloud at the plane of one of said surfaces, means for abstracting one of the divided portions from the space bounded by said surfaces, means for absorbing power from the abstracted portion, a work circuit for utilizing the power obtained,
65 and means for feeding back a portion of the energy in said work circuit into said oscillating cloud in the proper phase to continue the oscillation thereof.

8. In an electron multiplier wherein electrons
70 are directed against a cathode surface to produce secondary emission therefrom, the method of power production comprising oscillating electrons against and away from said surface to produce an electron cloud augmented by secondary
75 electrons at each impact therewith, abstracting

from the cloud through apertures in said surface a definite proportion of the electrons therein, and absorbing the energy from the abstracted electrons.

9. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises feeding energy to said cloud and abstracting energy from said cloud within different spatial boundaries.

10. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises dividing said cloud at each impact feeding energy to one portion of said cloud to continue multiplication and abstracting useful energy from the other portion.

11. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises absorbing energy from said cloud, using said energy to sustain oscillation of said cloud until an equilibrium current is reached, abstracting electrons from said cloud, absorbing energy from said abstracted electrons, and adding said energy to that previously absorbed from said cloud to create regenerative oscillation thereof.

12. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises feeding energy to electrons traveling along one set of paths, changing the paths, and abstracting power from said electrons while in said changed paths.

13. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises feeding energy to electrons traveling along a diametrical path, shifting the electrons to a different diametrical path, and absorbing power from said electrons while in said different path.

14. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises feeding energy to electrons traveling along one set of paths, continuously diverting a portion of said cloud into a different set of paths, and absorbing energy from said electrons while in said different paths.

15. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises feeding energy to said cloud to maintain oscillation of the cloud across a space in a predetermined path, shifting the oscillation to a different predetermined path, and absorbing power from the electrons in the latter path.

16. In combination, a pair of opposed electrodes capable of emitting secondary electrons at a ratio greater than unity, a second pair of op-

posed electrodes incapable of emitting secondary electrons, adjacent said first pair, means for feeding energy to electrons in the space between said first pair of electrodes to produce electron multiplication by cyclical impact therewith, and means associated with said second pair of electrodes for absorbing power from said electrons.

17. In combination, a pair of opposed electrodes capable of emitting secondary electrons at a ratio greater than unity, a second pair of opposed electrodes incapable of emitting secondary electrons, said pairs being alternately disposed to describe a symmetrical space, means for feeding energy to electrons in the space between said first pair of electrodes to produce electron multiplication by cyclical impact therewith, and means associated with second pair of electrodes for absorbing power from said electrons.

18. In combination, a pair of opposed electrodes capable of emitting secondary electrons at a ratio greater than unity, a second pair of opposed electrodes incapable of emitting secondary electrons, said pairs being alternately disposed to describe a cylindrical space, means for

causing electron oscillation between said first pair of electrodes to cause secondary emission therefrom, means for rotating the oscillation path around the axis of said cylinder, and means associated with said second pair of electrodes for absorbing power from electrons in said rotated path.

19. In combination, a pair of opposed electrodes capable of emitting secondary electrons at a ratio greater than unity, a second pair of opposed electrodes incapable of emitting secondary electrons, said pairs being alternately disposed to describe a cylindrical space, means for causing electron oscillation between said first pair of electrodes to cause secondary emission therefrom, means for rotating the oscillation path around the axis of said cylinder, means associated with said second pair of electrodes for absorbing power from electrons in said rotated path, and means for collecting electrons contacting said second pair of electrodes due to said rotation.

PHILO T. FARNSWORTH.

Nov. 8, 1938.

P. T. FARNSWORTH

2,135,615

MULTIPACTOR

Filed Feb. 11, 1936

2 Sheets-Sheet 1

Fig. 1.

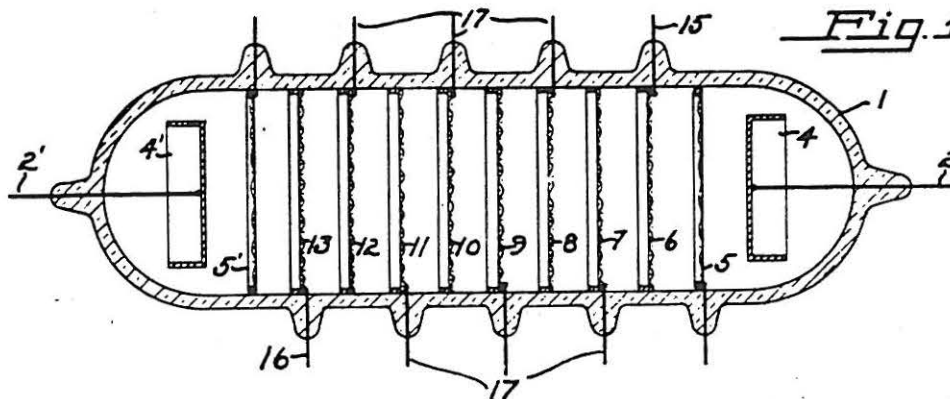


Fig. 2.

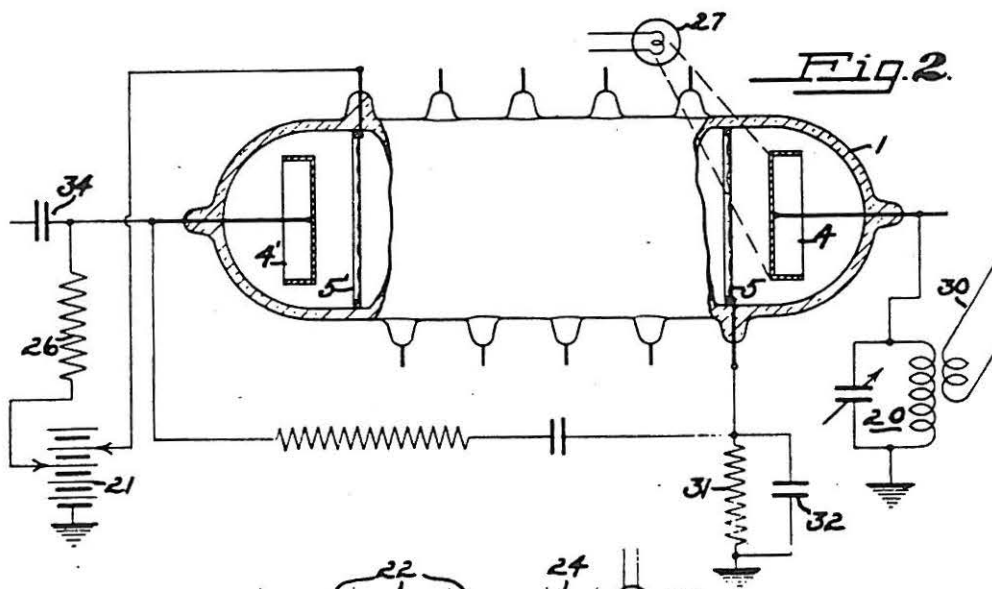
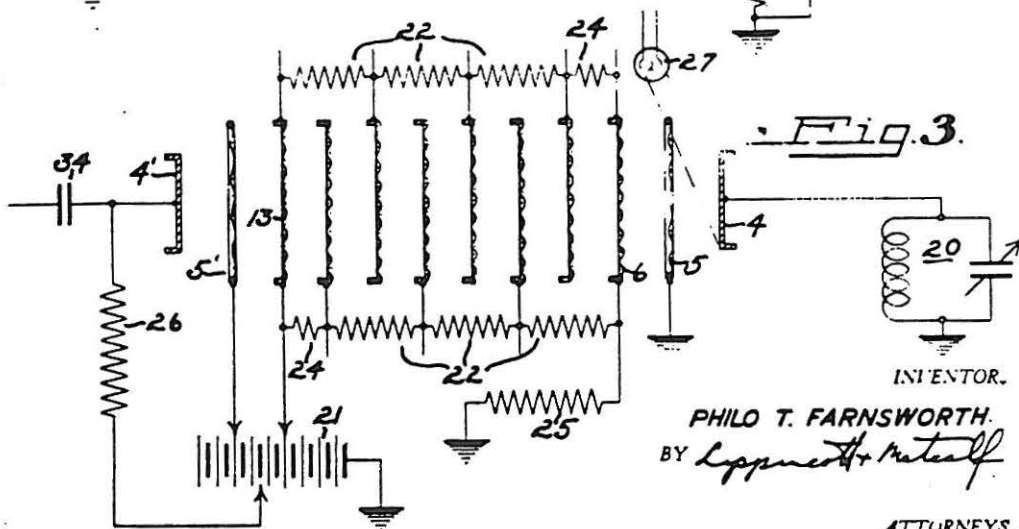


Fig. 3.



INVENTOR.

PHILO T. FARNSWORTH.
BY *Lippincott & Matself*

ATTORNEYS.

Nov. 8, 1938.

P. T. FARNSWORTH

2,135,615

MULTIPACTOR

Filed Feb. 11, 1936

2 Sheets-Sheet 2

Fig. 4.

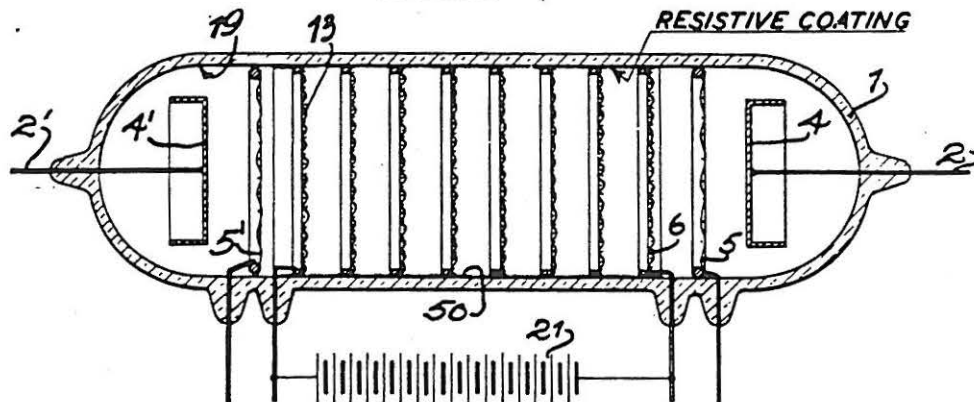
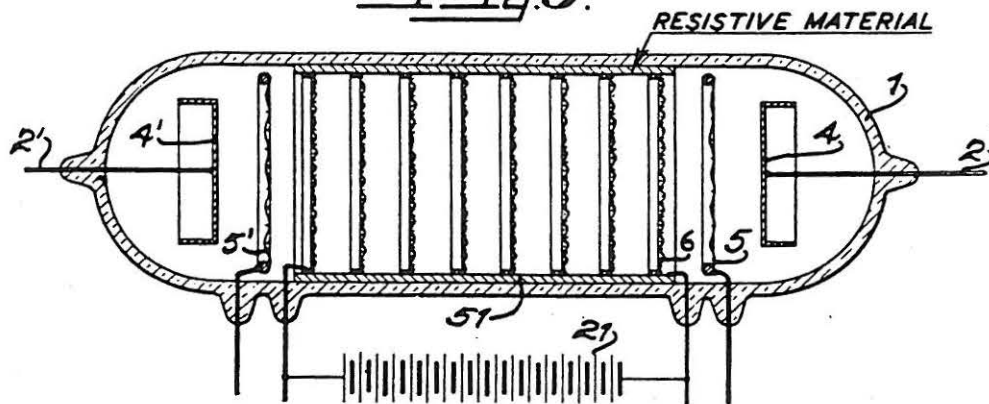


Fig. 5.



INVENTOR,
PHILO T. FARNSWORTH.
BY
Lippincott & Metcalf
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,135,615

MULTIPACTOR

Philo T. Farnsworth, San Francisco, Calif., assignor to Farnsworth Television Incorporated, San Francisco, Calif., a corporation of California

Application February 11, 1936, Serial No. 63,424

3 Claims. (Cl. 250—27.5)

This invention relates to multipactors, or electronic amplifiers wherein a current amplification is obtained by successive electron impacts each releasing secondary electrons. The instant application is particularly directed to multipactors for use in radio receiving circuits, as either detectors or amplifiers, or for the two purposes in combination.

Among the objects of my invention are: To provide a multipactor which will give any desired degree of amplification; to provide a multipactor which requires no external field for guiding the electron flow; to provide a multipactor wherein no filament circuit is necessary, so that any portion of the device may be operated above ground potential; to provide a device which may be used either as a detector or as an amplifier having linear characteristics; to provide a multipactor which may be excited by either direct or alternating potentials; and to provide a device wherein the degree of amplification obtained is completely under control.

My invention possesses numerous other objects and features of advantage, some of which, together with the foregoing, will be set forth in the following description of specific apparatus embodying and utilizing my novel method. It is therefore to be understood that my method is applicable to other apparatus, and that I do not limit myself, in any way, to the apparatus of the present application, as I may adopt various other apparatus embodiments, utilizing the method, within the scope of the appended claims.

Referring to the drawings,

Figure 1 is a view showing a preferred embodiment of the multipactor tube of this invention in longitudinal cross section.

Figure 2 is a similar view, partly in elevation and partly in section, showing schematically the external connections of the device as used as a detector-amplifier in a radio receiving circuit.

Figure 3 is a diagrammatic representation of the fundamental circuit of the multipactor itself, with such external circuit elements as are necessary for an explanation of the operation.

Figure 4 is a sectional view of my invention utilizing a resistive coating as a voltage divider.

Figure 5 is a similar view showing the use of a tubular electrode of resistive material as a voltage divider.

Considered broadly the multipactor of this invention comprises a primary cathode from which initial electrons are emitted, these electrons being directed at a series of foraminated secondary cathodes which are capable of emitting secondary

electrons at a ratio to impacting primary electrons which is greater than unity. Means are provided for maintaining a substantially uniform or increasing potential gradient along this series of secondary cathodes, each acting as an anode to the preceding cathode in the series, and means are also provided for collecting the electron flow from the last cathode of the series. There is also preferably provided an electrostatic shield between the primary cathode and the first of the secondary cathodes which may be operated as a control electrode or grid, and for many purposes it is also advisable that the primary cathode should be photo-emissive rather than thermionic.

This arrangement may be better understood by reference to the preferred form of the device shown in the drawings, wherein the reference character 1 refers to a tubular vitreous envelope which is evacuated to as high degree as is practical. This tube is symmetrical, and sealed through each end is a lead 2, 2' which is connected to a primary cathode 4, 4'. These cathodes may conveniently be made of silver, and provided with photo-electric surfaces of the well known silver-oxide-caesium type.

Mounted in front of each of the cathodes and slightly spaced therefrom is an electrostatic shield 5, 5'. These shields comprise metal screens, each formed of very fine wire with relatively open mesh so it will be highly permeable to the electron stream. As it is undesirable that the shields should emit secondary electrons they may be made of nickel with carbonized surfaces.

Spaced uniformly between the two electrostatic shields is a series of secondary cathodes 6 to 13, inclusive. Each of these cathodes is foraminated, the ratio of their over-all area to the combined area of the foraminations being preferably of the order of 3 or 4 to 1. The cathodes may be made of sheet material and the openings punched therein, or they may be made of fine meshed screen suitably supported, as is shown in the drawings, the latter construction being somewhat preferable. Like the primary cathode the material of their construction is preferably silver and they are provided with silver-oxide-caesium surfaces which render them photoelectric and also capable of emitting secondary electrons at a ratio to impacting primaries of 6 to 8. It is of some slight advantage if the holes through the cathodes are not aligned, but as will be shown later, this is of relatively small importance as regards the over-all effect of the device.

The first secondary cathode 6 and the last

secondary cathode 13 are provided with leads 15 and 16, respectively. It is also convenient for some purposes to provide individual leads 17 for the intermediate cathodes 7 to 12.

- 5 Preferably, and necessarily if the leads 17 be not provided, the interior wall 19 of the tube 1 is metalized between the cathode 6 and the cathode 13, so that the tube itself forms a hollow resistor 50 with the secondary cathodes in electrical contact therewith. The shields 5 and 5' should be insulated from this metalized surface. Any of the well known conducting coatings may be used, a coating of nickel which is so thin as to be transparent being quite suitable for the purpose, 15 and from the standpoint of power conservation it is desirable that the resistance between the cathodes 6 and 13 be of the order of from 50,000 ohms to 1 megohm. These are not limiting values, however.

- 20 The fundamental circuit device as ordinarily used is shown in Figure 3. The signal voltage, which may be considered as supplied across the tuned circuit 20, is supplied to the cathode 4, and the shield 5 is grounded. A source of potential 21 supplies to the secondary cathode 13 a positive potential with respect to ground. The impedances 22 represent the resistive coating on the inside of the tube, or, when this is absent, they may be connected externally as shown. 25 When so connected, the impedances 24 should be about half of the value of the impedances 22, and an additional impedance 25 connected between the cathode 6 and ground, should be of such value that the potential drop between 35 ground and the cathode 6, and that between each of the successive cathodes of the secondary series is about the same, thus establishing a practically uniform potential gradient along the tube. For best results, however, the uniformity should not be exact, but the gradient should increase slightly from the cathode 6 to the anode, as this assists in getting all of the newly emitted secondaries through the aperture. The device will operate even with a decreasing gradient, although less 45 effectively.

- The cathode 4' is connected through an output resistor 26 to a point on the source 21 which will give a like potential drop between the cathodes 13 and 4' to that between any pair of adjacent secondary cathodes, while the electrostatic shield 5' is, in most instances, a few volts positive to the cathode 4'.

- If, now, the cathode 4 be illuminated from a source of light 27, photoelectrons will be emitted 55 therefrom, and will pass through the electrostatic shield 5 to impinge upon the secondary cathode 6. When reaching the cathode these electrons will be traveling at relatively high velocity and a proportion of them will impact the cathode 60 while others will pass through it, the relative numbers being almost exactly in the ratio of solid area to open area in the cathode. If the cathode be of wire netting, with the spaces between the wires equal to the diameter of the wire, the proportion intercepted will be almost exactly three-fourths.

- The impacting primaries will release secondary electrons from the cathode 6 at a ratio which is dependent upon their velocity of impact. The 70 secondaries will be of low velocity, and experience has shown that practically all of the released electrons will be drawn through the apertures and accelerated toward the secondary cathode 7, where the phenomena of release of secondaries by impact will be repeated. The forma-

tion of the cathodes will, in general, cause a strong curvature of the lines of force at the apertures or foraminations, so that it is the exception rather than the rule when an electron travels straight through; in general they will be deflected, and diffused practically uniformly over the succeeding secondary cathode. As far as the number of electrons which impact the successive secondary cathodes is concerned, it therefore makes practically no difference whether the apertures be aligned or not.

The current multiplication that takes place at each stage is dependent upon the ratio P of secondary to primary electrons and the ratio q of the total area of the secondary cathode to the combined area of cathode and the apertures therein. With an initial number of primary electrons m , the number of electrons leaving the secondary cathode 6 will be $m(Pq+1-q)$, the first term within the parenthesis representing the proportion of secondary electrons liberated at the secondary cathode, while $1-q$ represents the proportion of the electrons which are primaries that have passed through the apertures. A similar increase takes place at each of the secondary cathodes, and for the total device the current amplification is expressed by the quantity $m(Pq+1-q)^n$, where n is the number of secondary cathodes.

Upon leaving the cathode 13, the electrons pass through the electrostatic shield 5' (where a few of them will be collected) and will impact the cathode 4', where further release of secondaries will occur. These final electrons are attracted toward the shield 5' at low velocity and will be collected by the shield.

The degree of amplification which may be obtained by a device of this character may be readily computed. With the electron-emitting surfaces described, the value of P may easily be from 6 to 8, and can, by special precautions, be made still higher. Taking P as 6, and q as .75, the amplification at each of the foraminated secondary cathodes is 4.75. As there are eight secondary cathodes shown in the illustrated embodiment, the current amplification up to and including the cathode 13 is 4.75^8 or something over 244,000. With a ratio of six secondaries to one primary from the cathode 4', the current in the cathode circuit will be five times this 244,000+, while that to the shield 5' will be six times this value, giving a current amplification of about 1,220,000 or 1,460,000, depending upon whether the output circuit be taken as the circuit of the cathode 4' or that of the shield 5'. Either electrode may be used as the output, the two being 180° out of phase, and the desirability of using one or the other electrode as the output circuit depending upon the phase upon which it is desired to use the output signal.

The ratio of the current to the collector 5' and that in the circuit of the cathode 4' will always be

$$\frac{P}{P-1}$$

since the current through the impedance 26 is decreased by that supplied by the electrons impacting on the cathode 4'.

The over-all amplification of the device can be controlled by varying voltage supplied by the source 21 between ground and the cathodes 4' and 13. With practically all secondary emitters, the ratio of secondary to primary electrons increases with voltage from zero to a maximum,

the increase being substantially linear for small voltages and falling off as the voltage increases. Above the maximum point the ratio decreases very gradually with increasing voltage, the maximum being at the apex of a rather broad and flat-topped curve. For this reason, if the voltage gradient is selected for a maximum secondary-primary ratio, the decrease in amplification if an electron passes through one secondary cathode and impacts upon the second, is relatively small.

If the secondary cathodes were perfectly flat and infinitely thin the probability of an electron missing the first cathode would be one in four, with the structure described. The probability of its passing through all of the foraminated cathodes would therefore apparently be

$$\left(\frac{1}{4}\right)^n$$

or something less than one in 65,000. This, however, is based upon the assumption that the impacting electrons are traveling parallel to the axis of the device, and it has already been shown that they will, in general, make a slight angle therewith, and since the cathodes actually have a finite thickness the chance of any one electron getting all the way through without making an impact is even less than that set forth. Less than one electron in sixteen will pass through two successive cathodes and less than one in sixty-four through three. The final amplification may therefore be controlled very accurately by regulating the potential drop through which the majority of the electrons will fall before an impact, the device ceasing to amplify altogether if the ratio of secondaries to primary electrons become unity.

Figure 2 shows schematically a method of utilizing the tube in a radio receiving circuit, the impedances 22 being assumed in this case to be the metalized tube surface. Here the signal voltage is supplied from an antenna or radio frequency transmission line 30 coupled to the inductor of the tuned circuit 20. The shield 5, instead of being connected to ground directly, is connected thereto through a biasing resistor 31, shunted by a "grid condenser" 32. If the light from the source 27 be filtered so that that falling on the cathode is all in the red or infrared region of the spectrum, the initial velocity of emission of electrons from the cathode 4 will be low and quite uniform, and the number collected by the shield will be very accurately controlled by the signal voltage, increasing the efficiency of detection. If "white" or mixed radiation be used to illuminate the cathode the velocities of emission will be of more random character as will also be the case if a thermionic instead of a photo-electric cathode be used.

As has been stated before, a certain number of the electrons from the cathode 4 will be collected by the shield. The grid-condenser-leak combination 31, 32 determines the bias acquired by the shield from the electrons so collected, and hence the performance of the device. With a low value of resistance 31 and relatively large condenser 32 the bias may be made such that the device amplifies linearly, so that the voltage, which appears across the output impedance 26 and is applied through the blocking condenser 34 to any succeeding element in the circuit, will be at radio frequency. By increasing the resistance of the impedance 31 and decreasing the size of the grid condenser, so that the time constant

of the circuit is of the proper value for grid-leak detection, the device will act as a detector and the output will vary at audio frequency. It is obvious that the device can also be used as a detector by so biasing the shield that flow to the cathode 6 occurs only during the negative half of the potential cycle as impressed on the cathode 4.

It will be seen that the performance of the device may be varied greatly in character by relatively slight changes in the output circuit, particularly by varying the relative potentials of the cathode 4' and shield 5'. If the shield be sufficiently positive so that all the electrons emitted by the cathode 4' are collected, the last stage of the device operates as a linear amplifier and increased current causes the electrode 4' to swing positive. If the shield be made sufficiently negative so that all electrons emitted by the electrode 4' are returned thereto, the final stage of multiplication is without effect, the amplification derived from the device is simply that due to the foraminated secondary cathodes and the electrode 4' becomes the true anode of the device and swings negative with increased current. If, however, the relative potentials of the shield and electrode 4' be such that heavy current from the cathode would swing the electrode 4' positive with respect to the shield, while with lighter currents the shield is the more positive, the current through the impedance 26 can build up only to a certain definite maximum, but below this maximum will vary in proportion to the electron flow. Under these conditions the output circuit acts as a detector, maximum detection occurring if the device be so adjusted that maximum current flows in the impedance 26 at zero signal.

It will also be apparent that as far as the relative potentials of the cathode 4' and shield 5' are concerned, it makes no difference to which of these electrodes the impedance 26 is connected, the only difference being the phase of the voltage drop therethrough.

Where detection is accomplished in the output circuits, the initial cathode 4 and shield 5 may be used to supply automatic volume control for the system, the integrating circuit 31-32 being given a time constant which is long in comparison with the period of the lowest modulating frequency present in the signal, and the impedance of the circuit being sufficiently low so that the shield will block the emission from the cathode 4 to only the desired degree.

With proper adjustment of the voltages on the electrodes 4' and 5', and proper choice of the impedance 26, the negative voltage characteristic will cause oscillation in this circuit, and either heterodyne or zero-beat detection may be accomplished with the device. Furthermore it is not necessary that the input be applied at radio frequency, for the apparatus will operate equally well on audible or sub-audible frequencies.

Because the device is symmetrical it is possible to replace the D. C. source 21 by an A. C. source of low or high frequency, and the multipactor will operate to amplify or modulate at such frequency giving many of the advantages of the radio-frequency type of multipactor as described in my copending application Serial No. 692,585.

It is now, however, essential to the operation of the device that it be made symmetrical. Any type of collector for the electrons from the final stage may be used for many of the purposes to which it is adapted.

Various other modifications will at once sug-

gest themselves; for example, the resistor which establishes the potential gradient need not be a metal film, but may be a tube 51 of high resistance material such as graphite, carborundum, selenium, or "Thyrte", having appreciable thickness, and may be self-supporting or deposited on the glass wall as required to give the necessary structural strength together with the desired resistance. Furthermore, the secondary-emitting surfaces need not be photo-electric, but may be of aluminum, nickel, or any other material whose secondary electron primary electron ratio is greater than unity.

I claim:

15 1. A current amplifier comprising an evacuated envelope, a primary cathode within said envelope, a series of secondary cathodes each comprising a woven screen having a surface capable of emitting secondary electrons at a ratio to impacting primary electrons greater than unity, an electrostatic shield screen positioned between said primary cathode and said secondary cathodes, and means for collecting the electrons emitted from the last secondary cathode of said

series, said shield screen having a mesh larger than the mesh of said cathodes.

2. An amplifying and detecting tube comprising a photo-emissive cathode, an electrostatic screen of small projected area mounted in front of said cathode, a series of foraminated secondary cathodes mounted in spaced relationship in front of said screen, each of said secondary cathodes having a surface capable of emitting secondary electrons at a ratio to impacting primaries greater than unity and the foraminations in adjacent cathodes being offset to reduce the probability of an electron emitted from said primary cathode traversing the entire series of secondary cathodes without impacting thereon, and means for collecting the electron current emitted from the last cathode of the series.

3. A tube in accordance with claim 2 wherein the last cathode and collecting means comprise respectively a photo-sensitive electrode and an electrostatic screen substantially similar to the cathode and its screen therein previously described.

PHILO T. FARNSWORTH.

2,141,837 ✓

Fig. 1.

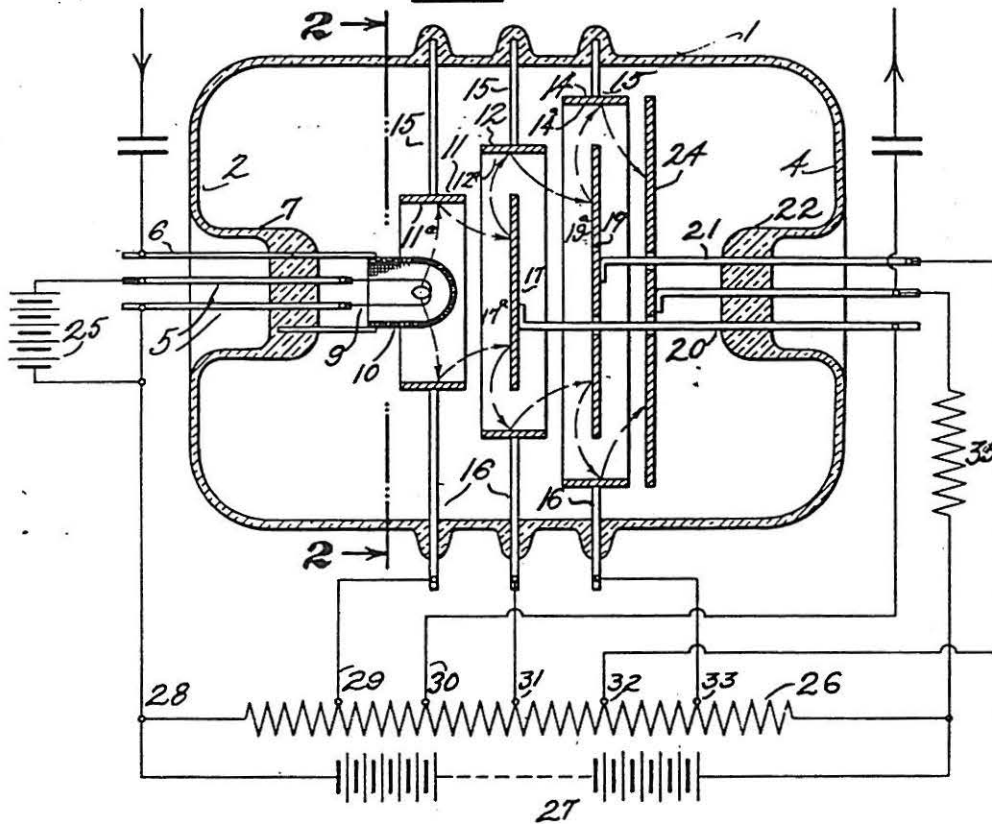
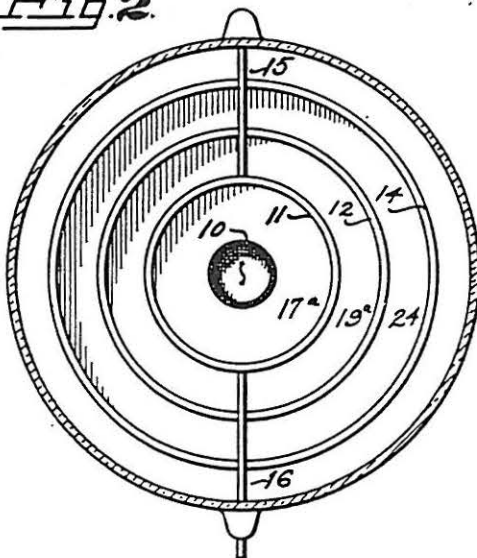


Fig. 2.



INVENTOR,
PHILO T. FARNSWORTH.
BY
Lippincott & Metcalf
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,141,837

MULTISTAGE MULTIPACTOR

Philo T. Farnsworth, San Francisco, Calif., assignor to Farnsworth Television Incorporated, San Francisco, Calif., a corporation of California

Application June 1, 1936, Serial No. 82,888

3 Claims. (Cl. 250-175)

My invention relates to electron multipliers, and more particularly to that type wherein electrons are directed to successively impact a series of surfaces to produce a current augmented by secondary emission at each impact.

Among the objects of my invention are: To provide an electron multiplier embodying simplicity in construction; to provide an electron multiplier in which space charge limitations are a minimum; and to provide an electron multiplier the arrangement of which is such as to facilitate the movement of electrons.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

In the drawing:

Figure 1 is a sectional view through a preferred embodiment of my electron multiplier.

Figure 2 is a sectional view taken in the line 2-2 of Figure 1.

In the preferred embodiment of my invention, an evacuated cylindrical envelope 1 closed by end walls 2 and 4 has supported axially there-within, as by leads 5 and 6 sealed through stem 7, a filamentary cathode 9 and a grid 10. A series of short cylinders 11, 12 and 14 are supported in spaced co-axial relation longitudinally of the envelope axis by means of anchor pins 15 and leads 16 respectively fused in and sealed through the envelope 1. The endmost cylinder 11 of the series is disposed adjacent the cathode 9 and the cylinders of the series are of progressively increasing diameters as shown. The interior surface elements 11a, 12a, and 14a of these cylinders are treated to provide a surface capable of readily emitting secondary electrons at a ratio greater than unity when impacted by a primary electron traveling at the proper velocity.

Disposed within the cylinders 12 and 14 in spaced relation thereto are disks 17 and 19 supported by leads 20 and 21 sealed through stem 22 of the envelope end wall 4. The surfaces 17a and 19a are likewise sensitized for secondary emission and I have found that the surface elements 11a, 12a, 14a, 17a, and 19a may be sensitized by the deposition thereon in any well known manner of thin film of thorium, caesium, potassium, or calcium. However, any material capable of emitting secondaries on impact is satisfactory.

A final disk 24 similar in structure to disks 17 and 19 is provided as a collector, not sensitized

surface being necessary for this disk. It will be noted that the disks are of progressively increased diameter and arranged opposite the ends of the cylinders.

The multiplier is rendered active by activating the filament 9 from a source 25 and attaching a resistor 26 across a source of potential 27, taps 28 to 33 being taken from the resistor and leading to the filament and alternately to the cylinders and plates 11, 17, 12, 19, and 14, respectively, to produce progressively increasing potentials thereon, the end of the resistor being connected through output impedance 35 to the anode plate 24, the impedance being arranged for utilization in any well known manner.

Energized in the manner above indicated, electrons leaving the filament 9 are accelerated through the grid 10, and attracted to the surface 11a of higher potential, impact the same to cause secondary electrons to be emitted. The secondary electrons so emitted are attracted to the disk surface 17a in a similar manner with secondary emission resulting at surface 17a. Surface 17a acting as a source, the electrons emitted are attracted to surface 12a.

In this manner the flow of electrons between successive surfaces is augmented and the electrons emitted from surface 14a are collected on the anode 24. It will be observed that the successive emitting surfaces are so relatively arranged that the electrons take a zig-zag course, cascading from surface to surface in the manner indicated generally by the arrows in Figure 1, and that the path continues to increase in cross-sectional area as the multiplication increases, thus holding electron concentrations within desirable limits.

While I have shown the first emitting surface to be cylindrical, it is apparent that the electrons from the cathode may be first impacted upon the disk surface 17a, the surrounding cylinder 11 being omitted. It is furthermore apparent that any desired number of multiplications may be obtained by varying the number of surfaces, and that either a disk or a cylinder may be utilized for an anode collector.

While the construction of an electron multiplier herein described is well adapted for carrying out the objects of the present invention, it is understood that various modifications and changes may be made without departing from the invention which is considered to include all such modifications as lie within the scope of the following claims:

I claim:

1. An electron multiplier comprising a series of alternately cylindrical and plane secondary electron-emitting surfaces mounted in cascade, each of said cylindrical surfaces and each of said plane surfaces being progressively increased in size from one end to the other in the series, and means for liberating secondaries from the smallest surface.
2. An electron multiplier comprising an envelope, a series of axially spaced cylindrical secondary electron-emitting elements mounted therein, and plane secondary-electron emitting elements, each mounted axially adjacent one of

said cylinders and within the succeeding cylinder.

3. An electron multiplier comprising an envelope containing a source of electrons, a cylindrical surface capable of producing secondary electrons at a ratio greater than unity upon electron impact therewith surrounding said source to receive electrons from said source, a planar surface opposite one end of said cylindrical surface and collecting means surrounding said planar surface to attract secondary electrons.

PHILO T. FARNSWORTH.

Sept. 5, 1939.

P. T. FARNSWORTH

2,172,152

RADIO FREQUENCY MULTIPACTOR AMPLIFIER

Filed Feb. 21, 1938

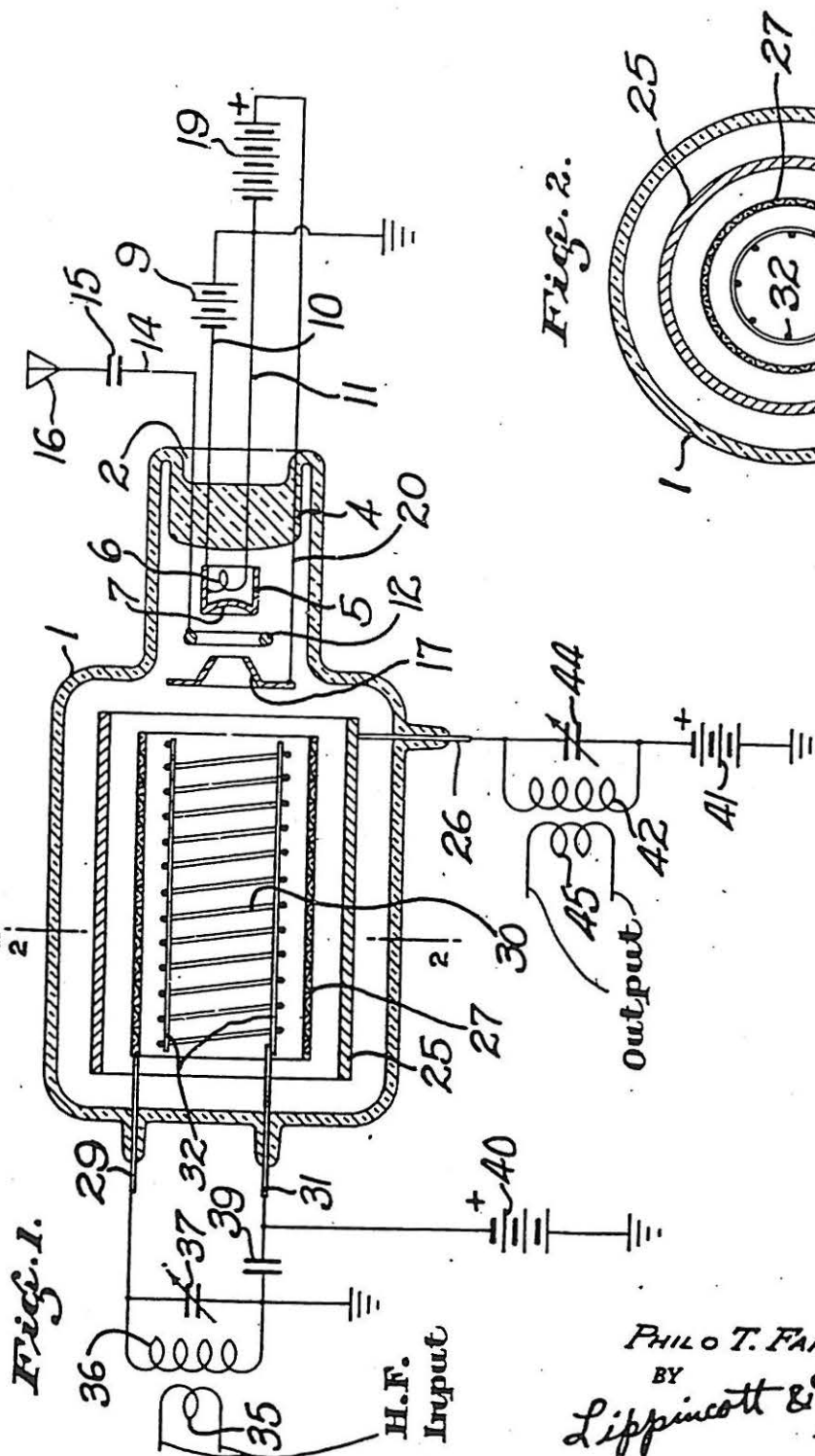


Fig. 2.

INVENTOR.
PHILO T. FARNSWORTH.
BY
Lippincott & Metcalf
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,172,152

RADIO FREQUENCY MULTIPACTOR
AMPLIFIER

Philo T. Farnsworth, Springfield Township, Montgomery County, Pa., assignor, by mesne assignments, to Farnsworth Television & Radio Corporation, Dover, Del., a corporation of Delaware

Application February 21, 1938, Serial No. 191,707

6 Claims. (Cl. 179-171.5)

This invention relates to electron multiplying devices, and particularly to a radio-frequency multipactor amplifier.

The objects of this invention are:

- 3 To produce an electron multiplier particularly adapted to act as a radio-frequency amplifier; to produce a radio-frequency multipactor amplifier having a photosensitive cathode; to produce a radio-frequency amplifier using repeated
- 10 impacts on secondarily emissive surfaces to increase the output current; to provide means for utilizing photo-emission and secondary emission together in a multipactor amplifier; to provide a multipactor amplifier in which the output current is linearly responsive to light directed upon a photosensitive element therein; to provide such an amplifier in a form wherein a signal may be modulated upon the output; to provide a multipactor amplifier wherein the use of focusing
- 20 fields is not necessary; to provide a multiplier amplifier in which multiplication may be started by ionized particles existing therein, by photo-emission, or by an electron gun.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

- 30 Various types of electron multipliers, both a.-c. and d.-c., have been developed by me, and those associated with me, forming the subject matter of a number of United States patents, of which the following are illustrative: Electron multiplying device No. 2,071,515, Oscillation generator No. 2,071,516, and other applications now in prosecution.

The present application is concerned only with a.-c. multipliers, and in the form presented is particularly suited to amplify a radio-frequency carrier and permit modulation of a signal current thereon in a single tube.

In the drawing:

- 45 Fig. 1 is a schematic sectional view of a tube embodying my invention, together with a circuit diagram indicating a preferred mode of operation.

Fig. 2 is a sectional view of my device taken along line 2-2 of Fig. 1.

- 50 In the arrangement shown in Fig. 1, an evacuated envelope 1 of glass or similar material has formed at one end thereof a re-entrant stem 2 terminated by a conventional press 4. An electron gun of conventional type is supported on
- 55 said stem, having a heater cathode 5 having a

resistance coil 6 therewithin and a concave emitting face 7. The coil 6 may be energized by a d.-c. current source 8, such as a storage battery, through leads 10 and 11 sealed through press 4, lead 10 acting also as a support for the cathode 5. The emitting face 7 is preferably coated with thermionically active material to increase the strength of current given off, using for this purpose any of the materials and methods well known in the art.

A ring-shaped control electrode 12 is positioned immediately before the concave surface 7, a lead 14 sealed through the press 4 acting as a support and providing an external connection through which signal current may be led from a blocking condenser 15 connected to an antenna 16 or other source.

In registry with cathode 5 and control electrode 12 is positioned a gun type anode 17 positively energized from a d.-c. potential source 19 through a supporting lead 20 sealed through the press 4. The gun thus formed is in axial alignment with a multiplying chamber formed by a cylindrical collecting anode 25 supported by a lead 26 sealed through said envelope 1. Concentrically within anode 25 is a cathode screen 27 formed of fine wire gauze sensitized for photo-emission and to provide a high secondary emission ratio and supported by a lead 29 sealed through the envelope 1. The screen is preferably formed of fine, woven silver wire, but may also be made by punching out a sheet or any other known method for producing a finely apertured structure in which the ratio of apertured area to total area is of the order of one to four.

The silver may be oxidized, or coated with caesium which in turn is oxidized, to increase the ratio of secondary emission. Any of the photo-emission aiding and emission ratio increasing means known in the art are deemed a full equivalent of this cathode structure treating method.

Concentrically within cathode 27 is a helical accelerating anode 30 supported by a lead 31 sealed through the envelope 1. Anode 30 may be formed by winding spaced turns of wire into a helix, and maintaining the separation between adjacent turns by spot welding to spacing rods 32 evenly spaced within the periphery of the helix parallel to the axis thereof.

In operation, the current to be amplified is applied to a carrier input circuit 35, to which is inductively coupled an amplifier input coil 36 tuned by a variable capacitance 37 shunted thereacross. One side of coil 36 is connected through lead 29 to the secondarily emissive and photosen-

active cathode screen 27. The other side of coil 36 is grounded and connected through a blocking condenser 39 to the accelerating anode 30 through lead 31. To the anode 30 is also connected the positive terminal of a source 40 of steady d.-c., the negative terminal of which is grounded.

A positive potential is also applied to collecting anode 25 through lead 26 from a d.-c. source 41, the negative pole of which is also grounded. Between source 41 and lead 26 is inserted an output coil 42 tuned by a variable capacitance 44, and having inductively coupled thereto a coil 45, from which the amplified and modulated carrier output may be taken for further use.

If, now, a carrier be applied to coil 35, an alternating potential will be set up between the accelerating anode and the cathode screen, in addition to the d.-c. potential on anode 30, reaching its full value when the capacitance 37 is adjusted to make the amplifier input circuit resonant at the carrier frequency.

Free electrons in the multiplying space will be attracted by the positive potential on the anode 30, but due to the small area presented by the anode, the greater number of electrons will pass through and continue toward the screen 27, on which the greater number will strike, producing secondaries. Some will pass through, however, the ratio being very nearly that of the apertured area to the total area, or one to four.

These electrons passing through will be further accelerated by the potential on collecting anode 25, and on collection will flow off through the output circuit including coil 42 and variable capacitance 44.

When the carrier frequency is raised above ten megacycles it is found necessary to provide a source of electrons in order that multiplication may reach satisfactory current values in the time available, and for this purpose it is possible to direct a light upon the photosensitive cathode. The photo-emission produced thereby permits current to build up rapidly, the current being in its maximum value a linear function of the illumination intensity up to the point of space charge saturation. The light source and the optical system for focusing its rays upon the cathode are not shown in the figure, however, inasmuch as I preferably utilize an electron gun as described above, since it possesses advantages in regard to modulation.

Returning now to the point where the electrons supplied by the source are accelerated by the anode 30, pass therethrough and produce secondaries by impact on the cathode screen, it will be seen that while a carrier is applied between cathode 27 and anode 30, there will be a continuously varying potential therebetween, fluctuating in value about the d.-c. potential difference due to source 40. The paths followed by the secondaries will depend upon these changing potentials. If the particular electrons are knocked out of the cathode when the anode 30 is least positive, the potential on collecting anode 25 will be controlling, and the electrons will be drawn thereto and collected.

If the electrons commence their flight from the screen cathode when the anode 30 is most positive, some of them will be attracted back toward it, pass therethrough, and repeat the secondary producing impact on the screen cathode. Others will pass immediately through the screen and be collected on anode 25. By proper adjustment of the potentials, repeated multiplication producing trips into and out of the space

bounded by the anode may be secured, and as is now well known in the art, a greatly amplified output current secured. The output may be usefully applied from inductance 42 in the collecting anode circuit.

The output current is linearly proportional to the electron supply at the beginning of each cycle, as stated with reference to the photosensitive cathode as described above, and so by applying a signal current to the control electrode 12 of the electron gun, the carrier will be modulated thereby. It will thus be seen that the device herein presented affords a simple method of modulating a signal current on a radio-frequency carrier, and greatly amplifying the modulated carrier.

The following is claimed:

1. A radio-frequency multipactor amplifier tube having an evacuated envelope containing an electron gun comprising a cathode and an anode cooperating when energized to produce an electron beam, a control electrode between said cathode and anode, means for applying a signal current to said control electrode, and a multiplying chamber in registry with said gun, including a cylindrical collecting anode adapted to be positively energized by a steady source of d.-c., a secondarily-emissive electron-permeable cylindrical cathode held concentrically within said collecting anode, and a cylindrical electron-permeable accelerating anode concentrically placed within said cylindrical cathode and adapted to be positively energized.

2. A radio-frequency multipactor amplifier tube having an evacuated envelope containing an electron gun comprising a cathode and an anode cooperating when energized to produce an electron beam, a control electrode between said cathode and anode, means for applying a signal current to said control electrode, and a multiplying chamber in registry with said gun, including a cylindrical collecting anode adapted to be positively energized by a steady source of d.-c., a photosensitive secondarily-emissive electron-permeable cylindrical cathode held concentrically within said collecting anode, and a cylindrical electron-permeable accelerating anode concentrically placed within said cylindrical cathode and adapted to be positively energized.

3. A radio-frequency multipactor amplifier tube comprising an evacuated envelope having therein a collecting anode adapted to be positively energized, an electron-permeable secondarily emissive cathode within said collecting anode, an electron-permeable accelerating anode within said cathode adapted to be positively energized, an electron gun in registry with said accelerating anode, comprising a cathode and an apertured anode arranged when energized to produce an electron beam, and a control electrode arranged to be energized by a signal current.

4. A radio-frequency multipactor amplifier tube, comprising an evacuated envelope having therein a cylindrical collecting anode arranged to be positively energized, an electron-permeable photosensitive secondarily emissive cylindrical cathode concentrically placed within said collecting anode, a helical accelerating anode concentrically supported within said cathode and arranged to be positively energized, and an electron gun positioned to direct, when energized, a beam of electrons into said helical anode, said gun having a control electrode arranged to be energized by signal potentials.

5. A radio-frequency multipactor amplifier, 75

including an evacuated envelope having therein an accelerating helical anode, an electron-permeable secondarily emissive cathode concentric thereabout, a cylindrical collecting anode concentrically placed about said cathode, an electron beam source having a control electrode and arranged to direct electrons into said helical anode, leads sealed through said envelope to said electron beam source and said control electrode, means connected with said leads for energizing said source, means for applying signal potentials to said control electrode through said lead there-
 10 to, leads sealed through said envelope to said accelerating anode, said secondarily emissive cathode, and said collecting anode, a variable input impedance connected in series with a blocking condenser across said cathode and said helical anode, a carrier frequency input circuit coupled to said variable input impedance, a d.-c. potential source having its positive connected to said accelerating anode lead and its negative grounded, a variable output impedance connected to said collecting anode lead, an output work circuit coupled to said output impedance, and a positive d.-c. source, having its negative end grounded, connected through said variable output impedance to said collecting anode.

6. A radio-frequency multipactor amplifier, including an evacuated envelope having therein an accelerating helical anode, an electron-per-

meable secondarily emissive cathode concentric thereabout, a cylindrical collecting anode concentrically placed about said cathode, an electron beam source having a control electrode and arranged to direct electrons into said helical anode, leads sealed through said envelope to said electron beam source and said control electrode, means connected with said leads for energizing said source, means for applying signal potentials to said control electrode through said lead there-
 5 to, leads sealed through said envelope to said accelerating anode, said secondarily emissive cathode and said collecting anode, a variable input impedance connected in series with a blocking condenser across said cathode and said helical anode, a carrier frequency input circuit coupled to said variable input impedance whereby said accelerating anode and said secondarily emissive cathode may be energized in opposite phase by a carrier current, a d.-c. potential
 10 source having its positive connected to said accelerating anode lead and its negative grounded, a variable output impedance connected to said collecting anode lead, an output work circuit coupled to said output impedance, and a positive
 15 d.-c. source, having its negative end grounded, connected through said variable output impedance to said collecting anode.

PHILO T. FARNSWORTH. 20

Sept. 26, 1939.

P. T. FARNSWORTH

2,174,487

SELF-EXCITED ALTERNATING CURRENT MULTIPLIER

Filed March 22, 1937

Fig. 1.

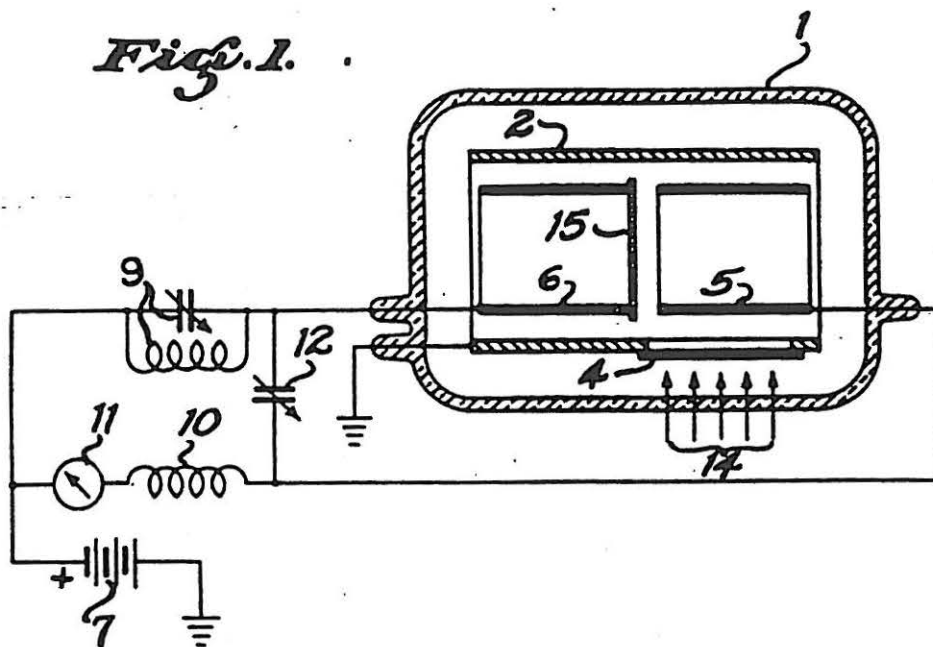
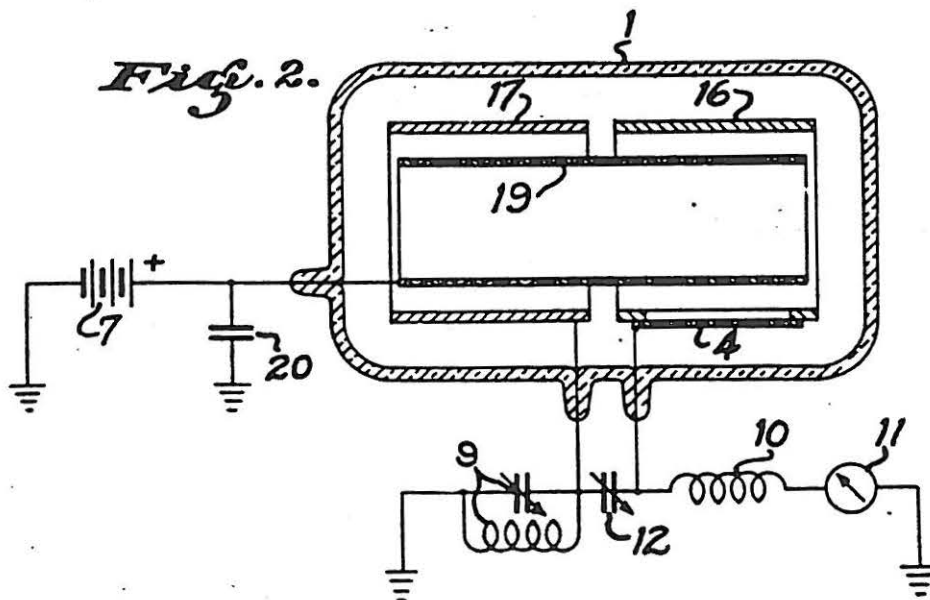


Fig. 2.



INVENTOR.
PHILO T. FARNSWORTH.
BY *Lippincott & Metcalf*
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,174,487

SELF-ENERGIZED ALTERNATING CURRENT
MULTIPLIER

Philo T. Farnsworth, Springfield Township,
Montgomery County, Pa., assignor, by mesne
assignments, to Farnsworth Television & Ra-
dio Corporation, Dover, Del., a corporation of
Delaware

Application March 22, 1937, Serial No. 132,324

5 Claims. (Cl. 250-27)

My invention relates to electron multipliers, and more particularly to an electron discharge device wherein linear electron multiplication takes place to the end that an amplified output may be secured of an electron input, the device being energized by self-generated alternating current.

Among the objects of my invention are: to provide a means and method for amplifying small electron currents; to provide a combined photo-electric cell and electron multiplier; to provide a system wherein, in a single envelope linear electron multiplication takes place together with alternating current generation; to provide linear amplification of photo-emission; to provide a combined photo cell, electron multiplier, and driver within a single envelope, and utilizing at least certain electrodes in common; to provide a three-electrode photo cell wherein electron multiplication of the photo-emission is obtained with linear amplification; to provide a means and method of controlling the output of a photo cell; to provide a means and method of amplifying the output of a photo cell; and to provide a simple and efficient method of energizing an electron multiplier with alternating current generated in the same envelope.

My invention possesses numerous other objects and features of advantage, some of which, together with the foregoing, will be set forth in the following description of specific apparatus embodying and utilizing my novel method. It is therefore to be understood that my method is applicable to other apparatus, and that I do not limit myself, in any way, to the apparatus of the present application, as I may adopt various other apparatus embodiments, utilizing the method, within the scope of the appended claims.

Referring to the drawing:

Figure 1 is a diagrammatic, sectional view of one form of tube structure embodying my invention, together with a circuit diagram showing operating connections.

Figure 2 is a similar view of a modification of my invention.

In my prior applications, for an Electron multiplying device, Serial No. 692,585, filed October 7, 1933, Patent No. 2,071,515, dated Feb. 23, 1937; and an Oscillation generator, Serial No. 733,837, filed July 5, 1934, Patent No. 2,071,516, dated Feb. 23, 1937, I have described electron multipliers and oscillators operating by the repeated impact of a cloud of electrons against a surface capable of emitting secondaries at a ratio greater than unity, and I have disclosed and claimed as one modifica-

tion of the device, a diode structure. I have also pointed out in both of these cited applications that certain methods of treating surfaces for the production of secondaries at a ratio greater than unity leave the surface in a condition wherein photo-emission may also be obtained. In addition, I have pointed out that these multiplier structures may be utilized in two manners. First, as a linear electron multiplier wherein the electrodes are driven, or in other words, supplied with alternating potentials from an external source. In which case, linear outputs of initial input electrons may be obtained. I have further pointed out that it is possible to cause these devices to generate self oscillations when properly connected, and I have shown that in the latter instance the tubes usually operate at an equilibrium point where space charge tends to destroy linearity of output, when a controlled input is utilized.

While it is possible, therefore, to build a multiplier wherein only two electrodes are utilized, and where the initial electrons are supplied to it, it is not practical to allow the device to self-oscillate and thus obtain an output which is a direct function of the input. Such a structure, however, would give a linear output provided the electrodes are driven from another source.

I have discovered that by the addition of only a single additional electrode, I am able to cause one part of the device to generate oscillations to energize another portion of the device to the end that the driven portion will give a linear response to initial input electrons.

In this present application I have described my structure basically comprising three electrodes with their appropriate circuits as being supplied with initial electrons liberated by the action of light, i. e., photo-emission; but I wish it to be distinctly understood that the same action can be obtained with the same electrode structure and circuit, irrespective of whether the initial electrons are liberated by the action of light or are liberated within operating space of the electrodes from other sources. In other words, my present device is capable not only of amplifying photo-emission, but also any emission whose component electrons are liberated or otherwise projected into the operating space of the device. Such modifications of my device are well within the knowledge of those skilled in the art, and, while I have shown the preferred construction which answers the requirements very effectively, I do not desire to be confined to the precise details either of construction or arrangement or mode of application, but aim in my claims to cover all

modifications which do not involve a departure from the spirit and scope of the invention as set forth in the appended claims.

Other broad aspects of my invention may be more fully understood by direct reference to the figures, which show two modifications, both attaining the same result.

In Figure 1, an envelope 1 is provided with a cylindrical cathode 2 perforated close to one end thereof with an aperture covered by a screen 4. Centrally positioned within the cathode 2 are two adjacent cylindrical anodes, a photo cell anode 5 and an oscillator anode 6. These anodes are approximately the same size and shape, and each one co-operates with approximately one-half of the inner surface of the cathode. This inner surface is sensitized in this embodiment to perform a dual function; it must produce secondary electrons at a ratio greater than unity upon electron impact therewith, and it must also in this particular adaptation product photoelectrons under the influence of light. Fortunately, a caesium-silver oxide surface will fulfill both of these requirements, and I therefore prefer to make the entire cathode of silver, oxidize the inner surface, and deposit metallic caesium thereon until a balance is reached where secondary emission and photo-emission are both good. While I have found that the two maxima do not coincide, they are sufficiently close so that if either one be checked the other will be within the proper operating range.

After the inner surface of the cathode has been sensitized the tube is exhausted, sealed, and connected in its operating circuit. The oscillator anode 6 is connected to the positive end of an oscillator source 7 through a resonant circuit 9. The cathode is grounded and the photo cell anode 5 is connected to the positive end of anode source 7 through a radio frequency choke 10 and a work circuit 11, diagrammatically represented in this case by a current indicator. A variable condenser 12 is bridged across the two anodes.

In operation, as soon as the anode source 7 is connected to the oscillator anode 6 the electron multiplier comprising anode 6 and cathode 2 starts to operate as a multiplier oscillator. Electrons within the space bounded by anode 6 are accelerated away from and against cathode 2 at a frequency determined by resonant circuit 9, and at each impact with the cathode generate additional secondary electrons until the current generated builds up to an equilibrium value. There will be, therefore, a variation of potential across resonant circuit 9, and this potential is transmitted to anode 5 through the variable condenser 12; the amount of energizing potential reaching anode 5 depending, of course, upon the adjustment of the condenser 12.

In the meantime, if light, as represented by arrow 14, is directed into the interior of the cathode cylinder, this light illuminates the interior wall of the cathode adjacent photo cell anode 5. Photoelectrons are emitted which are, because of the driving potential on anode 5, accelerated away from and against the inner surface of cathode 2 adjacent anode 5, and are multiplied, the multiplied electrons eventually being collected by anode 5 as uni-directional pulses. Radio frequency choke 10 keeps radio frequency energy from passing through the work circuit, but the uni-directional pulses received by anode 5 pass readily through this choke and through the work circuit 11. Thus, for an extremely small light value, high output currents are obtained, and as

the photo cell multiplier combination is driven the output will be linear, or substantially so, within a wide range. The frequency of self-oscillation generated by the device is, of course, determined by the resonant circuit 9 and may be, for example, between five and forty megacycles, depending on the number of secondary emission impacts desired in the photo cell end of the device.

The two operating spaces within the device are separated by an insulating shield 15 positioned on one of the anodes, dividing the space and preventing electrons from crossing from one operating space into the other.

It will be seen, therefore, that the system shown in Figure 1 has a single cathode and a double anode. However, an alternative construction is shown in Figure 2, and there is little to choose between the two. In this latter case, the cathode is divided into two parts, a photo cell cathode 16 and an oscillator cathode 17, whereas a single anode 19 extends co-axially with both cathodes and over substantially the entire extent thereof. In this case, the single anode is supplied with steady potential from anode source 7, and the oscillator cathode 17 is connected to the anode 19 through resonant circuit 9 grounded and blocking condenser 20. In this instance, the output is taken directly from the photo cell cathode 16 through radio frequency choke 10 and work circuit 11 to ground, and the multiplication control is performed by the variable condenser 12 connecting the two cathodes. Light enters the device through the photo cell cathode 16 and screen 4 in exactly the same manner as was described for Figure 1, and the operation is identical. There is little difference between the two embodiments shown except that under certain circumstances it is possible to sensitize the two cathodes differently in the embodiment shown in Figure 2 so that maximum photo-emission is obtained in the photo cell end, and maximum secondary emission obtained in the oscillator end. This is an advantage rather than a drawback inasmuch as the best photo-emitters are also good secondary emitters, although the converse is not always true.

As explained above, it will be within the knowledge of those skilled in the art to substitute an electron gun a hot filament, or electrons liberated by other means within the driven structure for the photo-emitting combination, and the use of the device as a multiplying photo cell is illustrative only, although, as a photo cell it obviously has a wide range of uses.

I claim:

1. An electron multiplier comprising a single envelope containing a pair of diode electron multiplier structures, external circuit means for operating one of said structures as an electron multiplier, external circuit means for operating the other of said structures as an electron multiplier oscillator, and means for connecting the oscillator output to energize said multiplier.

2. An electron multiplier comprising an envelope containing a unipotential cathode surrounding a perforated anode, a second unipotential cathode surrounding said perforated anode, circuit means for causing oscillation generation by electron impact at a ratio greater than unity upon electron impact with one of said cathodes under the influence of said anode, means for energizing the other cathode from the oscillations generated for electron multiplication by secondary emission, and means for liberating electrons

within the operating space of said latter cathode and said anode.

3. An electron multiplier comprising an envelope containing a unipotential cathode surrounding a perforated anode, a second unipotential and photoelectric cathode surrounding said perforated anode, circuit means for causing oscillation generation by electron impact at a ratio greater than unity upon electron impact with one of said cathodes under the influence of said anode, means for energizing the other cathode from the oscillations generated for electron multiplication by secondary emission, and means for illuminating the latter cathode to liberate photoelectrons.

4. An electron multiplier comprising an envelope containing a unipotential cathode surrounding a perforated anode, a second unipotential cathode surrounding said perforated anode, circuit means for causing oscillation generation by electron impact at a ratio greater than unity upon electron impact with one of said cathodes

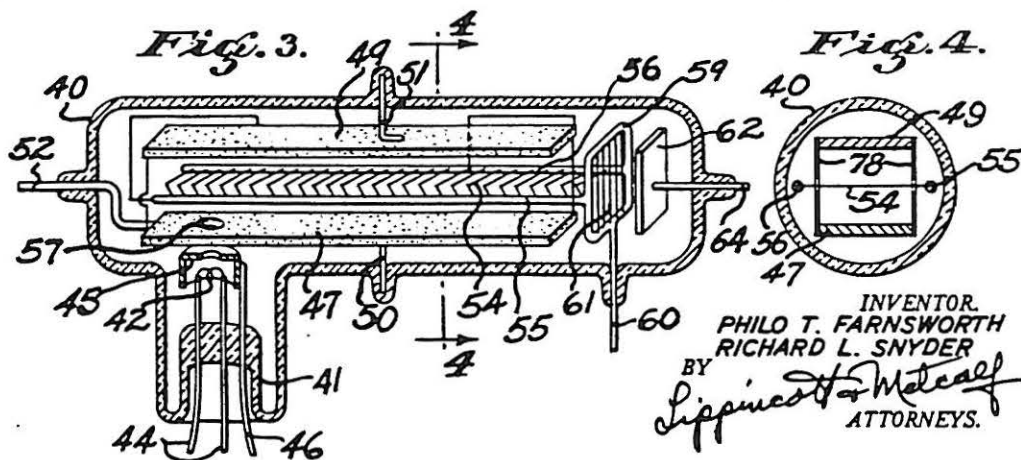
under the influence of said anode, means for energizing the other cathode and said anode from the oscillations generated for electron multiplication by secondary emission, and means for liberating electrons within the operating space of said latter cathode and said anode, both of said cathodes being at the same potential. 5

5. An electron multiplier comprising an envelope containing a unipotential cathode surrounding a perforated anode, a second unipotential cathode surrounding said perforated anode, circuit means for causing oscillation generation by electron impact at a ratio greater than unity upon electron impact with one of said cathodes under the influence of said anode, means for energizing the other cathode from the oscillations generated for electron multiplication by secondary emission, and means for liberating electrons within the operating space of said latter cathode and said anode. 10 15 20

PHILO T. FARNSWORTH.

2,179,996

Filed Nov. 9, 1936



UNITED STATES PATENT OFFICE

2,179,996

ELECTRON MULTIPLIER

Philo T. Farnsworth, Springfield Township, Montgomery County, Pa., and Richard L. Snyder, Borough of Glasboro, N. J., assignors to Farnsworth Television & Radio Corporation, Dover, Del., a corporation of Delaware

Application November 9, 1936, Serial No. 109,934

13 Claims. (Cl. 250—27)

Our invention relates to means for electron multiplication, and particularly to multipliers utilizing an electron drift along continuous secondarily emissive surfaces.

5 Among the objects of our invention are: To provide more efficient means for electron multiplication; to provide high gain direct- and alternating-current multipliers; to provide multiplying units which are free from the necessity for servicing at frequent intervals; to provide multiplying units so compact that they may be installed in cables or other places where space is limited; to provide multipliers which are operable upon local battery supply, or which may be fed through signal-carrying lines; to provide multipliers having a low threshold point; to provide multipliers wherein the degree of multiplication may be varied over wide limits; to provide means for creating an electron drift, whereby successive electron impacts may occur at points of increasingly higher potential along continuous secondarily emissive surfaces; and to provide electron drift in an electron multiplier to minimize space charge limitations therein.

20 Our invention possesses numerous other objects and features of advantage, some of which, together with the foregoing, will be set forth in the following description of specific apparatus embodying and utilizing our novel method. It is therefore to be understood that our method is applicable to other apparatus, and that we do not limit ourselves, in any way, to the apparatus of the present application, as we may adopt various other apparatus embodiments, utilizing the method, within the scope of the appended claims.

In the drawing:

Figure 1 is a partially sectional view of our multiplier connected schematically for alternating-current energization.

40 Figure 2 is a schematic circuit diagram of a multiplier embodiment particularly suited to direct-current energization.

Figure 3 is a partially sectional, schematic view of the embodiment shown in Figure 2.

45 Figure 4 is a partially sectional view taken along line 4—4 of Figure 3.

The theory of electron multiplication by successive impacts of a modulated number of electrons upon secondarily emissive surfaces is well known since the development of the art and publication thereof by Farnsworth and his associates. The present application is particularly concerned with means for producing an electron drift along a continuous surface, and related

embodiments are dealt with in the Farnsworth and Snyder application entitled "Repeater", filed October 31, 1936, Serial No. 108,568, since matured into United States Patent No. 2,143,146, issued January 10, 1939.

The invention may be better understood by reference to the drawing.

In Figure 1 is shown one of our multiplier tubes schematically connected for operation, to be driven by alternating current. The tube comprises an evacuated, sealed, cylindrical envelope 1 of glass or other insulating material, having a radially extended neck 2 at one end, the neck terminating in a conventional press 3 on a reentrant stem 4. Through press 3 are sealed a pair of connecting leads 5 supporting a cathode, here shown as a filament 6, and a lead 7 which supports a grid 9 in position between filament 6 and the main body of the tube. A grounded battery 10 connected to leads 5 heats the filament 6. The signal input is applied to grid 9 through an input lead 11 and condenser 12. The end of envelope 1 opposite neck 2 is terminated by a conventional press 13 on a reentrant stem 14, bearing a cathode support 15 sealed through press 13, the cathode-supporting and connecting lead 16, and anode lead 17, located preferably on the longitudinal geometrical axis of the tube. Within the tube 1 a circular collecting plate 19 is fixed on and normal to the anode lead 17. Centrally attached thereto is a high-resistance anode wire 20 held in axial alignment with the tube by a spring 21, fixed to a connecting lead 22, sealed through the end 24 of the envelope 1. Battery 25 feeds a continuous current to anode 20 through leads 17 and 22 and a variable resistor 26. The negative side of battery 25 is carried to a radio-frequency ground 27. Cylindrical cathode 29 is held symmetrically about anode 20 by supporting leads 15 and 16. An aperture 30, in line with filament 6, is provided through the wall of cathode 29.

A master oscillator 31 is connected through a variable condenser 32 and lead 15 to the cathode 29. A path to ground from lead 15 is made available through a choke coil 34, resistor 35, and battery 36. The output lead 33 is fed through a condenser 37 tied to the multiplier side of resistor 35. The battery 36 maintains a constant positive component upon cathode 29 of a few volts above ground potential. A solenoid 33 wound about envelope 1 is provided, and is energized by a battery 38 to set up a magnetic field longitudinally of the envelope 1.

In operation, filament 6 emits electrons when

energized by battery 10, of which a number modulated in accordance with the signal output is permitted to pass through grid 9. Cathode 29 is positively biased by battery 36: The electrons passed by grid 9 are attracted thereto; most of them pass through aperture 30, while the remainder are collected on the cathode 29.

Those electrons passing through aperture 30 are accelerated toward anode 20 by the positive potential thereon, which is preferably of the order of 500 volts above ground, and is controllable by the variable resistor 26.

Relatively few of the accelerated electrons will be collected on the anode, due to its small superficial area and the deflection caused by the longitudinal magnetic field of solenoid 33. The majority will pass by and continue to travel toward the opposite wall of cathode 29, being decelerated after passing the anode in the same degree as their initial acceleration.

The cathode potential has, during this time, become increasingly positive under excitation from the oscillator 31, and this added potential causes the electrons to strike with sufficient velocity to knock out a number of secondary electrons. The interior of cathode 29 is coated, for greatest efficiency, with a highly emissive material, caesium on an oxidized silver surface being a preferred form. These secondaries are attracted toward the anode, which they in most part pass, impact the opposite cathode wall, again aided by the changing potential from the oscillator 31, knock off more secondaries, and repeat. This process would continue, with an increasing cloud of electrons passing back and forth, until the space charge caused an equilibrium condition near the input stream were it not for our method of causing an "electron drift", whereby the electron cloud is moved along the tube toward the collecting plate 19.

This drift is produced by the potential drop along anode wire 20, cooperating with the alternating current on cathode 29. Since this wire has a high resistance, and the voltage of battery 25 is high, a large gradient exists, with the points of higher positive potential near the collecting plate 19, and the lower potential at the end of anode 20 adjacent spring 24.

Hence, each electron is attracted toward the anode in a path curving toward the higher potential points; successive passages bring the electron to the collecting plate, accomplishing the return circuit to the cathode through the radio-frequency ground 27, battery 36, resistor 35, choke coil 34 and lead 16. From the potential drop across the resistor 35, the useful output of the tube is obtained, through blocking condenser 37 and output lead 39.

It is apparent that in order to insure the numerous passages across the cathode necessary to obtain high multiplication, the frequency of the oscillator 31 must be properly co-ordinated with the dimensions of the cathode and the potential of battery 25, since polarity reversals of the cathode must be so timed as to supply the electrons with sufficient impact velocity, and yet permit the secondaries to escape toward the anode. The electrons will, however, get slightly out of phase on each passage, since the added velocity approaching the walls will slightly reduce the average time of flight, and after a number of trips the oscillator will begin to oppose instead of aid. When this occurs, the electrons will not strike the cathode, but will oscillate in a constantly decreasing arc within the cathode until they are picked

up by the anode 20. It is from these collected out-of-phase electrons that part of the anode current is obtained.

The "electron drift" is also controllable by varying the gradient along the anode 20. Changing the value of resistor 26 changes the potential drop between plate 19 and spring 24, and hence changes the amount of deflection during each electron passage across the tube. This varies the number of multiplication cycles, and hence the output current developed.

It should be noted that, while the anode potential may be many hundreds of volts, the potential supplied by the driving oscillator 31 need only be sufficient to produce a secondary-generating impact, and may be of the order of 20 volts, depending on the magnitude of the anode potential and the characteristics of the particular emissive surface used.

Choke coil 34 prevents the oscillator from impressing its output on the signal output through lead 39, while permitting free passage of the signal current through resistor 35, and permitting battery 36 to maintain a bias on cathode 29 such that there will be no cut-off effect at the aperture 30 other than that exercised by grid 9 in accordance with the signal input.

The "electron drift" principle is also incorporated in the multiplier shown in Figures 2 to 4, which is driven by direct current.

Figure 3 is a partially sectional view of the multiplier within an envelope 40 of glass or similar material. A reentrant stem 41 is extruded near one end of envelope 40 and at right angles to the major axis thereof. A cathode, shown conventionally as a filament 42, is supported within the reentrant stem by leads 44 sealed therethrough. A control electrode, shown as an apertured shield 45, is supported by a connecting lead 46, also sealed through the reentrant stem, in such position that some of the electrons emitted by cathode 42 are permitted to pass into the main body of the envelope 40. Within envelope 40, the space between them constituting the multiplying chamber, are disposed two parallel plates 47 and 49, formed of material having high electrical resistance, and coated on the opposed surfaces with discrete particles of material having high secondary emission characteristics, such as caesium or caesium-silver oxide. The alignment of the plates 47 and 49 is maintained by supporting studs 50 and 51 sealed into envelope 40, and external connection is provided through a lead 52.

Midway between, and parallel to, plates 47 and 49, is a herringbone lattice or grid 54 of low-resistance wire, supported by two rods 55 and 56 of high-resistance material. The apices of the lattice wires 54 are directed toward the cathode end of plates 47 and 49, where an aperture 57, disposed through plate 47 in registry with the apertured control electrode 45, provides an entrance for electrons from filament 42 into the multiplying chamber. The grid-supporting rods 55 and 56 extend beyond the ends of plates 47 and 49 opposite aperture 57, terminating in a rectangular rim 59 formed at right angles to and integrally with the rods, the rim and entire grid assembly being supported by a lead 60 sealed through envelope 40. Across rim 59 is stretched a conducting grid 61. A collecting anode 62, supported by a lead 64 sealed through the end of envelope 40, is disposed parallel to grid 61.

Figure 4 shows a schematic sectional view, taken along line 4-4 of Figure 3, illustrating

the manner in which the electrons moving between plates 47 and 49 are prevented from straying out of the multiplying chamber. Mica plates 78, apertured to permit the passage of grid wires 54, are used to enclose the space between plates 47 and 49.

The circuit diagram for operation of the embodiment of Figures 3 and 4 is shown in Figure 2. The filament 42 is heated by a source of energy not shown; of the emitted electrons, a number modulated by the input signal is admitted to the multiplying chamber through aperture 57. The control is exercised by apertured electrode 45, upon which a varying charge is impressed from condenser 65 by the signal current in the input line 66. The end of the multiplying chamber nearest the cathode is connected to the negative side of a high-potential battery 67, the positive side of which is applied to the collecting plate 62 through a resistor 69. In practice, the plate 62 may be about 600 volts positive with respect to the low-potential end of the multiplying chamber. Battery 67 is tapped at a point about 100 volts less positive than plate 62, and through lead 60 connected to the rectangular frame 59 and grid 61. The high-resistance rods 55 and 56 are likewise tapped by a lead 70 at a point about 100 volts less positive than grid 61, and connected to the high-potential end of plates 47 and 49. Opposite points on plates 47 and 49 are maintained at equal potential by leads 71 and 72, connecting together the high- and low-potential ends respectively of the two plates.

A constant difference of potential of 100 volts between opposite points on the plates 47 and 49, and the rods 55 and 56, is maintained by leads 70 and 74. Lead 74 connects the low-potential ends of the rods 55 and 56 to plate 49 opposite a point on the rods 100 volts positive above the rod-ends. Lead 52 from the low-potential plate ends is returned to the negative side of battery 67 to complete the circuit.

The electrons admitted through aperture 57 are attracted toward the lattice grid 54, but due to its comparatively open character, the majority are not collected, and their momentum carries them on toward the plate 49. Since the admittance velocity is low, and the acceleration due to grid 54 is neutralized by the decelerating effect once the electrons have passed through, the impact velocity would be too long to cause secondary emission were it not for the deflection due to the field gradient on the grid 54. The effect of the gradient is intensified by the herringbone construction: the electrons are constrained to the longitudinal center of the multiplying chamber as well as deflected toward the high-potential end. In consequence of the longitudinal deflection, the electrons will strike upon plate 49 at a point a number of volts more positive than was plate 47 at the aperture 57, and will retain sufficient energy to knock secondaries out of the coating on plate 49.

These secondaries will in turn be attracted toward grid 54, deflected toward the high-potential end, pass through the grid, and strike plate 47 at a point still more positive than that on plate 49 from which they originated. When the electron stream reaches the high-potential end of the multiplying chamber, it is drawn toward grid 61, passes through, and is collected upon anode plate 62. In returning to battery 67 from plate 62, a potential drop through resistor 69 is set up which is utilized to charge condenser

75 and send current through output lines 76 and 77.

The number of passages across the multiplying chamber, and hence the degree of amplification, is controlled by the potential gradient, and hence by the voltage of battery 67.

The similarity in the two embodiments presented lies in the use of an electron drift along, as well as across, a continuous emitting chamber, under the influence of a potential gradient set up in an intermediate electrode, the anode, in cooperation with an assisting potential on the chamber walls set up either by an external oscillator or another voltage gradient.

To those skilled in the art it is obvious that the form of all the elements involved may be varied within wide limits, as may the spacing of the electrodes, the values of resistance and potential used, the material forming the emissive surfaces, the cathode embodiment, and so forth, without departing from the spirit and scope of the invention. The essential feature of the invention is the combination of means to produce an electron drift within the multiplier, whereby space current limitations may be removed, and the degree of multiplication controlled.

We claim:

1. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, opposed secondarily emissive cathode surfaces, one of said surfaces being positioned to intercept said electron stream, a perforate anode positioned parallel to and midway between said cathode surfaces, and means for producing potential gradients along said cathodes and said anode.

2. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, opposed secondarily emissive cathode surfaces, one of said surfaces being positioned to intercept said electron stream, a perforate anode positioned parallel to and midway between said cathode surfaces, means for setting up a positive potential on said anode relative to said cathode surfaces, and means for producing potential gradients along said cathodes and said anode.

3. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, opposed secondarily emissive cathode surfaces, one of said surfaces being positioned to intercept said electron stream, a perforate anode positioned parallel to and midway between said cathode surfaces, means for setting up a positive potential on said anode relative to said cathode surfaces, and means for producing equal potential gradients along said cathodes and said anode.

4. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, opposed secondarily emissive cathode surfaces, one of said surfaces being positioned to intercept said electron stream, a perforate anode positioned parallel to and midway between said cathode surfaces, means for setting up a positive potential on said anode relative to said cathode surfaces, means for producing equal potential gradients along said cathodes and said anode, and means for maintaining opposite points on said cathode surfaces at equal potentials.

5. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, opposed secondarily emissive cathode surfaces, one of said surfaces

being positioned to intercept said electron stream, a perforate anode positioned parallel to and midway between said cathode surfaces, means for charging said cathodes positively, means for setting up a positive potential on said anode relative to said cathode surfaces, means for producing equal potential gradients along said cathodes and said anode, and means for maintaining opposite points on said cathode surfaces at equal potentials.

6. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, parallel cathode plates formed of high-resistance material, a thin layer of discrete particles of secondarily emissive material having a low work function disposed upon the opposed surfaces of said plates, one of said surfaces being positioned to intercept said electron stream, a perforate anode positioned parallel to and midway between said cathode surfaces, means for setting up a positive potential on said anode relative to said cathode surfaces, and means for producing potential gradients along said cathodes and said anode.

7. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, parallel cathode plates formed of high-resistance material, a thin discontinuous layer of high secondary emissivity deposited upon the opposed surfaces of said plates, one of said surfaces being positioned to intercept said electron stream, a perforate anode positioned parallel to and midway between said cathode surfaces, means for setting up a positive potential on said anode relative to said cathode surfaces, and means for producing equal potential gradients along said cathodes and said anode.

8. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, parallel cathode plates formed of high-resistance material, a thin discontinuous layer of high secondary emissivity deposited upon the opposed surfaces of said plates, one of said surfaces being positioned to intercept said electron stream, a perforate anode positioned parallel to and midway between said cathode surfaces, said anode comprising a pair of high resistance rods connected by a plurality of conductors, means for setting up a positive potential on said anode relative to said cathode surfaces, and means for producing equal potential gradients along said cathodes and said anode.

9. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, parallel cathode plates formed of high-resistance material, a thin discontinuous layer of high secondary emissivity deposited upon the opposed surfaces of said plates, the end of one of said plates being positioned to intercept said electron stream, an anode, positioned midway between said cathode plates, comprising a pair of high-resistance rods connected by a plurality of V-shaped conductors, the apices of said conductors being directed toward the end of said cathode plates at which

said modulated beam is intercepted, means for setting up a positive potential on said anode relative to said cathode surfaces, and means for producing equal potential gradients along said cathodes and said anode.

10. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, opposed secondarily emissive cathode surfaces, one of said surfaces being positioned to intercept said electron stream, a perforate anode positioned parallel to and midway between said cathode surfaces, means for producing potential gradients along said cathodes and said anode, means for diverting electrons from between said cathode surfaces at the most positively charged portions thereof, and means for collecting said diverted electrons.

11. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, parallel cathode plates formed of high-resistance material, a thin discontinuous layer of high secondary emissivity deposited upon the opposed surfaces of said plates, an anode comprising a pair of high-resistance rods connected by a plurality of conductors, an anode ring formed normal to and integral with said rods, a plurality of conductors positioned across said ring, a collecting plate disposed parallel to said anode ring, and separate leads from said electrodes sealed through said envelope.

12. An electron multiplier comprising an evacuated envelope having therein means for producing an electron stream, parallel cathode plates formed of high-resistance material, a thin discontinuous layer of high secondary emissivity deposited upon the opposed surfaces of said plates, one of said surfaces being positioned to intercept said electron stream, a perforate anode positioned parallel to and midway between said cathode surfaces, said anode comprising a pair of high-resistance rods connected by a plurality of V-shaped conductors having the apices thereof directed toward the point of interception of said modulated beam, said rods terminating at the ends opposite said beam interception point, in a rectangular rim formed homogeneously with said rods and normal thereto, a conducting grid disposed across said rim, a collecting plate positioned in registry with said rim, means for setting up a positive potential on said anode relative to said cathode surfaces, means for producing equal potential gradients along said cathodes and said anode, means for setting up a positive charge on said grid relative to the most positive of said V-shaped conductors, and means for charging said collecting plate positively with respect to said grid.

13. In an electron multiplier having an anode and secondarily emissive cathode surfaces arranged to be serially impacted, means for producing a unidirectional electron drift parallel to said cathode surfaces between successive cathode impacts, including means for setting up a potential gradient along said anode parallel to said cathode surfaces.

PHILO T. FARNSWORTH,
RICHARD L. SNYDER.

Nov. 18, 1941.

P. T. FARNSWORTH

2,263,032

COLD CATHODE ELECTRON DISCHARGE TUBE

Original Filed Nov. 4, 1936

2 Sheets-Sheet 1

Fig. 1.

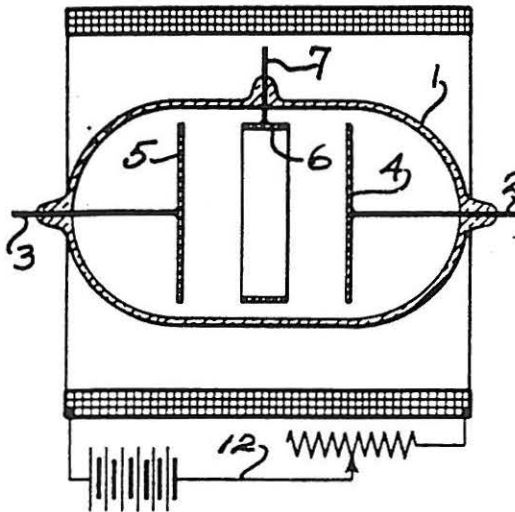


Fig. 2.

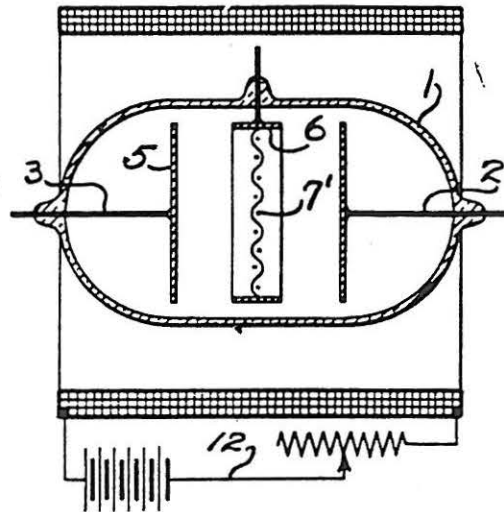


Fig. 3.

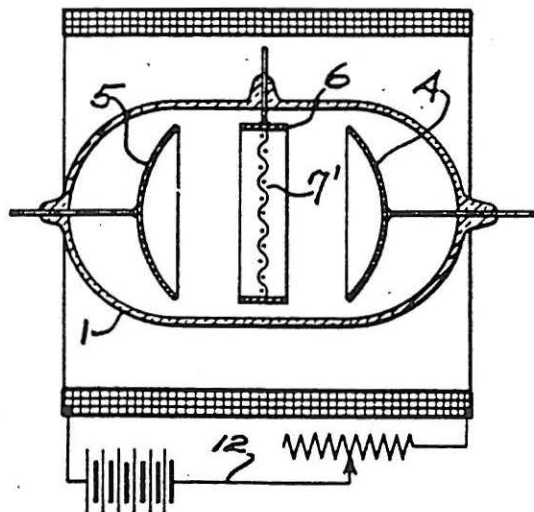
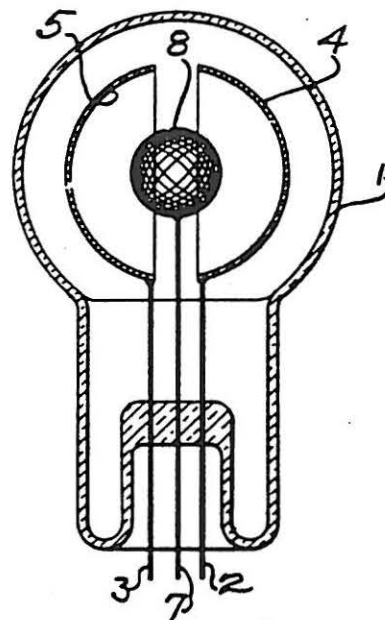


Fig. 4.



INVENTOR,

PHILO T. FARNSWORTH.

BY *Lippincott & Metcalf*
ATTORNEYS.

Nov. 18, 1941.

P. T. FARNSWORTH

2,263,032

COLD CATHODE ELECTRON DISCHARGE TUBE

Original Filed Nov. 4, 1936

2 Sheets-Sheet 2

Fig. 5.

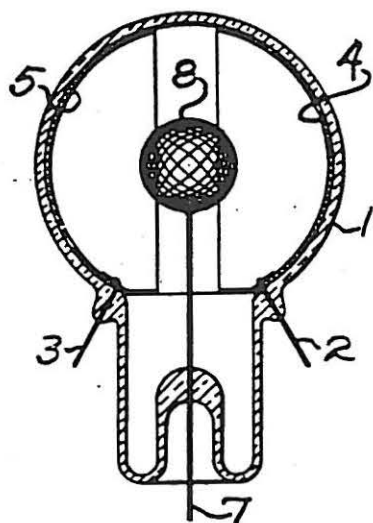


Fig. 6.

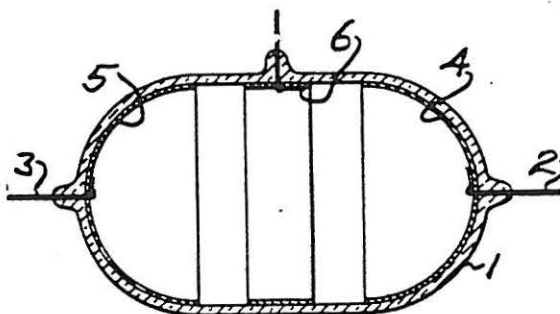
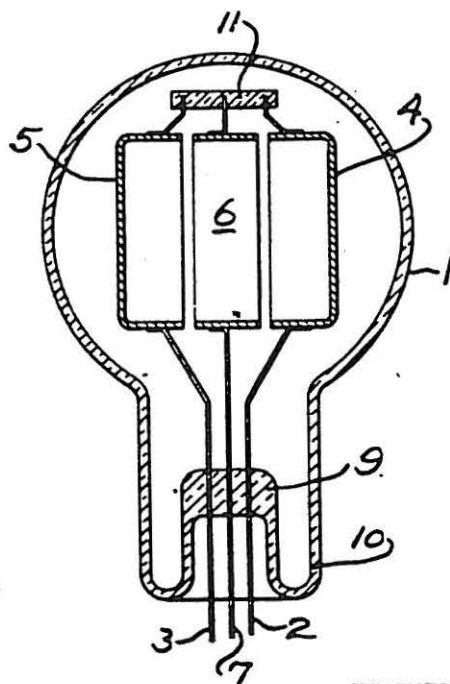


Fig. 7.



INVENTOR,

PHILO T. FARNSWORTH.

BY *Lippincott & Metcalf*
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,263,032

COLD CATHODE ELECTRON DISCHARGE
TUBE

Philo T. Farnsworth, Philadelphia, Pa., assignor
to Farnsworth Television & Radio Corporation,
New York, N. Y., a corporation of Delaware

Original application November 4, 1936, Serial No.
109,154. Divided and this application April 5,
1939, Serial No. 266,137

2 Claims. (Cl. 250-174)

My invention relates to an oscillation generator tube, and more particularly to such a tube utilizing cold cathodes, and is a division of my copending application, Serial No. 109,154, filed November 4, 1936, now United States Patent No. 2,184,910 issued December 26, 1939, which in turn is a continuation-in-part of the following patents: Oscillation generator, Patent No. 2,071,516, issued February 23, 1937; Electron multiplying device, Patent No. 2,071,515, issued February 23, 1937.

The two prior patents mentioned immediately above describe and claim a method of electron discharge tube operation and circuits used to practice the method, whereas the present application deals solely with the tube structure capable of producing oscillations, or electron multiplication, when utilized in accordance with the methods and in the circuits above referred to.

The primary object of this invention is to provide a new type of electron multiplier and oscillation generator tube.

Among the other objects are: To provide an electronic oscillator tube capable of converting direct current energy into oscillations at extremely high frequencies; to provide an electron multiplier tube having a minimum of electrodes; to provide an oscillation generator and electron multiplier utilizing cold cathodes; and to provide a new and improved electron discharge device having cold electrodes, and capable of electron multiplication and oscillation generation, when energized.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawings:

Figure 1 is a longitudinal sectional view of a simple form of my invention.

Figure 2 is a longitudinal sectional view of a multiplier tube having a screen anode.

Figure 3 is a longitudinal sectional view of a tube having concave cathodes.

Figure 4 is a longitudinal sectional view of a tube having electrodes describing concentric, spherical surfaces.

Figure 5 is a longitudinal sectional view of a tube similar to Figure 4, but having the cathodes deposited on the envelope.

Figure 6 is a longitudinal sectional view of a tube having concave cathodes deposited on the wall of the envelope.

Figure 7 is a longitudinal sectional view of a tube having concave electrodes providing electrostatic focusing.

In my prior patents mentioned above, I have described a method and system for electron multiplication and oscillation generation, utilizing, as an electron discharge device, a tube comprising three electrodes. Two of these electrodes are cathodes having opposed surfaces which are sensitized to emit secondary electrons at a ratio greater than unity, when impacted by traveling electrons, and the third electrode is an accelerating anode located between the cathodes. All of the tubes herein to be described operate in one mode, simply by connecting the two cathodes by a resonant circuit and supplying the anode with an accelerating potential. Certain of the tubes herein to be described are adapted for use in combination with a longitudinal magnetic field parallel to the electron paths, whereas others, as will be later described, utilize electrostatic focusing, automatically obtained by the shape of the electrodes.

Referring directly to the figures for a more detailed description of my improved tube structure, in various modification, and referring first to Figure 1, an envelope 1 is provided at each end with cathode lead wires 2 and 3, to which are attached a pair of facing cathodes 4 and 5. The opposed surfaces of cathodes 4 and 5 are treated so that they will emit secondary electrons at a ratio greater than unity upon electron impact therewith.

I find that one of the most satisfactory methods of sensitizing these surfaces is to make the cathodes from silver, or at least with a silver inner surface, oxidize the silver, and deposit caesium thereon until maximum thermionic emission is obtained. However, inasmuch as these devices operate by repeated electron impacts, it will be obvious that less sensitive surfaces may be used and an extra impact provided to bring the output of the tube to a high value. The cathodes, for example, may be made from a nickel-barium alloy, and be treated, during exhaust, to have opposed surfaces containing barium. Or, again, the entire material of the cathodes may be made of aluminum, for example, which will give emission at a ratio greater than unity when impacted by an electron traveling at velocities easily obtained. I do not, therefore, wish to be limited to any particular type of surface, but simply state that the surface should be capable of emitting secondary electrons at a ratio greater than

unity when impacted by electrons traveling at velocities obtainable in operation.

An anode is provided with the customary anode lead 7 passing through the envelope, and in its simplest form this anode is merely a ring 6 surrounding the space between the two cathodes in which the electrons oscillate. Inasmuch as the longitudinal magnetic field is used in conjunction with this type of tube, electrons from one cathode are accelerated to hit the other and opposing cathode, because the magnetic field prevents immediate collection by the surrounding anode. This field may be produced by solenoid circuit 12.

Figure 2 shows a modified anode structure where, in addition to the ring 6, there is a screen 7' dividing the space between the two cathodes.

Figure 3 shows another modification wherein the cathodes 4 and 5 are formed slightly concave to each other, and with this type of structure there will be some electrostatic focusing which may be supplemented by an additional magnetic field.

Figure 4 illustrates a modification in which the cathodes 4 and 5 are spherical surfaces approaching hemispheres, and the anode, in this case, is in the form of an apertured spherical electrode, preferably made by winding fine wires into a mesh sphere 8. In this case no magnetic field is needed, the electrostatic field of the electrodes themselves providing a focus such that electrons from one cathode will be sure to reach the opposing cathode, passing through the Faraday space formed by the sphere 8. It is preferable, of course, that the sphere 8 be concentric with the sphere described by the cathodes.

In Figure 5 I have shown a modification of the same structure as shown in Figure 4, except that the cathodes 4 and 5 here are deposited as a film upon the interior of the envelope itself. Otherwise, the structure is identical.

In Figure 6 I have shown a modification combining the envelope films of Figure 5 with the

type of anode utilized in Figure 1, except that here the anode ring is, itself, a film on the envelope wall.

In Figure 7 I have shown an electrode arrangement similar to that of Figure 6, except that in this case the cathodes 4 and 5, and the anode ring 6, form a cylindrical chamber, so that electrostatic focus is present to a high degree, and in this particular instance I have shown the electrodes mounted in the usual manner upon a reentrant stem 3 located in an envelope arm 10. The electrodes are maintained in position within the envelope by an insulating bead 11 to which all the electrodes are attached, as is well known in the art.

Other modifications of the three fundamental electrodes herein described and claimed will be immediately apparent to those skilled in the art, and shall be deemed to be included within the scope of the claims hereto appended.

I claim:

1. An electron discharge tube comprising an envelope, deposits of conducting material on opposed interior surfaces of said envelope, said deposits being spaced and electrically separate, said deposits also having substantially equal areas and being capable of producing secondary electrons at a ratio greater than unity upon electron impact therewith, and an additional spherical electrode surrounding a portion of the space between said deposits.

2. An electron discharge tube comprising an envelope, deposits of conducting material on opposed interior surfaces of said envelope, said deposits having substantially equal areas and being electrically separated but disposed with their edges closely adjacent to provide a substantially closed electron chamber, and an additional spherical electrode surrounding a portion of the space within said chamber.

PHILO T. FARNSWORTH.

Aug. 31, 1937.

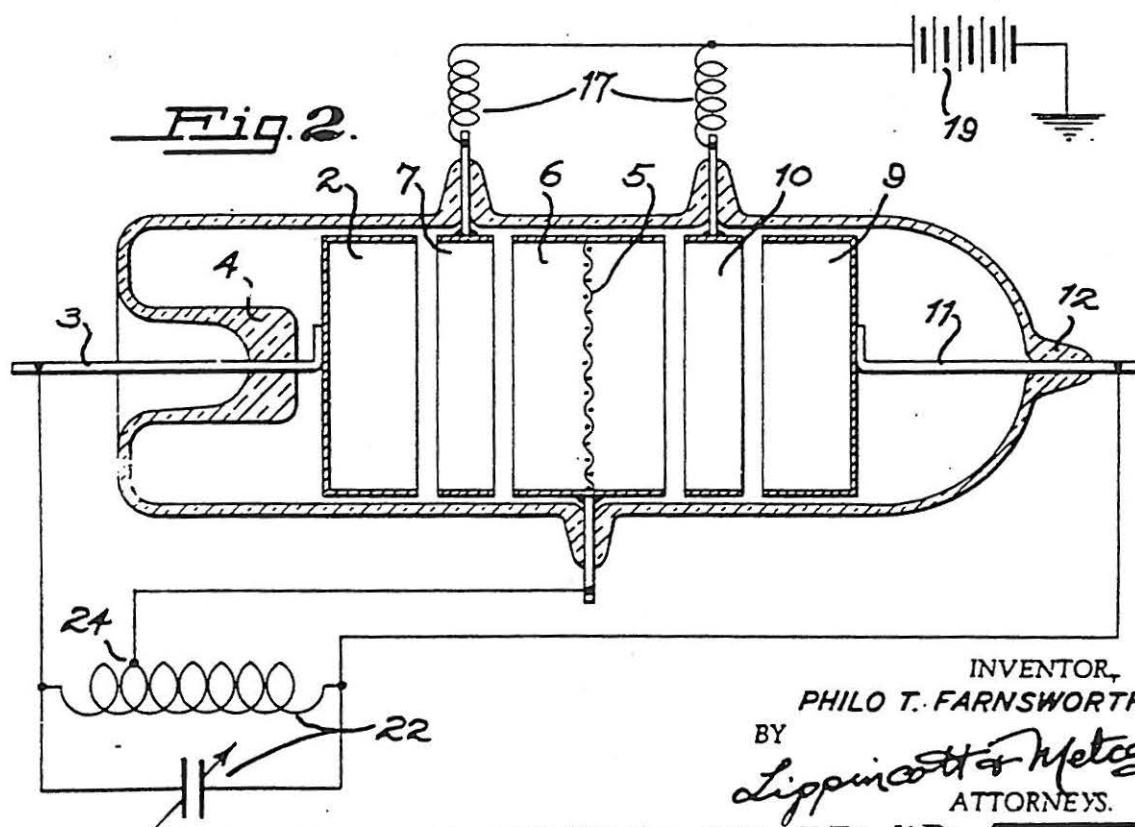
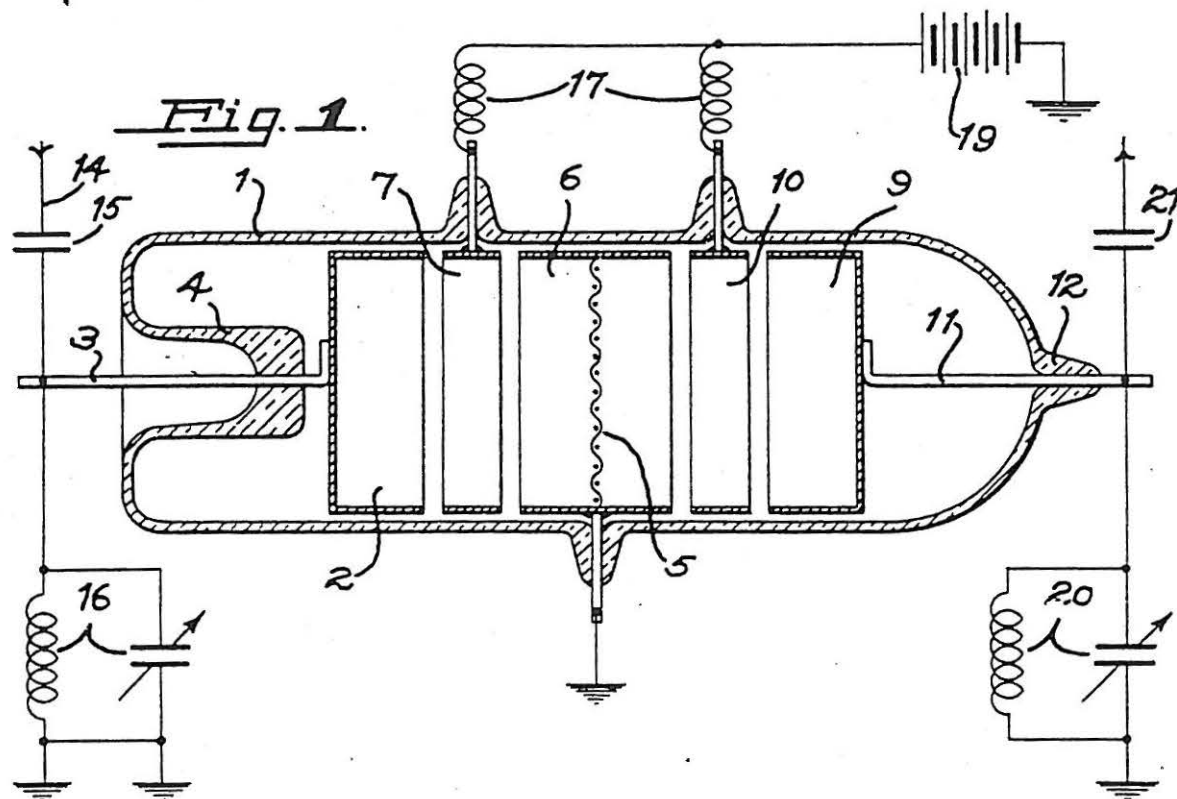
P. T. FARNSWORTH

2,091,439

MULTIPACTOR OSCILLATOR AND AMPLIFIER

Filed Feb. 24, 1936

2 Sheets-Sheet 1



INVENTOR,
PHILO T. FARNSWORTH.
BY
Lippincott & Metcalf
ATTORNEYS.

Aug. 31, 1937.

P. T. FARNSWORTH

2,091,439

MULTIPACTOR OSCILLATOR AND AMPLIFIER

Filed Feb. 24, 1936

2 Sheets-Sheet 2

Fig. 3.

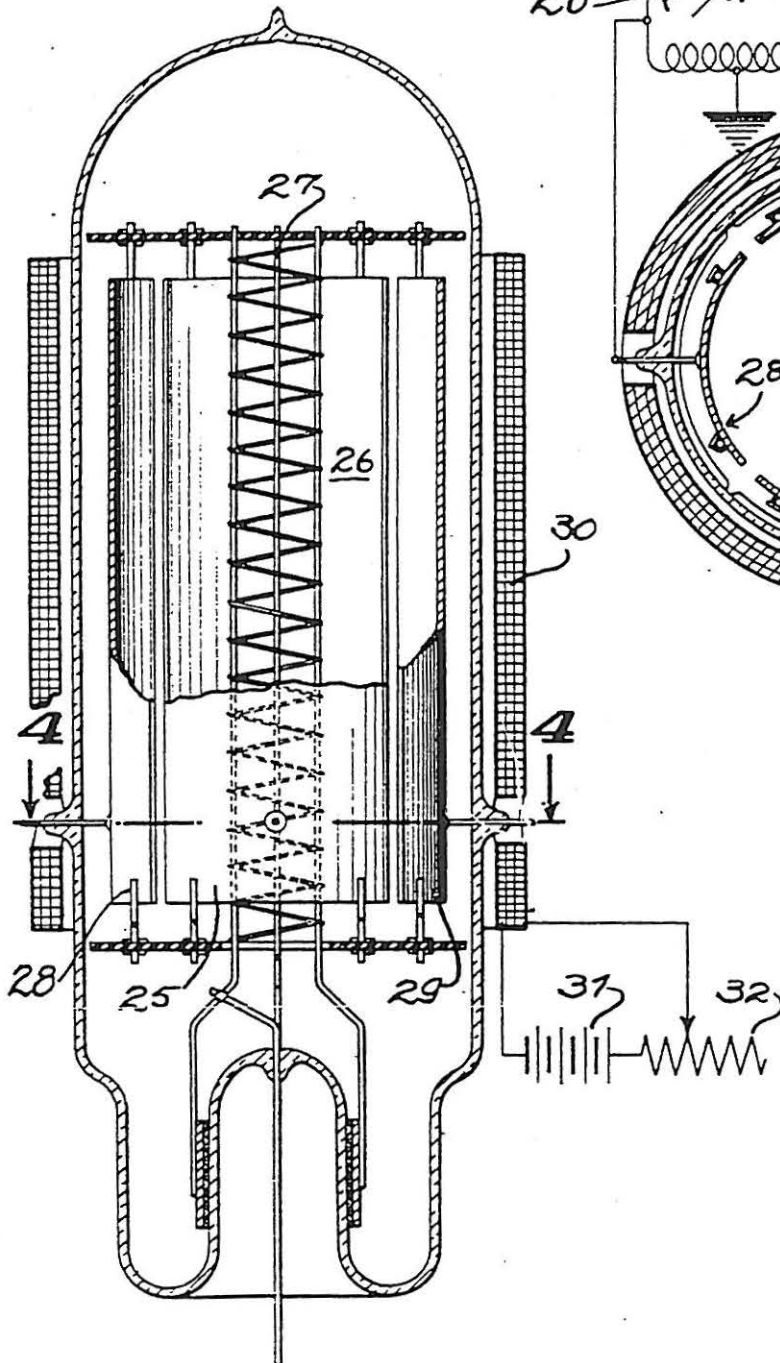
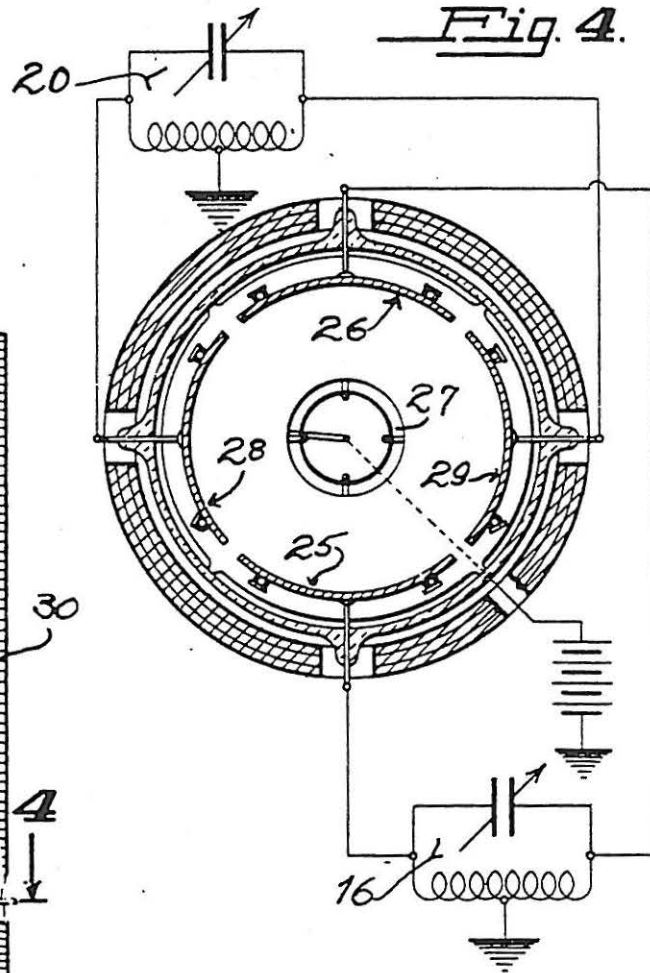


Fig. 4.



INVENTOR,

PHILO T. FARNSWORTH.

BY

Lippincott & Metcalf

UNITED STATES PATENT OFFICE

2,091,439

MULTIFACTOR OSCILLATOR AND AMPLIFIER

Philo T. Farnsworth, San Francisco, Calif., assignor to Farnsworth Television Incorporated, San Francisco, Calif., a corporation of California

Application February 24, 1936, Serial No. 65,465

19 Claims. (Cl. 250-27)

My invention relates to a multifactor oscillator and amplifier, and more particularly to a means and method of utilizing secondary emission for the production of electron multiplication.

This device operates broadly on the principles set forth in my prior application, Serial No. 692,585, filed October 7, 1933, for an "Electron multiplying device", and my prior application, Serial No. 706,965, filed January 17, 1934, for "Methods of electron multiplication".

The present application deals with a multifactor structure and method of operation where multiplication and collection are separated. The present device is, in common with the previous types of multifactors described by me, capable of producing amplification by electron multiplication, and by proper connection can be made to generate self-sustaining oscillations.

The primary object of this invention is to provide an improved means and method of abstracting power from a multifactor.

Other objects of my invention are: To provide an oscillator which will convert direct current energy at extremely high efficiency; to provide an oscillator of the high vacuum type which is not subject to the instability and inconsistencies which such phenomena introduce; to provide an oscillator and amplifier which has no heated electrode of the thermionic type, and which is correspondingly free of the difficulties and complications introduced by cathode heating surfaces; to provide an electron multiplier structure which is capable of generating self-sustained oscillations and which may be readily modulated; to provide a means and method of operating a combined multifactor and output structure having a common cathode; to provide a means and method of creating an oscillating cloud of electrons, and a means and method of absorbing power from this cloud; and to provide a simple and efficient multifactor tube.

My invention possesses numerous other objects and features of advantage, some of which, together with the foregoing, will be set forth in the following description of specific apparatus embodying and utilizing my novel method. It is therefore to be understood that my method is applicable to other apparatus, and that I do not limit myself, in any way, to the apparatus of the present application, as I may adopt various other apparatus embodiments, utilizing the method, within the scope of the appended claims.

Referring to the drawings:

Figure 1 is a diagram of the multifactor structure

together with a multiplier circuit, of a preferred form embodying my invention.

Figure 2 is a sectional view and circuit diagram embodying the tube shown in Figure 1, connected to be a self-oscillator.

Figure 3 is a view, partly in section and partly in elevation, of a multifactor structure utilizing four electrodes describing a cylinder around the central anode.

Figure 4 is a sectional view taken as indicated by the line 4-4 in Figure 3, together with an operating circuit attached thereto.

The operation of my electron multiplier or multifactor, as I desire to call my device, depends upon the transference of energy between an oscillating cloud of electrons and an oscillating E. M. F., usually established between a pair of opposed cathodes, treated or otherwise capable of producing secondary electrons at a ratio greater than unity when impacted by the oscillating electron cloud. If the energy transfer be from the oscillating E. M. F. to the electron cloud, the electrons strike the cathodes and give rise to the secondary electron multiplication phenomena. If, on the other hand, energy is absorbed from the oscillating cloud of electrons, the oscillating field between the cathodes is intensified, and the tube may sustain oscillations in the cathode circuit.

The present invention concerns a device where both of these phenomena are produced in differing but adjacent structures, electrons being passed, preferably through a common cathode, from one to the other.

Considering then, first, the condition where energy is transferred from the applied E. M. F. to the electron cloud, I find that when the period of the oscillating cloud of electrons is close to the resonant frequency of a circuit connecting the cathodes, that the tube acts as a highly efficient electron multiplier and, in many cases, will self-oscillate if energy is withdrawn from the multifactor structure and used, at least in part, to supply the oscillating E. M. F. applied to the cathodes, energy in this case, of course, being supplied from a D. C. source applied to an anode preferably positioned between the two cathodes.

When the period of the oscillating cloud of electrons is close to the resonant frequency of the circuit connecting the cathodes, it is found, experimentally, that the tube generates oscillations which are largely determined by the resonant frequency of the tuned circuit.

The foregoing E. M. F. initiator by the multi-

cation process, a cloud of electrons of the proper phase to absorb energy from the oscillations. This cloud of electrons would oscillate by itself at approximately the same frequency as that of the circuit, except for the fact that the R. F. itself accelerates the cloud and makes the trip across the tube less than a half period of the tuned circuit. The mere fact that the electrons are speeded up insures that they strike the cathode. The returning group of electrons also make the trip in slightly less than one-half cycle. The result is that the fastest electrons very rapidly get out of phase with the potential. The electron distribution in the cloud, however, reshapes itself at each half period because the rate of multiplication is large compared to the amount of phase shift.

The process results, however, in electrons being fed from the multiplication phase into the opposite phase wherein an electron is decelerated rather than accelerated by the R. F. Electrons in this phase do not strike the cathodes at all, but continue to oscillate between them, delivering energy to the external circuit as they are slowed down by the R. F. If the probability of an electron striking the anode is sufficiently small, equilibrium current results when the electrons are fed from the multiplying phase into the energy-giving phase at the same rate as the electrons are multiplied at the cathode, and electrons of the energy-giving phase never strike the cathode until they have given substantially all their energy to the oscillating circuit.

I may desire, however, as in the present case, not to abstract power directly from the multiplier structure, but to utilize directly a portion of the oscillating cloud of electrons in another structure closely associated with the first, and withdraw the multiplied output from the second structure.

My invention may be more fully understood by direct reference to the drawings, which show an improved type of multiplier structure connected, in Figure 1, as a direct electron multiplier.

The tube itself comprises a conventional type of multiplier, as hitherto described and claimed by me in the applications referred to above, comprising a pair of opposed cathodes, one of which, preferably the end electrode in an envelope 1, is in the form of a cup-shaped cathode 2, the interior of the cup facing the remainder of the structure.

The cup-shaped cathode 2 may be mounted in any convenient manner, such as on a lead 3 passing through a reentrant stem 4 in the end of the tube.

The opposing cathode may conveniently be located at approximately the midpoint of the tube, and comprises a screen cathode 5 extending across the tube and preferably positioned within a cathode cylinder 6.

Between the two cathodes is positioned a multiplier anode 7, preferably in the form of a cylinder whose walls are in the same projected surface as determined by the walls of the cup 2 and the cylinder 6.

The interior of the cathode cup 2 and the surface of the cathode screen 5 are preferably sensitized so that they will emit secondaries at a ratio greater than unity, when impacted, and this sensitization, which is performed in order that the highest possible ratio may be obtained, may be accomplished by forming the cathodes of silver, oxidizing the silver, and depositing caesium thereon, for example. Such a surface makes a

very efficient secondary emissive surface, with ratios as high as one primary to six secondaries, when impacted at the proper velocity, but I do not wish to be limited to such a formed surface as even untreated nickel has been found to have an emission ratio greater than unity; and any surface, formed or unformed, having such a ratio will be satisfactory, although, of course, multiplication can be accomplished with a lesser number of impacts with the materials having higher ratios.

At the opposite end of the envelope 1 is positioned what may be called a collector cathode cup 9. This cup may be identical in form and shape with the multiplier cathode 2, and between the collector cathode cup 9 and the central cathode cylinder 6 is positioned a second anode 10, identical with the first anode 7.

I prefer to position all five electrodes so that they shall be symmetrical, with the spacing between cathodes 2 and 5 equal to the spacing between cathodes 5 and 9.

Collector cathode 9 is supported on a lead 11 passing through a seal 12 in the end of the tube. Collector cathode 9, however, differs from multiplier cathode 2 in that its inner surface is preferably of a nature that it will not emit secondaries, at least secondary emission will be reduced to a minimum; and I have found that a carbonized nickel surface in this position will prevent, to a large extent, secondary emission.

After the electrodes have been assembled as described, the tube is, of course, baked out, degassed, evacuated, and the surfaces formed on cathodes 2 and 5.

For multiplication, the tube is connected as shown in Figure 1. On the multiplier end radio frequency is fed into the input connection 14 through a blocking condenser 15, to cathode 2 through lead 3, and cathode 2 is connected through a tunable resonant circuit 16 to the screen cathode 5 through suitable ground connections. Anodes 7 and 10 are connected together through separate radio frequency chokes 17 to a D. C. anode source 19, the opposite end of which is also grounded, the positive end of this source being connected to the anodes.

The collector cathode 9 is connected through an output resonant circuit 20 to ground, and the output may be taken from this cathode through blocking condenser 21. All that is necessary to set the tube into oscillation is to energize the anodes 7 and 10, as there will be, in the space between cathodes 2 and 5, a sufficient number of free electrons which are accelerated toward one or both of the cathodes by the potential of the anode, to strike thereon and cause the initiation of secondary emission.

If, then, a radio frequency is applied between the cathodes 2 and 5 and controlled by means of the tuned circuit 16, and the time of flight of the electrons between cathodes 2 and 5 is adjusted by means of placing upon the anode 7 the proper potential so that the time of flight corresponds to the period of the input, oscillations of the electrons between the two cathodes will occur and repeated impacts with the cathodes will take place with the release of secondary electrons at each impact.

Inasmuch as the field between the cathodes is so arranged either by the construction of the cathodes, as shown, or by an external electric field, as has been pointed out in my prior cited applications, certain definite members of travel

occurs, and a definite multiplication factor will be reached before equilibrium current is arrived at in the tube. Thus, there will occur within the multiplier end of the tube, electron multiplication; and I prefer, with this type of tube, to so adjust the constants on the two cathodes and the anode of the multiplier structure, that a maximum equilibrium current is reached.

The structure just described, however, differs from previous multipactor structures in that the central cathode 5 is apertured. This means that at each time the electron cloud reaches the plane of cathode 5, a certain number of electrons impact and create secondaries which are used to continue the multiplication process, but others of the electrons pass directly through the aperture in cathode 5 and enter the output structure comprising cathode 5, anode 10 and cathode 9.

In this structure, however, conditions are different. The output cathode 9 has been treated to prevent secondary emission, and if cathode 9 is connected to cathode 5 through a tuned circuit 20, the electrons passing through the central cathode 5 will oscillate back and forth between cathodes 9 and 5, and energy will be absorbed from them as they oscillate between cathodes 9 and 5; in other words, in the output structure, energy is being absorbed from the electrons.

The advantage gained in taking energy out of the tube in this manner is that phase shift of the oscillating electrons in the output structure is unimportant. In other words, any electrons in the output portion of the tube which get out of phase, and therefore are in a position to absorb energy from the oscillations, strike the cathodes and are absorbed by them, and as the potential on the anodes in each portion of the tube can be adjusted so that the electron oscillation frequency coincides with that of the tuned circuits and with the E. M. F. to be amplified, both structures operate completely in phase.

It will be understood, of course, that the output structure does, in no sense, create electron multiplication; it is in effect a multiplier structure with the exception that the cathode 9 absorbs all electrons striking it, and will not release secondaries. In other words, by using symmetrical structure operating in phase, I have separated multiplication and output. I create the oscillation of the electron cloud and supply power to it, in one structure, with multiplication; and I absorb power from the cloud, without multiplication, in the other structure.

I have thus eliminated the necessity within the multiplier structure of developing a large out-of-phase component, in order that power be absorbed from the cloud. In other words, it is necessary, as above explained, in order to create an output from the ordinary multiplier, to absorb power from a component of the electron cloud which is out of phase with the multiplying cloud. In this case only enough power is absorbed to continue multiplication.

Such an arrangement leads to a high conversion efficiency, and also leads to a high efficiency self-oscillator. For example, I have shown a circuit in Figure 2 where the output cathode 9 is coupled to the input cathode 2 through a common tuned circuit 22, an intermediate tap 24 being taken from the inductance of the tuned circuit to the central apertured cathode 5. Such a connection causes self-oscillation of the multiplier structure comprising cathodes 2 and 5 and

the output structure comprising cathodes 5 and 9 together with anode 10. This power is fed back to the input structure, and thus the E. M. F. is regeneratively amplified and an extremely efficient oscillator results.

Another structural embodiment utilizing my method of electron collection is shown in Figures 3 and 4. In this tube, opposed multiplying cathodes 25 and 26 are connected through the tunable resonant circuit 15. Cathodes 25 and 26 are sensitized, as were cathodes 2 and 5, for secondary emission, and in this case the anode is a central spiral 27.

Output cathodes 28 and 29 are also positioned in opposed relation, the four cathodes 25, 26, 28 and 29 being positioned to form a cylinder, each cathode, however, being electrically separated, and output cathodes 28 and 29 are also connected by tunable resonant circuit 20. Output cathodes do not emit secondaries and may be of carbonized nickel, as explained above for output cathode 9. The anode 27 is supplied with a positive potential from the anode battery 19.

I also prefer to provide, preferably by means of a focusing coil 30 energized by focusing source 31 under the control of a resistor 32, a feeble magnetic field in the tube with the lines of force axial, so that there will be a progression of the electron oscillation paths in the direction from multiplier cathodes to output cathodes. For example, when radio frequency is applied between the multiplier cathodes 25 and 26, either from a driver or by causing the two multiplying cathodes to become a self-oscillatory structure, the electrons of the proper phase for multiplication tend to oscillate so that they are traveling along the center line connecting the multiplying cathodes, and the electrons oscillating in the phase to give up their energy to the output circuit 20 tend to swing around at right angles to the multiplier cathodes. The application of the magnetic field effectively prevents the output electrons from swinging around, so that they are absorbing power. There is therefore, due to this field, a continuous drift of multiplying electrons over to the output cathodes 28 and 29, where they are collected after giving up their energy to the output circuit.

The main advantage of this type of structure over the structure heretofore described is that all of the current built up by multiplication is eventually converted into oscillating power, thus resulting in a very high efficiency.

Other circuits utilizing the means and method herein described will readily suggest themselves to those skilled in the art, the circuits shown being in the nature of examples only.

I claim:

1. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, means for diverting a portion of said cloud into a space apart from that bounded by said surfaces, and means for absorbing power from said diverted portion within said space.

2. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, one of said sur-

cloud to pass therethrough at the time of each impact, and means for absorbing power from the electrons passing through said apertures.

3. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, means for dividing said cloud at the plane of one of said surfaces, means for abstracting one of the divided portions from the space bounded by said surfaces, and means for absorbing power from the abstracted portion.

4. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, means for dividing said cloud at the plane of one of said surfaces means for abstracting one of the divided portions from the space bounded by said surfaces, means for absorbing power from the abstracted portion, and a work circuit for utilizing the power obtained.

5. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, means for dividing said cloud at the plane of one of said surfaces, means for abstracting one of the divided portions from the space bounded by said surfaces, means for absorbing power from the abstracted portion, a work circuit for utilizing the power obtained, and means for feeding energy from said work circuit into said oscillating cloud.

6. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, means for dividing said cloud at the plane of one of said surfaces, means for abstracting one of the divided portions from the space bounded by said surfaces, means for absorbing power from the abstracted portion, a work circuit for utilizing the power obtained, and means for utilizing a portion of the energy in said work circuit to cause continued oscillation of said cloud.

7. An electron multiplier comprising a pair of opposed surfaces capable of emitting secondary electrons at a ratio greater than unity when impacted, means for causing an electron cloud to oscillate between said surfaces to create repeated multiplying impacts therewith, means for dividing said cloud at the plane of one of said surfaces, means for abstracting one of the divided portions from the space bounded by said surfaces, means for absorbing power from the abstracted portion, a work circuit for utilizing the power obtained, and means for feeding back a portion of the energy in said work circuit into said oscillating cloud in the proper phase to continue the oscillation thereof.

8. In an electron multiplier wherein electrons are directed against a cathode surface to produce secondary emission therefrom, the method of power production comprising oscillating electrons against and away from said surface to produce an electron cloud augmented by secondary

from the cloud through apertures in said surface a definite proportion of the electrons therein, and absorbing the energy from the abstracted electrons.

9. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises feeding energy to said cloud and abstracting energy from said cloud within different spatial boundaries.

10. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises dividing said cloud at each impact feeding energy to one portion of said cloud to continue multiplication and abstracting useful energy from the other portion.

11. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises absorbing energy from said cloud, using said energy to sustain oscillation of said cloud until an equilibrium current is reached, abstracting electrons from said cloud, absorbing energy from said abstracted electrons, and adding said energy to that previously absorbed from said cloud to create regenerative oscillation thereof.

12. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises feeding energy to electrons traveling along one set of paths, changing the paths, and abstracting power from said electrons while in said changed paths.

13. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises feeding energy to electrons traveling along a diametrical path, shifting the electrons to a different diametrical path, and absorbing power from said electrons while in said different path.

14. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises feeding energy to electrons traveling along one set of paths, continuously diverting a portion of said cloud into a different set of paths, and absorbing energy from said electrons while in said different paths.

15. In an electron multiplier structure wherein an electron cloud is oscillated against and away from a surface to produce secondary emission therefrom upon impact therewith, the method of abstracting power from said cloud which comprises feeding energy to said cloud to maintain oscillation of the cloud across a space in a predetermined path, shifting the oscillation to a different predetermined path, and absorbing power from the electrons in the latter path.

16. In combination, a pair of opposed electrodes capable of emitting secondary electrons at

posed electrodes incapable of emitting secondary electrons, adjacent said first pair, means for feeding energy to electrons in the space between said first pair of electrodes to produce electron multiplication by cyclical impact therewith, and means associated with said second pair of electrodes for absorbing power from said electrons.

17. In combination, a pair of opposed electrodes capable of emitting secondary electrons at a ratio greater than unity, a second pair of opposed electrodes incapable of emitting secondary electrons, said pairs being alternately disposed to describe a symmetrical space, means for feeding energy to electrons in the space between said first pair of electrodes to produce electron multiplication by cyclical impact therewith, and means associated with second pair of electrodes for absorbing power from said electrons.

18. In combination, a pair of opposed electrodes capable of emitting secondary electrons at a ratio greater than unity, a second pair of opposed electrodes incapable of emitting secondary electrons, said pairs being alternately disposed to describe a cylindrical space, means for

causing electron oscillation between said first pair of electrodes to cause secondary emission therefrom, means for rotating the oscillation path around the axis of said cylinder, and means associated with said second pair of electrodes for absorbing power from electrons in said rotated path.

19. In combination, a pair of opposed electrodes capable of emitting secondary electrons at a ratio greater than unity, a second pair of opposed electrodes incapable of emitting secondary electrons, said pairs being alternately disposed to describe a cylindrical space, means for causing electron oscillation between said first pair of electrodes to cause secondary emission therefrom, means for rotating the oscillation path around the axis of said cylinder, means associated with said second pair of electrodes for absorbing power from electrons in said rotated path, and means for collecting electrons contacting said second pair of electrodes due to said rotation.

PHILO T. FARNSWORTH.

DISCLAIMER

2,091,439.—*Philo T. Farnsworth*, San Francisco, Calif. MULTIPACTOR OSCILLATOR AND AMPLIFIER. Patent dated August 31, 1937. Disclaimer filed January 5, 1942, by the assignee, *Farnsworth Television & Radio Corporation*.

Hereby enters this disclaimer to claims 1, 3, 4, 8, 9, 10, 12, 14, 15, and 16 in said specification.

[Official Gazette January 27, 1942.]

CERTIFICATE OF CORRECTION.

Patent No. 2,091,439.

August 31, 1937.

PHILO T. FARNSWORTH.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 74, for the word "members" read numbers; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 4th day of October, A. D. 1938.

Henry Van Arsdale

Dec. 26, 1939.

P. T. FARNSWORTH

2,184,910

COLD CATHODE ELECTRON DISCHARGE TUBE

Filed Nov. 4, 1936

2 Sheets-Sheet 1

Fig. 1.

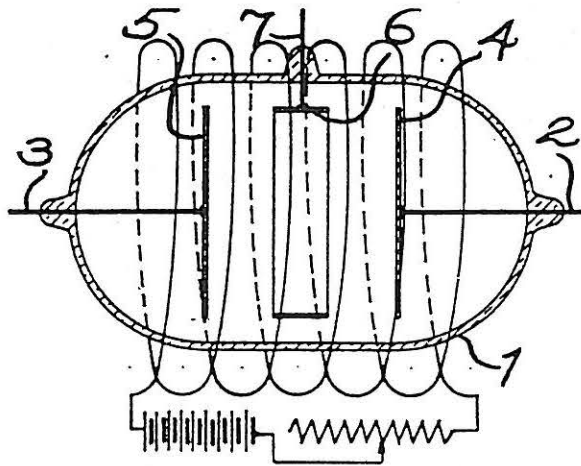


Fig. 2.

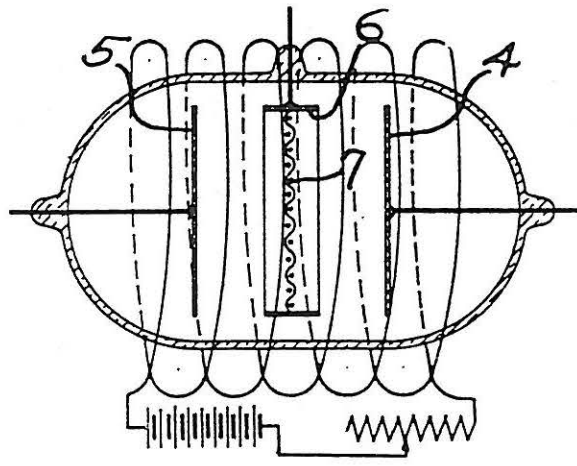


Fig. 3.

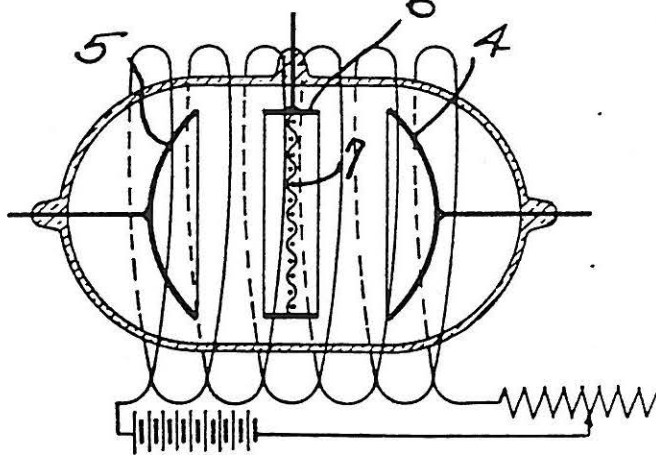


Fig. 5.

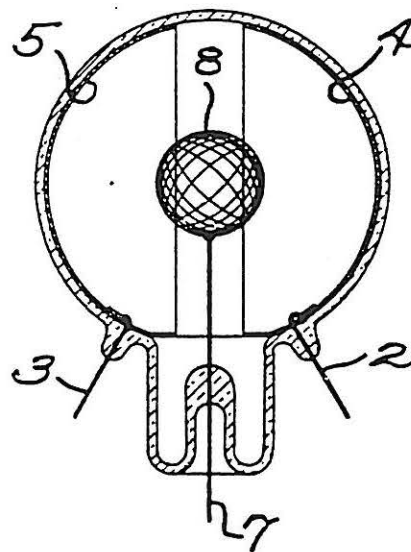
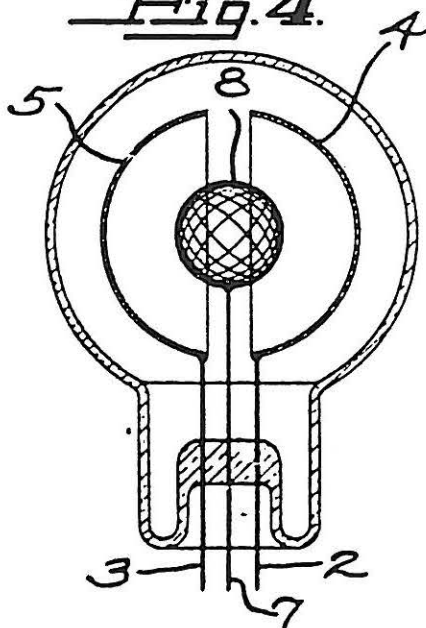


Fig. 4.



INVENTOR,
PHILO T. FARNSWORTH.
BY
Lippincott & Metcalf
ATTORNEYS.

Dec. 26, 1939.

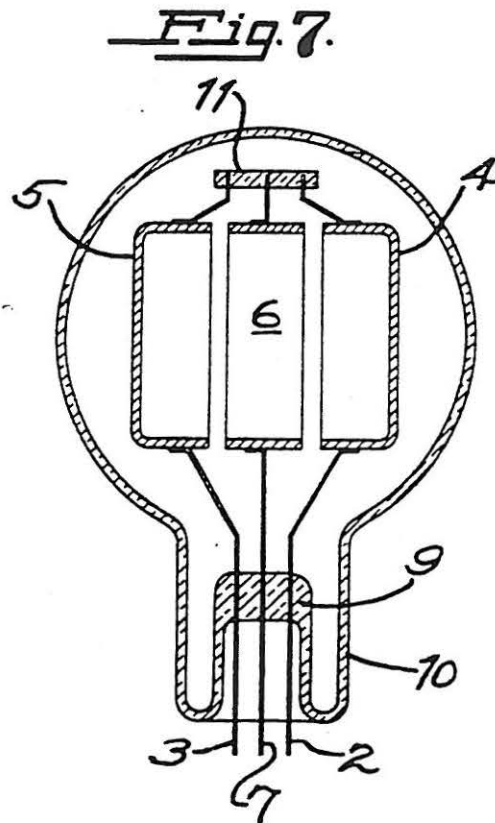
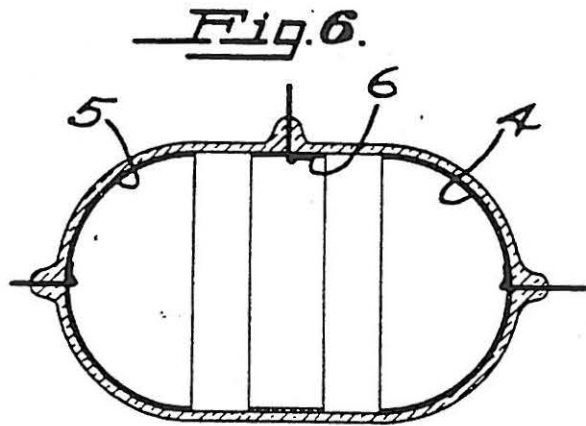
P. T. FARNSWORTH

2,184,910

COLD CATHODE ELECTRON DISCHARGE TUBE

Filed Nov. 4, 1936

2 Sheets-Sheet 2



INVENTOR,

PHILO T. FARNSWORTH.

BY

Lippincott & Metcalf

ATTORNEYS.

UNITED STATES PATENT OFFICE

2,184,910

COLD CATHODE ELECTRON DISCHARGE
TUBE

Philo T. Farnsworth, Springfield Township, Montgomery County, Pa., assignor, by mesne assignments, to Farnsworth Television & Radio Corporation, Dover, Del., a corporation of Delaware

Application November 4, 1936, Serial No. 109,154

3 Claims. (Cl. 250—174)

My invention relates to an oscillation generator tube, and more particularly to such a tube utilizing cold cathodes.

The present application is a continuation in part of my prior application, Serial No. 733,837, filed July 5, 1934, for an "Oscillation generator", issued February 23, 1937, as United States Patent No. 2,071,516 and is also a continuation in part of my prior and copending application, Serial No. 692,585, filed October 7, 1933, for an "Electron multiplying device", issued February 23, 1937, as United States Patent No. 2,071,515.

The two prior applications mentioned above describe and claim a method of electron discharge tube operation and circuits used to practice the method, whereas the present application deals solely with the tube structure capable of producing oscillations, or electron multiplication, when utilized in accordance with the methods and in the circuits above referred to.

The primary object of this invention is to provide a new type of electron multiplier and oscillation generator tube.

Among the other objects are: To provide an electronic oscillator tube capable of converting direct current energy at extremely high frequencies; to provide an electron multiplier tube having a minimum of electrodes; to provide an oscillation generator and electron multiplier utilizing cold cathodes; and to provide a new and improved electron discharge device having cold electrodes, and capable of electron multiplication and oscillation generation, when energized.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawings:

Figure 1 is a longitudinal sectional view of a simple form of my invention.

Figure 2 is a longitudinal sectional view of a multiplier tube having a screen anode.

Figure 3 is a longitudinal sectional view of a tube having concave cathodes.

Figure 4 is a longitudinal sectional view of a tube having electrodes describing concentric, spherical surfaces.

Figure 5 is a longitudinal sectional view of a tube similar to Figure 4, but having the cathodes deposited on the envelope.

Figure 6 is a longitudinal sectional view of a tube having concave cathodes deposited on the

Figure 7 is a longitudinal sectional view of a tube having concave electrodes providing electrostatic focusing.

In my prior applications above referred to, I have described a method and system for electron multiplication and oscillation generation, utilizing, as an electron discharge device, a tube comprising three electrodes. Two of these electrodes are cathodes having opposed surfaces which are sensitized to emit secondary electrons at a ratio greater than unity, when impacted by traveling electrons, and the third electrode is an accelerating anode located between the cathodes. All of the tubes herein to be described operate in one mode, simply by connecting the two cathodes by a resonant circuit and supplying the anode with an accelerating potential. Certain of the tubes herein to be described are adapted for use in combination with a longitudinal magnetic field parallel to the electron paths, whereas others, as will be later described, utilize electrostatic focusing, automatically obtained by the shape of the electrodes.

Referring directly to the figures for a more detailed description of my improved tube structure, in various modifications, and referring first to Figure 1, an envelope 1 is provided at each end with cathode lead wires 2 and 3, to which are attached a pair of facing cathodes 4 and 5. The opposed surfaces of cathodes 4 and 5 are treated so that they will emit secondary electrons at a ratio greater than unity upon electron impact therewith.

I find that one of the most satisfactory methods of sensitizing these surfaces is to make the cathodes from silver, or at least with a silver inner surface, oxidize the silver, and deposit caesium thereon until maximum thermionic emission is obtained. However, inasmuch as these devices operate by repeated electron impacts, it will be obvious that less sensitive surfaces may be used and an extra impact be provided to bring the output of the tube to a high value. The cathodes, for example, may be made from a nickel-barium alloy, and be treated, during exhaust, to have opposed surfaces containing barium. Or, again, the entire material of the cathodes may be made of aluminum, for example, which will give emission at a ratio greater than unity when impacted by an electron traveling at velocities easily obtained. I do not, therefore, wish to be limited to any particular type of surface, but simply state that the surface should be capable of emitting secondary electrons at a

electron traveling at velocities obtainable in operation.

An anode is provided with the customary anode lead 7 passing through the envelope, and in its most simple form this anode is merely a ring 6 surrounding the space between the two cathodes in which the electrons oscillate. Inasmuch as the longitudinal magnetic field is used in conjunction with this type of tube, electrons from one cathode are accelerated to hit the other and opposing cathode, because the magnetic field prevents immediate collection by the surrounding anode.

Figure 2 shows a modified anode structure where, in addition to the ring 6, there is a screen 7 dividing the space between the two cathodes.

Figure 3 shows another modification wherein the cathodes 4 and 5 are formed slightly concave to each other, and with this type of structure there will be some electrostatic focusing which may be supplemented by an additional magnetic field.

Figure 4 illustrates a modification in which the cathodes 4 and 5 are spherical surfaces approaching hemispheres, and the anode, in this case, is in the form of an apertured spherical electrode, preferably made by winding fine wires into a mesh sphere 8. In this case no magnetic field is needed, the electrostatic field of the electrodes themselves providing a focus such that electrons from one cathode will be sure to reach the opposing cathode, passing through the Faraday space formed by the sphere 8. It is preferable, of course, that the sphere 8 be concentric with the sphere described by the cathodes.

In Figure 5 I have shown a modification of the same structure as shown in Figure 4, except that the cathodes 4 and 5 here are deposited as a film upon the interior of the envelope itself. Otherwise, the structure is identical.

In Figure 6 I have shown a modification combining the envelope films of Figure 5 with the type of anode utilized in Figure 1, except that here the anode ring is, itself, a film on the envelope wall.

In Figure 7 I have shown an electrode arrangement similar to that of Figure 6, except that in this case the cathodes 4 and 5, and the anode ring 6, form a cylindrical chamber, so that electrostatic focus is present to a high degree, and in this particular instance I have shown the electrodes mounted in the usual manner upon

a reentrant stem 9 located in an envelope arm 10. The electrodes are maintained in position within the envelope by an insulating bead 11 to which all the electrodes are attached, as is well known in the art.

Other modifications of the three fundamental electrodes herein described and claimed will be immediately apparent to those skilled in the art, and shall be deemed to be included within the scope of the claims herewith appended.

I claim:

1. An electron discharge device comprising an envelope containing a pair of cup-shaped cathodes having their rims substantially parallel and their concavities facing each other, the interior surfaces of said cathodes being capable of producing secondary electrons at a ratio greater than unity upon electron impact therewith, and a ring-shaped anode positioned between said cathodes, the edges of said cathodes being closely adjacent all of the edges of said ring whereby a substantially closed electron chamber is formed.

2. An electron discharge device comprising an envelope containing a pair of cup-shaped cathodes having their rims substantially parallel and their concavities facing each other, the interior surfaces of said cathodes being capable of producing secondary electrons at a ratio greater than unity upon electron impact therewith, and a ring-shaped anode positioned between said cathodes and following the contour of a surface extended between said rims, the edges of said cathodes being closely adjacent all of the edges of said ring whereby a substantially closed electron chamber is formed.

3. An electrical discharge device comprising a non-conductive envelope containing a pair of cup-shaped cathodes having their rims substantially parallel and their concavities facing each other, the interior surfaces of said cathodes being capable of producing secondary electrons at a ratio greater than unity upon electron impact therewith, and a ring-shaped anode positioned between said cathodes, the edges of said cathodes being closely adjacent the edges of said ring-shaped anode whereby a substantially closed electron chamber is formed, said cathodes and said anode being electrically separate electrically conductive deposits on the inner wall of said envelope.

PHILO T. FARNSWORTH.

Feb. 23, 1937.

P. T. FARNSWORTH
OSCILLATION GENERATOR
Filed July 5, 1934

2,071,516

2 Sheets-Sheet 1

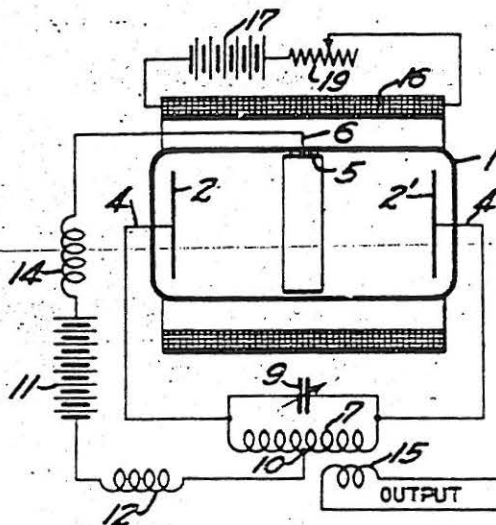


Fig. 1

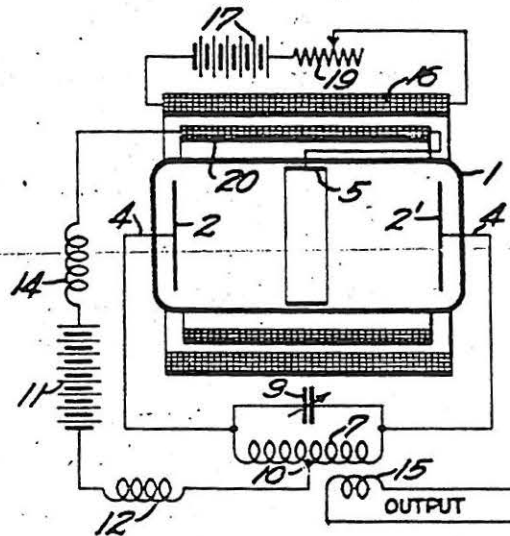


Fig. 2

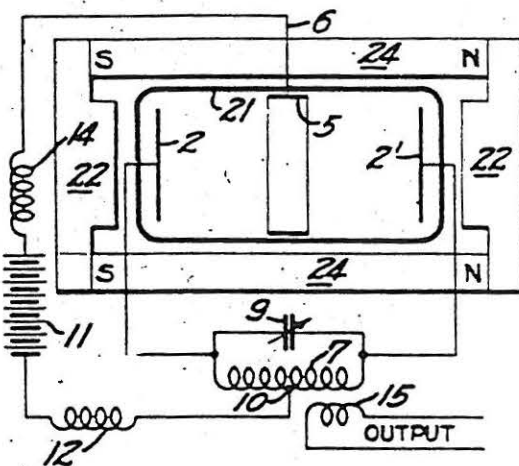


Fig. 3

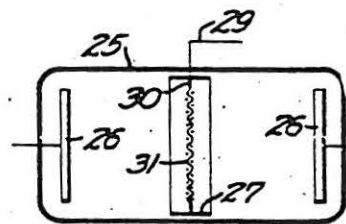


Fig. 4

INVENTOR.
PHILO T. FARNSWORTH
BY *Lippincott & Metcalf*
HIS ATTORNEYS.

Feb. 23, 1937.

P. T. FARNSWORTH

2,071,516

OSCILLATION GENERATOR

Filed July 5, 1934

2 Sheets-Sheet 2

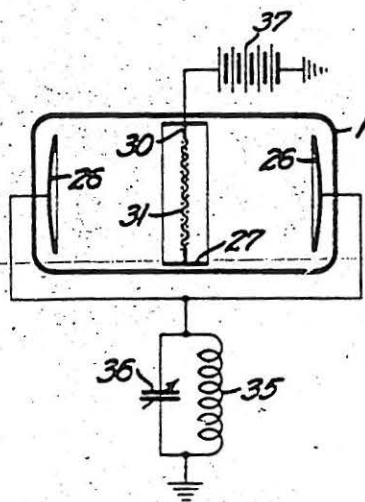


Fig. 5

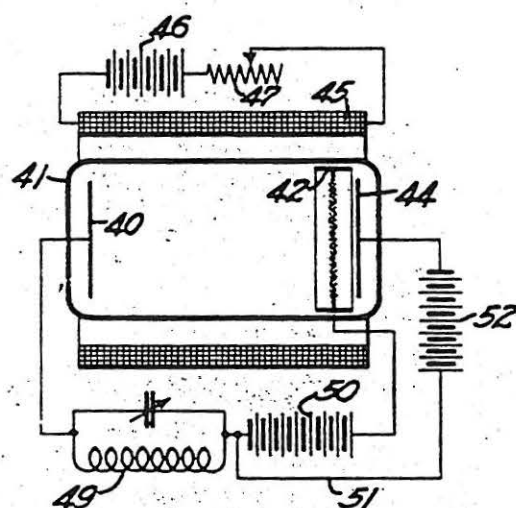


Fig. 6

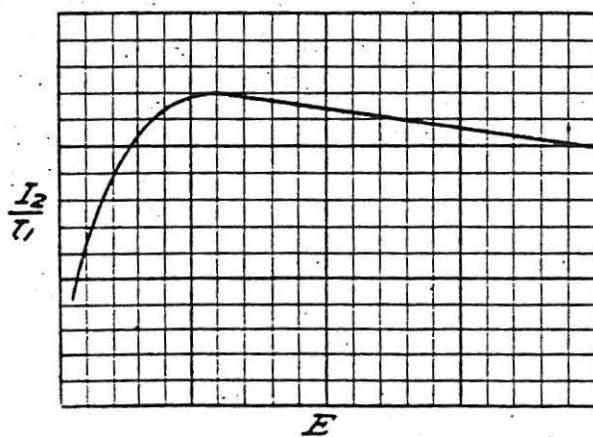


Fig. 7

INVENTOR.
PHILO T. FARNSWORTH
BY *Lippincott & Matcalf*
HIS ATTORNEYS.

UNITED STATES PATENT OFFICE

2,071,516

OSCILLATION GENERATOR

Philo T. Farnsworth, San Francisco, Calif., assignor to Farnsworth Television Incorporated, a corporation of California

Application July 5, 1934, Serial No. 733,837

27 Claims. (Cl. 250—36)

This invention relates to electronic oscillators, and particularly to oscillators wherein the electron flow is derived, substantially in its entirety, from so-called "secondary electrons" liberated from solid conductors by bombardment.

The primary object of this invention is to provide a new type of electronic oscillator. Among the other objects are: To provide an oscillator which will convert direct current energy at extremely high efficiencies; to provide an oscillator which is substantially free from frequency limitations, and is particularly adapted to the generation of oscillations at frequencies above 30 megacycles; to provide a type of oscillator which is equally well adapted for the generation of either very small or very large amounts of power; to provide an oscillator wherein the electrical circuits are symmetrical, so that the neutral point of the circuit may be grounded without introducing difficulties or complications; to provide an oscillator of the high vacuum type, which is independent of ionization phenomena and is not subject to the instabilities and inconsistencies which such phenomena introduce; to provide an oscillator which is easily "triggered off"; and to provide an oscillator having no heated electrode of the thermionic type, and which is correspondingly free of the difficulties and complications introduced by cathode heating circuits.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawings:

Figure 1 is a schematic diagram showing one form of the oscillator of my invention, including the oscillating tube and its associated circuits.

Figure 2 is a diagram showing a modification of the form of oscillator shown in Figure 1, wherein the amplitude of oscillation is self-limiting.

Figure 3 is a cross sectional view showing an oscillator tube positioned within a permanent magnet guiding-field structure.

Figure 4 is a cross sectional view of a modified form of the tube which will generate oscillations without the use of a guiding or focusing field.

Figure 5 is a circuit diagram illustrating a tube of the type shown in Figure 4 with a different type of oscillating circuit from that shown in Figure 1.

Figure 6 is a schematic diagram showing a modified form of my invention wherein an asymmetrical tube and circuit are employed.

Figure 7 is a graph showing the characteristic form of a secondary emission curve.

In my copending application, Serial Number 692,585, filed October 7, 1933, I have described an electron multiplying device wherein, by utilizing the phenomena of secondary electron emission, extremely small currents may be multiplied to give very large final outputs. The initial current necessary in this apparatus may be so small as to be immeasurable by any ordinary method, e. g., the photoelectric current emitted from nickel by light in the visible spectrum. I have there pointed out the regenerative nature of the multiplication, stating that by back coupling the output of this device into its input, self-sustaining oscillations can be produced. This application specifically relates to the production of such self-sustaining oscillations by the method therein indicated.

Considered in its broad aspect, the essential features of the invention comprise a pair of electrodes defining an electron path. A cloud of electrons oscillated along this path by potentials applied to the electrodes, and striking one of them, which may be termed cathode, with sufficient velocity to release secondary electrons at a ratio greater than unity as compared with the impacting primary electrons, causes a current flow from a d-c source of potential included in a circuit with the electrodes. A potential drop due to this current is applied in phase to apply the necessary impacting velocity to the oscillating cloud of electrons, and thus the oscillation becomes self-sustaining and relatively large amounts of oscillating power may be withdrawn from the circuit. The energy for maintaining the oscillation is, of course, derived from the d-c source, which must be sufficiently high in potential to release the secondary electrons at the required ratio.

For the oscillations to be self-starting as well as self-sustaining, the requirements are somewhat more rigorous. If an exciting oscillation of sufficiently high voltage be applied initially, there will be enough casual electrons present in the space between the electrodes to build up the secondary emission currents of the values required to produce the necessary voltage drop with almost any electrode material, provided the electrons are sufficiently accurately guided along their path so that there is little probability of their being collected before they strike the cathode. In order that the oscillations be self-starting, however, the work function of the cathode surface should be

as low as possible, and for this reason it is preferred to provide the cathodes with surfaces of photoelectric material, such as the alkali metals, potassium hydride, or the extremely sensitive caesium silver oxide surfaces which have proved the best of those that have yet been tried in the laboratory for this purpose. With such a surface it has been found that almost any shock to the circuit will start the operation, even under the most unfavorable conditions. After the device has been operating a time and the electrodes become warm, it becomes more difficult to prevent oscillations than it is to start them.

Considering the invention now in greater detail, Figure 1 shows a form of my invention which is one of the simplest and most readily constructed and operated. The vacuum tube which forms the heart of the apparatus is of the type described in my prior application above referred to, and comprises an evacuated envelope 1 of cylindrical form, having cathodes 2, 2' mounted in the opposite ends thereof. The cathodes are supported by lead wires 4, which are sealed through the walls of the envelope, and comprise discs of pure silver whose surfaces have been oxidized and coated with caesium in a manner well known for the formation of photoelectric cells. An anode 5, comprising a ring fitting snugly the walls of the tube is mounted midway between the two cathodes, connection being made to the anode through a lead 6 sealed through the wall of the tube.

Connected between the two cathodes is an oscillating circuit comprising an inductor 7 in parallel with a variable condenser 9. A central tap 10 on the inductor connects through a potential source 11 to the anode, preferably through radio frequency chokes 12 and 14, which, although not strictly necessary, improve the performance of the apparatus and increase its oscillating output. A secondary coil 15, coupled to the inductor 7 may be used to withdraw power from the circuit, this method of coupling being shown as typical of many well known methods of withdrawing energy from any oscillating circuit.

Surrounding the tube is a solenoid 16, which is supplied with direct current from a source 17, the current being accurately adjustable by means of the rheostat 19.

Consider the circuit in the non-oscillatory state, and that electrons are released from approximately the center of the cathode 2 with zero velocity. Such electrons would be accelerated toward the anode 5, and, in the absence of the focusing field due to the solenoid 16, would probably strike the anode and be removed from the inter-electrode space. If, however, the focusing coil be excited to the proper value, its field will guide the electrons past the anode to a point on the opposite cathode 2' corresponding to that on the cathode 2 from which they were originally liberated. During their flight they are accelerating up to the time they reach the median plane of the anode, while from this point on they are decelerated by the electrostatic field supplied by the source 11, and, under the conditions mentioned, will arrive at the opposite cathode with zero velocity, having occupied in flight a time determined by the potential of the source 11 and the distance between the two cathodes.

If the resonant circuit comprising coil 7 and variable condenser 9 be tuned to a frequency whose half period is approximately equal to the time of flight of the electrons, the original liberation of the electrons from the cathode 2 will cause a current to flow from the source through one-

half of the inductor 7 to the cathode 2. This provides a potential drop which appears on the two cathodes in such phase as to accelerate the flight of the electrons causing them to impact the second cathode 2' with a finite velocity. If this velocity be sufficient to release electrons from the second cathode at a ratio greater than unity, the difference between the number of impacting primary electrons and emitted secondary electrons forms a current which is supplied to the other branch of the inductor 7, causing a voltage drop in opposite phase, which accelerates the space current through the tube in the opposite direction. The secondary electrons emitted therefore impact the first cathode in increased numbers and with increased velocity, and the oscillation quickly builds up to a point where it is limited either by space charge effects within the tube, by loss of energy to the output circuit, or by some other extraneously introduced factor.

The factors which determine how readily such an oscillation will start are the dimensions of the tube, the voltage of the source 11, the focusing current, and the material of the cathode surface. The dimensions and the voltage determine the gradient between the two cathodes. The velocity with which any electron strikes the opposing cathode is determined almost entirely by the integrated effect of the oscillating potential during its time of flight. It will, therefore, have maximum velocity of impact if its entire flight is accomplished during one-half cycle of oscillating potential, i. e., during a portion of the cycle wherein the potential of the cathode from which it was emitted is always negative with respect to the opposed cathode. Whether this be also the condition for maximum emission upon impact, or not, depends upon the portion of the secondary emission curve upon which the tube is operating. The curves of nearly all materials are of substantially the shape shown in Figure 7, but the coordinate values vary greatly for different materials. If the voltages are such that impact occurs with a velocity corresponding to the ascending branch of the curve, an increase in velocity will result in a corresponding increase in number of secondary electrons emitted at each impact. If, however, the voltage corresponds to the crest of the curve there will be no increase in the number of secondaries per impact with increased voltage, while if the voltage increases to the point where the descending branch of the curve is in use, an increased potential will result in a decreased number of secondaries.

The effect of the focusing field upon the oscillation is dependent upon the number of electrons which it permits to be collected by the anode. When oscillations are first started all of the available electrons are necessary to create the new secondaries, and therefore, under starting conditions, the focus should be quite critically adjusted. When equilibrium is reached, however, it is obvious that all electrons in excess of the number of impacting primaries must be collected in each half cycle. With a very plentiful supply of primaries, and a high secondary-primary ratio, the focusing becomes very much less critical as soon as the oscillation has started, and decreasing the intensity of the focusing field will, in general, actually cause a large increase of oscillating power. Experience has shown that the oscillations will continue with approximately one-tenth of the focusing field required to start them.

The effect of the material of the cathode sur-

faces upon the action of the device is obvious. With the caesium surfaces here described, one of the readiest ways of starting oscillation is by flashing a light upon one of the cathodes. The oxide caesium surfaces, moreover, have an extremely low work function, and secondary ratios as high as 4 or 5 are readily obtainable. This obviously leads to quick build-up of circulating current in the oscillatory circuit and consequent quick and easy starting.

To give some actual values, and thus indicate the order of magnitude of the circuit constants involved, a tube of the character described having a spacing of 5.5 centimeters between the cathodes, was operated at frequencies varying between 30 megacycles and something over 100 megacycles. The corresponding voltages of the d-c source required to give the necessary corresponding times of flight varied between 350 volts for the lower frequency and 800 volts for the higher one.

Under these conditions it was found that oscillation could be started by flashing a light on one cathode as mentioned above, by a sudden closing of the circuit to the source 11, or even by suddenly closing the focusing field circuit. After the circuit has been in operation for a few moments, permitting the cathodes to become warm, and thus reducing the effective energy which must be derived from an impacting electron in order to cause secondary emission, such shocks became unnecessary, and oscillation would occur without any appreciable electrical shocks to start them.

It should be noted that although the order of the period of the tuned circuit should be approximately twice the time of flight of electrons under the d-c field component, this value is not critical. For each value of accelerating voltage there is a fairly wide range of tuning over which the circuit will oscillate. Within this range the resonant frequency of the tuned circuit is a primary factor in determining the frequency of oscillation. Minor factors are the accelerating voltage and the amplitude, since this latter factor affects the velocity of the electrons and hence affects the mean time of flight. The value of the focusing field, due to its effect upon amplitude, and upon the length of the electron path, also affects frequency to a slight extent.

Once oscillation has started in the system, it will continue to build up in amplitude until the number of electrons collected by the anode in each half cycle is equal to the excess of secondary over primary electrons. If the proportion of the total electron cloud collected were independent of the density of the cloud, the amplitude of the oscillation might continue to build up almost indefinitely, for it will be seen that in the device of my invention there is no fixed limit to the electron emission as there is in the ordinary thermionic tube.

In actual operation, however, the greater the density of the cloud the greater will be the proportion collected, since the increased space charge with high densities repels the peripheral electrons with greater force and tends to drive electrons to the anode. This sets a limit to the amplitude of oscillation, but it is very easy to construct tubes where this limit is so high that the tube will be destroyed before it is reached. It may therefore be necessary in certain instances to reduce the focusing current as soon as the oscillation is started, in order to prevent destruction of the tube by overheating.

If the voltage builds up to a point where the secondary emission curve is operating upon its descending branch, this also makes the amplitude of oscillation self-limiting, the voltage increasing until the proportion of secondaries to primaries falls to a point where the excess of electrons is equal to the number collected. It will be recognized that the load withdrawn from the oscillating circuit also has an effect in limiting the amplitude, in that this load acts effectively to decrease the voltage drop produced in the oscillating circuit by a current of definite amount, and hence affects the primary-secondary ratio. With certain types of load it may be highly desirable to operate the tube upon the descending branch of the curve, since in this case an increased load, by decreasing the accelerating voltage, increases the number of electrons emitted. This, in turn, increases the voltage drop, and causes equilibrium to reestablish itself at a point corresponding to the changed load.

The relation between the tuning of the resonant system to the time of flight of the electrons as determined by the accelerating voltage may also limit the amplitude of oscillation.

Analytical solution of the effect of varying the oscillatory component of the accelerating potential upon the time of flight, and hence upon the tuning of the resonant circuit for maximum output, is extremely difficult, and at the date of this application for patent is only partially complete. In general, the time of flight varies with the phase of emission, with the amplitude of the oscillating potential, and with the shape of the electrostatic fields and the portion thereof through which the electron falls. There will, for any amplitude of oscillation, be only one or at most two phases of emission for which the time of flight is exactly one-half cycle, and it follows that there will usually be a difference in phase between the flight of any group of impacting electrons and that of the secondaries which are released thereby. This phase shift may be either increased or decreased by an increase in amplitude of oscillation. If increased, it serves to set a limit to amplitude, for if it be such that the highest emission ratio occurs at a phase where the emitted electrons never reach the opposed cathode, or reach it with insufficient velocity to cause further emission, the oscillation will tend to die out. It is for this reason that the half period of the tuned circuit should be of the same order of magnitude as the time of flight. Within this limit it is easy to find a frequency whereat oscillation will start, and once started, to find the conditions of optimum operation. Theoretically, with the tube of Figure 1, oscillation may occur where the time of flight is the time of any odd number of half cycles, but starting such oscillations is difficult where the time is greater than that of one-half cycle.

Another mode of limiting the amplitude of oscillation is shown in Figure 2. With the exception noted hereafter, the circuit of Figure 1 is duplicated in this arrangement, and the various elements thereof are identified by similar reference numbers. The exception is that the direct current component supplied by the source 11 is passed through a solenoid 20 which surrounds the tube. In the usual case, where a decrease of focusing current increases the intensity of oscillation, the solenoid is so connected as to "boost" the main focusing field, thus imposing a condition less favorable to oscillation and limiting output.

It is by no means necessary that a solenoid be used to provide the guiding field. Figure 3 indicates a method of mounting the tube within a permanent magnetic structure, which will produce a similar effect. The tube 21 is mounted between pole-pieces 22, which concentrate and direct the magnetic field established by permanent magnets 24.

Electrostatic methods of guiding the electron cloud may be utilized as well as electromagnetic ones. In the tube shown in Figures 1, 2, and 3, the electrostatic fields are strongly curved, and the electromagnetic focusing fields are necessary in order to guide the electrons between the cathodes. In the tube of Figure 4, however, the lines of force in the electrostatic fields are substantially straight within the electron path, and it may therefore be operated without the use of electromagnetic focusing. This tube comprises an envelope 25 within which are mounted the opposed cathodes 26, preferably slightly concave, substantially as within the tubes already described. Midway between the cathodes is a conducting band 27, fitted snugly within the walls of the envelope and connected with a lead 29 sealed through the wall of the tube. Projecting inwardly from the center of the band is an annular diaphragm 30, and secured across the opening in the diaphragm is a gauze or grid 31, preferably formed of extremely fine wire of open mesh so that the actual area which it offers to the electron stream is extremely small as compared with the total area of the aperture.

With this structure the lines of force between the edges of the cathode and the anode are somewhat curved, but those passing down the center of the tube are almost straight. The chance that an electron liberated from the central portion of either cathode will be collected by the anode is very small, the travel being in nearly straight lines. This tube will be found to be somewhat more difficult to set into oscillation than those utilizing the magnetic guiding field, but it is none-the-less operative, and it offers the advantage that no extraneous focusing equipment is necessary.

While the tube of Figure 4 may be utilized in the same circuit as the one first described, the fact that the anode forms an electrostatic shield also permits its use in a circuit of somewhat different type as shown in Figure 5. In this case the two cathodes are connected together, and the oscillating circuit comprising the inductor 35 and condenser 36 is connected between the junction of the two cathodes and the anode through the accelerating potential source 37. The negative end of the source is shown as connected to ground, as is the second terminal of the parallel resonant circuit. The resonant circuit is tuned to a frequency whose whole period is approximately equal to the time of flight of the electrons between the cathodes.

An electron released from either cathode will be attracted to the anode and will require approximately one-half cycle to reach this point. If the phase of the potential developed in the oscillating circuit by the electron flow from the cathode is correct, this potential will reverse after the electrons pass through the grid 31, so that this potential will still be effective to accelerate the electrons during the remainder of the journey down the tube and will cause the secondary electrons to be emitted by impact with the cathode as before. With this form of circuit there will, in general, be two electron clouds oscillat-

ing through the tube in opposite directions, and passing through each other at approximately the plane of the anode. The circuit is less readily oscillatory than those previously shown, in that it derives energy from the d-c source but once in each cycle instead of twice as in the cases previously described. It has, however, the characteristic that capacity between the cathodes and anode is less for the same frequency of operation, and hence when especially high frequencies are desirable it may offer certain advantages.

Figure 6 shows a form of the device in which but a single secondary emissive cathode is used. This cathode 40 is mounted in one end of the evacuated envelope 41. Near the other end of the envelope is an anode 42 of the same type as that described in connection with the tube of Figure 4, and immediately behind this anode is positioned an auxiliary cathode 44, which need not have a photo-emissive surface. A focusing coil 45 is shown as supplied by a battery 46 and rheostat 47, but it is to be understood that any means of guiding the electron cloud, either electromagnetic or electrostatic, may be used.

A parallel oscillating circuit 49 is connected in series with the cathode 40 and anode 42 through the accelerating potential source 50. A connection 51 leads from the negative end of the source 50 through a biasing potential source 52 to the auxiliary cathode 44, the potential of the source 52 being sufficient to maintain the auxiliary cathode always negative to the cathode 40.

In this case the action of the device is substantially the same as that of one-half of the tube of Figure 5. Electrons released from the cathode 40 reach the anode in approximately one-half cycle. Passing through the anode they are immediately reversed in direction by the field between the anode and the auxiliary cathode, and return through the anode at the same velocity which they had attained on first reaching it. By this time, however, the oscillating potential between anode and cathode has reversed, so that approximately one full cycle after being released from the cathode 40 they again impact it with a velocity due to the integrated effect of the oscillating voltage during their time of flight. The release of additional secondary electrons and repetition of the cycle occurs as before.

The circuit of Figure 6 has the same disadvantages compared with that of Figures 1 and 2 as does the circuit of Figure 5, with the additional disadvantage that a certain number of the electrons will be collected each time the cloud passes through the anode 42. After the oscillation has become stabilized this is no material disadvantage, but it does render the oscillation more difficult to start. On the other hand, the anode-cathode capacity which is effectively shunted across the oscillating circuit is only one-half that of the already small capacity contributed by the structure of Figure 5. Thus the use of this arrangement may be justified in certain circumstances, even though an auxiliary oscillator, later removed, may be necessary to start it in oscillation.

It should be recognized that the action of the oscillators here described is complex, that many factors enter into the final result, and that, owing to the interaction of these factors, a change in some one condition may, in certain instances, produce directly the opposite effect from what might generally be expected. Thus imposing a load on the oscillator will usually change the phase as well as the magnitude of the

potentials in the oscillating circuit, and for many conditions of tuning and accelerating voltage will increase the intensity of oscillation even though the tube be operating on the rising branch of the secondary emission curve. Similarly special conditions may be found where increase of focusing field increases oscillation intensity, instead of decreasing it, as is the usual case. Anomalies of this character are probably more apt to occur as limiting conditions for self-oscillation are approached, for under these circumstances a minor or secondary effect, operating in conjunction with the limiting factor, may overshadow the effect which ordinarily dominates.

A somewhat similar state of affairs may exist as regards the optimum degree of vacuum in the oscillating tube. All of the earlier experiments with the device were made with as high a degree of vacuum as could be secured—much higher than that in the ordinary three element tube or in the old style, gaseous discharge type of X-ray tube. Collision ionization phenomena within the tube are undesirable. Nevertheless, there is considerable evidence that small amounts of adsorbed gases on the electrodes themselves are advantageous where high secondary emission ratios are desired, and it is therefore highly probable that operation of the device will be facilitated by the presence within the tube of small quantities of inert gas, such as helium, neon, or others of the same group, as long as the mean free path of electrons within the tube is longer than the inter-electrode distances.

I claim:

1. An oscillation generator comprising an evacuated envelope, a plurality of electrodes within said envelope including an anode and a cathode capable of emitting secondary electrons at a ratio to primary electrons greater than unity upon impact by such primary electrons, a potential source sufficient to accelerate electrons to a velocity causing emission from said cathode at said ratio, means including circuitual connections between said electrodes for producing traversal and retraversal of the space between said electrodes by the secondary electrons emitted from said cathode to produce self-oscillation within said circuitual connections.

2. An oscillation generator comprising an evacuated envelope, a plurality of electrodes within said envelope including an anode and a cathode capable of emitting secondary electrons at a ratio to primary electrons greater than unity upon impact by such primary electrons, a potential source sufficient to accelerate electrons to a velocity causing emission from said cathode at said ratio, and means for applying said potential to said electrodes, and means for cyclically modifying said potential by current flow to cause a cloud of electrons in a space path therebetween to oscillate back and forth along said path and periodically to impact said cathode with sufficient velocity to maintain said cloud of electrons at undiminished density independently of accretions thereto by other than secondary electrons.

3. An oscillation generator comprising an evacuated envelope, a plurality of electrodes within said envelope including an anode and a cathode capable of emitting secondary electrons at a ratio to primary electrons greater than unity upon impact by such primary electrons, a potential source sufficient to accelerate electrons to a velocity causing emission from said cathode

at said ratio, and means including a resonant circuit for modifying the potential from said source to cause the electron cloud developed by the impacting primary electrons to traverse and retrace the space between said electrodes in response to the oscillating potential developed in said resonant circuit by the movement of said electron cloud.

4. An oscillation generator comprising an evacuated envelope containing a pair of opposed cathodes having surfaces adapted to emit electrons by impact and an anode positioned therebetween, means for imparting velocities to electrons emitted from said cathodes toward the opposed cathodes past said anode, an impedance connected to cause secondary electrons liberated from one of said cathodes to flow therethrough, and means for applying the voltage drop caused by electron flow in said impedance to impart sufficient additional velocity to the liberated secondary electrons to cause release of additional secondary electrons by impact with the other cathode.

5. An oscillation generator comprising a pair of opposed surfaces capable of emitting by impact a number of secondary electrons greater than the number of impacting primary electrons, an anode positioned to collect a portion of said secondary electrons, means for guiding a portion of said secondary electrons at least as great as the number of primary electrons from either cathode toward the other in avoidance of said anode, a current source for supplying the deficiency of electrons caused by the secondary emission from said cathodes, and circuitual connections including said cathodes and said source for applying a voltage drop caused by the flow of secondary electrons from one of said cathodes to accelerate said electrons toward the other cathode to a velocity sufficient to cause secondary emission of electrons therefrom at a ratio greater than unity.

6. An oscillation generator comprising a pair of opposed cathodes capable of emitting secondary electrons by impact in excess of the number of impacting primary electrons, a source of potential great enough to impart sufficient electron velocity to cause emission of secondary electrons in said amount of impact with said cathodes, and means including said source of potential and a resonant circuit for applying potential from said source to cause electrons liberated by impact from said cathodes alternately to impact the opposing cathode.

7. An oscillation generator comprising a pair of opposed cathodes adapted to emit secondary electrons by impact, an anode positioned between said cathodes, means for guiding a portion of secondary electrons emitted from either of said cathodes past said anode toward the other cathode, a parallel resonant circuit connecting said cathodes, and a source of potential connected to apply a voltage between said cathodes and said anode great enough to accelerate electrons to a velocity sufficient to cause emission of secondary electrons from said cathodes at a ratio greater than unity.

8. An oscillation generator comprising an evacuated envelope, a pair of opposed cathodes positioned within said envelope, an anode so positioned between said cathodes as to permit the greater portion of a space current passing between said cathodes to pass uncollected by said anode, a parallel resonant circuit connecting said cathodes, and a source of potential connected to

apply a voltage between said cathodes and said anode great enough to accelerate electrons to a velocity sufficient to cause emission of secondary electrons from said cathodes at a ratio greater than unity.

9. An oscillation generator comprising an evacuated envelope, a pair of opposed cathodes positioned within said envelope and having surfaces of photoelectric material, an anode so positioned between said cathodes as to permit the greater portion of a space current passing between said cathodes to pass uncollected by said anode, a parallel resonant circuit connecting said cathodes, and a source of potential connected to apply a voltage between said cathodes and said anode great enough to accelerate electrons to a velocity sufficient to cause emission of secondary electrons from said cathodes at a ratio greater than unity.

10. An oscillation generator comprising a pair of opposed cathodes adapted to emit secondary electrons by impact, an anode positioned between said cathodes, means for guiding a portion of secondary electrons emitted from either of said cathodes past said anode toward the other cathode, a parallel resonant circuit connecting said cathodes, and a source of potential sufficiently great to excite secondary emission from said cathodes at a ratio greater than unity connected between said anode and a point intermediate the terminals of said parallel resonant circuit.

11. An oscillation generator comprising an evacuated envelope containing a pair of opposed cathodes and an annular anode surrounding the path therebetween, means for establishing a magnetic field longitudinal of said path to guide electrons therealong between said cathodes, a source of potential sufficient to excite secondary emission from said cathodes at a ratio greater than unity, and circuit connections between said anode, cathodes and source for applying a voltage drop resulting from emission from either of said cathodes in a direction to accelerate the emitted electrons toward the other cathode.

12. An oscillation generator comprising an evacuated envelope, a pair of opposed cathodes within said envelope spaced to provide a free electron path therebetween, a cooperating anode positioned to collect electrons deviating from said path, means for guiding electrons from either of said cathodes along said path, a source of potential great enough to cause secondary emission of electrons from said cathodes at a ratio to impacting electrons greater than unity, and circuit connections between said cathodes, anode and potential source for applying a potential drop caused by electron emission from one of said cathodes to impart to said electrons a velocity of impact against the other cathode sufficient to cause further secondary emission.

13. An oscillation generator comprising an evacuated envelope, a pair of opposed cathodes within said envelope spaced to provide a free electron path therebetween, a cooperating anode positioned to collect electrons deviating from said path, means for guiding electrons from either of said cathodes along said path, a source of potential great enough to cause secondary emission of electrons from said cathodes at a ratio to impacting electrons greater than unity, and a resonant circuit connecting said cathodes, anode and source and tuned in relation to the time of flight of electrons between said cathodes as determined by the potential of said source to apply a resonant

potential to increase the velocity of impact of electrons following said path.

14. An oscillation generator comprising an evacuated envelope, a pair of opposed cathodes within said envelope spaced to provide a free electron path therebetween, a cooperating anode positioned to collect electrons deviating from said path, means for guiding electrons from either of said cathodes along said path, a source of potential great enough to cause secondary emission of electrons from said cathodes at a ratio to impacting electrons greater than unity connected to said anode, and a parallel resonant circuit whose half period is of the same order of magnitude as the time of flight of electrons along said path under the influence of said source connected between said cathodes and having a connection intermediate its ends to said source.

15. An oscillation generator comprising an evacuated envelope, a pair of opposed cathodes within said envelope spaced to provide a free electron path therebetween, a cooperating anode positioned to collect electrons deviating from said path, means for guiding electrons from either of said cathodes along said path, a source of potential great enough to cause secondary emission of electrons from said cathodes at a ratio to impacting electrons greater than unity, and resonant connections between said cathodes, anode and source for applying a voltage drop resulting from a flow of electrons from one of said cathodes and supplied by said source to accelerate said electrons to a velocity of impact with the opposing cathode sufficient to excite secondary emission therefrom at greater than unity ratio.

16. An oscillation generator comprising an evacuated envelope, a pair of parallel opposed cathodes spaced within said envelope and defining an electron path therebetween, an annular anode surrounding said path, a source of potential sufficiently great to impart an electron velocity which will excite secondary emission from said cathodes at a ratio greater than unity connected to said anode, and a resonant circuit tuned to a frequency whose half period is of the order of magnitude of the time of flight of an electron between said cathodes under the influence of said potential source connected between said cathodes and having an intermediate terminal connected through said source to said anode.

17. An oscillation generator comprising an evacuated envelope, a pair of parallel opposed cathodes spaced within said envelope and defining an electron path therebetween, an anode grid intermediate said cathodes comprising an electrostatic shield of small actual area, to permit the passage therethrough of a relatively large number of infalling electrons, a source of potential sufficient to cause secondary emission of electrons from said cathodes at a ratio greater than unity connected to said anode, a connection between said cathodes, and an oscillating circuit connecting said anode and source and said cathodes tuned to a frequency whose period is of the order of magnitude of the time of flight of an electron between said cathodes under the influence of the potential of said source.

18. The method of generating self-sustaining oscillations by means of secondary emitting surfaces which comprises the steps of causing an electron flow to impact such a surface at sufficient velocity to cause an emission of secondary electrons therefrom at a ratio greater than unity,

causing a flow of current consequent to said emission to produce a voltage drop, and applying said voltage drop to accelerate said electrons to a like impact with another such surface.

19. The method of generating electrical oscillations which comprises forming a cloud of electrons, oscillating said cloud along a path by applying accelerating potentials thereto, maintaining said cloud by causing the release of secondary electrons by impact at the end of said path, and deriving the potentials for causing said impacts from the currents comprising said secondary electrons.

20. The method of generating electrical oscillations which comprises forming a cloud of electrons, oscillating said cloud along a path by applying accelerating potentials thereto, withdrawing a portion of the electrons from said cloud at each oscillation thereof to supply useful power, causing said cloud to generate by impacts at the ends of said path sufficient electrons to maintain said cloud and supply those withdrawn therefrom, and deriving the potentials for causing said impacts from the currents comprising said secondary electrons.

21. An oscillation generator comprising a pair of opposed cathodes, means for causing a cloud of electrons to oscillate between said cathodes and impact thereon with velocity sufficient to maintain the density of said cloud by the secondary electrons emitted by said impacts, and means for deriving from the current flow comprising said secondary electrons the energy required to give to said cloud the impacting velocity.

22. An oscillation generator comprising an evacuated envelope containing an anode and cathode structure including opposed surface portions capable of emitting secondary electrons at a ratio to impacting primary electrons greater than unity, means including said anode for directing the flow of a portion of the electrons from one of said surface portions toward the other without impacting said anode, means for causing a current flow resultant upon the emission of electrons from said cathode structure to produce a potential on said anode so phased in relation to the time of emission of said electrons as to cause them to impact said cathode structure with sufficient velocity to cause the emission of further secondary electrons.

23. An oscillation generator comprising an evacuated envelope containing an anode and a cathode structure capable of emitting secondary electrons at a ratio to impacting primary electrons greater than unity, means including said anode for directing electrons emitted by said cathode structure in a path avoiding said anode and returning to said cathode structure, and means connecting said cathode structure and

said anode for applying potentials due to current flow resultant upon emission of electrons from said cathode structure to said electrons during their traversal of said path to impart thereto a final velocity sufficient to cause them to impact said cathode structure and release further secondary electrons thereby.

24. An oscillation generator comprising an evacuated envelope containing an anode and cathode structure, means including said anode for directing electrons liberated from said cathode in paths terminating in said cathode structure, and means for causing electrons traversing said paths to develop potentials between said anode and said cathode structure sufficient to cause impact of said electrons with said structure causing emission of a greater number of secondary electrons than impacting primary electrons.

25. The method of generating self-sustaining oscillations which comprises the steps of generating a cloud of electrons, subjecting said electrons to an electrostatic field directed towards a common center of oscillation from a plurality of directions whereby electrons component of said cloud released on one side of said center will tend to oscillate about said center, withdrawing energy from certain of said oscillating electrons to damp the oscillations thereof to bring them to rest at said center of oscillation, applying a portion of the energy thus withdrawn to other electrons component of the cloud to increase their net energy, and utilizing the additional energy of said last named electrons to cause them to release further electrons within said field.

26. The method of generating self-sustaining oscillations which comprises the steps of establishing an electrostatic field releasing electrons in said field, causing said electrons to oscillate about a center of oscillation within said field, causing the oscillation of said electrons to so modify said field as to transfer energy from certain of said electrons to others, and using the excess energy transferred to electrons whose energy is increased to release further electrons in said field.

27. The method of generating self-sustaining oscillations by means of secondary electron-emitting surfaces, which comprises the steps of generating an electrostatic field between a pair of such surfaces directed toward a common center, releasing electrons within said field to oscillate about said center, generating an oscillating potential from the motion of said electrons, and applying said potential to modify said field in such phase as to cause certain of said electrons to impact said surfaces with sufficient energy to release additional electrons within said field.

PHILO T. FARNSWORTH.

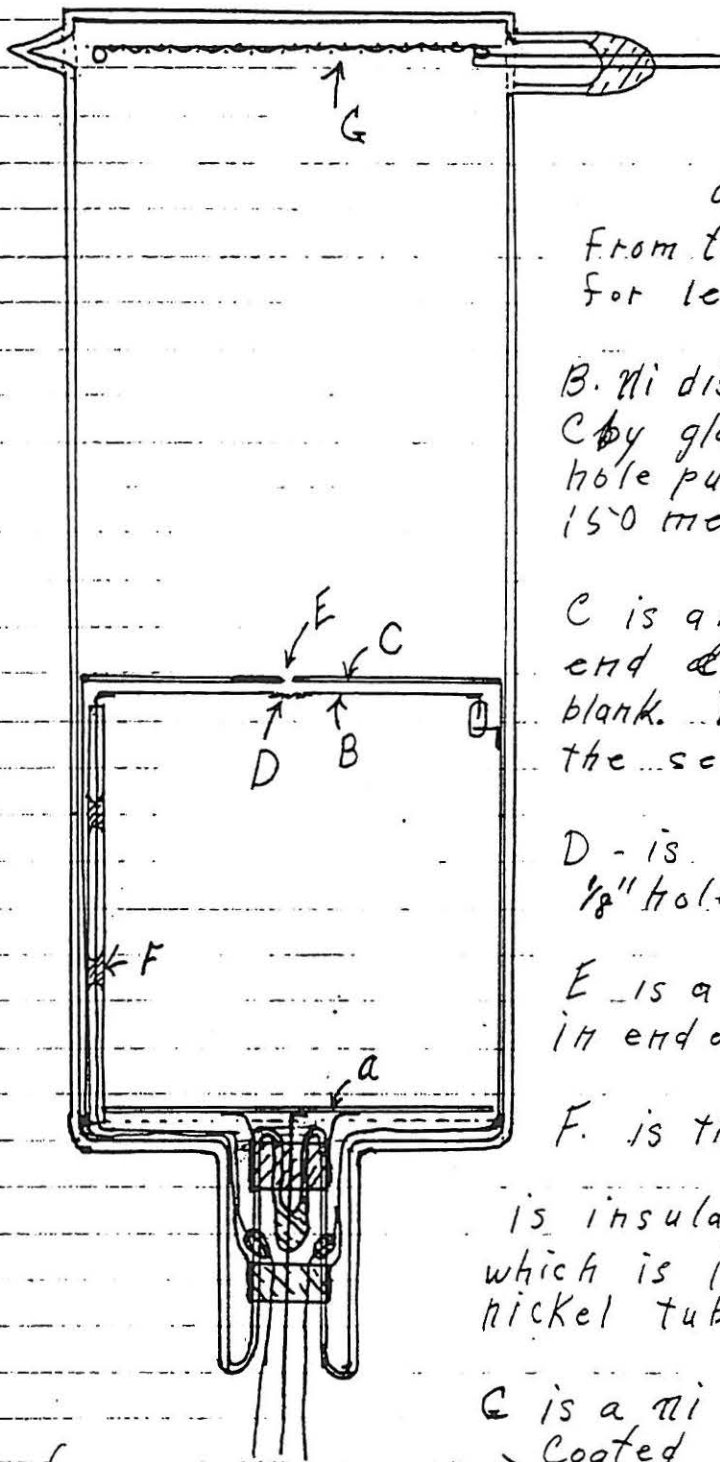
DAILY NOTES

DATE Aug. 24, 1933,

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron Multiplier Dissector ^{1st} Pumping ENGINEER B. C. Hardner

This tube was built and tested, but would not oscillate, therefore no multiplication.



A - Nickel Disc supported from top collar on stem. With cutout for lead F thus

B. Ni disc supported from Shield C by glass beads, and having $\frac{1}{8}$ " hole punched in center with 150 mesh screen welded across.

C is a nickel cylinder with one end closed fitting snugly in glass blank. This unit is supported from the second collar on stem.

D - is 150 mesh screen over $\frac{1}{8}$ " hole.

E is a .030" square aperture in end of can C.

F. is the lead to disc B and is insulated by $\frac{1}{8}$ " glass tubing which is in turn inclosed in a nickel tube for shielding.

G is a Ni screen 150 mesh Coated with Sodium used as a photoelectric surface.

(Approx $\frac{1}{2}$ Full size.)

DAILY NOTES

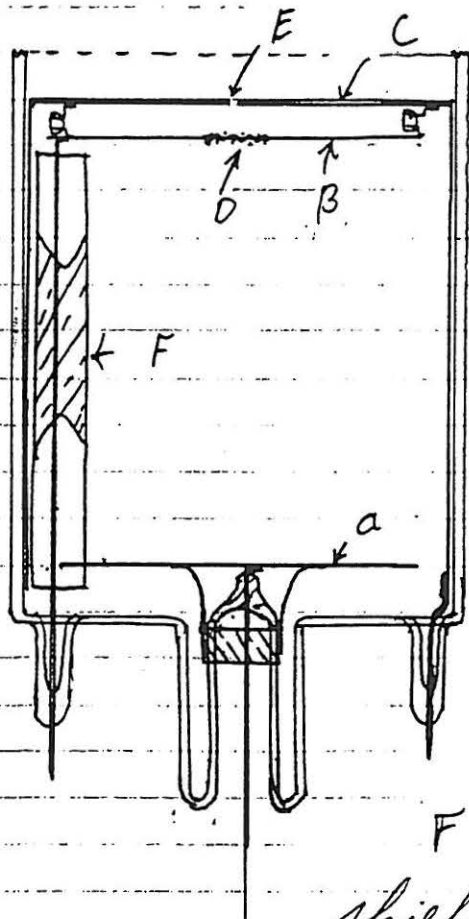
DATE Aug 26, 1933.

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron Multiplier Dissector 2nd

ENGINEER B. C. Gardner

The tube was rebuilt and exhausted but no photoelectric surface formed. This time it oscillated all night. The multiplier end of the tube only was changed as shown. The lead-outs are much heavier and designed for lower capacity between elements



and designed for lower capacity between elements

- (A) Same as in 1st tube except larger cutout for F.
- (B) hole enlarged to $\frac{3}{8}$ " and spaced 1 C.M. from C.
- (C) is same except leadout route changed, and moly replacing the air. of the Barrel.

D $\frac{3}{8}$ " diameter 150 mesh screen

F enlarged to $\frac{1}{2}$ " diameter shield + insulator and wire enlarged to 1040'.

DAILY NOTES

DATE Aug 28 1933

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron Multiplier Director

ENGINEER B. C. Hardner.

The tube as shown last page (Aug. 26)
repumped and potassium distilled on cathode
screen.

This tube will oscillate and gives good
multiplication.

DAILY NOTES

DATE Sept. 33

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron Multiplier DetectorENGINEER BC Gardner

A new tube was made like the one described Aug 26-28 (my notes)

A cesium oxide cathode was formed and it was found that the H. F. ionized the gas in the multiplying chamber.

The tube was then repumped very carefully. (baked about 7 hours.) and a cesium oxide surface formed, then partially spoiled by admitting small quantities of oxygen.

The purpose being, to oxidize any excess cesium. This tube seemed to be hard enough and gave good multiplication.

DAILY NOTES

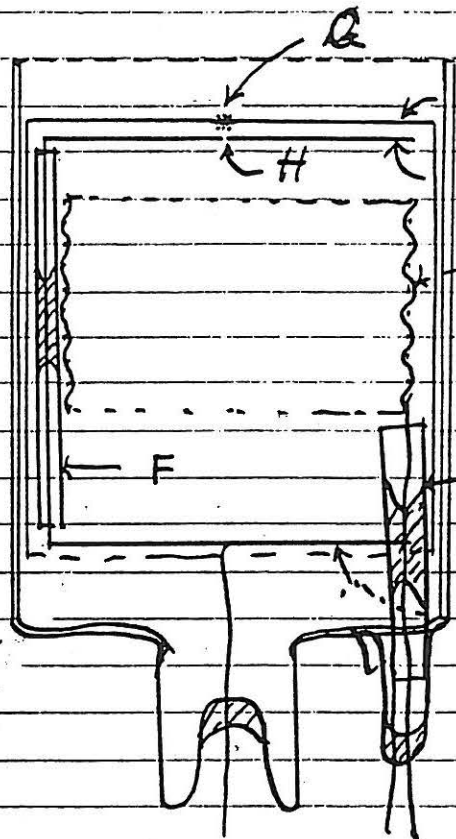
DATE Oct 1933

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron M. Dissector

ENGINEER B. L. Gardner

a - is a Ni cylinder
about $4\frac{1}{4}$ " Diam. $4\frac{3}{4}$ " Long
closed one end.



- a B. Ni disc. 4" Diam spaced $\frac{1}{8}$ "
carbonize
- b from end of (a) by beads

- d C disc like B.

d. 900 mesh screen (Ni) $2\frac{1}{2}$ " long

e $3\frac{1}{2}$ " Diam. Supported from
(a) by beads.

e is a glass insulator for
lead to d. Shielded by Ni
cylinder. $\frac{3}{8}$ " Diam

f. Shielded insulator similar to e connecting
b to d. $\frac{1}{8}$ " Diam.

g aperture in end of (a) $\frac{1}{8}$ " Diam covered with
Ni screen.

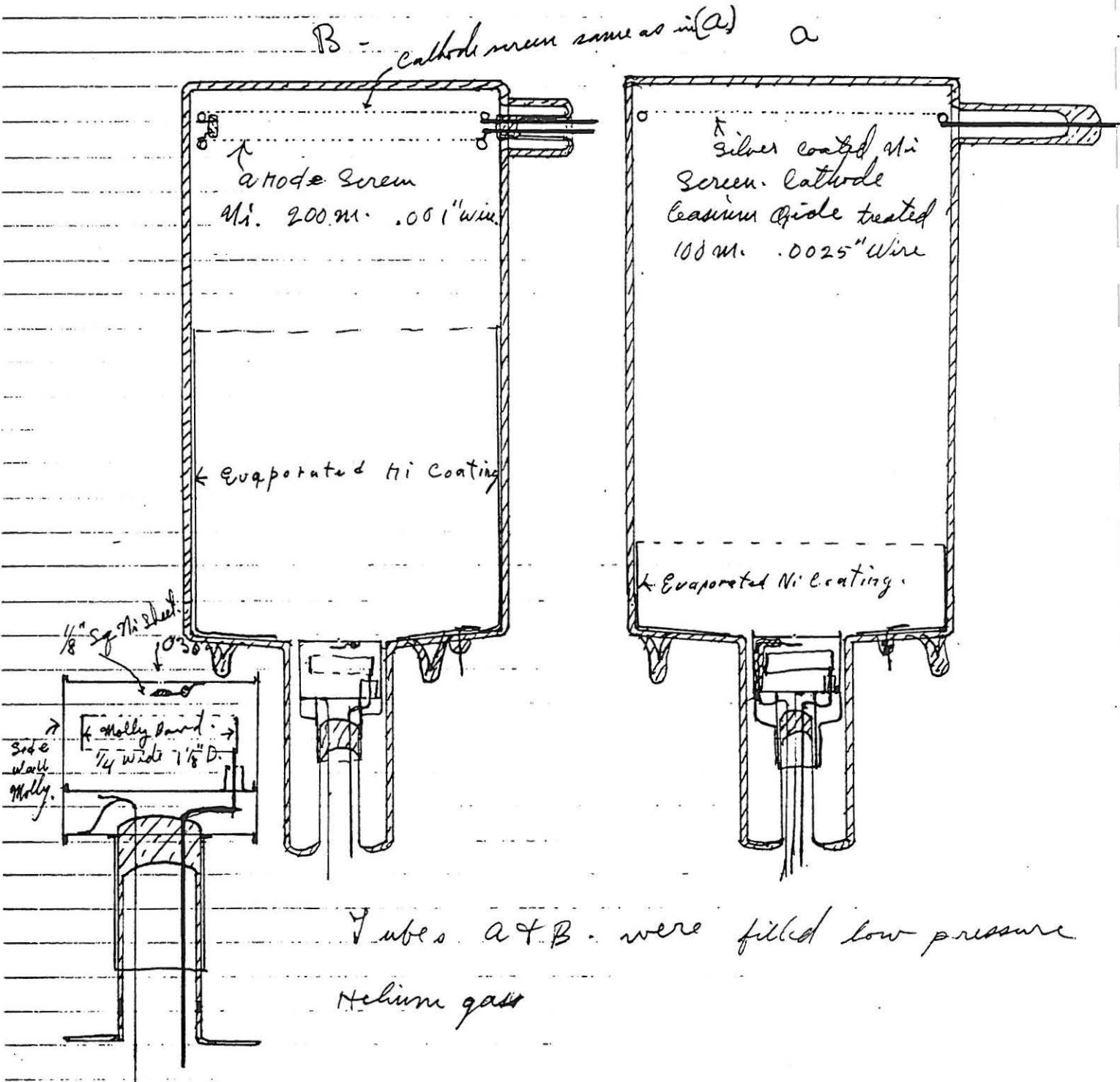
h .030" aperture in b

filled very low pressure argon

DATE Oct 31 & Nov 2 1933 **DAILY NOTES**
TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron MI E. sector

ENGINEER B. C. Gardner



c. Multiplier chamber C. (same as in B) was also tried out in a small tube using a cathode ray gun as an electron source.

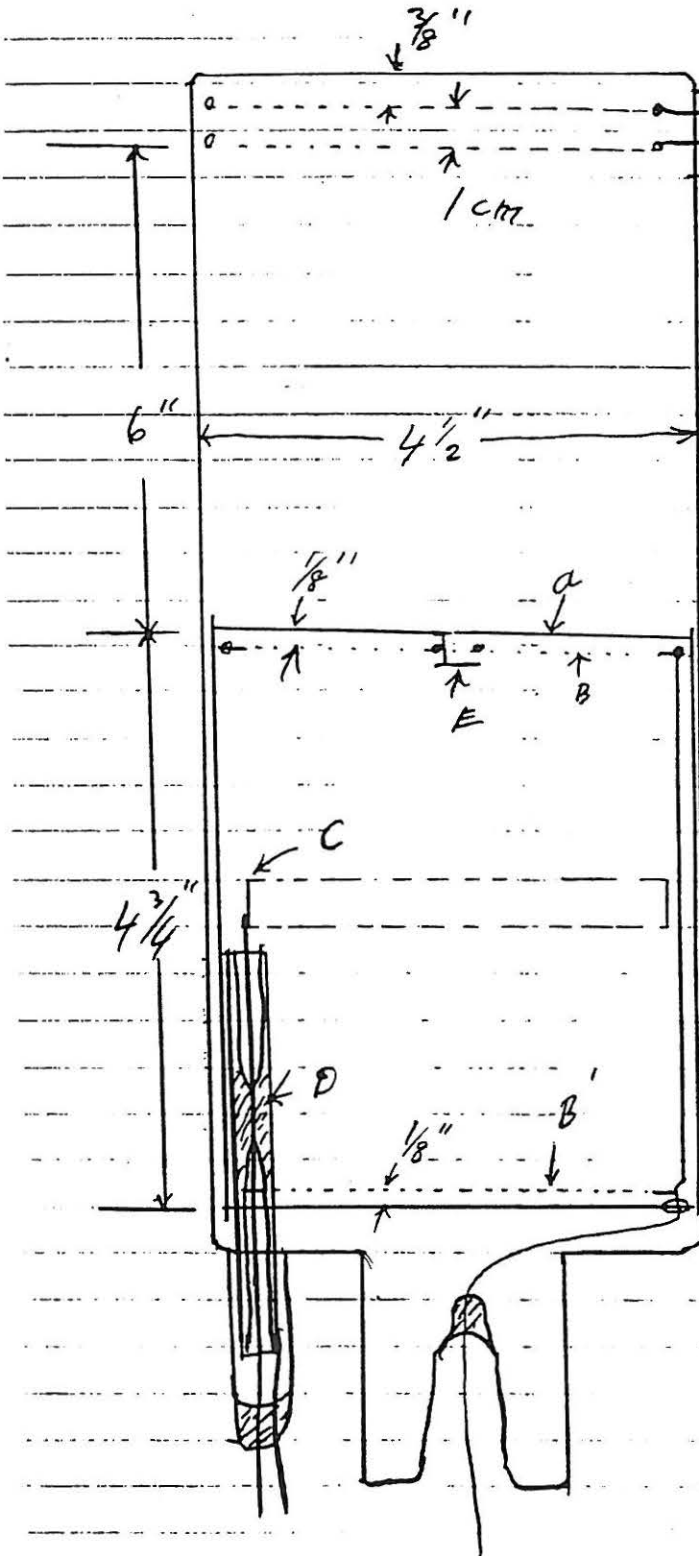
DAILY NOTES

DATE Nov 9 '33.

TELEVISION LABORATORIES, (LTD.)

SUBJECT C.M. Director

ENGINEER BE Gardner



← Cathode & Anode screens
Same as in tube B page 16

A is a German silver can
closed both ends with
.030" opt in end.

B & B' Screens of .003" tungsten
wire approx 10 per in. Supported

on beads from can. (B)
having 1/4" sq. hole in center

C. German Silver Band 1/4" wide
clears can 3/8" and supported
therefrom by beads.

D Insulated shielded lead
from Q

E 1/4" sq Ni Plate 5/16" from
aperture in (A) and connected
thereto.

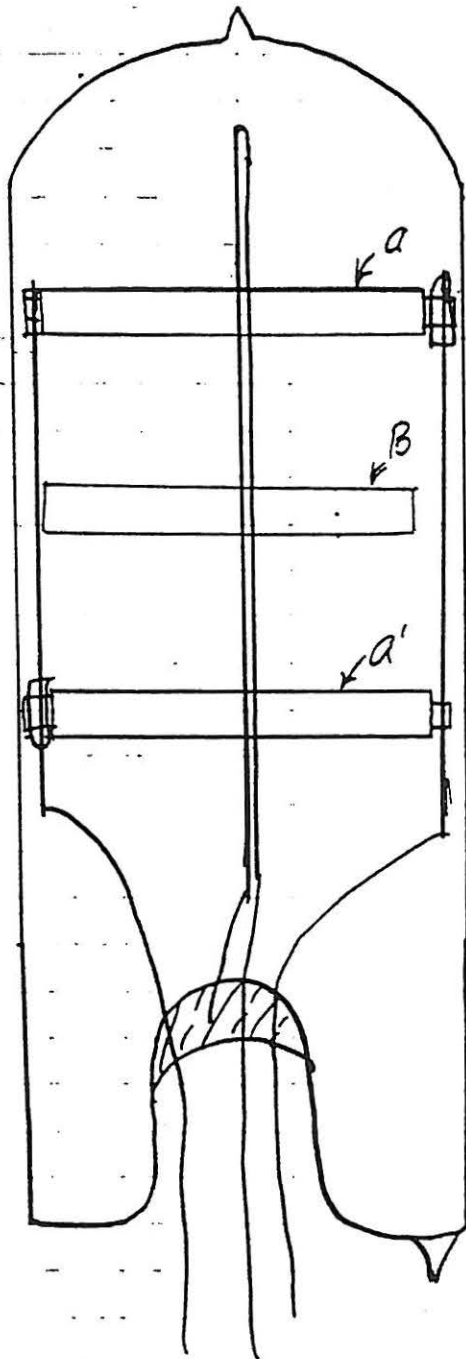
DAILY NOTES

DATE Nov. 11, 1933.

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron Multiplier

ENGINEER B. C. Gardner



a & a' are silver cups 2" Diam
 $\frac{1}{4}$ " Deep, side casing
 treated.

B. Ni Bar 2" Diam $\frac{1}{4}$ " wide

DAILY NOTES

DATE Nov. 13, 1933,

TELEVISION LABORATORIES, (LTD.)

SUBJECT Py-metal screen

ENGINEER B. L. Gardner

Some trouble has been found in making the small U shaped flaps bend with increased temperature.

At present I see two causes for the trouble. To begin with the Photo Engraver has to have an etched or pickled surface, to put the image on. (reason: polished metal will not wet.)

Now if this surface has irregularities of the same order of the thickness of our film of metal, it would have a tendency to nullify the Py-metal action. ~~namely~~ thus. ~~the~~ each hill & hollow would tend to work as a separate unit, and then also the whole sheet would be rigidified by such a ribbed structure.

The other snag was observed. When I wrote some small letters with asphalt paint on polished metal and then plated. There was a tendency for the flap to curl slightly like a shoe horn. This would completely stop the curling in the other direction.

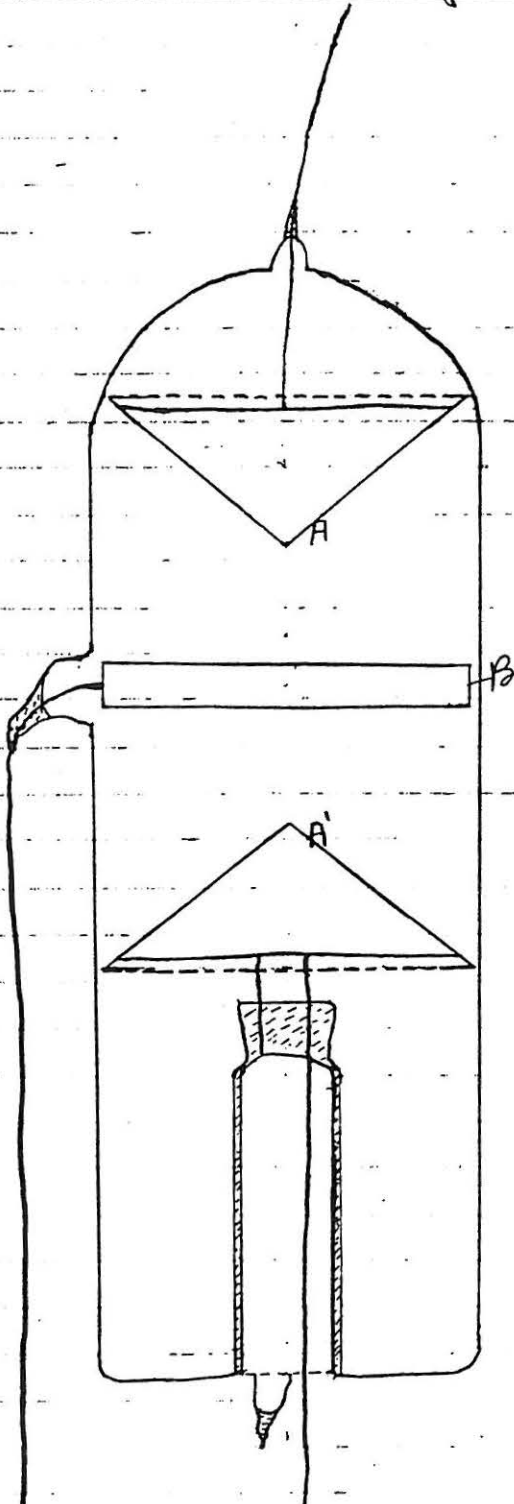
DAILY NOTES

DATE 11/14/33

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron Multiplier

ENGINEER B. C. Gardner



A & A' are silver cones
silver oxide caesium coated.

B - N. Band as in tube on
page 22

See page to page

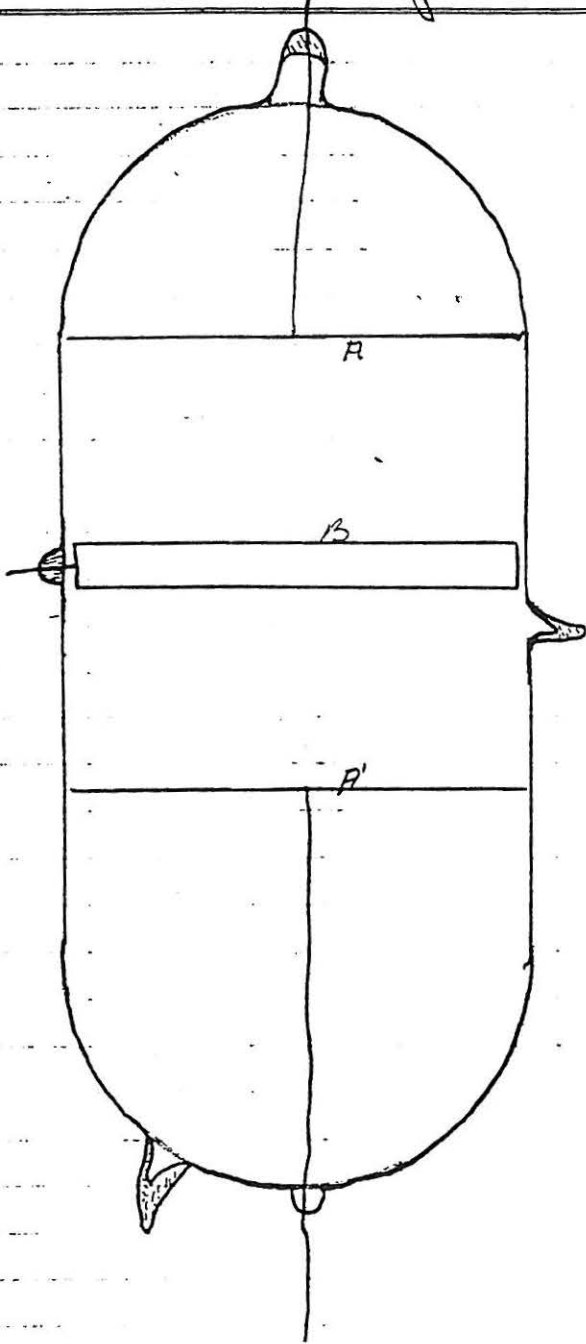
DAILY NOTES

DATE 11/16/23

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron Multiplier

ENGINEER B. C. Gardner



A + A' are silver plates, silver oxide caesium coated.

B - H. band as in tube on Page 22 + 23

Drawn to size

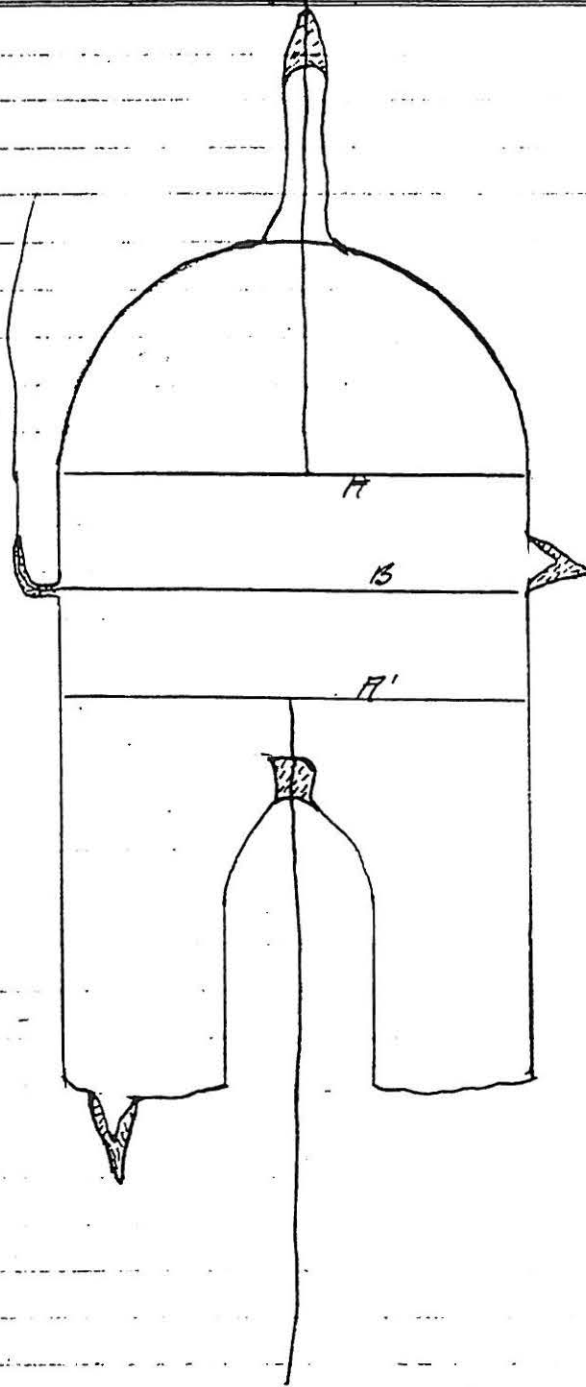
DAILY NOTES

DATE 11/18/33

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron Multiplier

ENGINEER B. C. Gardner



H + H' are silver plates, silver

oxide cesium coated

B - Tungsten ring

SUBJECT

Multipliers.
without magnetic field

ENGINEER

H. Salinger.

It was found that the magnetic field could be dispensed with, though ~~the~~ it seems to stabilize the performance of the tube a little.

Without magnetic field, the following observations were made.

- (1) There exists a region where the tube amplifies oscillations, i.e., ~~in the LC-circuit~~ if an oscillation was impressed on the LC-circuit, it carries a higher current with the tube than without it. This is called the region ~~V₁~~ V₁.
- (2) Under certain conditions, the same effect can be obtained, but with quite negligible anode current. (~~V₂~~) (V₂).
- (3) Self-sustained oscillations can be got [0].
- (4) The effects (1)-(3) can be got under certain, rather narrow conditions. In the other region, strong anode currents are observed, but the r.f. current is small. With the tube used, in cases of very heavy anode currents a glow was observed.

The following were the readings:

- a) driven Oscillations, $f_{LC} = 31.5$ mc. frequency independent of the anode voltage.

V_a	i_a	i_r
0	1 ²⁵	90
100	3	104
200	10	110
300	13.5	87
400	13	63
600	11	25
800	10	~10
1000	5	<10
1200	4	~0
1400	5	~18
1600	11	25

x) f_{LC} was at resonance with the applied frequency. This caused a small value of i_a even at $V_a = 0$.

But between 1600 and 1500 also a state could be obtained, where $i_a = 1.5$ and $i_r = 106$ [V₂]

FARNSWORTH TELEVISION INCORPORATED

SUBJECT

Multipactor - continued.
without magnetic field

ENGINEER

H. Salinger

(b) same conditions, $V_a = 600$ V, frequency 31.5 mc. f_{LC} was varied

f_{LC} (mc)	i_a	i_r
31.5	11	~25
33.1	17	35
34.5	33	49
36.2	35	58
37.9	33	60 (full power)

(c) same as a, higher frequency, $f = f_{LC} = 34.5$ mc.

V_a	i_a	i_r
0	15	72
200	"	76
300	10.5	86
400	14	68
600	14	35
800	30	25
1000	48	20

glow discharge begins.

d) $V_a = 800$ V, f_{LC} varied, $f = 34.5$ mc.

f_{LC}	i_a	i_r
34.5	25	22
36.2	48	40
37.9	750	48

e) After the readings of the last line, the oscillator was cut off. Now self-sustained oscillations started, but with different frequency:

f_{LC}	f	V_a	i_a	i_r
37.9	38.4	800	750	48
34.5	36.4	"	48	30
33.1	35.3	"	39	20
31.6	34.7	"	33	12
30.1	34.3	"	29	10
28.9	34.0	"	22	10

(over)

SUBJECT

Multiflexions - continued
without magnetic field.

ENGINEER

H. L. Lutz.

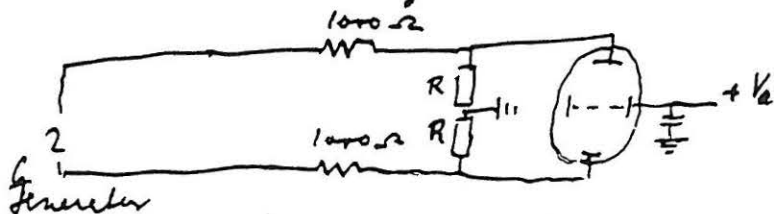
The following general remarks apply:

V_1 is found at rather low anode voltages, which would, according to the formulas of page 29 ~~apply~~ correspond to about half the exciting frequency. On the contrary, V_2 is found at potentials which would correspond to a much higher frequency than was applied.

The oscillations could easily be started in the described way, i.e. starting with driven oscillations and taking off the generator at a point of strong anode current. They could not be started with a spark.

+

New arrangement:



The resistances R, R were $= 5000 \Omega$ and in some of the experiments to be described $= 10000 \Omega$. ~~No oscillations~~
No self-sustained oscillations could be gotten with a spark-gap, but driven oscillations were obtained.
The ratings are to be found on the next page.

FARNSWORTH TELEVISION INCORPORATED

SUBJECT

Multiplexors - continued.
without magnetic field.

ENGINEER

H. Langer.

(a) 32.0 mc.

V_a	i_a
660	starts, instable
680	30
800	40
900	45 glow discharge
1100	very instable
1200	13
1400	1 1/2

backwards same readings.

(b) 29.7 mc.

V_a	i_a
560	starts, instable
600	23.5
800	33
880	jumps down to 20
1000	10
1200	0

(c) 34.4 mc.

V_a	i_a
800	starts, 32
900	45
1000	> 50
	glow discharge
1400	jumps down to 17
1600	3

same backwards.

(d) $V_a = 600 V$

f (mc)	i_a (ma)
> 30.6	0
30.6	instable
29.7	17.5
27.5	20

(e) $V_a = 800 V$

f	i_a
35.4	starts
33.9	10
33.1	18
32.8	28
31.3	31.5
30.7	32
29.1	30
27.5	26.5

(f) $V_a = 1000 V$

f	i_a
35.4 mc.	~23-30
34.8	37
33.9 47.2	40
31.6	41
29.5	jumps down to 13
27.8	0.

From the data of (e) the natural frequency would be deduced
as $f_0 = 1.085 \sqrt{V}$. This is tested more fully on next page.

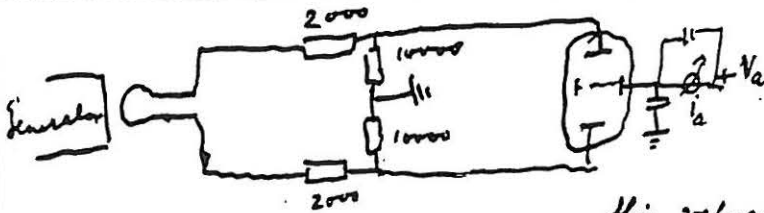
FARNSWORTH TELEVISION INCORPORATED

SUBJECT

Multipactor without mag. field
unhindered.

ENGINEER

H. Schenck.



For different frequencies,
the voltage V_a giving maximum
 i_a was measured. But

this value proved to depend on the degree of
coupling. Even at loose couplings, were the anode currents were
weak, jumps in the i_a -curve could not be avoided.

f	V_a	$\frac{1}{f} \sqrt{V_a}$
37.5	1470	1.029
36.5	1420	1.033
35.0	1310	1.033
31.4	1080	1.030
27.4	650	.915
27.6	530	.935
22.1	430	.937
20.1	360	.945
29.7	780	.940
31.1	840	.933
33.7	1080	.975
35.4	1240	.994
35.8	1320	1.015

But after that, it was recognized
that the drop in the anode current is

caused by
the 10000 ohm resistors caused the
apparent dependence on the degree of
coupling. So these resistances were
replaced by a center-tapped choke coil.

No definite results were however
taken, as there still were jumps in the
curves. Putting 10000-ohm in series.

with the anode also gave no definite improvement.

But the data prove that very nearly $f = \sqrt{V_a}$, i.e., nearly
linear electron field inside the tube.

SUBJECT

Multipactor experiments

ENGINEER

H. Lamm Jr.

Various experiments with the multipactors were carried out. The general observations were as follows:

- (1) The state V_2 (page 32) was studied, especially with an old tube:

 This tube gave a slight anode current (~ 5 mA) when the anode voltage V_a was between 50 and 600 V. Above 600 V, the region V_2 began, with an amplification of about 5, independent of V_a (between 600 and 1400 V). Anode current 0.

A magnet fixed in the axial direction, i.e. transverse, was tried. It had no influence, except in shifting the beginning of the V_2 behaviour to 800 and 1000 V.

- (2) With the usual type of tube, without any magnetic field, spurious oscillations were got, i.e. with frequencies of about 25 ~~off~~ - 35 mc (driven oscillations) anode frequency was found in certain regions of V_2 , about 1.5 - 4 mc lower than the existing frequency. No ~~very~~ definite results were obtained, which therefore are not communicated here.

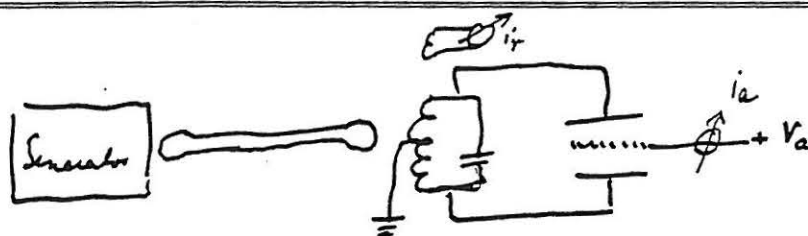
- (3) The maximum r.f. current is sometimes gotten by detuning the LC circuit. This means, that the tube is acting like a capacitor or inductor. In this manner (judging the positive or negative reactance of the tube by the maximum r.f. reading obtainable) the equivalent circuit of the multipactor tube could be measured. But its behaviour is decidedly non-linear, showing different jumps etc. which it was not possible to overcome. ~~Eq.~~ So this investigation was not carried on.

SUBJECT

Modulation with multipactor.

ENGINEER

H. Salinger.



With the multipactor tube $\textcircled{C}$, not using a magnetic field, the region V_1 and its neighbourhood was found to give a fairly good ~~oscillation~~ ^{modulation}, using driven (not self-sustained) oscillations. The characteristics are given ~~in~~ ^{on} graphs 13 a-c.

Different arrangements were tried, such as

- (1) 10000Ω shunt resistance on V_a
- (2) $2 \times 100 \Omega$ in series with the two cathodes
- (3) a capacity parallel to V_a
- (4) changing the primary voltage by adjusting the coupling,

but no essential difference was found.

It proved however impossible to duplicate the observation on the usual type of tubes, ~~and~~ (circular disks as cathodes and an anode ring).*)

As seen from graph c, there are two regions of the characteristics which might serve ~~as~~ for modulation purposes. The anode current in both regions is very small, so the power needed for modulation is of the order of one watt.

Frequencies between 28 and 41 mc were used. 13^d is a graph taken with somewhat more accurate readings, using a shunt condenser at V_a .

*) Erroneously! The table on page 32 shows the same behaviour between 200 and 800 V. Only the anode current was much stronger.

SUBJECT

Modulation with multiplexers

ENGINEER

H. Salinger

The problem of the last ~~page~~ was studied again. It was observed that the maximum reading of rf current was at always the same setting of the LC-circuit [using a constant driving frequency] ~~as that~~ in the left part of the curves of graph 13, where the rf current decreases with increasing voltage. This however was only valid, if the LC-circuit was not coupled too tightly to the transmitter. At tighter couplings, and throughout the right part of the curves, the circuit had to be reset for any new voltage V_a , to get maximum rf current.

This indicates that to avoid frequency modulation, only the left part of the curves is usable, and that the rf voltage has to be not too high. (A very slight detuning effect of the discharge was however still noticeable even under the most favorable conditions).

4/21/37 At 25 mc, the method still worked (though with an additional peak, as at 28 mc, graph 13 d), but at 22 mc, the left part of the curves has nearly disappeared.

DAILY NOTES

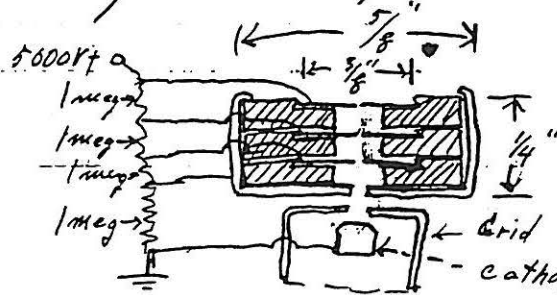
DATE 1/6/36

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron gun

ENGINEER B. L. Gardner

The new feature in this element setup is a new type multipole anode.

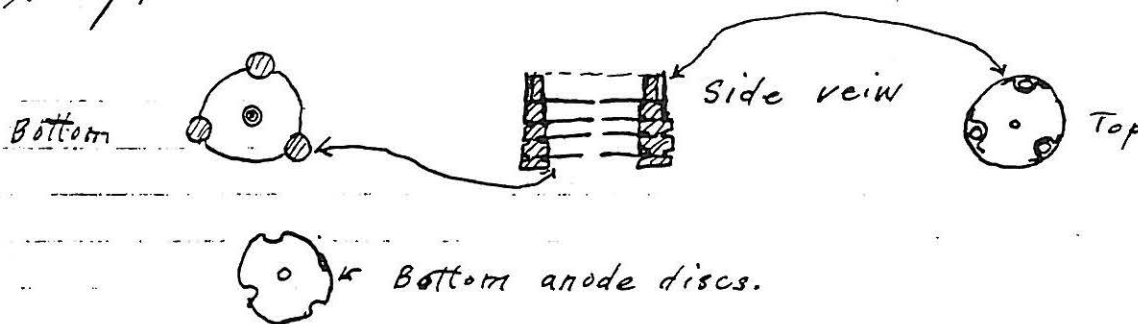


The grid hole	1/16"
1st anode "	1/16"
2nd " "	3/64"
3rd " "	1/32"
4th " "	.008"

Shaded sections. cured Soapstone
insulators

This first setup gave us no spot at all due to possible misalignment.

Another one was made with a different insulator setup.



This element acted rather queerly, but when properly adjusted gave a very bright unfocused spot about 1/4" in Diam ¹⁵ from gun. This was

DAILY NOTES

DATE 1/6/36

TELEVISION LABORATORIES, (LTD.)

SUBJECT Coit. Electron Gun

ENGINEER BCH-

surrounded by two hazy concentric halos
probably secondary emission from the successive
anode apertures. The anode went out of line
during the R.F. outgassing treatment

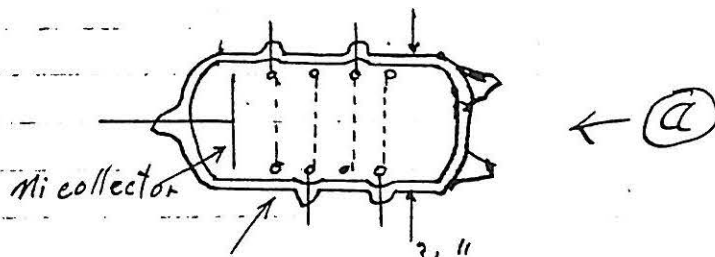
DAILY NOTES

DATE 1/16/36

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron Multiplier

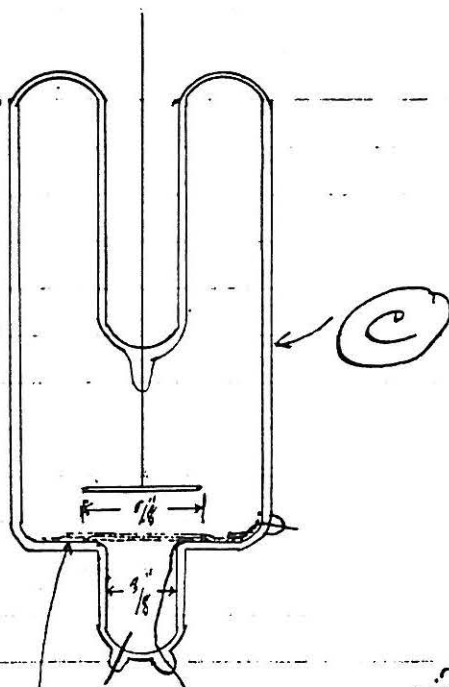
ENGINEER B. L. Gardner



Silver CaO secondary
emission screens 56% open
150 mesh spaced 3/16" apart

first try with
air sensitivity
& screen
100 Megs.
between Silver
Screen & Copper
film.

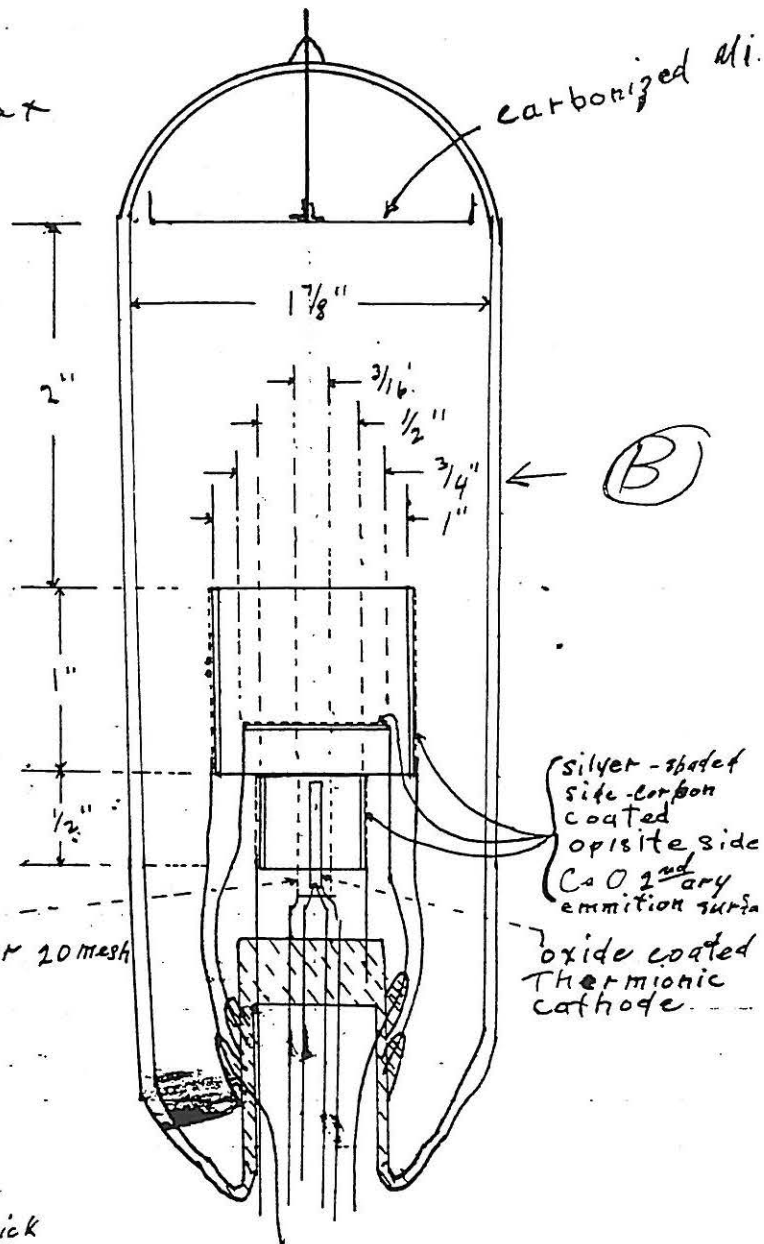
Vacuum leak
developed.
before checking
grid action



circular 20 mesh
Grid.

silver faced
glass.

150 mesh silver screen rolled .0015" thick
coated with mag oxide insulation, with copper
evaporated over this. Silver side CaO treated



DATE 2/8/37

DAILY NOTES

FARNSWORTH TELEVISION INCORPORATED

SUBJECT

DC Multiplier

ENGINEER

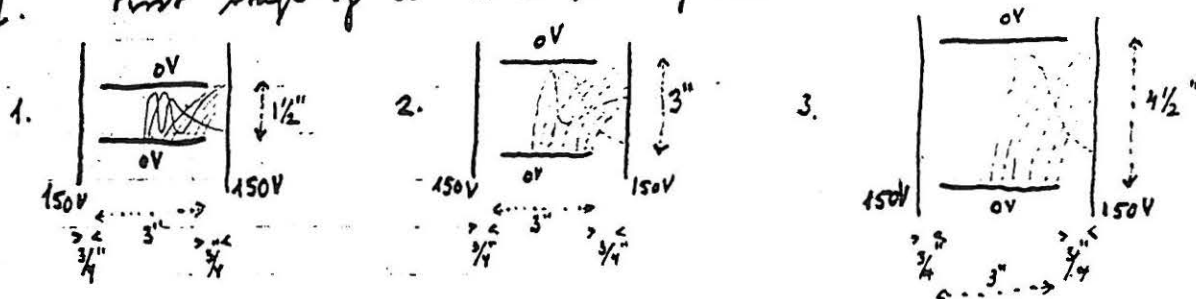
Salinger

A series of experiments was undertaken to study the motion of electrons in electrostatic fields. Use was made of a model method, by letting small steel balls fall down a stretched rubber cloth. So they are moving on a two-dimensional surface, which in the case of actual electrons would mean that the fields are supposed to be plane.

In the actual tests, the vertical scale was supposed to be 200 V per inch. Of course, any change in the voltage scale would not affect the electron paths, but only the time of flight. But, as explained later, in the models it is essential to have the rubber surface rather smooth, avoiding by slopes and undulations.

The initial velocity of secondaries is always assumed to be zero.

I. First stage of a d.c. multiplier.



The electron paths are shown in pencil. Electrons originating in the center of the emission plate oscillate a few times before traveling into the next multiplier stage. This occurs the more, the smaller the distance between the two plates at 0V is. Therefore, arrangements 2 and especially 3 are better than no. 1.

The next experiments deal with ~~potential~~ changes in the potentials.

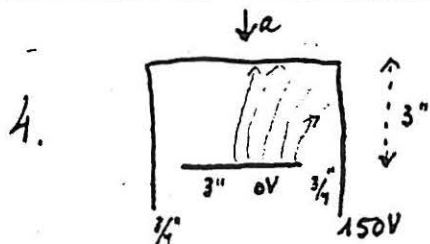
(over)

FARNSWORTH TELEVISION INCORPORATED

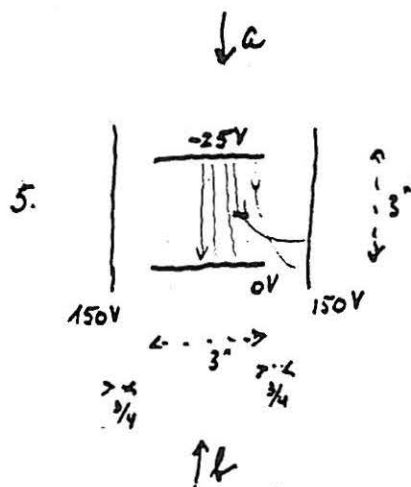
SUBJECT

Mc. Multiplier
Continuation

ENGINEER

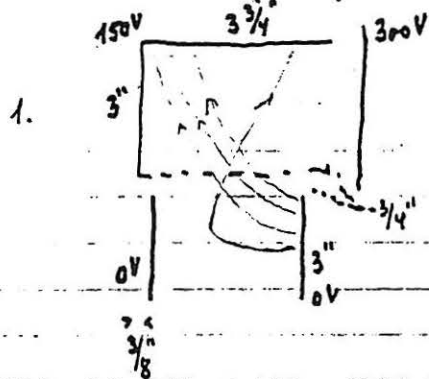
Launfer

Electrons are supposed to come from *a* and pass through an aperture in the upper plate. Most of the secondaries are seen to strike this plate again, so this arrangement will not work.



If the ^{primary} electrons come from *a*, the secondaries generated at the lower plate travel in paths very similar to those in arrangement 2. If the primaries start from *b*, the paths of the secondaries are as shown. Therefore, this arrangement will work if the primaries come from *a*, but not if they arrive in direction *b*.

II. Second stage of a d.c. multiplier.



No electrons leaking through the gaps. This is as it should be.

The next trial was made to see whether the grid ~~could~~ could be left away. The picture at the next page shows that the electron paths are all right, but it was found that the new secondaries generated at *a* in the second stage could not be

DATE 2/6/37

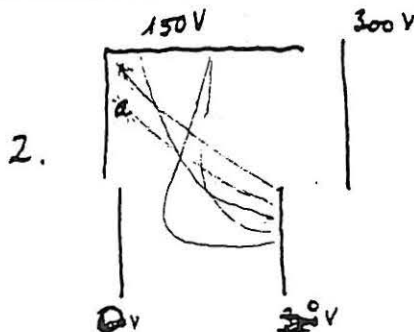
DAILY NOTES

FARNSWORTH TELEVISION INCORPORATED

SUBJECT

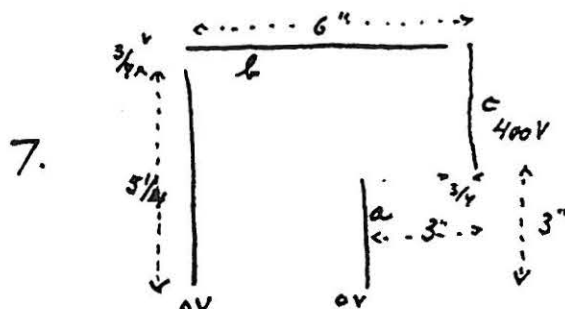
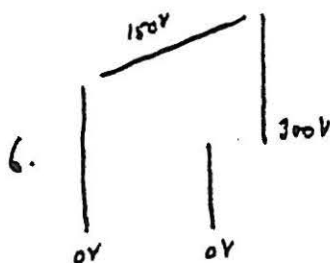
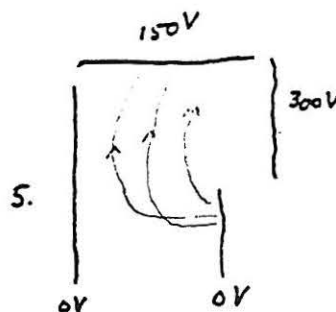
DC Multipliers
Construction

ENGINEER

Salinger

drawn to the third stage.

Various arrangements as 3, 4, 5, 6 were tried to overcome this difficulty but none was found to work satisfactorily.



It was tried whether an improvement could be got by making one of the surfaces a thin layer in which a resistance drop along the surface could be ^{maintained}. E.g., a layer of graphite, 10^{-6} cm thick, could be made to have a resistance of about 600 ohms, with the dimensions as occurring in actual multipliers. The effect was tried in arrangement 7. ~~But~~ It was found that electrons generated at b were drawn to the next stage, but did so in gliding along the surface b. This is objectionable. It was also tried to raise the potential of a by 25V, but then electrons starting at a did not get off. So these trials were abandoned.

(over).

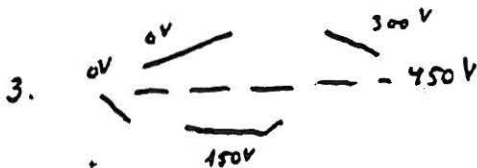
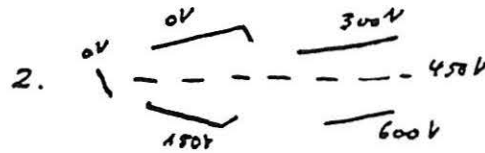
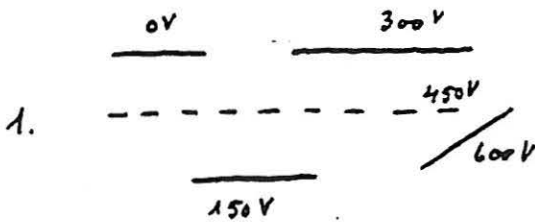
DATE 2/9/37

DAILY NOTES

FARNSWORTH TELEVISION INCORPORATED

SUBJECT 3-Stage MultiplierENGINEER Langer.III. 3-Stage Multiplier with one single grid.

In these trials, the vertical scale was 400 V per inch. Arrangements like 1-3 were tried, but not satisfactory.



At least a rather unsymmetrical arrangement, shown to scale on the next page, was satisfactory. The loathed part of stage 1 was needed as a sort of deflection plate, but electrons starting here do not go immediately to the ~~end~~ collector. So the primary beam must not hit this part of the first stage.

IV. 3-Stage Multiplier without any grid.

On page 20, a drawing is made of an arrangement that worked. Here, as in the last example, the shape and the dimensions were rather critical.

Some critical remarks on the method used are found on page 21.

DATE 7/31/51

DAILY NOTES

FARNSWORTH TELEVISION INCORPORATED

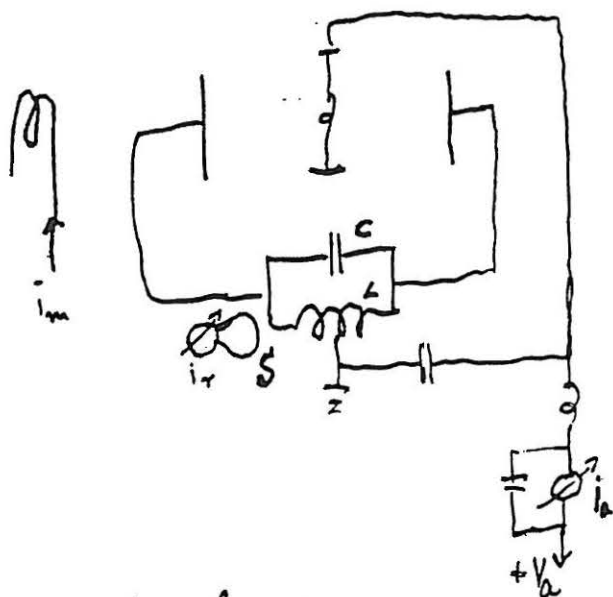
SUBJECT

- Multipactor experiments

ENGINEER

H. Salinger

The multipactor experiments were resumed with a better set-up. The tube and coil are described on page 29.



A loop S was coupled to the LC circuit, and the readings is served as a measure of the generated oscillations.

The results are given on graphs 11 and 12. graphs a and c give the dependence of the generated frequency f , i_a and i_r on the tuning of the LC circuit for two values of V_a . It is seen that the reading i_a shows no similarity to the strength of the generated oscillations.

This strength depends decidedly on the magnetic field (only the value at the center is plotted in the drawings), as graph b [for two tunings of the LC circuit and $V_a = 400V$] and d [$V_a = 640V$] show. The influence of V_a is shown on graph e.

Using the figures of page 29, the voltages would correspond to the following natural frequencies:

V_a	f_0 (linear)	f_0 (parabolic)
360	19.0	24.3
400	20.0	25.6
500	22.4	28.7
640	25.3	32.4
750	27.4	35.1

The curves seem to indicate, that the linear case is more nearly approached than the parabolic one.

3/9/37

DAILY NOTES

FARNSWORTH TELEVISION INCORPORATED

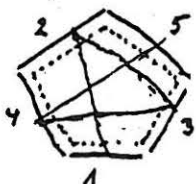
SUBJECT

DC Multipliers.

ENGINEER

J. S. Lutz

DC Multipliers with one common grid were investigated. As an example, consider the pentagon tube. 1.-5 are electrodes on different potentials, the grids have all the same potential. The electrons start at 1 and travel towards 2, 3, 4, 5 as shown. 5 is the collector.



The sequence of the potentials is

$$V_5 > V_g > V_4 > V_3 > V_2 > V_1.$$

The secondaries generated at any surface may be regarded as starting in normal direction, due to the collecting effect of the grid. But the primaries, being in a retarded field, arrive under some oblique angle. Now it might be that they don't strike the secondary emission plate at all.

If v_i is the total primary velocity, v_n the component of v_i normal to the plate, then the plate will only be hit if the component v_n is sufficient to overcome the retarding field between V_s and V_g .

Now the primaries come from a plate with potential V_{s-1} , and

$$v_i^2 = +\frac{2e}{m}(V_{s-1} - V_g), \quad v_n = v_i \cos \alpha.$$

So the electrons will only hit the plate V_s , if

$$v_n^2 > +\frac{2e}{m}(V_s - V_g), \quad \text{or if} \quad \cos^2 \alpha > \frac{V_g - V_s}{V_{s-1} - V_g}$$

If α gets too large, the plate V_s will become ineffective, unless the potentials are increased. For instance, $V_{s-1} = 0$, $V_g = 500$, $V_s = 700$ would give $\cos^2 \alpha > \frac{2}{5}$ or $\alpha < 26\frac{1}{2}^\circ$; whereas $V_{s-1} = 0$, $V_g = 500$, $V_s = 200$ yields $\cos^2 \alpha > \frac{3}{5}$ or $\alpha < 39\frac{1}{2}^\circ$.

(over)

x) $V_{s-1} - V_g$ is negative, but e also is negative.

DATE

4/26/37

DAILY NOTES

FARNSWORTH TELEVISION INCORPORATED

SUBJECT

Multifactors - continued.

ENGINEER

H. L. Langer

It was tried to measure the amount of power that could be handled. This however could only be estimated as follows: An oscillograph was put parallel to the LC-circuit. This increased the capacity so much, that only at the lowest frequency of 35.4 mc. readings could be taken.

It resulted, that with the present set-up peak-to-peak voltages up to 120 volt could be used, corresponding to an r.m.s. a-c voltage of 40 volts.

The ~~me~~ resonance resistance of the circuit was measured by paralleling resistances of 5000 and 12000 ohm to it, but the values were rather inconsistent, due to the capacity of the ~~leads~~ leads and of the resistances.

In any case, the resonance resistance with the cold tube parallel to it seems to be around 10000 Ω , and the resistance of the tube may be varied, say from 20000 to 5000 ohm by increasing the anode voltage. The power that can be dissipated by the tube is therefore of the order of $\frac{1}{2}$ watt.

DAILY NOTES

DATE Aug 28 37

TELEVISION LABORATORIES, (LTD.)

SUBJECT Data on Mp5 P.C. Multipacators

ENGINEER B. E. Gardner

1/pe	Set	Final Color	Ca Yield	Therm. emitt.	P.E. arc	M/I	Minutes Baked at 200° after Cs.	Remarks
72	72	light yellow	No	Dope	Rec	1155 924		No record except apparently over Caesiated & readjusted with Oxygen
78	78	Black	20M	.25x Mills	18 Rec	30800 28000	15	Oxidized to green Salt yield on Cs Co in at 220°C Dxy clean up necessary
79	79	lt yellow	22.5	.7	12 Rec	4235 5775		Cathode oxydized to 2 nd yellow Rest 2 nd brown. Great excess Ca Killed with O.
80	80	Dark Brown	No dope water	.2	1	N.C.	5	Not enough Ca due to water pollution
81	81	Dark Slate	14- Water loss	.7	7 Rec	1000 8470	10	Ca wet. Dxy same as #79 a small ammt of O was necessary
82	82	Black	18- w loss	.85	17 Rec	4235 1002	3	Usual Dxy low Ca yield all Cs shot in at once Therm came upto .4 mills Decreased to .3 then slowly upto .85 and then at 3 min started to decrease.
83	83	light yellow	12.5	.4 to .8	8 Rec	6930 10306	8	Good Cs yield, Ca admitted very fast Parts wet. Dxy admitted. Ca had to be distilled from exhaust tube.
84	84	Black & Dark Brown	14	.4	19 Relax	31000 30800	86	Good Cs yield Most of Cs shot in at 220°C Some Oxy admitted Baked 3 min More Ca + more oxy first adjustment .4 m. 2 nd adj peak .4. mills then m. at 3 min
86	86	Black	10	.45	9 Rec	2310 2772	15	Oxy to 2 nd Brown Cs shot in over 5 min at one time Therm .6 Without Oxy More Cs added and Killed with O and again a small ammt of Ca added to get best emission
85	85	Dark yellow	10	.7	8 Rec	4620 3850	4	Oxy 2 nd Brown to green Cs in slowly till Max Therm. No Oxy used
88	88	Black	11- water	.55	18	at 800V 13,100 at 1100 same volts per stage as Normal 34650	6	Oxy 2 nd Brown to green 1st large dose Ca Therm went right up to .8 mills. a little more was added Killing emission which gradually increased to .55 and at 6 min bake started to decrease and oven was turned off. NO Oxy used

DAILY NOTES

DATE Aug 28 '37

TELEVISION LABORATORIES, (LTD.)

SUBJECT CsO. Formation on D.C. Whetstones ENGINEER BE Gardner

According to most of the data taken on the Mp 5 tubes it seems that the best results are obtained when an excess of Cs is used and later taken up by admitting oxygen to the tube during formation. This makes formation of more than one tube at a time ~~very~~ very difficult. It also seems that it is necessary to take thermionic readings during formation. I hope to evolve a forming schedule for more or less mass production, but at present the above mentioned difficulties seem to prohibit such at present.

DAILY NOTES

TELEVISION LABORATORIES, (LTD.)

DATE Sept. 1, 1937.

SUBJECT Data on Mp5's

ENGINEER B. L. Gardner

pe	Serial NO	Final color	CaO/gide	Therm	Photo Electric	Effective M/g at 800 V/h	Mins Bake after Ca	Remarks
1p5	87	Black	20- water loss	.6	11	13090	3	usual oxy. Cs in at 225°C nearly all at once test followed in about 1 min. The 1st charge of Cs ran the therm to .8 mills and then a gradual decrease started. The 2nd charge ran it up to .6 and when it started down at 3 min the oven was turned off Cs yield seemed low. NO-OXY
								Recheck 11550
1p5	89	B/g/yk	12.5	.3	18	4620	13	Surface very spotty. Poor Ca yield usual oxy. Cs in over 3 min period seemed to require more than usual No oxy used after Cs entered
						Spec'd adjust- 5300		
1p	90	yellow Brown Cathode rest Black fold	20-	.25	18	15400	8	Poor Ca yield usual oxy. Cs in in several doses. OXY Necessary to get peak emission

DATE 10/4/39

DAILY NOTES

FARNSWORTH TELEVISION INCORPORATED

SUBJECT

Voltage controlled multiplex

ENGINEER

H. Salinger

If the use of a multiplex is considered for the amplification of a very weak voltage, the following difficulty exists:

A filament or a photocathode is the primary source of d.c. current. Electrons emitted will have an average energy, say V_0 volts. [Even in the most favorable case, a cold cathode excited with infrared light, V_0 is probably ~ 2 volts]. The current emitted, if the control grid is at V volts, is $J = J_0 e^{-V/V_0}$. If now a small signal ΔV [≈ 5 mV] is applied, we have $\frac{\Delta J}{J} = -\frac{\Delta V}{V_0}$. Thus in our example, $\frac{\Delta J}{J} = \frac{1}{400}$,

and in all the following stages the signal would be 400 times smaller than the d.c. component.

To avoid this, it is proposed to use the electrons rejected by the control grid and pull them, instead of back to the cathode, to the first multiplex stage. The control grid bias must be such that nearly all the electrons pass the grid, so that the d.c. component of the current which hits the target is small.

This current can then be expressed as $J' = J_0 (1 - e^{-V/V_0})$, neglecting grid losses, and we get $\frac{\Delta J'}{J'} = -\frac{\Delta V}{V_0} \frac{e^{-V/V_0}}{1 - e^{-V/V_0}}$. If $V \ll V_0$, this means

$\frac{\Delta J'}{J'} = -\frac{\Delta V}{V}$. Let us assume $V = 5$ mV, then $\frac{\Delta J'}{J'} = 1/10$; for $V = 5$ mV, $\frac{\Delta J'}{J'} = 1$. V is not the real bias on the grid, but the effective voltage in the grid plane.

Of course this means a very weak input to the multiplex, thus we should have an intense electron source, but we have to throw away about 99%.

A tube might look as shown on the next page.

Witnesses:

(1) P. HerbertDate Oct. 5, 1939(2) A. J. Mayle, Jr.Date Oct 5, 1939

FARNSWORTH

ELECTRONIC

10/4/39

DAILY NOTES

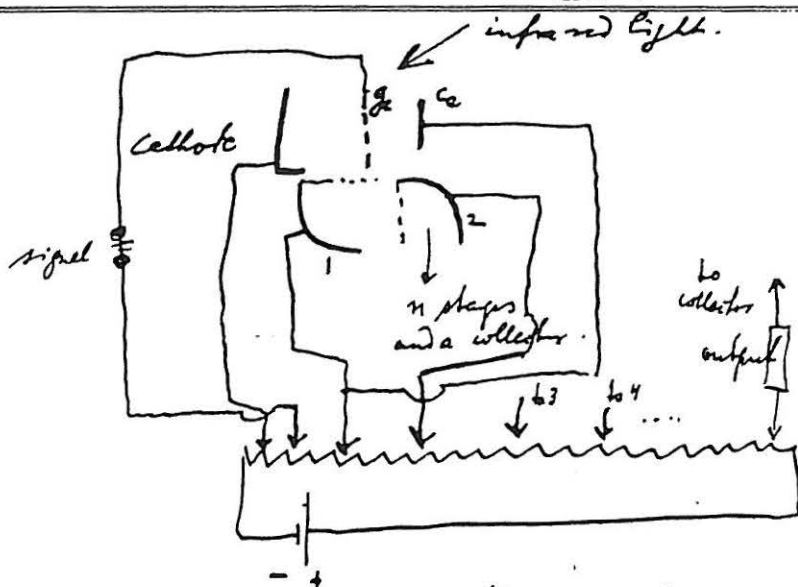
FARNSWORTH TELEVISION INCORPORATED

SUBJECT

Voltage controlled multiplication
continued.

ENGINEER

J. S. Latimer



G_c is a control grid; it is tied to a point slightly negative or slightly positive ~~of~~ against the cathode, the exact position depending upon the geometrical arrangement. C_2 is an auxiliary collector, which absorbs the electron that pass through G_2 . This auxiliary collector is shown as connected to the first multiplication stage;

this connection can be internal to the tube, or the arrangement might be such that C_2 is just the backplate of 1.

An accelerating grid may be interposed between cathode and control grid.

The first stage 1 is so structured that it will pull towards itself all the electrons rejected by G_c but not the ones emitted from the cathode. Ionization from G_c have to be avoided; therefore it is best to make G_c a very wide grid which is ~~then~~ negative against cathode.

Witnessed

J. H. Herbert

Oct 5, 1939

A. J. Mayle, Jr.

Oct 5, 1939

FARNSWORTH

12/27/38

DAILY NOTES

FARNSWORTH TELEVISION INCORPORATED

SUBJECT

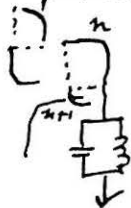
Automobile receiver

ENGINEER

H. Salinger

On Dec. 21st, Phil Farnsworth described the following idea to me. In order to get rid of the high filament current wasted in motor car receivers, the following arrangement (which of course is applicable also to other receivers) might be used:

Broadcasting signals are applied to the control grid of a multiphase. The electron source is a filament or a photocathode. In the n th stage is a circuit which is excited into dynatron oscillations. This corresponds to the variac oscillator of the a. k. a. type receiver. Together with the signal, the multiphase with them, by virtue of its nonlinear



characteristics, produce an intermediate frequency, which the output is tuned. A subsequent tube acts as second detector and may at the same time be the power amplifier.

To test this idea, an ordinary 11-stage tube (#192) was taken and excited by a c. light; thus the signal was 120 ω . The oscillating circuit was in the 11th stage, with a capacity of .03 μ f [nominal value] it gave about 150 ω . The 30 ω difference frequency was clearly visible on an oscilloscope.

The dynatron characteristics were measured. The maximum slope was 93000 ohms, at 45v in this stage. The light had to be adjusted so that the current in the 11th stage was about 200 μ a at this voltage. Between voltage values corresponding to a current between 80 and 370 μ a oscillations were started. Thus the oscillator circuit has to have ~~at least~~ at least 10^5 ohms resonant impedance. But a properly built 6 stage multiphase would suffice.

It was tried to enhance the modulation and thus the intermediate frequency by coupling into the 10th stage, but so far without much success. See next page:

(1)

Date

By

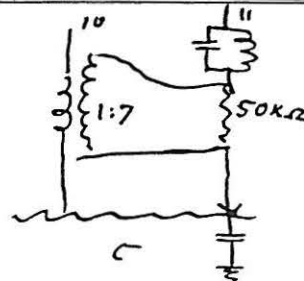
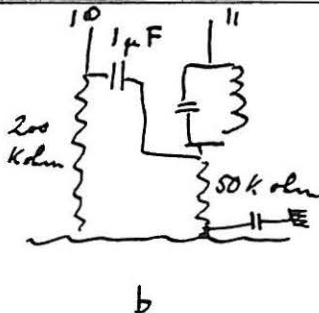
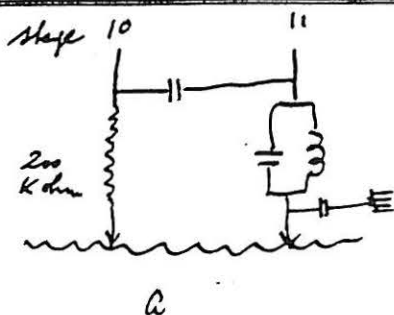
For

Check

DATE 12/27/39

DAILY NOTES

FARNSWORTH TELEVISION INCORPORATED

SUBJECT Automobile alarm.ENGINEER H. Schuyler

~~Diagram~~ arrangement a quenches the dysynchron oscillation. c did not work and probably gives the wrong phase. b was practical. It might give the desired effect if 1 megohm is used instead of 200 K ohm, but then ~~the~~ it is difficult to start the multivibrator, as the 1 megohm must be hot to a lower point on the voltage divider.

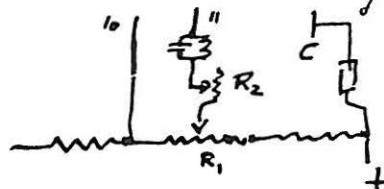
This was also tried. But it became rather evident that we got a feedback, the voltage fluctuation (all frequencies combined) on the 50 K ohm resistor being fed back to the 10th stage.

Finally it was found that the intermediate frequency is brought out much stronger if the conditions were set rather correctly so that it will just oscillate (resistors R_1, R_2)

Of course R_1 depends much on the position of the existing lamp, as its d.c. component is heavily charged.

Output about 10 μ in 300,000 ohms, can be

about 70% modulated by the intermediate freq. without becoming unstable.



Witnesses:

(1)

Date

(2)

Date

FARNSWORTH

DAILY NOTES

DATE 9/10/41

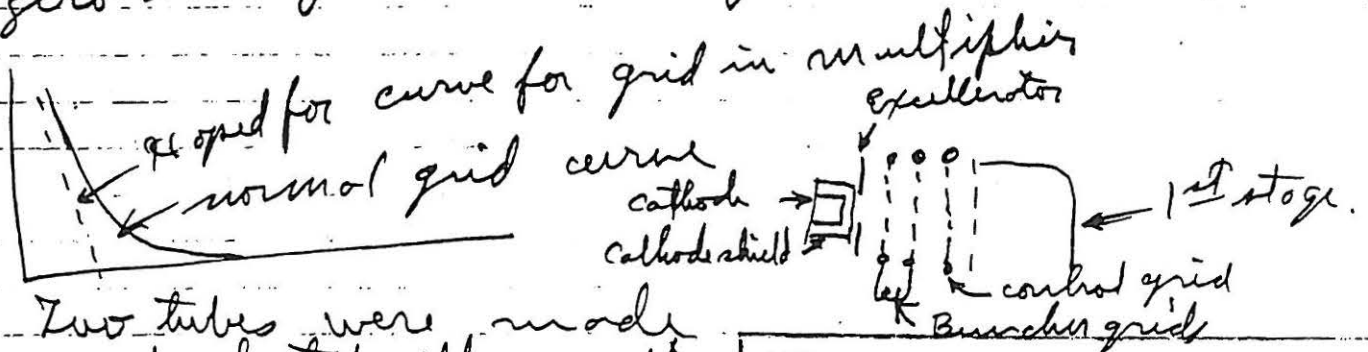
TELEVISION LABORATORIES, (LTD.)

SUBJECT Input Stage for Thermionic Electron Multiplier ENGINEER B. E. Gardner

Sept 4. 1941. I suggested this idea to Geo Hufnagel & Harold Bernhardt.

To pass an electron beam thru the equivalent of the first part or buncher of a velocity modulator tube. If my conception of the action of this device is correct, the slow electrons are speeded up the faster ones are slowed down.

Now by adjusting the amplitude of the feeding oscillator we may be able to change the various emission velocities of the electrons so that they will be going all the same speed. Then they are slowed down by proper fields and pass thru a control grid at low velocity thence into the first stage of a multiplier. It is hoped that we can bring the grid curve to something like linearity as the current approaches zero.



Two tubes were made up and tested. the results were encouraging but not as good as we need to make the multiplier a standout performer.

I took about 20 curves on the tube made and they are available for further study

Witnesses:

- (1) Geo R. Hufnagel
- (2) Sept 15 1941
- (3) H. E. Bernhardt
- (4) Sept. 15 1941

DAILY NOTES

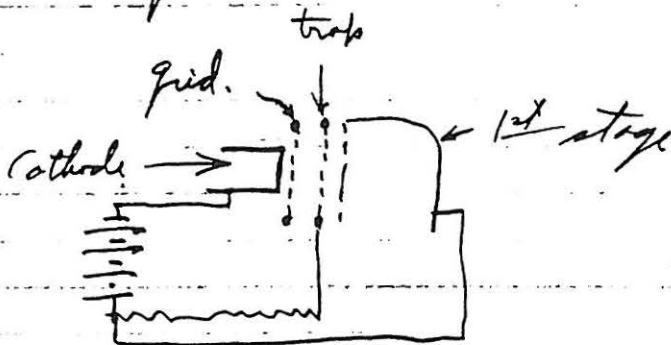
TELEVISION LABORATORIES, (LTD.)

DATE 9/15/41

SUBJECT Input Stage for Multystage

ENGINEER Bl Gardner

The next idea I had along this line was to use an (electron trap) to collect all the electrons represented by the bottom of the grid curve. This may be entirely a wrong conception but I think it worth trying.



Now when the current thru the grid is 0 the trap screen will maintain a high positive charge and if so designed will stop all the electrons until a point is reached where its potential is lowered so that the field of the 1st stage screen is predominant.

Then it will assume a very low potential and further current rise will be represented by electrons entering the 1st stage.

It may be that the first electrons entering the 1st stage will have an exponential characteristic. If so, it's just another funny idea.

Witnesses:

(1) J. R. Buffnagle

Sept. 15, 1941

(2) H. E. Baird

Sept. 15, 1941

FRANK W. B. L. CO. LTD.
NEW YORK, N. Y.

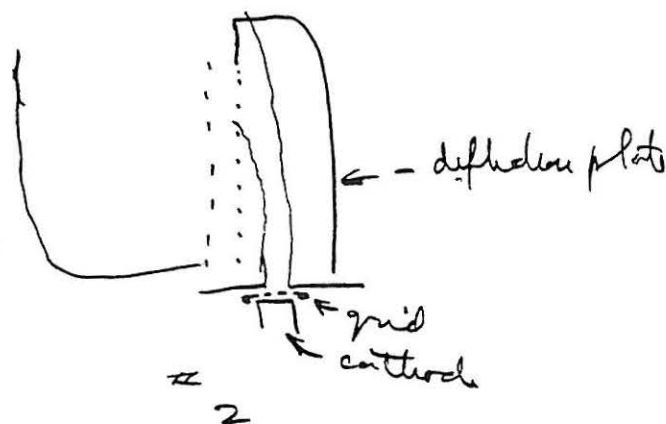
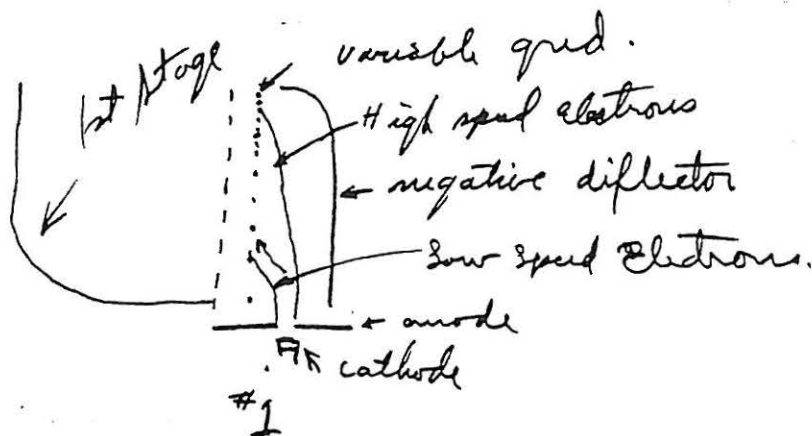
DAILY NOTES

DATE 9/15/41

TELEVISION LABORATORIES, (LTD.)

SUBJECT Input Stage for Electron Mult; ENGINEER B. E. Gardner

I got this idea today, of deflecting a low speed columnated beam of electrons so that their position of entering a grid would depend on their emission velocity. Now if a variable m.u. grid is used, they can be all cut off simultaneously and the grid curve should be near linear.



Another way to do the job might be to only deflect the beam enough to throw the lowest speed electrons into the multiplier stage. The field of the 1st stage screen to pull the beam over to it.

then the grid can be placed just over the cathode

a tube of this type is under construction

Witnesses:

() Jean W. Huffnagle

() Sept 15 1941

() H.E. Blankensat

() Sept 15 1941

For

DAILY NOTES

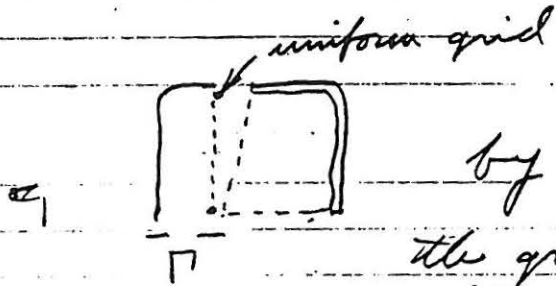
DATE Sept 19 1941

TELEVISION LABORATORIES, (LTD.)

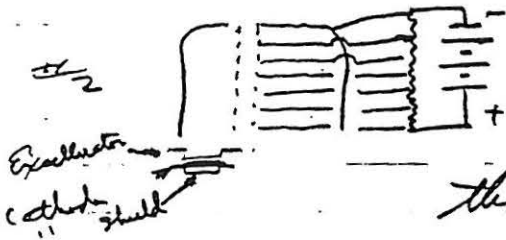
SUBJECT Input Stage for Therm. Malt

ENGINEER B. C. Gardner

There are at least two other ways of producing the equivalent of the Variable grid ~~that~~ shown on the Preceding page in figure 1



by putting a variable distance between the grid and 1st stage screen we get a grading grid sensitivity from top to bottom to compensate for varying emission densities



We get the same effect by putting a variable voltage gradient along the 1st stage screen.

A tube was made up to test the idea in #2

Several curves were made to show the effect of the variable gradient on the screen. 2 of which are shown on attached graph sheet.

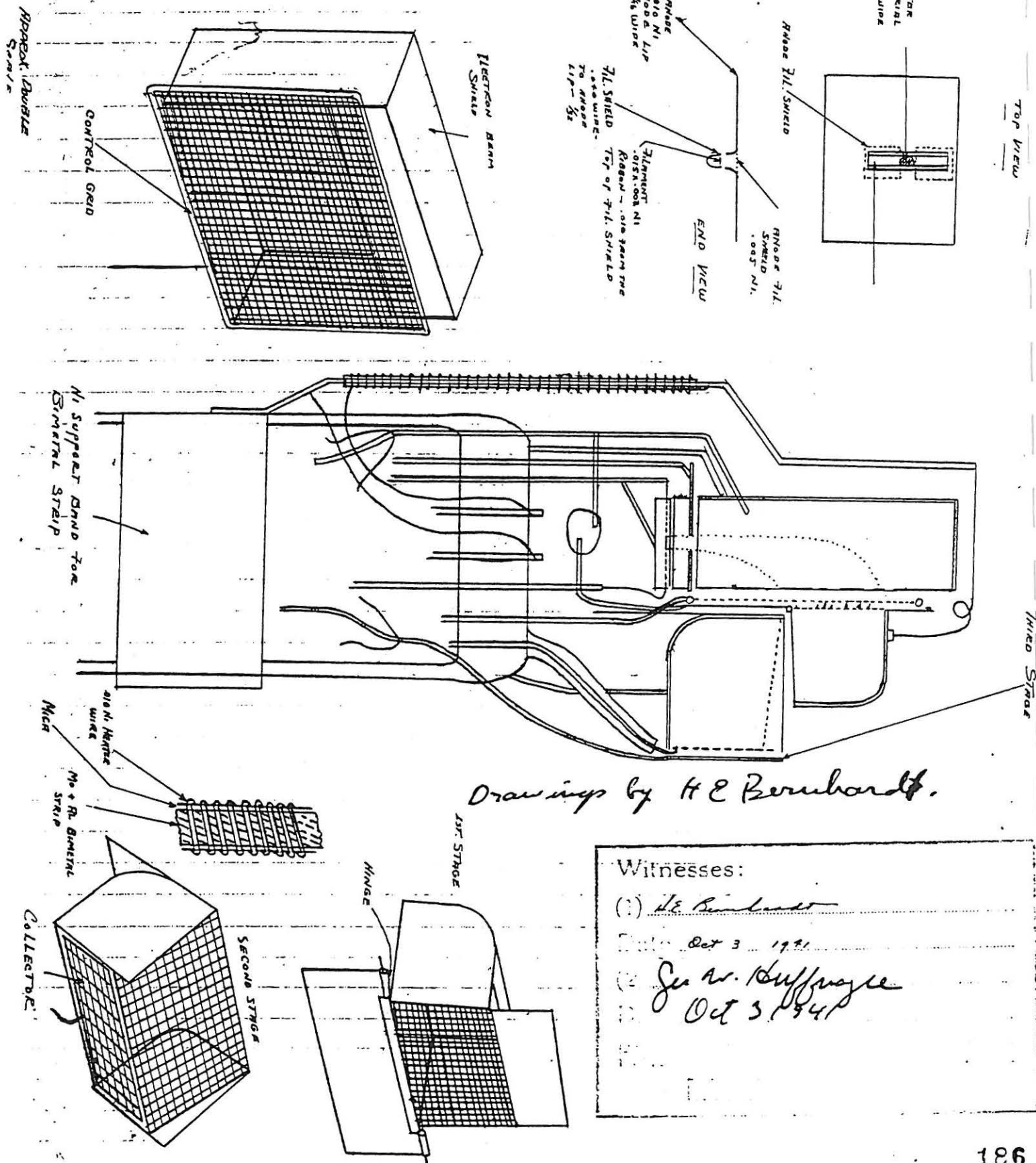
Witnesses:

() H. B. Bunker

Oct 3 1941

J. W. Cuffey
Oct 3 1941

ENGINEER B. L. Gardner



DAILY NOTES

DATE 3/16/42

TELEVISION LABORATORIES, (LTD.)

SUBJECT Cs Antimony thin P.E. Surface

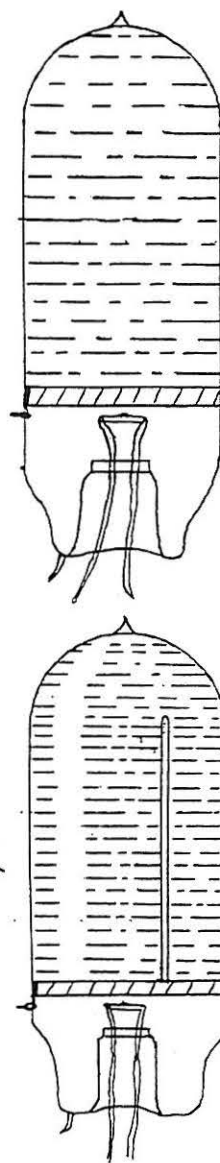
ENGINEER B.L. Gardner

This tube is representative of a series that were made in the development of a translucent Photo Surface for use in a camera tube suggested by P.T.F.

The antimony was evaporated from a small source onto a cylindrical blank to form a thickness wedge.

We obtained 60 ma/8 to wrap light and decided the limit was due to high resistance on the surface. Therefore several tubes were made having a thin Platinum under layer.

We have not as yet gotten the expected sensitivity to high light. But see no reason to think it can't be done.



Witnesses:

(1) Gen. W. Buffum
3/20/42

(2) H. Burchard
3-20-42

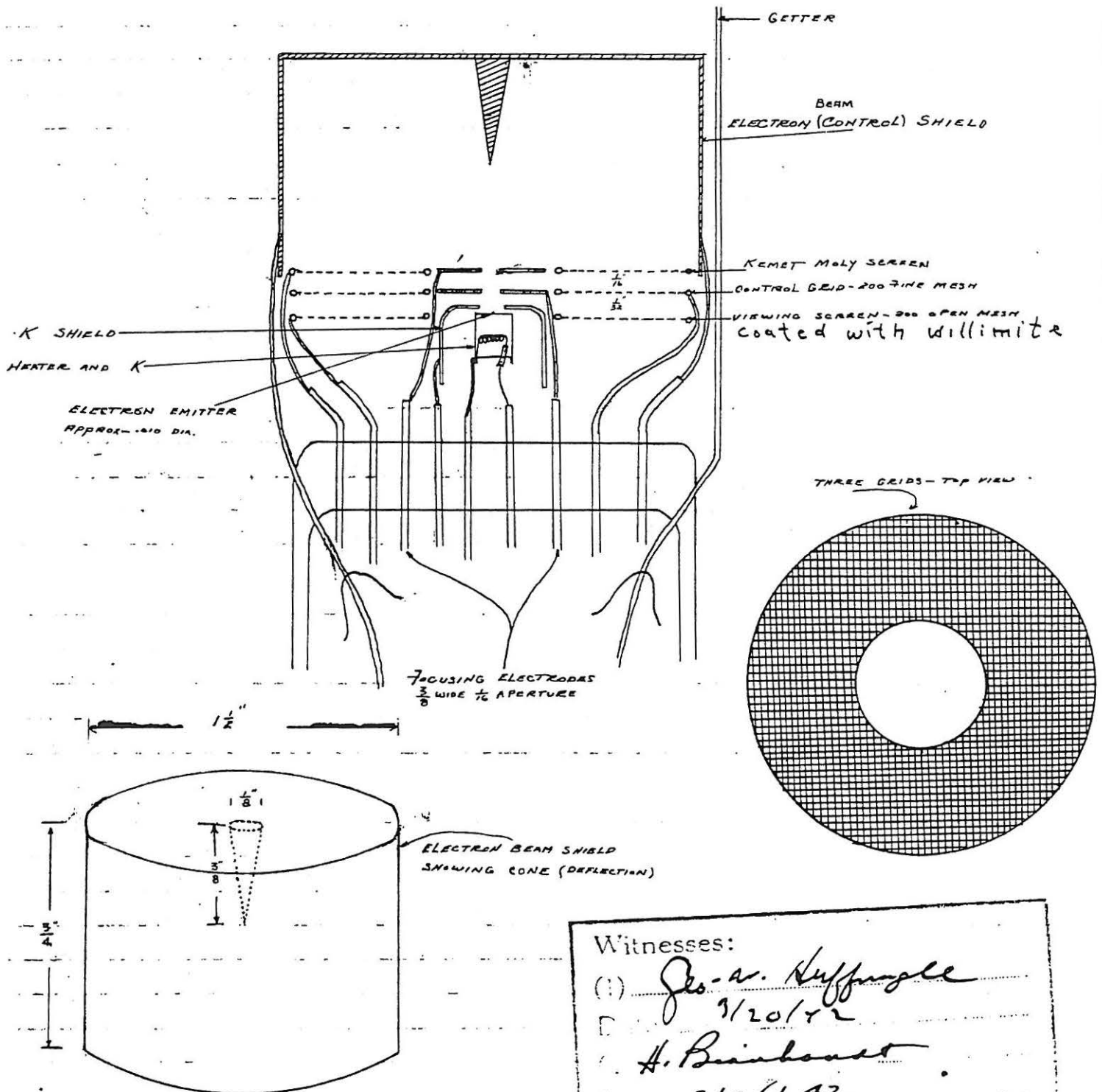
DAILY NOTES

DATE Mar 16 1942

TELEVISION LABORATORIES, (LTD.)

SUBJECT Electron Control

ENGINEER B. L. Gardner



Witnesses:

(1) Geo. A. Kuffner
3/20/42
H. Bernhardt
3/26/42

SCALE - APPROX. DOUBLE

H. BERNHARDT

★

Farnsworth's Cold-Cathode Electron Multiplier Tube Uses Neither Grid Nor Filament

By ARTHUR H. HALLORAN



Ralph M. Heintz (center) explains the operation of the Farnsworth Cold Cathode Tube to Bernard H. Linden (left), U. S. Radio Inspector, and Donald Lippincott (right), director of Television Laboratories, Inc.

THINK of a vacuum tube without filament or grid, thus requiring neither an A nor a C battery, which generates high-frequency oscillations! This is what P. T. Farnsworth, the television genius, accomplishes with the cold-cathode tube which he originally developed as a current-amplifier for use with his cathode-ray pickup tube. It is also an exceedingly efficient detector and modulator.

Its first public use as an oscillator was in a radio circuit whereby communication was maintained between San Francisco and Honolulu and between San Francisco and New York on September 13, 1934, over the Globe Wireless 35-meter channel. In this test, with 30 milliamperes at 1100 volts on the anode, the tube drove a pair of 150-watt tubes in the final amplifier of a transmitter at the

Heintz & Kaufmann factory in South San Francisco. The signals were received at both Honolulu and New York, and were reported as R9 by a ship 500 miles west of Honolulu. Wilkens of Dunedin, New Zealand, also heard the transmissions.

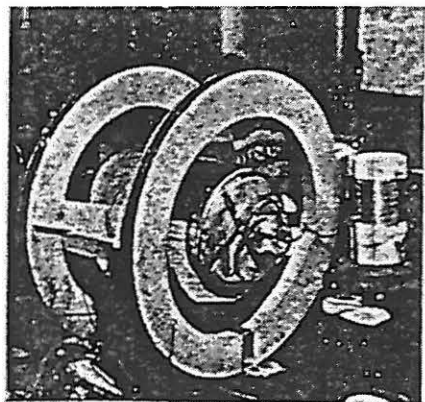
Previous laboratory tests proved that the tube is capable of generating oscillations of any desired frequency throughout the range from 200 kilocycles to 60 megacycles, these limits being set only by the dimensions of the available tuned circuits. An undistorted output of 25 watts was obtained from an input of 25 watts.

As an Amplifier

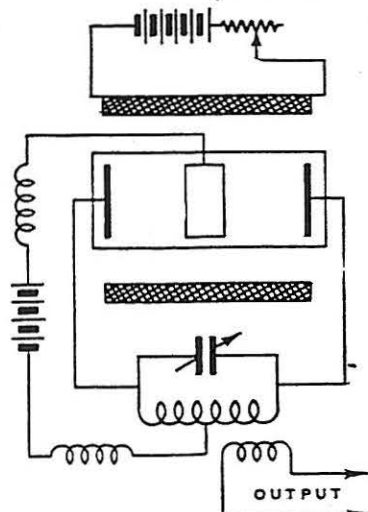
THE performance of this new type of tube depends upon the emission of secondary electrons from two cathodes which are bombarded with high-velocity primary electrons. The cathodes are coated with caesium silver oxide to enhance secondary emission. They, together with a central ring anode, are assembled in an evacuated glass tube. The tube is placed within a solenoid which is supplied with direct current so as to maintain an intense magnetic field throughout the length of the tube. When used as an amplifier, a high frequency voltage is applied to the cathode terminals and a D.C. voltage is applied to the anode terminal to hold it at a positive potential with respect to the cathodes, which are shunted by a coil and variable condenser in parallel. The shunt circuit is tuned so as to be in resonance for the applied high frequency voltage.

When the DC voltage is applied to the anode terminal, any free electrons in the inter-electrode space would immediately be drawn to the anode were it not that the longitudinal magnetic field neutralizes the transverse electrostatic field from the anode and

were it not for the high-frequency electrostatic field which draws them to the alternately positively charged cathodes. The strength of these several fields can be adjusted to allow an electron to be shuttled back and forth in a zig-zag path between the



The Electron Multiplier as a high-frequency self-excited oscillator.



Oscillator circuit for cold cathode tube.

cathodes any desired number of times before it is finally drawn out of circulation at the anode.

Each time that a high velocity electron strikes a cathode it causes the emission of from 2 to 8 secondary electrons, the number of secondaries depending upon the velocity of the impacting electron, and thus

(Continued on page 14)

Farnsworth Cold Cathode Tube

(Continued from page 6)

upon the amplitude of the voltage applied to the cathodes. Each emitted secondary, likewise causes the emission of more secondaries, so that the process is rapidly cumulative and gives rise to a tremendous amplification of current.

In the foregoing simplified account of the tube's operation as an amplifier, one important factor has been omitted. The anode attraction, which causes an electron to leave the vicinity of a cathode and which accelerates its velocity as it approaches the plane of the anode, also decelerates its velocity as it leaves the anode plane and approaches the second cathode, which is now positively charged so as to attract it. Its resultant velocity may therefore not be sufficient to cause emission from the second cathode. To insure emission, additional energy must be imparted to it, this energy being obtained from that stored in the resonant circuit, as indicated in the accompanying circuit diagram.

The high-frequency supply is of the order of 50 megacycles and is loosely coupled to the tuned circuit so as to apply from 25 to 90 volts across the cathode terminals. The positive potential on the anode may be 100 volts or more, depending upon the desired current output.

The tube has a discontinuous voltage-current output characteristic with a series of successively higher current peaks as the voltage is increased. Maximum current output is obtained when the anode voltage is just sufficient to allow an electron to travel from one cathode to the other during $\frac{1}{2}$ cycle of the high frequency excitation. Other successively lower peaks occur at anode voltages corresponding to transit times of $\frac{3}{2}$, $\frac{5}{2}$, $\frac{7}{2}$, $\frac{9}{2}$ cycles, the last being the least which has yet been measured.

(Continued on page 18)

Farnsworth Cold Cathode Tube

(Continued from page 14)

The external magnetic field is unnecessary when the cathodes are properly curved instead of being plane. Their curvature can be calculated to focus the electrons automatically for specified anode and cathode voltages. This eliminates the need of a DC supply for magnetic focusing.

The tube's theoretical output is twice that of an equivalent hot-cathode tube operated as a Class A amplifier. Its practical output is limited by the ability of the cathodes to withstand the high temperature to which they are subjected by bombardment from a rapidly increasing number of electrons. One test of a small tube showed an output of 100 watts of undistorted energy before the cathodes were destroyed by heat. Such destruction is prevented by means of resistors in the cathode leads. A small tube can be safely operated so as to deliver 45 milliamperes with 200 volts on the anode. It is to be noted that the tube operates as a current amplifier and that the amount of voltage amplification is dependent upon the resistance in the output circuit.

The theory of the tube's operation as a detector or modulator should be evident from the non-linear voltage-current characteristic and requires no elaboration here. It is especially sensitive in the detection of ultra-high frequencies.

IT IS a well known fact that any amplifier circuit generates oscillations when arranged to furnish an input voltage of proper magnitude and phase. Consideration of the manner in which Farnsworth's tube functions as an amplifier shows that it conforms to this requirement when connected to a resonant circuit which is tuned to a frequency whose half-period is equal to an electron's time of transit, as determined by the frequency of the oscillations applied to the cathodes.

But the great value of the Farnsworth tube resides in the fact that it is self-exciting, i.e., that it requires no external high frequency voltage when used as an oscillator. Aside from the energy which is required for the magnetic focusing field and which may not be needed eventually, the only external source of energy is that which maintains a positive potential on the anode. It apparently represents a new discovery in vacuum tube phenomena. Among engineers there is a difference of opinion as to its cause.

One plausible explanation is based on the assumption that there is no appreciable space charge effect in the tube when oscillations start. There are always some free electrons present in the inter-electrode space, if only those due to photoelectric emission from the cathodes. These are attracted by the anode when it becomes strongly positive but are prevented from immediately going to it by the longitudinal magnetic field. Their acceleration as they approach the plane of the

anode causes a current to flow, through the inductance coil in the tuned circuit, to one cathode. This provides an out-of-phase voltage drop which accelerates the electron toward the other cathode with sufficient velocity to cause secondary emission therefrom. The emitted electrons then establish a current flow through the other half of the mid-tapped coil and cause a voltage drop in opposite phase so as to accelerate the electron toward the first cathode which is thus caused to emit more secondaries. Repetition of this process quickly builds the current up to a point where it can be delivered to the output circuit without stopping the internal oscillations. The oscillating frequency is that to which the resonant circuit is tuned. This explanation has not been confirmed by physicists, but is presented only as a means for visualizing possible actions in the tube. When engineers disagree, the physicist must experiment.

Much work has yet to be done before standardized tubes will be available for experimental use. Television Laboratories Ltd. has licensed two factories for commercial production. But it will probably be a matter of some months before tubes are available for amateur use.

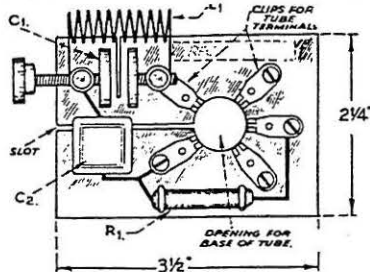
The New RCA 955 1/2-Meter Tube

By CLAYTON F. BANE

EVER since the ultra-high frequencies became known, research in these bands has been handicapped because the high inter-electrode capacity of conventional tubes effectively prevents them from efficiently oscillating or amplifying in conventional circuits at frequencies higher than approximately 30 MC. The high capacity of conventional tubes from grid to cathode and from plate to cathode makes it impossible to use Low-C grid and plate circuits and therefore the resonant voltage which could be applied to the tube is limited. In other words, this high capacity acts as an effective by-pass condenser which, to all intents and purposes, short-circuits the input and the output of the tube.

Under the direction of Mr. B. J. Thompson of the Research Laboratories of R.C.A. Radiotron Co., Inc., experiments were conducted with tubes specifically designed for use at the ultra-high frequencies. It was discovered that if all the physical dimensions of a conventional vacuum tube are proportionately reduced, the inter-electrode capacities can be tremendously reduced without causing an appreciable change in the electrical characteristics of the tube itself. The new RCA 955 is approximately the size of an acorn and, figuratively speaking, a microscope is needed to find the elements in the tube. In spite of its small size, the tube has a low plate resistance, 12,500 ohms, and a high amplification factor of 25 with the resulting high mutual conductance of 2,000 micromhos. Mutual conductance is a fairly accurate yardstick of tube performance, and regardless of the compromises which have been made to enable this tube to operate as a regenerative oscillator at a wavelength of only 20 inches, the mutual conductance is higher than any of the conventional general purpose triodes, such as the 56 and 76.

In order to keep the capacities low, no base is used on this tube. The leads to the grid,



Plan view of transmitter.

plate and indirectly-heated 6.3 volt cathode come directly out of the glass envelope, and are widely separated. No attempt should be made to solder to these wires because soldering usually results in breaking the glass envelope.

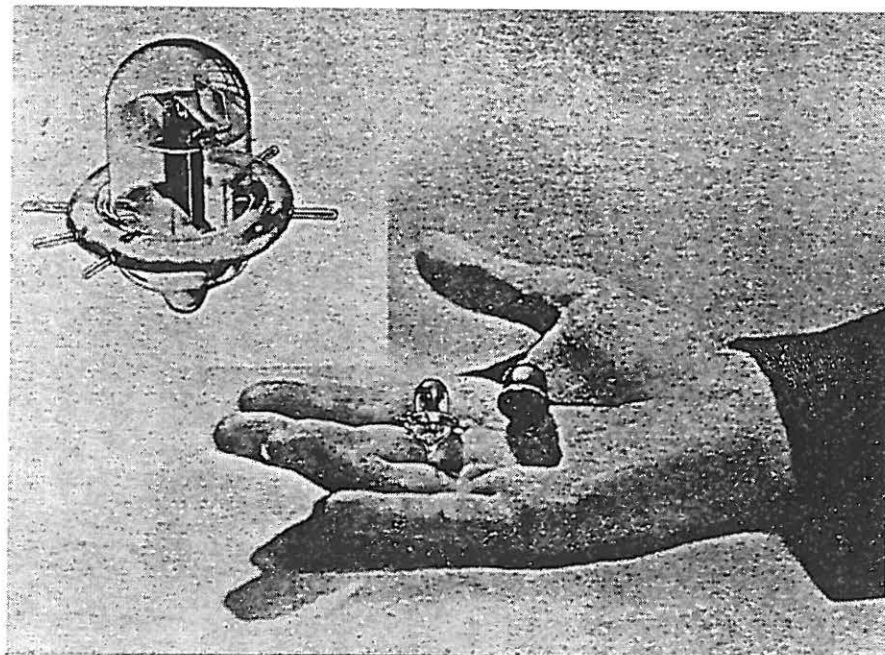
With very low internal capacities and excellent characteristics, this tube will come into prominence for 1/2 meter work, although it is in the high frequency field that such a tube will really prove its merit. Although a number of the present tubes will oscillate at around 2 or 3 meters, the 955, to the best of our knowledge, is the only tube that will operate in the conventional manner as low as 1/2 meter.

With the B-K type of oscillator used by many experimenters for operation at frequencies below one meter, a number of difficulties limit the effectiveness of such oscillators. In the B-K circuit the grid must run positive, while the plate is negative. The

power input to the tube is consequently greatly limited by the low heat dissipation of the average grid. With these limitations in mind it is easy to see why the conventional

left in the tank. It is safe to predict that the little tube will work nicely in the conventional Jones Self-Quenching circuit.

None of the troubles due to instability of oscillation were encountered. If this lack of crankiness is carried over to the super-regenerative receivers for ultra-high frequen-



Showing minute size of the new RCA 955.

type of oscillator is much to be preferred.

Using the little transmitter shown in the illustration, the 955 was given its first test. The extremely small size eclipsed anything in our previous experience, so we did not look forward to a great deal in the way of performance. However, the tube proved to be a very stable, vigorous oscillator. Calling on previous experience, we considered the number of turns in the tank and reached for the frequency meter which covered a range up to 60 megacycles. No deflection on the frequency meter galvanometer was visible, although the galvanometer coupled to the tank was showing a strong indication. The use of lecher wires was finally considered to determine the exact frequency of oscillation. We found that we were on 2 meters! Subsequent experiments showed that 1 meter was easily achieved, with a number of turns still

cies, it is reasonable to expect that records for two-way communication on low power will soon fall.

Here are some of the characteristics of the 955:

Heater voltage.....	6.3 volts
Heater current.....	0.16 amp.
Max. plate voltage.....	180 volts
Grid voltage.....	-5 volts
Max. plate current.....	4.5 MA
Mutual conductance.....	2000 micromhos
Amplification factor.....	25
Plate resistance.....	12,500 ohms

We understand that these tubes will soon be available through RCA-De Forest distributors for amateur and experimental use, but it should be emphasized that the tubes have been developed solely for the experimenter and are not to be considered as an addition to the standard line of receiving tubes.

RCA 955—CIRCUIT DIAGRAM AND SUGGESTED LAYOUT

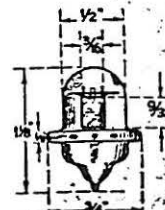
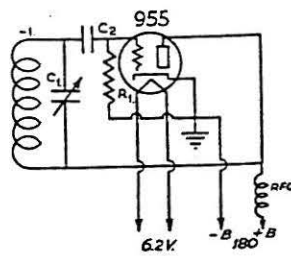
L1—8 turns, 1/2-in. outside diameter, No. 18 wire, spaced 1/4-in. between turns.

C1—Tuning condenser; 2 circular brass plates, 3/4-in. in diameter; 10/32 thread on adjusting screws.

C2—.00025 mica condenser, postage stamp type.

R1—15,000 ohms, 1 watt carbon resistor.

RFC—1/4-in. bakelite rod wound 1 1/2-in. with No. 32 DCC wire.



Circuit diagram of transmitter using RCA 955 tube.

SECTION

4

VRIL SIGNALS
AND
RAYs



TESLA MISTY WHITE SPACEWARD DISCHARGES

A most curious form of discharge is observed with such a coil when the frequency and potential are pushed to the extreme limit. To perform the experiment, every part of the coil should be heavily insulated, and only two small spheres—or, better still, two sharp-edged metal discs (*d d*, Fig. 11) of no more than a few centimetres in diameter—should be exposed to the air. The coil here used is immersed in oil, and the ends of the secondary reaching out of the oil are covered with an air-tight cover of hard rubber of great thickness. All cracks, if there are any, should be carefully stopped up, so that the brush discharge cannot form anywhere except on the small spheres or plates which are exposed to the air. In this case, since there are no large plates or other bodies of capacity attached to the terminals, the coil is capable of an extremely rapid vibration. The potential may be raised by increasing, as far as the experimenter judges proper, the rate of change of the primary current. With a coil not widely

differing from the present, it is best to connect the two primaries in multiple arc; but if the secondary should have a much greater number of turns the primaries should preferably be used in series, as otherwise the vibration might be too fast for the secondary. It occurs under these conditions that misty white streams break forth from the

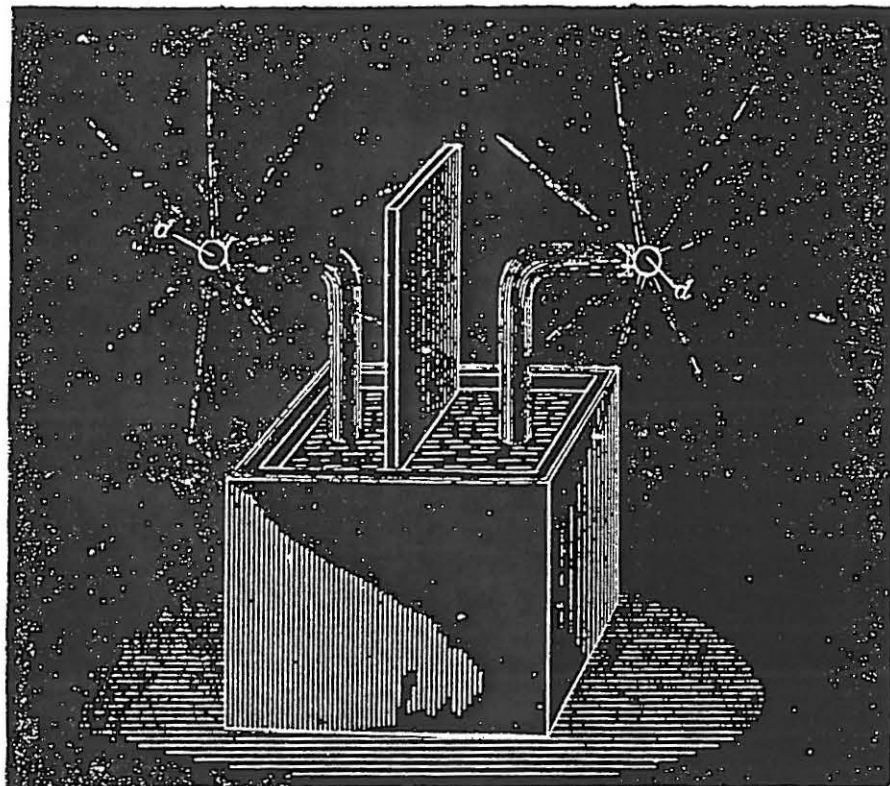


FIG. 11.—PHANTOM STREAMS.

edges of the discs and spread out phantom-like into space. With this coil, when fairly well produced, they are about 25 to 30 centimetres long. When the hand is held against them no sensation is produced, and a spark, causing a shock, jumps from the terminal only upon the hand being brought much nearer.

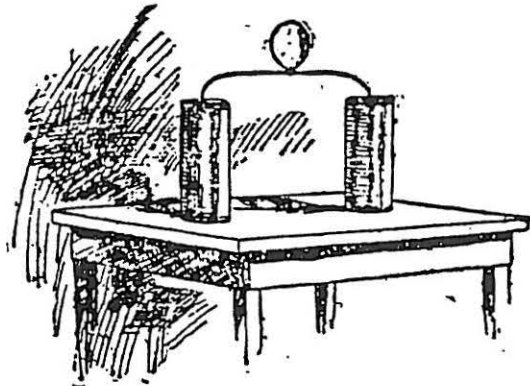
THE TESLA VACUUM LAMP.

DURING the past week Mr. Tesla has announced in various interviews with the reporters of the daily press that he has effected improvements in the methods of vacuum tube illumination announced by him in 1891. Speaking to a New York "World" reporter, Mr. Tesla is quoted as follows:

"There has been little change in the apparatus I now use compared with that I displayed at St. Louis. The basic principles are the same. I have simply made improvements and marked advances. I have found the causes of loss of energy and have largely overcome them. Already I can deliver 10 per cent. of the initial energy in a pure white light. This is three times the efficiency of an ordinary incandescent lamp."

The New York "Herald" of May 24 gives the following description and illustration of Mr. Tesla's improved lamp:

"It is a very simple looking contrivance. Two brass cylinders, looking for all the world like the empty shells of shot for a rapid fire cannon, stand about six inches apart. A light



THE TESLA VACUUM LAMP.

wire extends between the two, which probably contain coils, but about them Mr. Tesla will not say a word. Directly in the center of this thin wire is an ordinary electric light bulb used for incandescent lighting. The little point usually at the bottom of the bulb points upward. There is no filament in the vacuum. It appears merely as an ordinary bulb would appear if the carbon filament had been destroyed, but the interior has been exhausted of air many times more than the incandescent light bulb. When the current is turned into the electrodes and so into the bulb there is no foreign substance to burn. The electric molecules have the vacuum all to themselves. They move at the rate of from 3,000,000 to 4,000,000 vibrations a second. No one point gets bright and then seems to ignite the rest, as in the bulb usually seen. There comes a glow, just as there is a glow in the eastern sky at dawn, and then it becomes rapidly intenser, until the whole interior of the bulb sends out light, just as though a piece had been cut out of the edge of the sun and packed into the little glass receptacle."

According to the account in the "Herald" this lamp, with the same cubic contents as a 16 candle-power incandescent lamp is of 250 candle-power capacity.

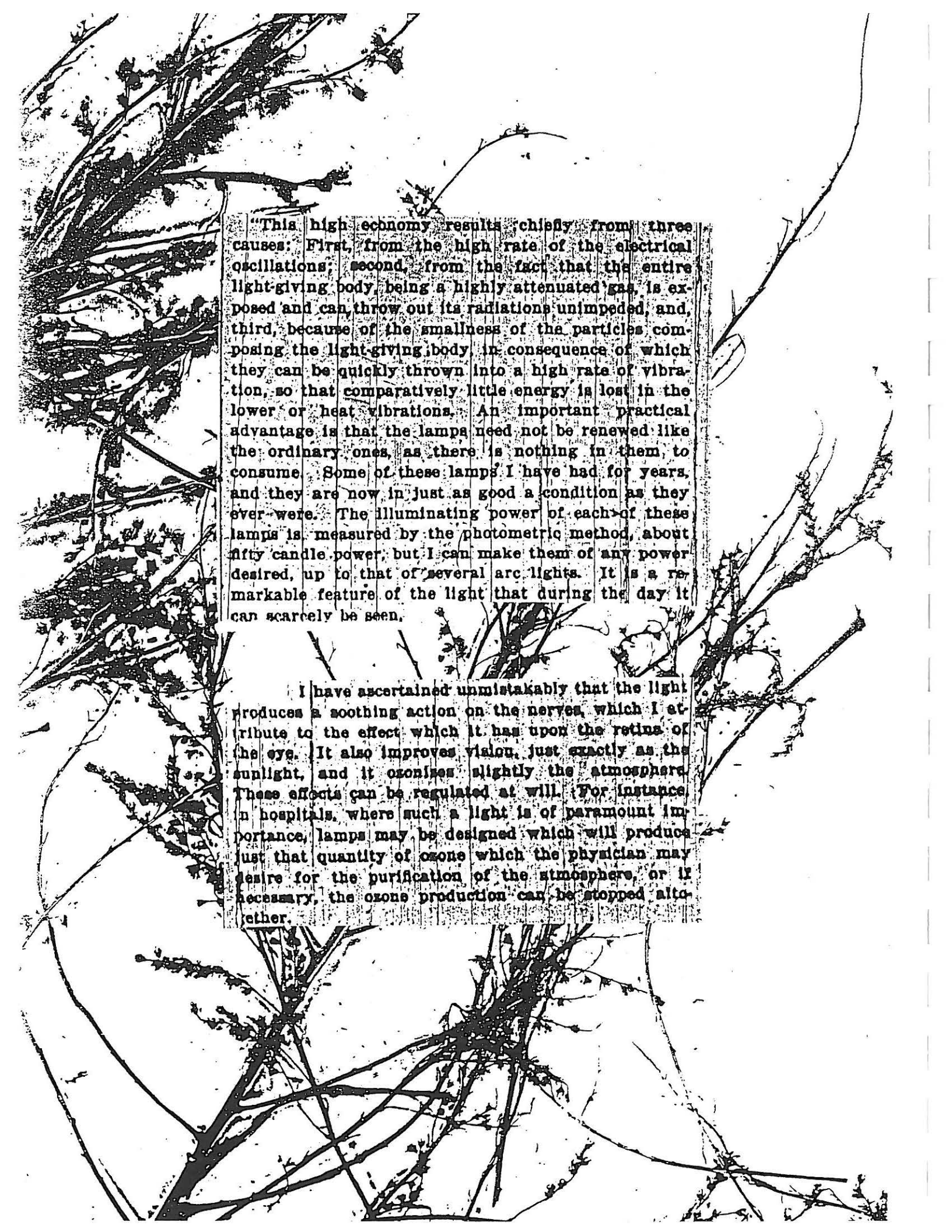
TESLA'S WIRELESS LIGHT.

Nikola Tesla has given to The New York Sun an authorized statement concerning his new experiments on the production of light without the aid of wires. Mr. Tesla says:

"This light is the result of continuous efforts since my early experimental demonstrations before scientific societies here and abroad. In order to make it suitable for commercial use, I had to overcome great difficulties. One of these was to produce from ordinary currents of supply electrical oscillations of enormous rapidity in a simple and economical manner. This, I am glad to say, I have now accomplished, and the results show that with this new form of light a higher economy is practicable than with the present illuminants. The light offers, besides, many specific advantages, not the least of which is found in its hygienic properties. It is, I believe, the closest approach to daylight which has yet been reached from any artificial source.

"The lamps are glass tubes which may be bent in any ornamental way. I most generally use a rectangular spiral, containing about twenty to twenty-five feet of tubing making some twelve to fourteen convolutions. The total illuminating surface of a lamp is from 300 to 400 square inches. The ends of the spiral tube are covered with a metallic coating, and provided with hooks for hanging the lamp on the terminals of the source of oscillations. The tube contains gases rarefied to a certain degree, determined in the course of long experimentation as being conducive to the best results.

"The process of light production is, according to my views, as follows: The street current is passed through a machine which is an electrical oscillator of peculiar construction and transforms the supply current, be it direct or alternating, into electrical oscillations of a very high frequency. These oscillations, coming to the metallic-coated ends of the glass tube, produce in the interior corresponding electrical oscillations, which set the molecules and atoms of the inclosed rarefied gases into violent commotion, causing them to vibrate at enormous rates and emit those radiations which we know as light. The gases are not rendered incandescent in the ordinary sense, for if it were so they would be hot, like an incandescent filament. As a matter of fact, there is very little heat noticeable, which speaks well for the economy of the light, since all heat would be loss.

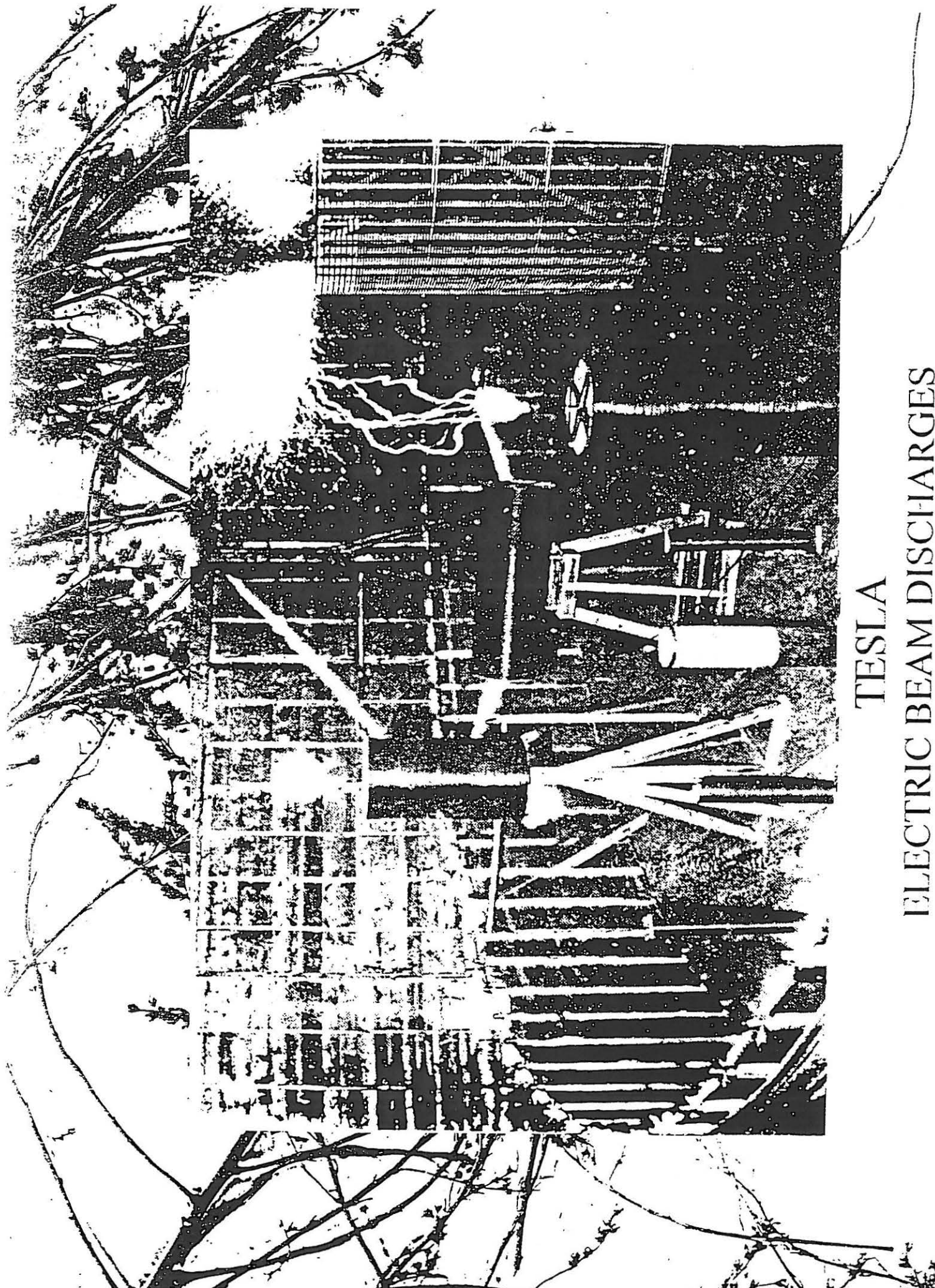


"This high economy results chiefly from three causes: First, from the high rate of the electrical oscillations; second, from the fact that the entire light-giving body, being a highly attenuated gas, is exposed and can throw out its radiations unimpeded, and, third, because of the smallness of the particles composing the light-giving body, in consequence of which they can be quickly thrown into a high rate of vibration, so that comparatively little energy is lost in the lower or heat vibrations. An important practical advantage is that the lamps need not be renewed like the ordinary ones, as there is nothing in them to consume. Some of these lamps I have had for years, and they are now in just as good a condition as they ever were. The illuminating power of each of these lamps is measured by the photometric method, about fifty candle power, but I can make them of any power desired, up to that of several arc lights. It is a remarkable feature of the light that during the day it can scarcely be seen.

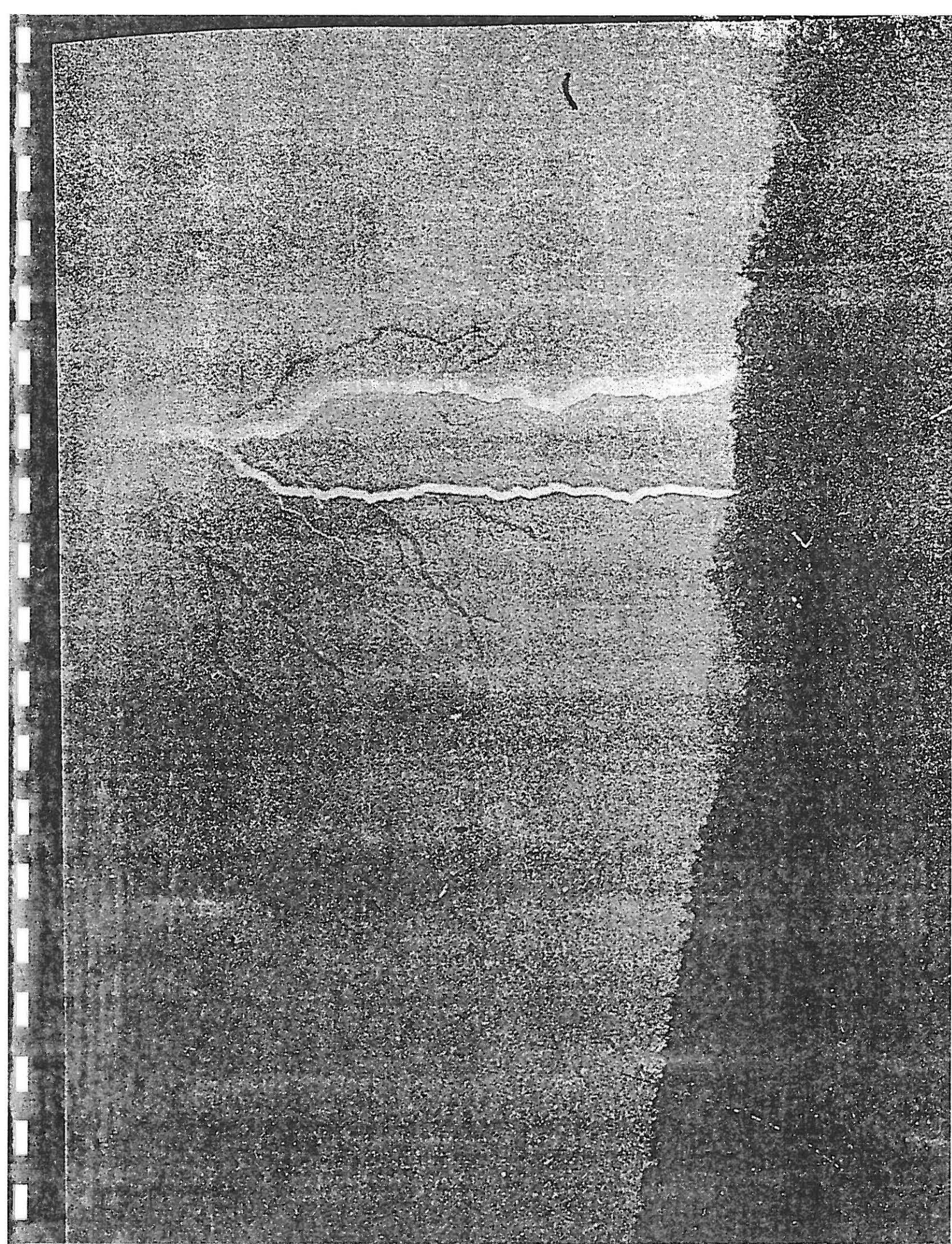
I have ascertained unmistakably that the light produces a soothing action on the nerves, which I attribute to the effect which it has upon the retina of the eye. It also improves vision, just exactly as the sunlight, and it ozonizes slightly the atmosphere. These effects can be regulated at will. For instance, in hospitals, where such a light is of paramount importance, lamps may be designed which will produce just that quantity of ozone which the physician may desire for the purification of the atmosphere, or if necessary, the ozone production can be stopped altogether.



"The lamps are very cheap to manufacture, and by the fact that they need not be exchanged like ordinary lamps or burners they are rendered still less expensive. The chief consideration in, of course, in commercial introduction the energy consumption. While I am not yet prepared to give exact figures, I can say that given a certain quantity of electrical energy from the mains, I can produce more light than can be produced by the ordinary methods. In introducing this system of lighting my transformer, or oscillator, will be usually located at some convenient place in the basement, and from there the transformed currents will be led as usual through the building. The lamps can be run with one wire alone, as I have shown in my early demonstrations, and in some cases I can dispense entirely with the wires. I hope that ultimately, we shall get to this ideal form of illumination, and that we shall have in our rooms lamps which will be set aglow no matter where they are placed, just as an object is heated by heat rays emanating from a stove. The lamps will then be handled like kerosene lamps, with this difference, however, that the energy will be conveyed through space. The ultimate perfection of apparatus for the production of electrical oscillations will probably bring us to this great realization, and then we shall finally have the light without heat or cold light. I have no difficulty now to illuminate the room with such wireless lamps, but a number of improvements must be made yet before it can be generally introduced."



TESLA
ELECTRIC BEAM DISCHARGES
1900



Tesla's Views on Electricity and the War

By H. WINFIELD SECOR

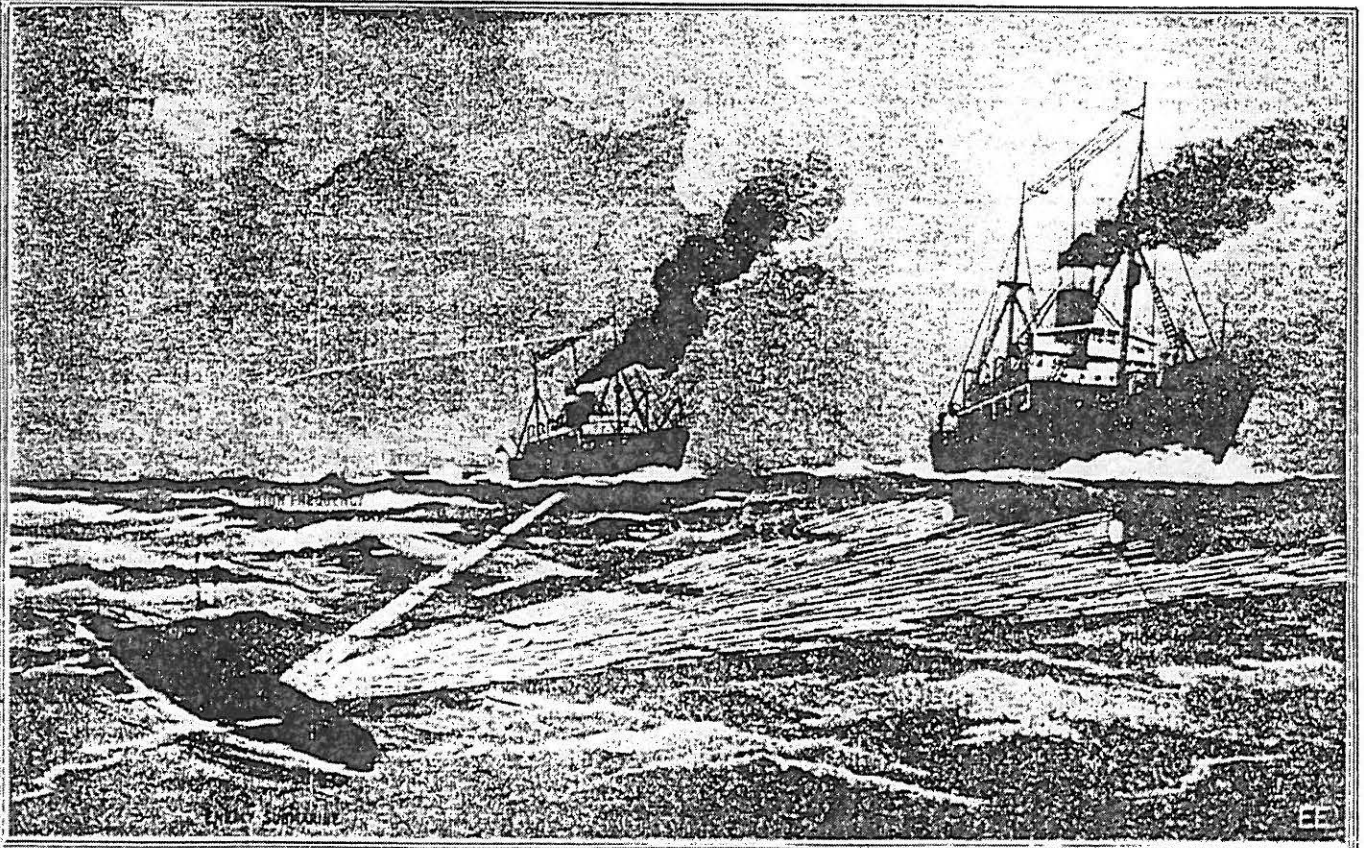
Exclusive Interview to THE ELECTRICAL EXPERIMENTER

NIKOLA TESLA, one of the greatest of living electrical engineers and recipient of the seventh "Edison" medal, has evolved several unique and far-reaching ideas which if developed and practically applied should help to partially, if not totally, solve

interview and some of his ideas on electricity's possible rôle in helping to end the great world-war are herein given:

The all-absorbing topic of daily conversation at the present time is of course the "U-boat." Therefore, I made that subject my opening shot.

capacity of chief electrician for an electric plant situated on the river Seine, in France, I had occasion to require for certain testing purposes an extremely sensitive galvanometer. In those days the quartz fiber was an unknown quantity—and I, by becoming specially adept, managed to pro-



Nikola Tesla, the Famous Electric Inventor, Has Proposed Three Different Electrical Schemes for Locating Submerged Submarines. The Reflected Electric Ray Method Is Illustrated Above; the High-Frequency Invisible Electric Ray, When Reflected by a Submarine Hull, Causes Phosphorescent Screens on Another or Even the Same Ship to Glow, Giving Warning That the U-boats Are Near.

the much-discussed submarine menace and to provide a means whereby the enemy's powder and shell magazines may be exploded at a distance of several miles.

There have been numerous stories bruited about by more or less irresponsible self-styled experts that certain American inventors, including Dr. Tesla, had invented among other things an electric ray to destroy or detect a submarine under water at a considerable distance. Mr. Tesla very courteously granted the writer an

"Well," said Dr. Tesla. "I have several distinct ideas regarding the subjugation of the submarine. But lest we forget, let us not underestimate the efficiency of the means available for carrying on submarine warfare. We may use microphones to detect the submarine, but on the other hand the submarine commander may employ microphones to locate a ship and even torpedo it by the range thus found, without ever showing his periscope above water.

"Many years ago while serving in the ca-

duce an extremely fine cocoon fiber for the galvanometer suspension. Further, the galvanometer proved very sensitive for the location in which it was to be used; so a special cement base was sunk in the ground and by using a lead sub-base suspended on springs all mechanical shock and vibration effects were finally gotten rid of.

"As a matter of actual personal experience," said Dr. Tesla, "it became a fact that the small iron-hull steam mail-packets (ships) plying up and down the river Seine

at a distance of 3 miles would distinctly affect the galvanometer!"

"How could this be applied to the submarine problem?" I asked.

"Well, for one thing," the scientist replied, "I believe this magnetic method of locating or indicating the presence of an iron or steel mass might prove very practical in locating a hidden submarine. And it is of course of paramount importance that we do find a means of accurately locating the sub-sea fighters when they are submerged, so that we can, with this information, be ready to close in on them when they attempt to come to the surface. Especially is this important when several vessels are traveling in fleet formation; the location and presence of the enemy submarine can be radiographed to the other vessels by the one doing the magnetic surveying and, by means of nets in some cases, or gun-fire and the use of hydro-aeroplanes sent aloft from the ships, the enemy under water stands a mighty good chance of being either 'bombed,' shelled or netted.

"However, a means would soon be found of nullifying this magnetic detector of the submerged undersea war-craft. They might make the 'U-boat' hulls of some non-magnetic metal, such as copper, brass, or aluminum. It is a good rule to always keep in mind that for practically every good invention of such a kind as this, there has always been invented an opposite, and equally efficient counteracting invention."

"How about this new electric ray method of locating submarines?" I ventured to ask.

"Yes, yes, I am coming to that," the master electrician parried. "Now suppose that we erect on a vessel, a large rectangular helix or inductance coil of insulated wire. Actual experiments in my laboratory at Houston Street (New York

City), have proven that the presence of a local iron mass, such as the ship's hull, would not interfere with the action of this device. To this coil of wire, measuring perhaps 400 feet in length by 70 feet in width (the length and breadth of the ship) we connect a source of extremely high frequency and very powerful oscillating current. By this means there are radiated powerful oscillating electro-static currents, which as I have found by actual experiment in my Colorado tests some years ago, will first affect a metallic body (such as a submarine hull, even tho made of brass or any other metal), and in turn cause that mass to react inductively on the exciting coil on the ship. To locate an iron mass it is not necessary to excite the coil with a high frequency current; the critical balance of the coil will be affected simply by the presence of the magnetic body. To be able to accurately determine the direction and range of the enemy submarine four exciting inductances should be used. With a single inductance, however, it would be possible to determine the location of a submarine by running the ship first in one direction and then in another, and noting whether the reactive effect caused by the presence of the submarine hull increased or decreased. The radiating inductance must be very sharply attuned to the measuring apparatus installed on the ship, when no trouble will be found in detecting the presence of such a large metallic mass as a submarine, even at a distance of 5 to 6 miles; of this I feel confident from my past experiments in the realm of ultra-high frequency currents and potentials."

"What particular experiments do you have in mind, Dr. Tesla?" I asked.

"The Colorado tests of 1898-1900. Wonderful were the results there obtained,

both those anticipated as well as those unexpected. As an example of what has been done with several hundred kilowatts of high frequency energy liberated, it was found that the dynamos in a power house six miles away were repeatedly burned out, due to the powerful high frequency currents set up in them, and which caused heavy sparks to jump thru the windings and destroy the insulation! The lightning arresters in the power house showed a stream of blue-white sparks passing between the metal plates to the earth connection. I could walk on the sand (ordinarily considered a very good insulator) several hundred feet from my large high frequency oscillator, and sparks jumped from my shoes! At such distances all incandescent lamps glowed by wireless power, and banks of lamp, connected to a few turns of wire arranged in a coil on the ground, were lighted to full brilliancy. The effect on metallic objects at considerable distances was really remarkable."

I asked him about the "Uliivi ray," which was accorded considerable newspaper publicity some time ago.

"The 'Uliivi ray' really was transplanted from this country to Italy," asserted Dr. Tesla. "It was simply an adaptation of my ultra-powerful high-frequency phenomena as carried out in Colorado and cited previously. With a powerful oscillator developing thousands of horsepower it would become readily possible to detonate powder and munition magazines by means of the high frequency currents induced in every bit of metal, even when located five to six miles away and more. Even a powder can would have a potential of 6,000 to 7,000 volts induced in it at that distance."

(Continued on page 270)

TESLA'S VIEWS ON ELECTRICITY AND THE WAR.

(Continued from page 230)

"At the time of those tests I succeeded in producing the most powerful X-rays ever seen. I could stand at a distance of 100 feet from the X-ray apparatus and see the bones of the hand clearly with the aid of a fluoroscope screen; and I could have easily seen them at a distance several times this by utilizing suitable power. In fact, I could not then procure X-ray generators to handle even a small fraction of the power I had available. But I now have apparatus designed whereby this tremendous energy of hundreds of kilowatts can be successfully transformed into X-rays."

"Could these ultra-powerful and unusually penetrating X-rays be used to locate or destroy a submarine with?" I interjected.

"Now we are coming to the method of locating such hidden metal masses as submarines by an electric ray," replied the electrical wizard. "That is the thing which seems to hold great promises. If we can shoot out a concentrated ray comprising a stream of minute electric charges vibrating electrically at tremendous frequency, say millions of cycles per second, and then intercept this ray, after it has been reflected by a submarine hull for example, and cause this intercepted ray to illuminate a fluorescent screen (similar to the X-ray method) on the same or another ship, then our problem of locating the hidden submarine will have been solved."

"This electric ray would necessarily have to have an oscillation wave length extremely short and here is where the great problem presents itself; i.e., to be able to develop a sufficiently short wave length and a large amount of power, say several hundred thousand or even several thousand horse-power. I have produced oscillators having a wave length of but a few millimeters.

"Suppose, for example, that a vessel is fitted with such an electric ray projector. The average ship has available from say 10,000 to 15,000 H.P. The exploring ray could be flashed out intermittently and thus it would be possible to hurl forth a very formidable beam of pulsating electric energy, involving a discharge of hundreds of thousands of horse-power. The electric energy would be taken from the ship's plant for a fraction of a minute only, being absorbed at a tremendous rate by suitable condensers and other apparatus, from which it could be liberated at any rate desired."

"Imagine that the ray has been shot out and that in sweeping thru the water it encounters the hull of a submarine. What happens? Just this:—The ray would be reflected, and by an appropriate device we would intercept and translate this reflected ray, as for instance by allowing the ray to impinge on a phosphorescent screen, acting in a similar way to the X-ray screen. The ray would be invisible to the unaided eye. The reflected ray could be firstly, intercepted by the one or more ships in the fleet; or secondly, it would be possible for the ship originating the ray to intercept the refracted portion by sending out the ray intermittently and also by taking advantage of what is known as the after-glow effect, which means that the ray would affect the registering screen an appreciable time after its origination. This would be necessary to allow the ship to move forward sufficiently to get within range of the reflected ray from the submarine, as the reflection would not be in the same direction as the originating ray."

"To make this clearer, consider that a concentrated ray from a searchlight is thrown on a balloon at night. When the

spot of light strikes the balloon, the latter at once becomes visible from many different angles. The same effect would be created with the electric ray if properly applied. When the ray struck the rough hull of a submarine it would be reflected, but not in a centered beam—it would spread out; which is just what we want. Suppose several vessels are steaming along in company; it thus becomes evident that several of them will intercept the reflected ray and accordingly be warned of the presence of the submarine or submarines. The vessels would at once lower their nets, if so equipped, order their gun crews to quarters and double the look-out watch. The important thing to know is that submarines are present. Forewarned is forearmed!

"The Teutons are clever, you know; very, very clever, but we shall beat them," said Dr. Tesla confidently. [It may be of interest to our readers to know that several important electrical war schemes will shortly be laid before the War and Navy Departments by Dr. Tesla, the details of which we naturally cannot now publish.]



Radio-telegraphy by Invisible Infra-red Radiation.—

Messrs. J. H. Stevens and A. Larigaldie have perfected a detector apparatus, particulars of which have recently been communicated to the Paris Academy of Sciences. With their device they have been able to obtain records of infra-red radiations over distances of more than 20 km., the best results being obtained with a thermocouple. In the tests as carried out the source of emission was an arc or electric lamp projector, the luminous flux of which was absorbed by a filter screen, a black glass coated with manganese-dioxide or gelatine. These screens absorb 50 per cent. of the total energy, but do not allow any rays which may affect the eye to pass. The receiver is a parabolic mirror arranged to trap the maximum of radiant energy; the thermopile being placed at the focus of this mirror. A metal plate $1/100$ mm. thick is autogenously welded to the point of a crystal of high thermoelectric power. The thickness of the plate and the diameter of the point of contact were kept as low as possible so as to form a whole of very low thermal capacity. The best results were obtained with a platinum plate and a crystal of tellurium tempered and welded in the direction of crystallisation. The junction is enclosed in a glass bulb having a special window. The thermocouple is mounted at the terminals of a lamp amplifier, the current being broken by a ticker of musical frequency. A potentiometer is connected up in the circuit in order to obviate all eddy currents due to the surrounding conditions which might cause a difference of constant temperature between the two junctions. The diminution in the radiant energy captured at the receiver is generally proportional to the distance covered from the transmitter, but regard must be had to the absorptive power of the atmosphere, which is sometimes low and sometimes considerable according to the proportions of water-vapour, fog, dust, &c. Where the thermopile is not used in telegraphy but in pyrometry, in tele-mechanics, or for revealing the presence of bodies whose temperature differs from that of the surroundings (e.g., of icebergs at sea), its current is passed into a fairly sensitive galvanometer to give a deflection of 3 to 4 mm. per micro-ampere (2 to 3 ohm coil). For ships the authors have designed a special double pivot galvanometer of the same sensitivity as the previous one, which is capable of working in any position and is unaffected by pitching or rolling. In September, 1913, signals were exchanged between two stations 14 km. apart. The transmitting station was provided with an arc projector of 1.50 m. In May of this year signalling experiments were made between two stations 7,500 metres apart. At the transmitting station there was a 0.40 m. mirror and an 800-watt nitrogen-filled electric lamp; while at the receiving station a gilt mirror of 0.24 m. was used.—*Technical Review.*



Infra-Red Rays used for Signalling

NEW METHOD IS BEING DEVELOPED.

Some few years ago a new means of practically secret signalling was developed by a number of engineers of the army and navy. It was first termed infra-red signalling, but later came to be known as "Dyscrasite."

It is not radio, but operates through the medium of infra-red light waves, which are invisible to the eye. As a conventional vacuum-tube receiver is used for reception and amplification of signals, and because a telegraph key or telephonic apparatus is employed to control a light beam, the system of communication is of interest to radio fans.

In the fall of 1916, T. W. Case discovered and reported upon the peculiar properties of lead antimony sulphide, when the long red rays of the spectrum fell upon a crystal of this chemical. First it was tried out in detecting the approach of electric cars, or rather detecting their powerful headlights, in New Auburn, N.Y. In this first experiment the tests showed results at a distance of about 300 feet. Refinements, however, with better lights, filters, and electrical galvanometers, increased the range to about a mile. The Sperry people became interested and further tests followed under the observations of army and navy officers, who evinced interest in connection with the possibility of secret signalling in battle and at sea. A two-mile test was successfully conducted both at night and in daylight between the Sperry building and the Woolworth tower, and upon reports of this success in 1917, General Squier, chief signal officer of the army, suggested a ten-mile test.

How It Was Developed.

It was this more military trial which led to the desire for making the received signals audible, and special vacuum tubes were developed. It was found that the pitch of the received signal note varied in wireless headphones with the intensity of the light on the filter. The ultimate distance reached with this improved means was about eight miles.

England became interested, and Lord Northcliffe witnessed a demonstration, following which he expressed a belief that it might serve in front line trenches as a means of secret signalling.

Later, further tests carried the range to 18 miles or from Fort Hancock, in New York harbor to the Woolworth Building, and another test indicated good reception of signals from the shore to a vessel at sea.

The Navy Department in discussing the possibilities reported that it might serve as a method of invisible signalling between vessels of a convoy proceeding without light, and that it would probably be valuable

in lighthouse work, aiding vessels to locate their positions off shore without using radio. The chief use to the navy, however, appeared to be as a means of secret communication, when vessels were proceeding without lights, or in battle. Its radius of action was found to be about 17 miles, while the cost of a complete set was comparatively low—about \$400.

This system, although not now in practical use, is not discarded—far from it. It has been termed "black radio," and several other strange and suggestive names. One of its important features is that it is directional, more like beam radio than pure radio broadcasts.

In recent dyscrasite communication tests, light rays are generated by an incandescent lamp, although a gas flame, and an arc light have been used. The light is situated in front of a parabolic mirror by means of which the divergence of the beam is controlled. The whole apparatus is housed in a light-proof case, with an opaque screen which permits only the invisible infra-red rays to pass out of the transmitter. Telegraphic signals are made by means of a shutter operated by a hand key. This shutter is located either outside the case or between the light and the mirror.

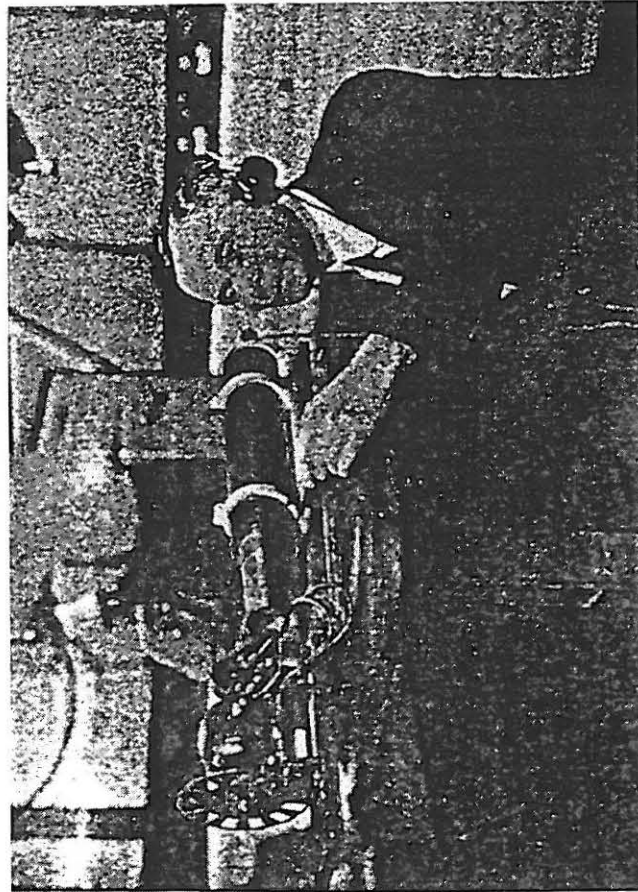
Telephonic impulses may be converted into light values by speaking against a drum controlling the gas supply, in the gas-flame system, which varies the gas pressure and modulates the light according to voice variations.

Transmitters Highly Directional.

At the receiving end of the circuit, detection is accompanied by inserting a piece of crystal, super sensitive to infra-red rays, at the focus of a parabolic reflector. The crystal forms part of a conventional vacuum tube circuit. Variations in the incoming infra-red rays impinging on the crystal alter the constants of the vacuum-tube circuit and produce variations audible in either headphones or a loud speaker.

Recently perfected dyscrasite transmitters are highly directional, having only an eight-degree divergence of beam, which makes for secrecy to a certain extent, although limiting its application in general communications. Another limitation of this apparatus is the fact that it is practical only for night signalling, the infra-red rays of the bright sunlight overshadowing its impulses, and paralyzing the detective elements. At night, however, it forms the only known means of communication, not subject to reception by ordinary means, such as visual, radio or sound detection, which indicates its value for secret signalling.





From a photograph made for POPULAR RADIO

HOW SECRET MESSAGES ARE RECEIVED BY INFRA-RED RAYS
Dr. W. W. Coblentz is here shown operating the receiving mechanism of the secret communication system that he has developed. Note the sector disk which breaks up the transmitted beam in an even sequence of impulses of an audible frequency.

The "Black Light Radio" — *A Secret Communication System That Uses Infra-red Rays*

A remarkable invention which may revolutionize all our present methods of short range signalling—especially for military use

By S. R. WINTERS

SECRECY is desirable in any form of communication and in warfare it is a prime necessity. All sorts of systems have been devised to make it possible to communicate by radio with the greatest amount of secrecy and with the least possibility of deliberate interference by enemy forces. But so far no system has been perfected that has these qualities to the required degree. Radio waves can be heard by the enemy as well as by the receiving station to which the message is being sent. Absolute secrecy in the transmission of messages over short distances, up to twenty miles, has been attained by a system developed by Dr. W. W. Coblentz of the Bureau of Standards, of the United States Department of Commerce. The veil of censorship which shrouded this invention during the world war has been lifted and for the first time the pub-

lic is given an insight into a method of signalling which cannot be detected or intercepted by the enemy.

In order to understand just how the new system works it may, perhaps, be worth while to consider the matter of the wavelengths that are used.

Everyone knows, of course, that the only difference between the waves of radio and ordinary light is a difference in the rate of oscillation. Light is a form of vibration just as are radio waves.

Violet light has the highest rate of vibration of any light which is visible to the human eye. Red light is at the other end of the scale of visibility and is the slowest vibration that affects the eye. When the vibrations are slower than the

rate which produces red light, we call them infra-red or heat waves and it is these waves that Dr. Coblentz uses in his new system.

A discovery by the Bureau of Standards as one of the minerals that can be used in a crystal detector, is extremely sensitive to the infra-red or dark rays, made this new system possible.

Molybdenite, it was found, acted under the stimulus of infra-red rays or waves, just as selenium does when it is exposed to ordinary light.

The apparatus used by this government bureau in signalling by invisible rays, in the preliminary tests, consisted of a holometer—an electrical instrument



From a photograph made for POPULAR RADIO

HOW MESSAGES ARE TRANSMITTED BY MEANS OF INFRA-RED RAYS
It has been found that infra-red rays can be reflected and concentrated in a single narrow beam like ordinary light so the transmitter consists, essentially, of an instrument that somewhat resembles an ordinary searchlight. The reflector and the source of light are specially adapted to the production and reflection of the infra-red band of waves.



From a photograph made for POPULAR RADIO

THE CRYSTAL DETECTOR THAT IS PARTICULARLY SENSITIVE TO INFRA-RED RAYS

"Molybdenite," known to all old-timers in the radio game as one of the mineral crystals that could be used to detect radio signals, was found by Dr. Coblentz to be extremely sensitive to infra-red rays. The small tube in his hands contains the molybdenite cell which makes the new system possible.

the photo-electrical conductivity. A signalling system which can utilize longer exposure of the receiver to the incident light will produce a greater change in the electrical conductivity.

"When using the sectored-wheel radio-telephone, the signal is recognized by the musical note emitted by the telephone receiver, the loudness of which is determined by the intensity of the incident radiations. The signal could be recognized also by a change in pitch of the sound

in the telephone receiver, provided apparatus can be devised to function by changing the pitch of the sound. This change in pitch was frequently observed in the French amplifier used in these experiments, but it was found to be inefficient and not reproducible. However, such a method is feasible. It is based upon the observation of T. W. Case that an audion bulb can be made to transmit a pulsating current. A change in current in the grid, or input, circuit causes a change in fre-

for measuring very small quantities of radiant heat—which was used in conjunction with a telephone and a vacuum-tube amplifying unit, common to the reception of radio communications. The instrument which determined the amount of radiant heat was, in this instance, merely used as a receiver of thermal or heat radiations, the rugged requirements of warfare precluding the use of a sensitive galvanometer. The receiving equipment, in the preliminary experiments, consisted of a thin blackened strip of platinum or gold leaf and a storage battery, which were connected in the conventional way.

The response of the bolometer to radiant energy in the form of heat waves, was intensified as the electric current was passed through an audio-amplifying circuit. Radiation was emitted from an acetylene flame, and the receiving equipment was exposed to the latter by means of a rotating disk which had 15 equally spaced openings.

The radio-telephone tests in which molybdenite was used instead of a gold leaf as a receiver involved a revision of the apparatus in certain particulars. Molybdenite and a dry-cell battery, which produced 40 to 60 volts, were connected directly to the input terminals of a radio receiving outfit, with three stages of amplification. A concave silver-on-glass mirror, 16 centimeters in diameter and 50 centimeters in focal length, was employed in concentrating the radiant energy upon the sensitive photo-electric substance. When the equipment is taken afield, a mirror, the disk with multiple

holes, and the molybdenite receiver, are mounted on a camera tripod. The disk somewhat resembles the prismatic ring invented by C. Francis Jenkins for the transmission and reception of photographs and motion pictures by radio.

"It is of interest to note that, when using the sectored disk, the molybdenite is exposed to radiation for only about 1/500 of a second," observes Dr. W. W. Coblentz, in outlining additional details of his remarkable invention.

"Nevertheless, in this short interval of time, the electrical conductivity undergoes a change sufficient to produce an audible signal. Hence it may be useful for lecture-room demonstration. Good results may be easily obtained by joining the molybdenite receiver in series with a telephone and a battery of dry cells of from 40 to 80 volts. However, for a really successful demonstration it is desirable to connect the crystal and a battery of dry cells of 30 to 60 volts directly to the input terminals of an amplifier.

Using a rotating sectored disc before the molybdenite receiver upon which is concentrated the light of an acetylene flame, the telephone emits a musical note of sufficient loudness to be audible in a remote part of the building.

"The method of producing a pulsating current in the telephone by interrupting the light which is incident upon the molybdenite, by interposing a rotating sectored wheel is inefficient in view of the fact that only one-half of the incident light is utilized and the exposure time is only about 1/500 of a second, which is not sufficient to permit a great change in

Why the Infra-red Signalling System Insures Secrecy:

- 1: It cannot be seen, or heard, or detected by any ordinary form of radio apparatus;
- 2: The signal is sent in only one direction in the form of a beam;
- 3: It can be operated without disclosing the position of the transmitter.

quency of the pulsating current, and hence a change in pitch of the sound produced in the telephone receiver. The time of exposure of the signal light can be made quite long, so as to utilize the full change in conductivity of the crystal receiver.

"This method of signalling seemed so attractive that an attempt was made to obtain a test of its efficiency as compared with the sectored-disk radiophone, using, in both devices, molybdenite for the receiver of the thermal radiations which were used in transmitting the signal.

"As we were unable to obtain the requisite apparatus and working solely upon the report that a suitably evacuated audion bulb can be made to function so as to change the pitch of the sound emitted by the telephone, the following apparatus was devised. An audion amplifier bulb, consisting of a grid, plate, and heating filament, was attached to an oil pump and evacuated to the pressure of mercury, which was found to produce the desired result. The wiring connection used was practically the DeForest audion connections with the grid potential positive. A resistance of 5 to 10 megohms is inserted in view of the fact that molybdenite has a comparatively low resistance, whereas it was found that the circuit must contain a high resistance in order to cause the audion bulb to function properly. The result of this test showed that owing to this high resistance, which was in series with the single receiver of molybdenite, but which did not function photoelectrically when exposed to light, the method of signalling by change in pitch was not so sensitive as the rotating-sectored disk radiophone. When several molybdenite receivers were joined in series so as to obtain the required high resistance when exposed to light, the sensitivity of this device was improved. As already mentioned, it is proposed to make artificial sensitive material.

"A photo-electric cell of the gas-ionic type—for example, the potassium hydride photo-electric cell—is well adapted for

use with this change-in-pitch method of signalling. The high resistance is used as ballast to the photo-electric cell. This combination was found to be the most sensitive of the radiophonic type of receivers yet tested. The applied voltage can be adjusted so that the telephone receiver emits a sound only when the photo-electric cell is exposed to light.

"Very instructive experiments can be performed with such a device. For example, the rate of charge and discharge can be adjusted so that the sound in the telephone is a series of clicks which increase in rapidity with increase in intensity of the exciting light. It is a simple task in glass blowing to arrange two electrodes and a heating strip (of platinum) to produce ionization.

"In secret signalling—the secret transmission of intelligence by means of invisible thermal radiations—radiometry attained its greatest triumphs and its most far-reaching applications.

"It is a method of signalling par excellence which, unlike electric-wave signalling, can be directed, which practically cannot be detected, and which can be operated without interference.

"The submarine can be combatted with depth bombs. Radio-telegraphy and telephony can be detected and interfered with, but the device for the secret transmission of intelligence by means of invisible thermal radiations, while still in its infancy, stands unique, as it can be operated without disclosing its position.

"Several writers (Ruhmer in Germany and Meissner in the United States) have written books which discuss secret signalling devices. Selenium was practically the only substance which was known at that time (1913) to be photoelectrically sensitive and which was discussed as a means of signalling.

"The unusually high photo-electric sensitivity, as well as the quickness of response of molybdenite to infra-red rays, renders this substance far superior to selenium as a radiophonic signalling device."

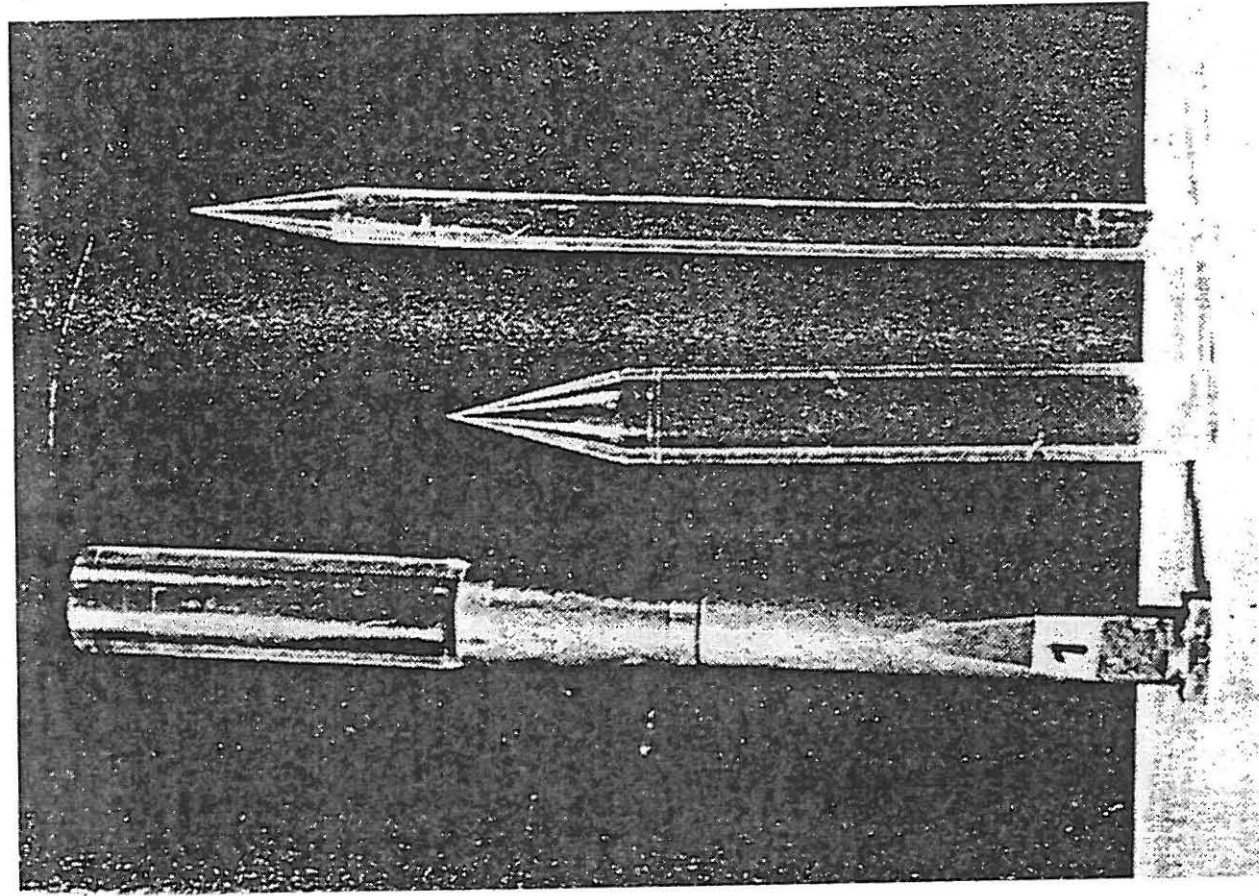
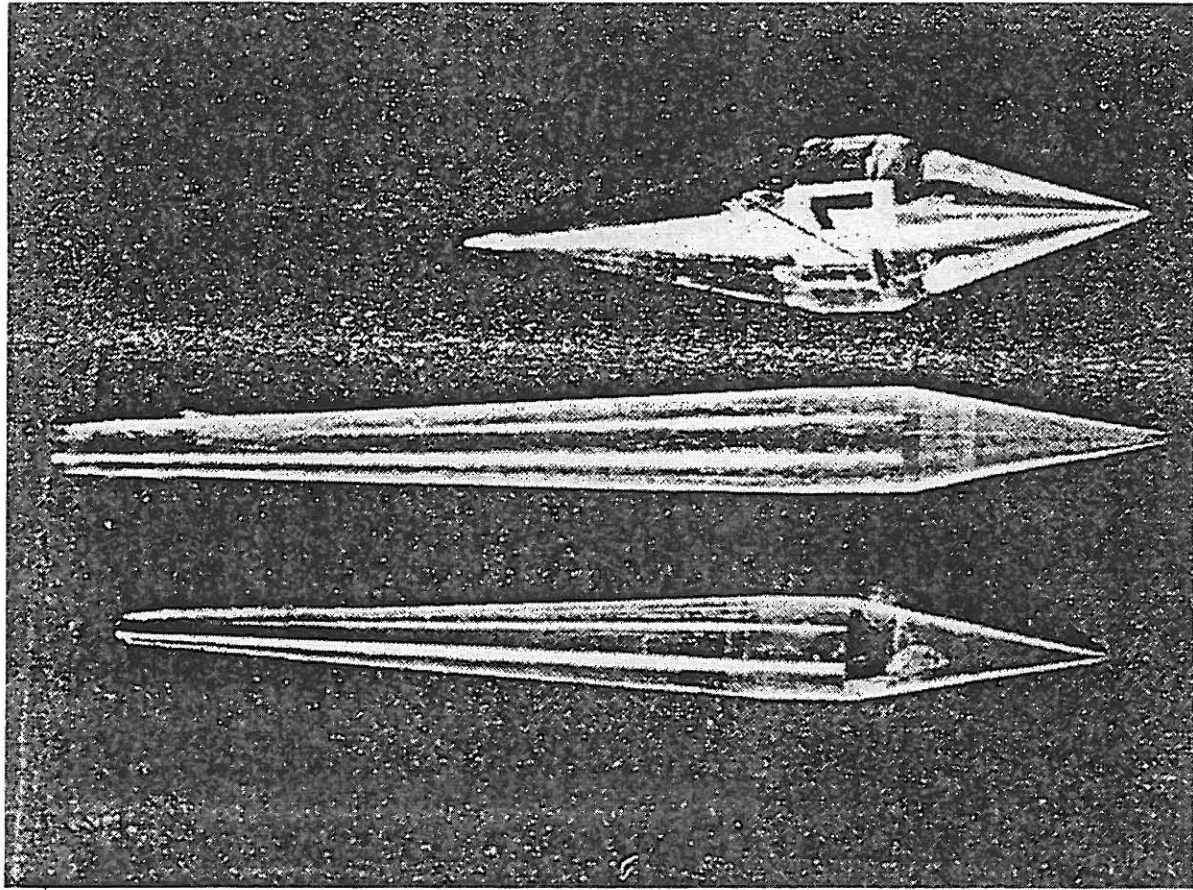


FIG.1.1. Cylindrical dielectric rod antennas. In the structure marked 1 the cylindrical dielectric rod is fitted into the mode transducer consisting of a rectangular metal waveguide gradually transformed into a cylindrical metal waveguide.

MICROWAVE CRYSTAL DIELECTRIC AERIALS

FIG. 1.2. Conical dielectric and dielectric-coated metal antennas. 1 is the dielectric-coated metal conical antenna.



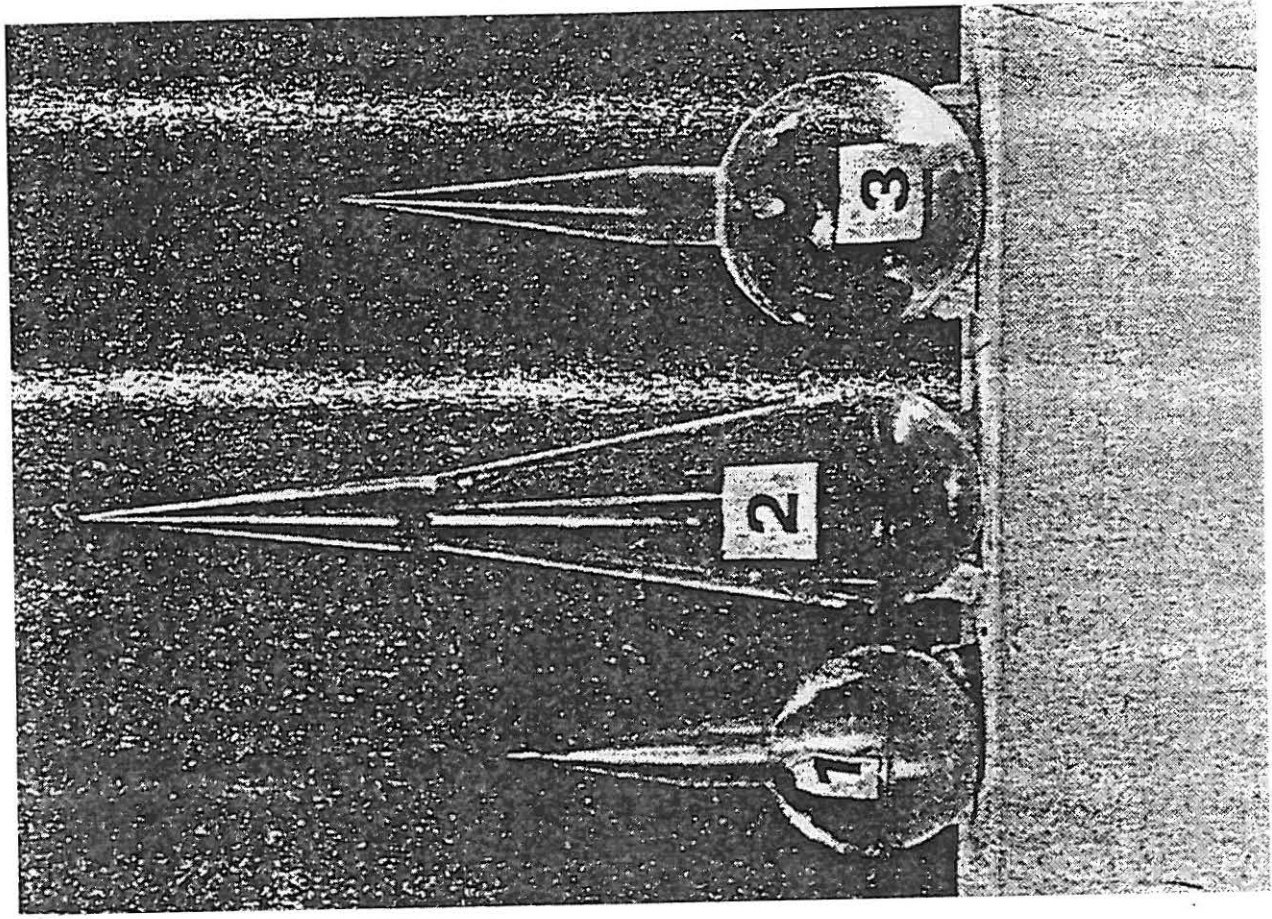


FIG. 1.3. Spherical dielectric and dielectric-coated metal antennas. 1 is a dielectric-coated metal sphere, 2 is a dielectric hemisphere on cone, 3 is a dielectric sphere.

FIG. 1.4. Tapered and
untapered rectangular
dielectric antennas

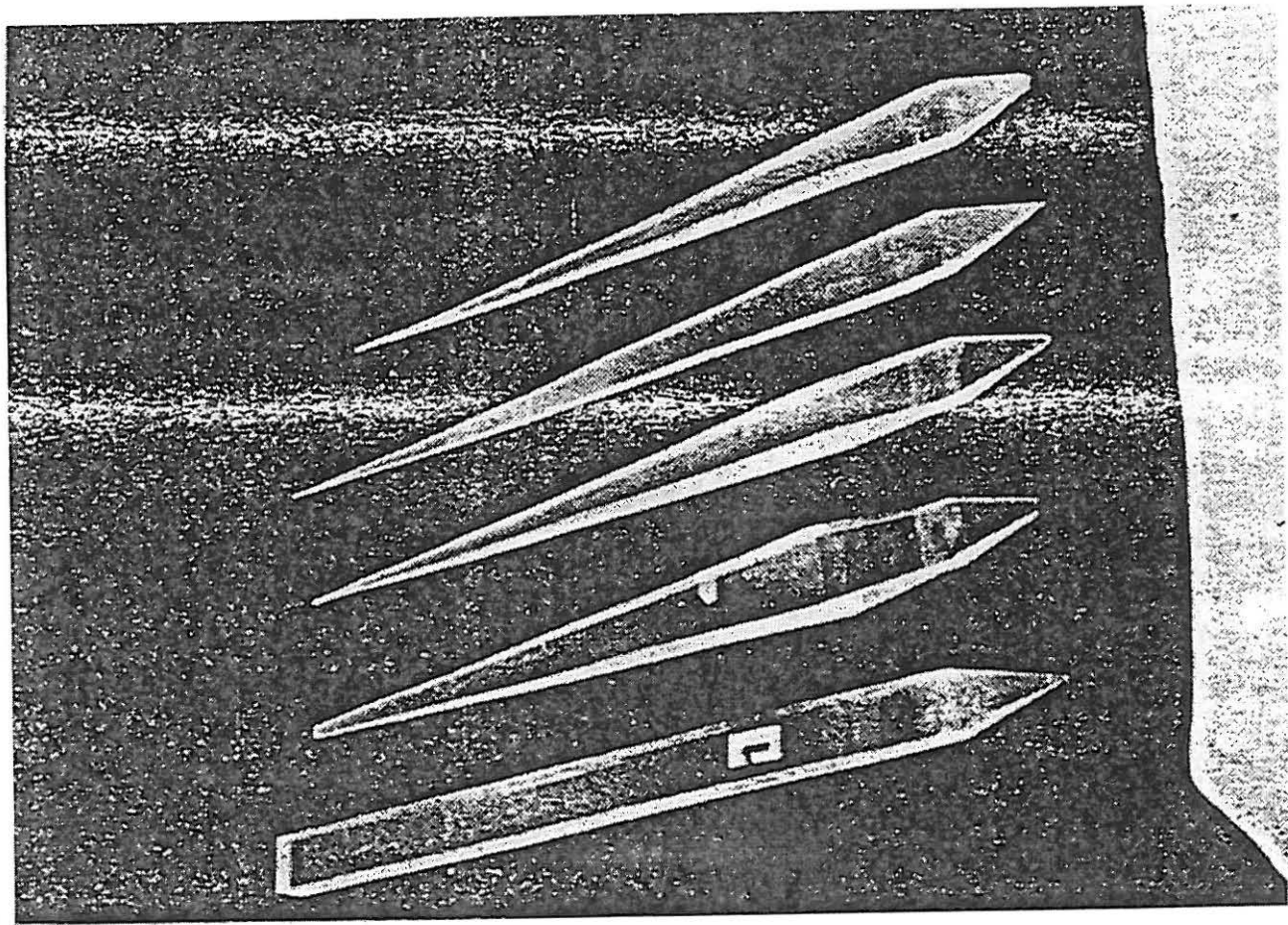
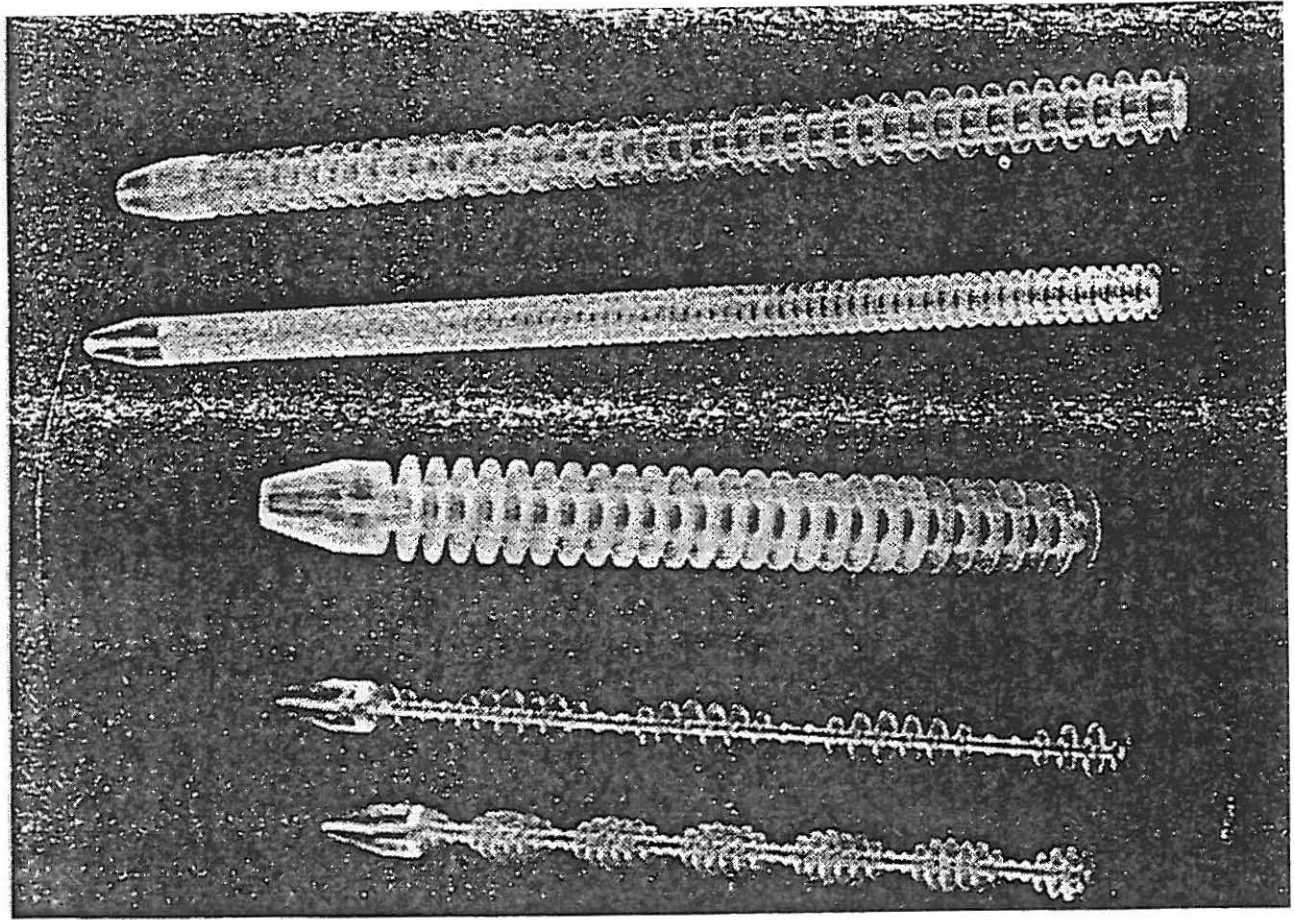
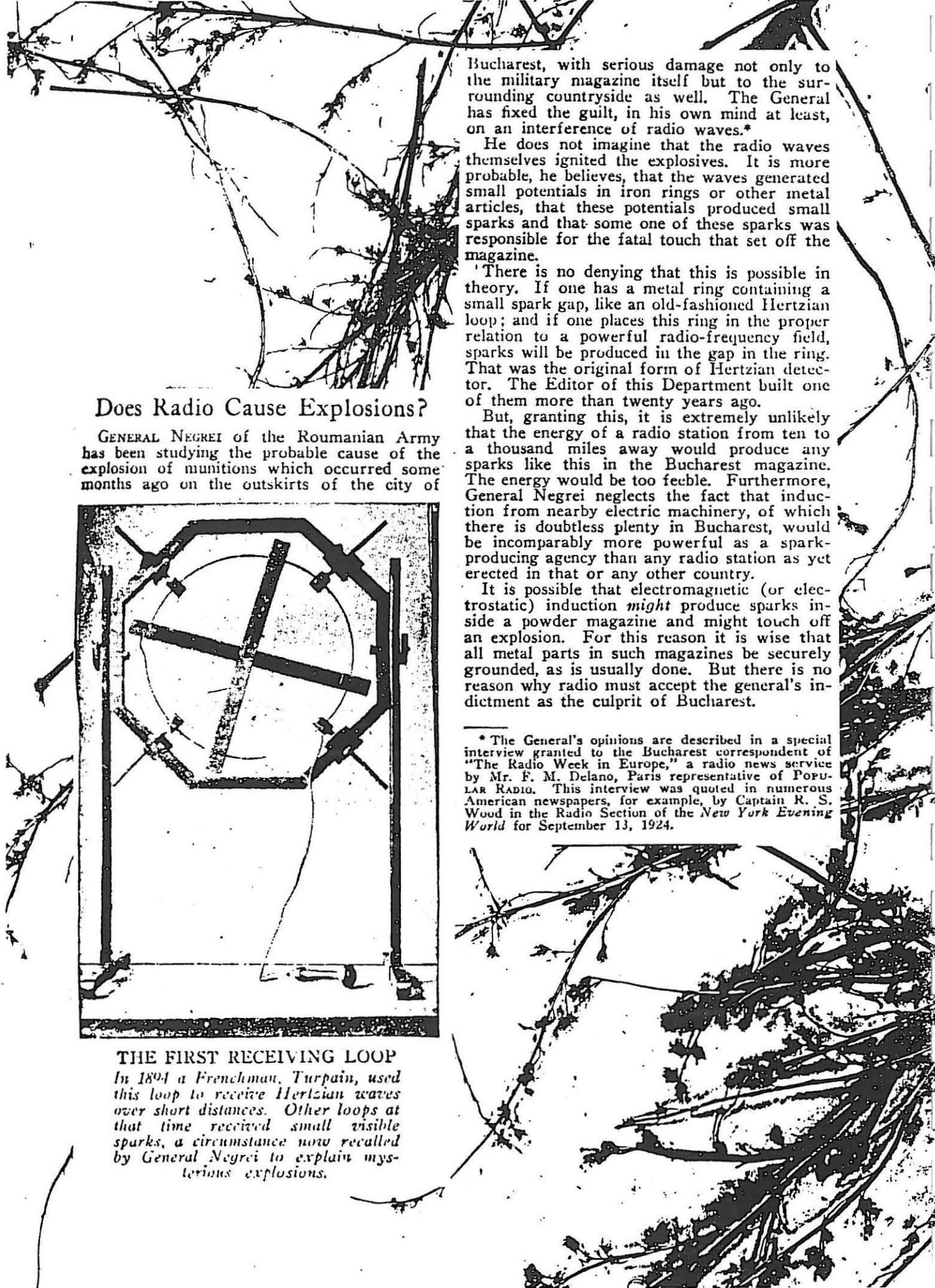


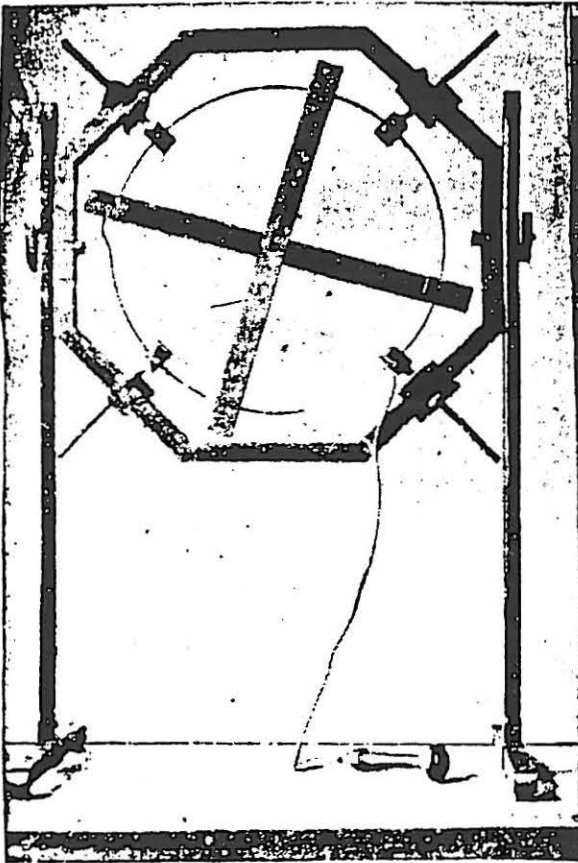
FIG.1.5. Corrugated
dielectric rod antennas





Does Radio Cause Explosions?

GENERAL NEGREI of the Roumanian Army has been studying the probable cause of the explosion of munitions which occurred some months ago on the outskirts of the city of



THE FIRST RECEIVING LOOP

In 1894 a Frenchman, Turpain, used this loop to receive Hertzian waves over short distances. Other loops at that time received small visible sparks, a circumstance now recalled by General Negrei to explain mysterious explosions.

Bucharest, with serious damage not only to the military magazine itself but to the surrounding countryside as well. The General has fixed the guilt, in his own mind at least, on an interference of radio waves.*

He does not imagine that the radio waves themselves ignited the explosives. It is more probable, he believes, that the waves generated small potentials in iron rings or other metal articles, that these potentials produced small sparks and that some one of these sparks was responsible for the fatal touch that set off the magazine.

There is no denying that this is possible in theory. If one has a metal ring containing a small spark gap, like an old-fashioned Hertzian loop; and if one places this ring in the proper relation to a powerful radio-frequency field, sparks will be produced in the gap in the ring. That was the original form of Hertzian detector. The Editor of this Department built one of them more than twenty years ago.

But, granting this, it is extremely unlikely that the energy of a radio station from ten to a thousand miles away would produce any sparks like this in the Bucharest magazine. The energy would be too feeble. Furthermore, General Negrei neglects the fact that induction from nearby electric machinery, of which there is doubtless plenty in Bucharest, would be incomparably more powerful as a spark-producing agency than any radio station as yet erected in that or any other country.

It is possible that electromagnetic (or electrostatic) induction *might* produce sparks inside a powder magazine and might touch off an explosion. For this reason it is wise that all metal parts in such magazines be securely grounded, as is usually done. But there is no reason why radio must accept the general's indictment as the culprit of Bucharest.

* The General's opinions are described in a special interview granted to the Bucharest correspondent of "The Radio Week in Europe," a radio news service by Mr. F. M. Delano, Paris representative of POPULAR RADIO. This interview was quoted in numerous American newspapers, for example, by Captain R. S. Wood in the Radio Section of the *New York Evening World* for September 13, 1924.



HARTIS & ELWING

THE RADIO GENERATOR THAT BLEW UP BOMBS IN 1898

Mr. Carl W. Mitman, of the United States National Museum, is shown with the vacuum-mounted, rotating generator used in demonstrations of radio bomb ignition in Madison Square Garden more than a quarter of a century ago. The tube is now in the National Museum.

An Electric-wave Generator Constructed in 1898

THERE has recently been deposited in the United States National Museum, at Washington, what is probably the first vacuum-tube generator ever built—a tube constructed by Mr. D. MacFarlan Moore, in 1898.

It is not built, of course, on the principle of the audion. On the contrary, it is really no more than a rotating generator for high-frequency current constructed inside a glass bulb, so that it could be operated in a vacuum. It was put together originally as a source of high-frequency current for the operation of gas-filled glow lamps, with which devices Mr. Moore was then working. It was used, however, as a generator of electric waves as well, and for a month in 1898 waves produced by this tube were used to ignite a bomb at the

opposite end of Madison Square Garden in New York, resulting in an exhibition explosion of a model of the battleship *Maine*.

The glass part of the tube is two and one-half inches in diameter and eleven inches long. Inside it is a metal shaft about one-eighth inch in diameter and which fits into bearings at the ends of the tube. The upper end of this shaft carries a heavy flywheel, while the lower end of it carries the commutator. The commutator has nine segments and four metal brushes bear against it, each of which is connected to a wire sealed into the glass of the tube.*

* Facts supplied by Mr. C. W. Mitman, Curator of Engineering, United States National Museum.

Ulivi's Experiments in Exploding Bombs With Infra-red Rays

THE press of Europe has much to say to-day about the experiments of the Italian engineer, Giulio Ulivi, who is said to be exploding bombs from a distance by means of the infra-red ray. The public exhibition in Florence a month ago, where four bombs floating on the surface of the River Arno were exploded in succession, has attracted much discussion. The SCIENTIFIC AMERICAN, in order that its readers may be in the current of popular opinion in the matter, presents an eye-witness story by a representative of the *Corriere della Sera* of Milan. The accounts lack the precision of scientific ones and are defective in just those places that a physicist particularly desires more information, but they seem to present a matter that is taken seriously in some quarters. It is evident that there is here either a belief on the part of the experimenter in his results or a splendidly well-staged act in necromancy. It is well further to say that there have been previous "demonstrations" by another which have some resemblance to these. They have been regarded with suspicion in scientific circles.

Ulivi chose for his assistant, Admiral Fornari, who at 9 o'clock one evening was rowed from the iron bridge into the middle of the Arno, placing in the water one after the other the four bombs. The fact of the immersion was communicated to Ulivi by means of flashes of light, and the return of the admiral to the river bank was also signaled.

The lights served to notify the Florentines of what was on foot, and in great numbers they gathered on the Lungarno. The houses along the river were teeming with population, even to their roofs. Carriages, autos, and trams carried unceasingly their passengers to the river and streams of pedestrians had the same goal. Some went to Monte Senario, where Ulivi had stationed himself. Accompanying Admiral Fornari were officers and engineers invited by the Minister of War to view the experiment.

"All at once," according to the *Corriere*, "the darkness was rent by a blinding flash, there was an explosion with a shower of sparks and these lighted a cloud of smoke that for a while hung over the river." In a quarter of an hour the second bomb was fired, and after about an equal interval, the third. The bombs had been floating with the current and here a delay ensued. When about twenty minutes had elapsed the people thought that the last bomb had escaped, but near

the bridge of the Graces it was located and a fourth detonation announced the complete success of the experiments.

It is represented that Ulivi wished to introduce the greatest difficulties and did not make up the bombs in the usual manner. He had already proved that glass and ebonite are transparent to the "radio-ballistic" rays and employed other insulators. The powder was inclosed in a capsule of gutta-percha and this in fiber, which another portion of the story suggests was waxed cord. Outside there was a sphere of porcelain, this incased in asbestos cardboard, and finally to inclose the whole, a jacket of wrought iron.

The bombs thus constructed could float about two thirds immersed. There is the claim that flotation is not necessary, and that the bombs could have been sunk to the bottom or buried in the earth without changing the results. But for such a public demonstration the safety of the spectators could be better assured by the method adopted.

SCIENTIFIC AMERICAN

July 4, 1914

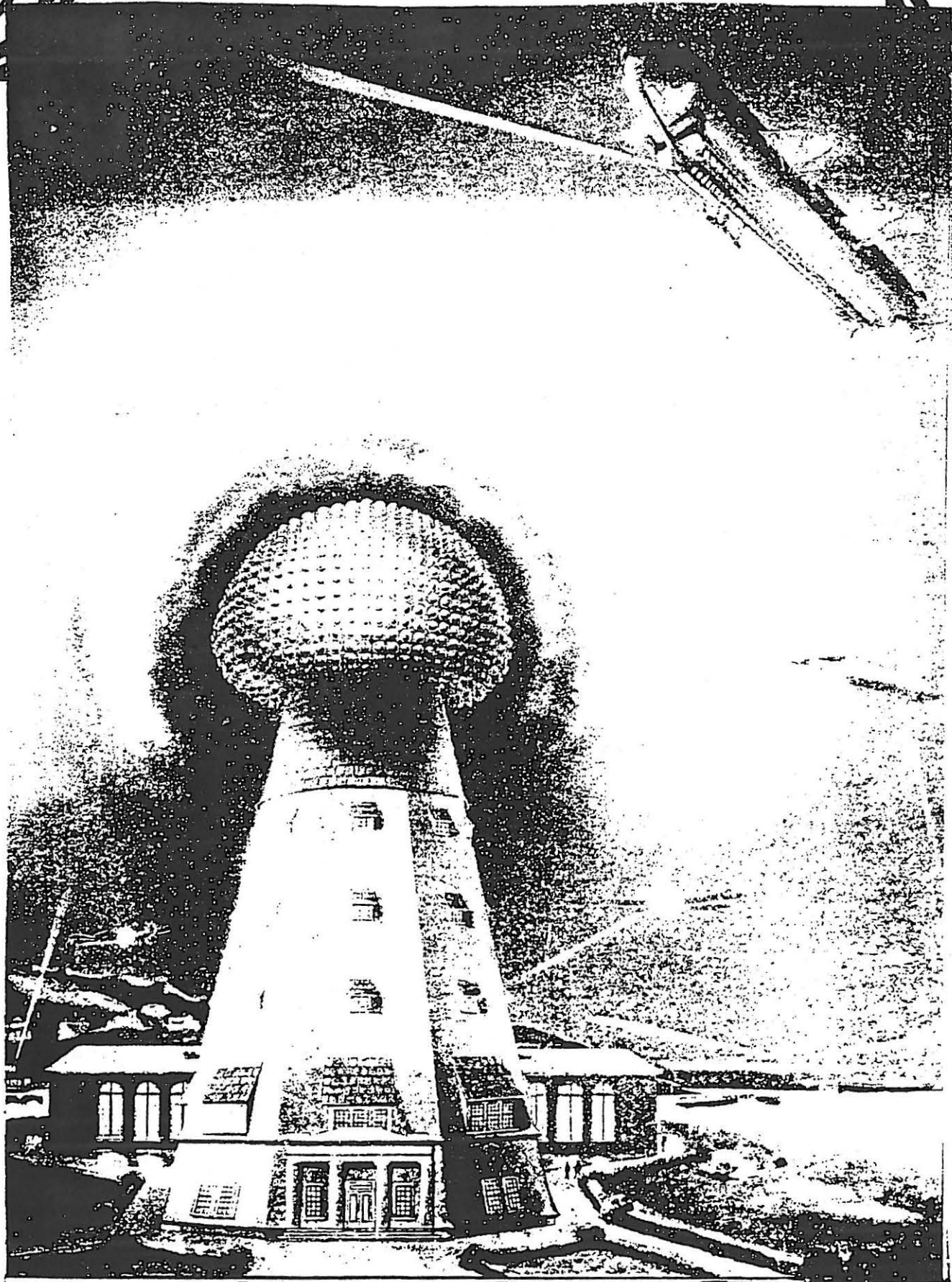
The distance from the river to Monte Senario, where Ulivi stationed himself, is ten and one third miles, and intervening are Fiesoli and the plain of the Arno. When the signals were received that the bombs were placed and the admiral ashore again, the engineer began at once to send forth his "spy-rays."

The popular description of the devices employed suggests two operations, the sending forth of the electrical "spy-rays," which diffuse themselves in all directions, and the production of infra-red rays. Other items in the outfit are a telemeter, a wireless apparatus for messages, a voltmeter, an ammeter, and a chronometer. In addition there is a battery which furnishes the energy for the action of the apparatus.

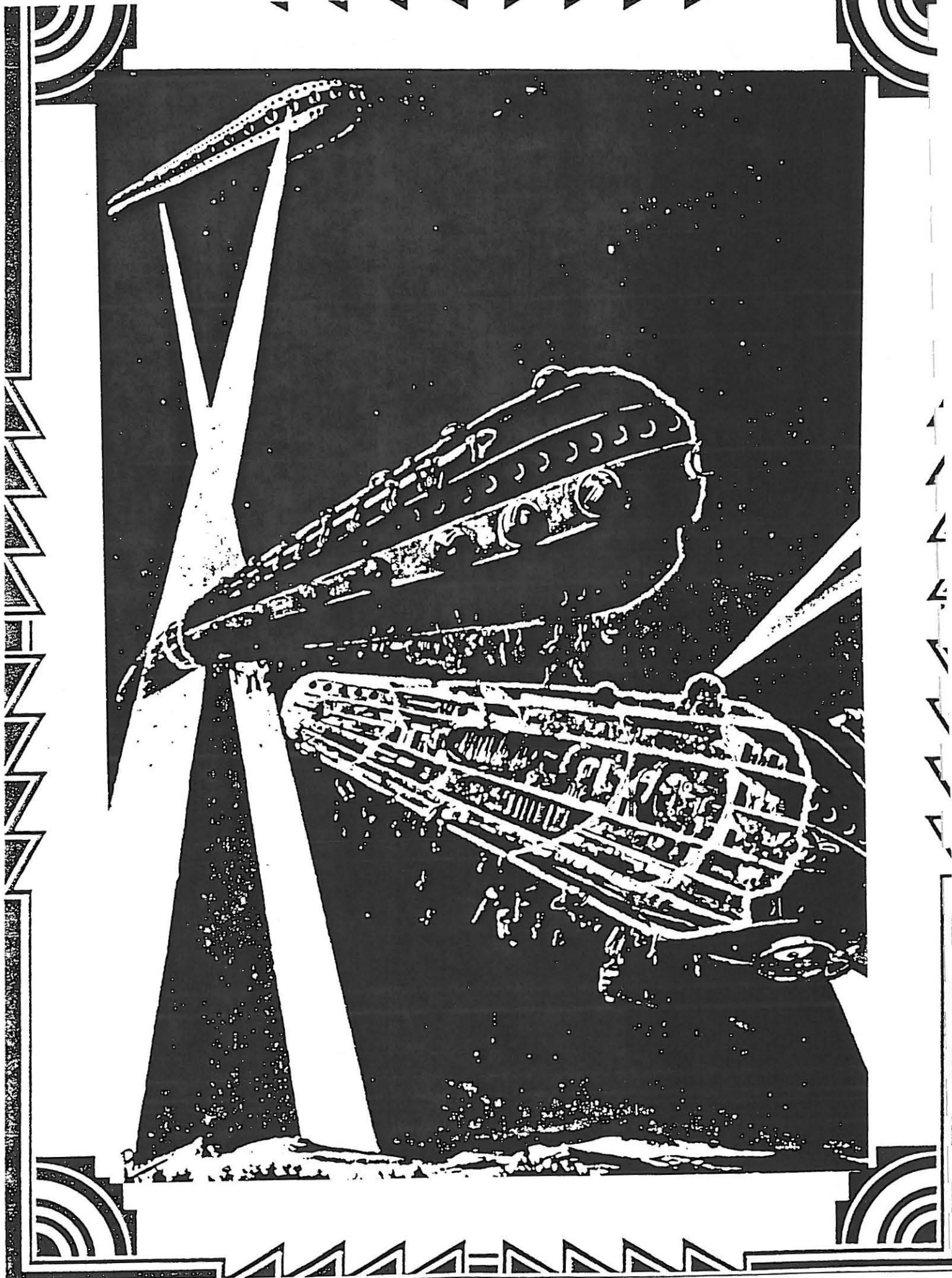
In operating, the "spy-rays" are first sent forth. When they encounter a metallic mass they free from it what may be termed, "return rays." On analysis the latter indicate with some precision to the operator, who has his head incased in a telephone helmet, the amount of metal, its radio-magnetic effect and the distance at which it lies. The operator then directs the infra-red rays which he produces toward the metallic object. As they pass through it they produce scintillations, or as he terms them, "M-rays," which locate the explosive.

If this story is really true, the possibilities are inconceivable. In offensive warfare Ulivi claims to be able to destroy forts, ships, and magazines, if they contain explosives, and practically eliminate war. On the other hand, if mineral veins or lodes can be thus detected there will be a most useful extension of the arts of peace.

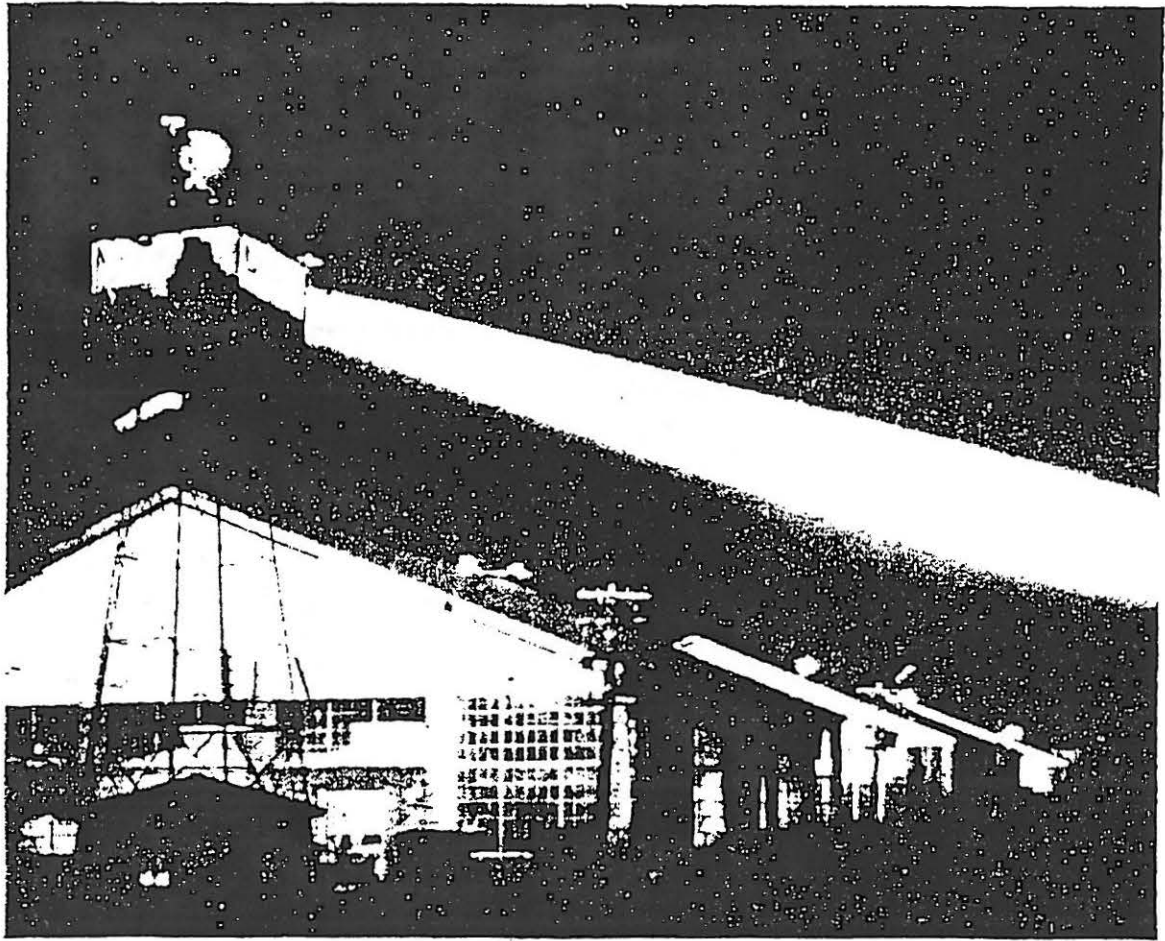
Ulivi, born in Tuscany, achieved distinction at the Technical Institute of Florence, was made laureate in Germany, and established himself in France some years ago, and afterward set up a physical research laboratory at Clichy. In working with the infra-red rays of the spectrum, he discovered strange phenomena that these waves produced at a distance. He found that in a stable, some hundreds of feet from his laboratory, the iron horseshoes produced electrical scintillations when under the influence of the infra-red rays. He referred the phenomenon to comparable ones in the production by one musical instrument of sympathetic tones in another instrument. With this idea of sympathetic vibrations he experimented with light, electricity, magnetism, and heat, and the transformation of one into the other. The outcome of these researches has been the ability to explode charges that are within metallic walls. This explanation, although it is set forth as the presentation of the "fundamental theory," leaves much to be desired in the completeness and relevancy of its statements.



THIS PHOTOGRAPH OF A MODEL SHOWS HOW THE TESLA TOWER BUILT ON LONG ISLAND, EIGHTEEN YEARS AGO, WOULD HAVE LOOKED COMPLETED. FROM ITS APPEARANCE NOBODY WOULD INFER THAT IT WAS TO BE USED FOR THE GREAT PURPOSES WHICH ARE SET FORTH IN HIS ACCOMPANYING ARTICLE.



The "Opaqueness" Theory of Radio



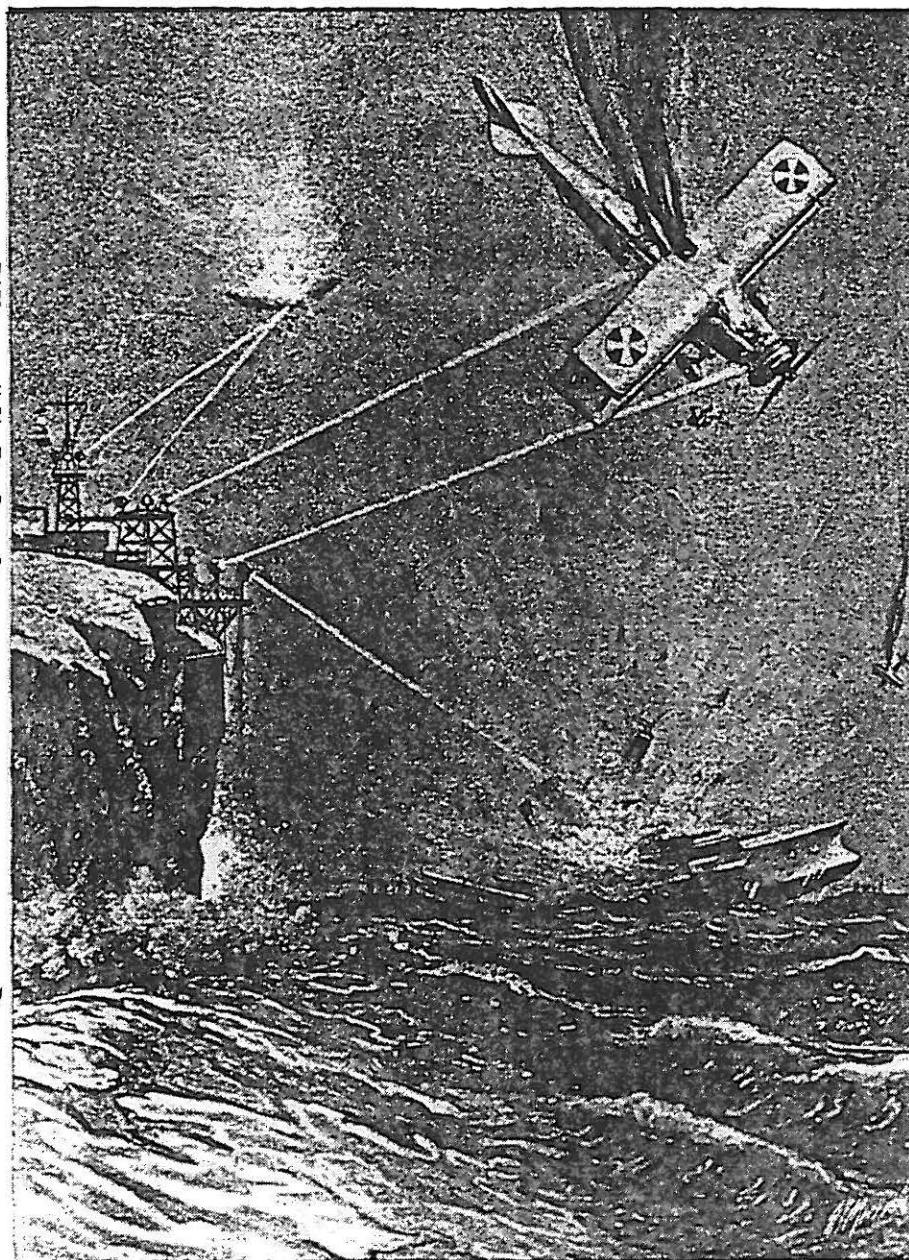
International

A LIGHT BEAM THAT "CONFIRMED" A WRONG THEORY OF RADIO

When this powerful searchlight beam, at the Air Mail Field at Maywood, Illinois, was turned on between a radio transmitter and the receiver to which the waves were passing, the effect of the light in ionizing the air decreased the perfection of reception. This was thought to prove the correctness of the "opaqueness" theory of radio.

LIGHT BEAMS AND HERTZIAN WAVES

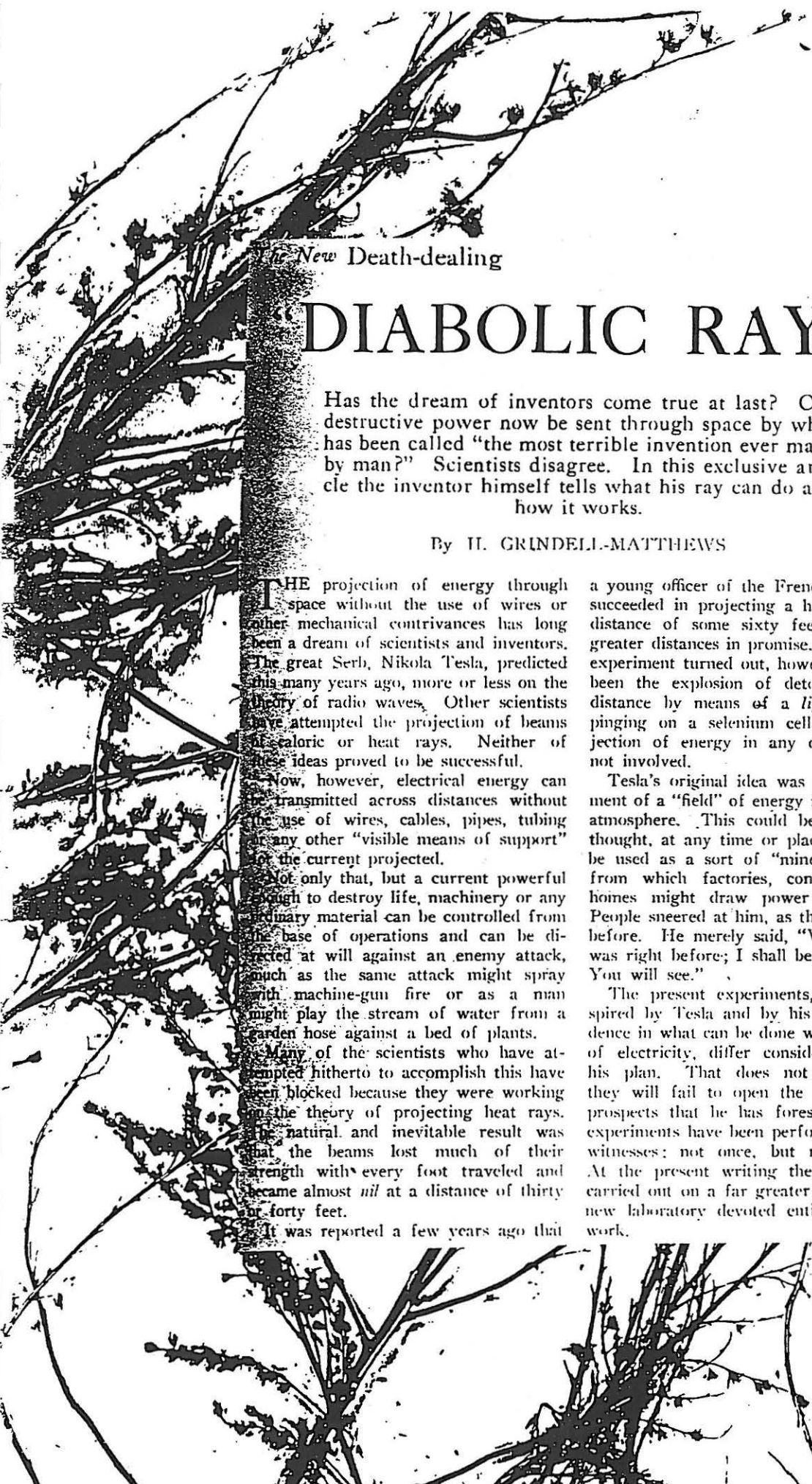
the "shadow" or "opaqueness" theory of radio promulgated recently by Mr. A. J. Musselman of Chicago, Illinois, and which received considerable attention in the newspapers.



This is a drawing made for POPULAR RADIO by Arthur Merrick

NARROW-CASTING DESTRUCTION WITH THE NEW CARRIER RAY

Power that can render machines helpless, as well as destroy life, can be directed against the enemy "much as a man may spray a stream of water from a garden hose upon a bed of plants," is one of the remarkable claims of the inventor.



The New Death-dealing

“DIABOLIC RAYS”

Has the dream of inventors come true at last? Can destructive power now be sent through space by what has been called “the most terrible invention ever made by man?” Scientists disagree. In this exclusive article the inventor himself tells what his ray can do and how it works.

By H. GRINDELL-MATTHEWS

THE projection of energy through space without the use of wires or other mechanical contrivances has long been a dream of scientists and inventors. The great Serb, Nikola Tesla, predicted this many years ago, more or less on the theory of radio waves. Other scientists have attempted the projection of beams of calorific or heat rays. Neither of these ideas proved to be successful.

Now, however, electrical energy can be transmitted across distances without the use of wires, cables, pipes, tubing or any other “visible means of support” of the current projected.

Not only that, but a current powerful enough to destroy life, machinery or any ordinary material can be controlled from the base of operations and can be directed at will against an enemy attack, much as the same attack might spray with machine-gun fire or as a man might play the stream of water from a garden hose against a bed of plants.

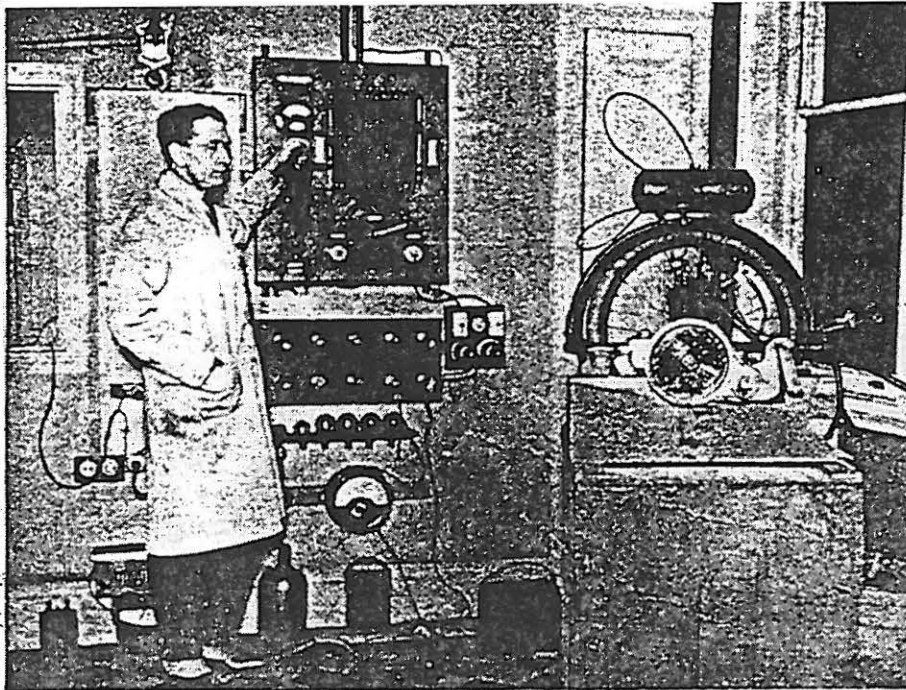
Many of the scientists who have attempted hitherto to accomplish this have been blocked because they were working on the theory of projecting heat rays. The natural and inevitable result was that the beams lost much of their strength with every foot traveled and became almost nil at a distance of thirty or forty feet.

It was reported a few years ago that

a young officer of the French army had succeeded in projecting a heat ray to a distance of some sixty feet, with still greater distances in promise. The actual experiment turned out, however, to have been the explosion of detonators at a distance by means of a light ray impinging on a selenium cell. The projection of energy in any quantity was not involved.

Tesla's original idea was the development of a “field” of energy in the higher atmosphere. This could be tapped, he thought, at any time or place and could be used as a sort of “mine” of power from which factories, conveyances or homes might draw power as needed. People sneered at him, as they had done before. He merely said, “Very well; I was right before; I shall be right again. You will see.”

The present experiments, though inspired by Tesla and by his quiet confidence in what can be done with the genii of electricity, differ considerably from his plan. That does not prove that they will fail to open the door to the prospects that he has foreseen. These experiments have been performed before witnesses: not once, but many times. At the present writing they are being carried out on a far greater scale in the new laboratory devoted entirely to this work.



R. M. LECHE, JR.

THE INVENTOR DEMONSTRATES HOW HE STOPS AN ENGINE BY MEANS OF HIS RAYS

When the carrier ray is turned on the magneto of this little motorcycle engine, the ignition system is instantly paralyzed. The motor stops. This can be done, Mr. Grindell-Matthews claims, without injuring the windings of the magneto, but, if desired, greater power can be used and the magneto or the whole engine can be destroyed.

It is easily understood that the technical secrets of the work cannot be described. There are many reasons for this.

For instance, should the methods be patented, they will become, like radio receiving circuits, the property of every amateur who is willing to spend the time and money necessary to build an apparatus of the sort.

Within these limitations, however, an attempt will be made to show that the theories and explanations that have been advanced during recent weeks by many scientists for the death-dealing rays which we have created over and over again in our London laboratory are more or less based on false premises.

The first experiment shown to witnesses was that of stopping a gasoline motor.

A small one-cylinder engine of a motor bicycle, together with the back wheel of the bicycle, were placed on a table at one end of the room and the engine was started. The generating apparatus for the "ray," about sixty feet away, was brought into action. One of the witnesses was told to give a signal at any time he wished. This had to be done by raising or dropping his arm, as the noise from the motor drowned out the human voice.

As he dropped his arm the invisible beam of the new ray was brought to bear upon the barking little engine,

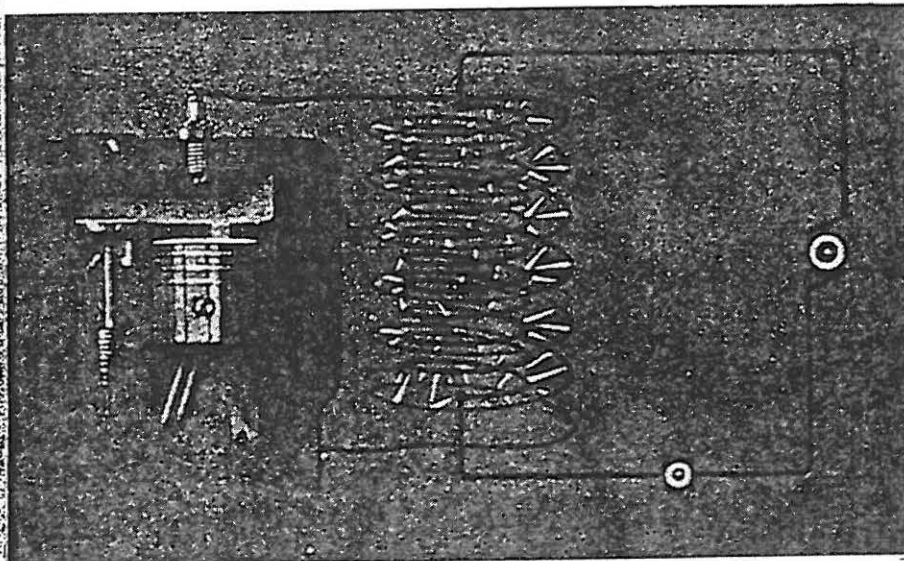
searching for that heart of any gasoline motor, the magneto. As the ray touched this, the roar of the exhaust died quickly into complete silence. The stopping force was promptly removed so as not to destroy the magneto windings. Again and again this experiment was repeated. Everyone was not only allowed, but urged, to go over the motor carefully to make sure that there were no wires or other attachments from the floor or from the ceiling that could aid in its control. All were satisfied that some unseen force had stopped the firing of the engine.

Next, a bit of black gunpowder was placed in a metal container at the other end of the room, and the ray was brought to bear upon it. In no time a sharp flash registered the explosion of the powder, showing the great heat which can be generated by the power used. That this may later be employed to blow up powder magazines, battleships and

other ammunition depots was suggested but it is problematical, for reasons that will be discussed further on.

A plain electric-light bulb of the usual house-lighting size was then held by two men standing well apart. The bulb was attached to two wires, one held by each of the men. There was no other connection with the rest of the laboratory or with the earth. When the ray was brought to bear upon the bulb it glowed brilliantly.

Then, as a final proof of the efficacy of the force behind this energy transmitter, a mouse was placed in a cage at the other end of the laboratory. This time, in order to make a quick and direct hit, thus avoiding unnecessary suffering, the ray was made visible as a beam of lavender or purple light. As this beam of light crept up and finally struck full upon the little animal, he reacted exactly as he would have done to the shock of a



from a drawing made for POPULAR RADIO by Arthur Merrick

HOW THE RAY "PARALYZES" THE MAGNETO WINDINGS OF AN ENGINE

The carrier ray itself, even when uncharged with power, is said to make the space around the coils of the magneto conductive of electricity. The current leaks across between the secondary windings and the primary ones. Sparks are no longer produced at the spark-plugs—and the engine stops.

light wire grounding through him. He was killed very quickly. He could have been killed instantly except for the danger of creating fire by applying the full force of the ray. The mouse was not burned or disfigured in any way.

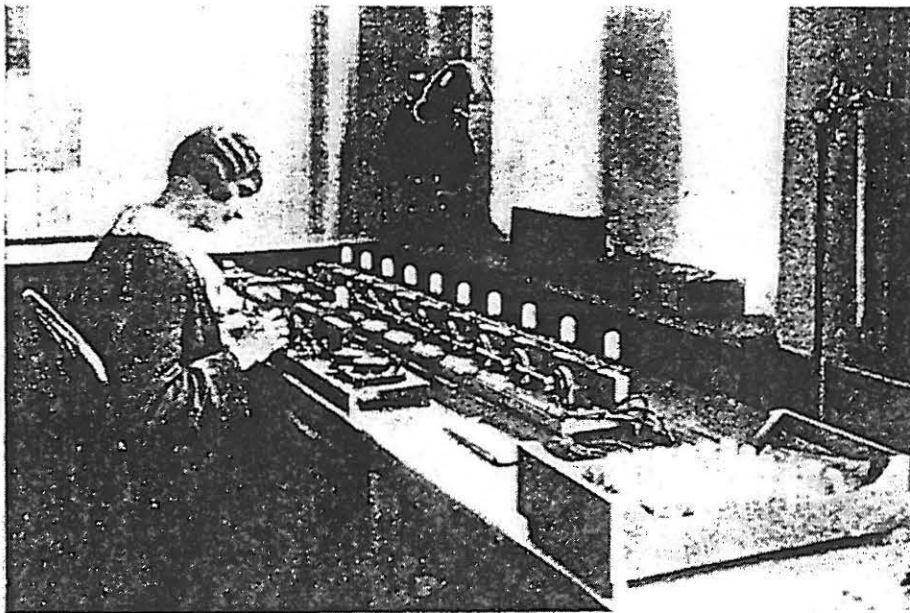
Actually, what the mouse received was an electric shock of the simplest kind. The destructive force behind the ray is nothing more than a high-potential, low-frequency current which grounds through the object with which the ray comes in contact exactly as though it were being applied through a piece of copper wire.

For example, the effect of the ray on wooden floors is the same as though the insulation had burned off the electric-light wiring or some other high-tension conductor, thus forming a short-circuit through the boards. The natural result is a little blaze as where bare wires come in contact with the flooring.

This generation of heat is the explanation of the firing of the gunpowder but it is not the secret of the stopping of the gasoline motor unless the magneto is completely destroyed. The cause of this stopping is primarily the "carrier beam" itself, along which the electric current is projected. Without the discovery of this carrier beam we would not have been able to continue our work.

This beam is nothing more or less than a conducting beam of secret composition; a development of our present knowledge of light waves and vibrations. It acts in the same way as does a cable or wire. Controlled as is a searchlight beam, it brings to bear upon the object at which it is pointed merely an electric contact. The destructive current then flows through this beam as it would through a metallic conduit.

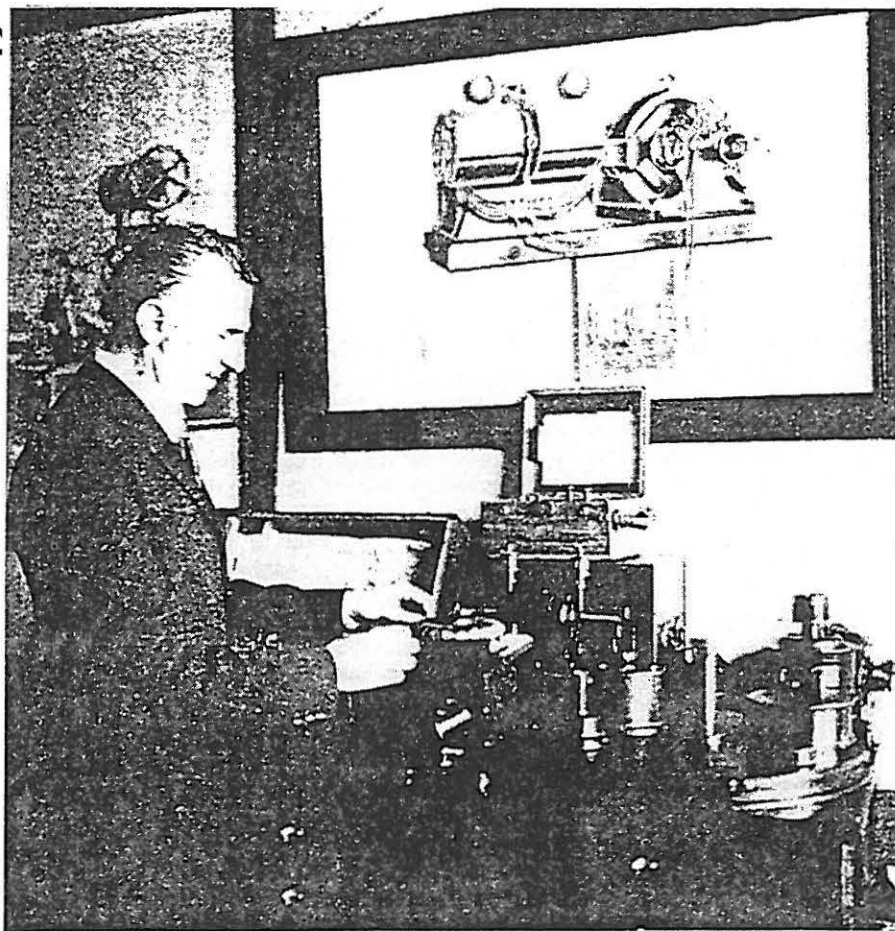
For working on a magneto the carrier



COMMERCIAL TELEPHONE AND ELECTRIC COMPANY

IS IONIZATION THE SECRET OF THE NEW CARRIER RAY?

European scientists have suggested that the secret may be the use of ultra-violet light. This light ionizes the air so that it becomes conductive of electricity. Ionization is already well known in radio; it is the principle that underlies the new sodium detector tube described in POPULAR RADIO for March, 1921. (This picture shows some of the sodium tubes under test in the laboratory.)



From a photograph made for POPULAR RADIO

THE FIRST INVENTOR TO EXPERIMENT WITH THE TRANSMISSION OF POWER BY RADIO

Nikola Tesla undertook to send energy by radio a generation ago, with elaborate apparatus in Colorado. His enduring belief in its ultimate success "has been my inspiration," states Mr. Grindell-Matthewes, "in developing the carrier ray."

beam is projected alone. As this beam comes in contact with the windings of the magneto it forms a conducting path between the primary and secondary windings, thus creating a short-circuit. For the aerial destruction of magnetos an electric current could be applied to the carrier beam and transmitted along it. This would burn the insulation between the windings, thus facilitating the

permanent shorting of the circuit.

For airplanes a ground is needed or the highest potential in the world could not do any damage. To form this ground and thus to complete the circuit, a second carrier beam, uncharged, is projected against the plane from a second station on the ground. Thus the plane forms the contact point between the two beams, the charged one and the uncharged one.



The current passes through the plane, which either burns up or becomes paralyzed.

An automobile or a protected ammunition dump is not so easy to attack. An armored car would need only to drag a chain or a heavy copper wire along the road. This would create a perfect ground. Current thrown, then, against the car along the carrier beam would simply enter the steel sides of the car and pass through them and the ground-chain into the earth, doing little or no damage. It might be possible, however, to project such a powerful stroke of current that the electrical field set up would stun or partially disable the driver, causing him to run off the road or into an obstacle.

With an airplane it would be practically impossible to insulate it or otherwise protect it and still have it air-worthy. Should the airplane be insulated, a different form of attack could be adopted; a series of shocks being delivered against it, like the blows from a hammer, rather than a steady stream of energy. These hammer-like blows would be almost irresistible for breaking down insulation or other resistance. Indeed, we have found great difficulty in our laboratory in insulating our apparatus against the assaults of the current.

It has been found that a high-frequency current flowing along this carrier beam gives it a much higher conductivity; so that now two generator plants are being used instead of only the one. One generator produces the low-frequency current that constitutes the power passed along the beam; the other supplies the separate current of higher frequency which serves to increase the conductivity.

The carrier beam itself is produced in its own special apparatus and projected through a glass lens. The two electric currents are introduced into it after it has passed through this lens, which

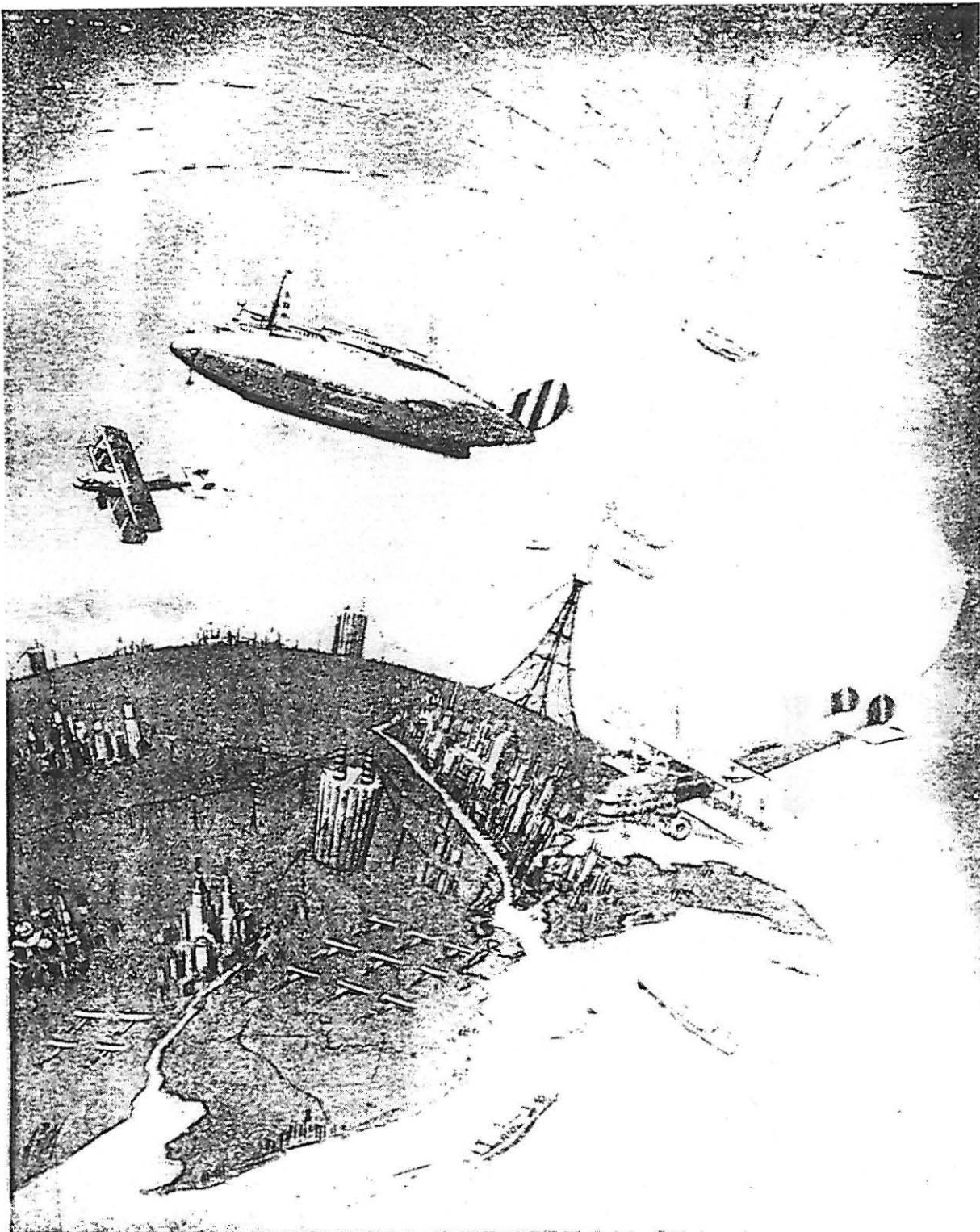
avoids any danger of melting the glass.

The spreading of the carrier beam with distance is much the same as that of a searchlight beam, so that the loss of current becomes quite high as the distance increases. Even so, a generating unit such as could be carried on an automobile truck would be sufficient, it is estimated, to supply current which would be effective at several hundred yards or even at one or two miles.

The tests were begun about eight months ago. Before the carrier-beam system was discovered the stopping of a motor (the test cited above) was being attempted at a distance of about ten inches. When at last we hit upon the carrier beam, within ten minutes, using the same generating group, the length of the laboratory had been traversed with equal success and the future of the work assured. So far, the full possible power has never been used, because of the cramped quarters.

The carrier beam can be made luminous if so desired, and this seems in the long run perhaps the most practical way of using it. The principal would be that of a tracer bullet. To see clearly what one is doing with the ray one must be able to follow it, especially at night. And if at times it seems desirable to make the ray invisible, a series of filters can be inserted which will take out the longer waves of the beam, rendering it absolutely secret.

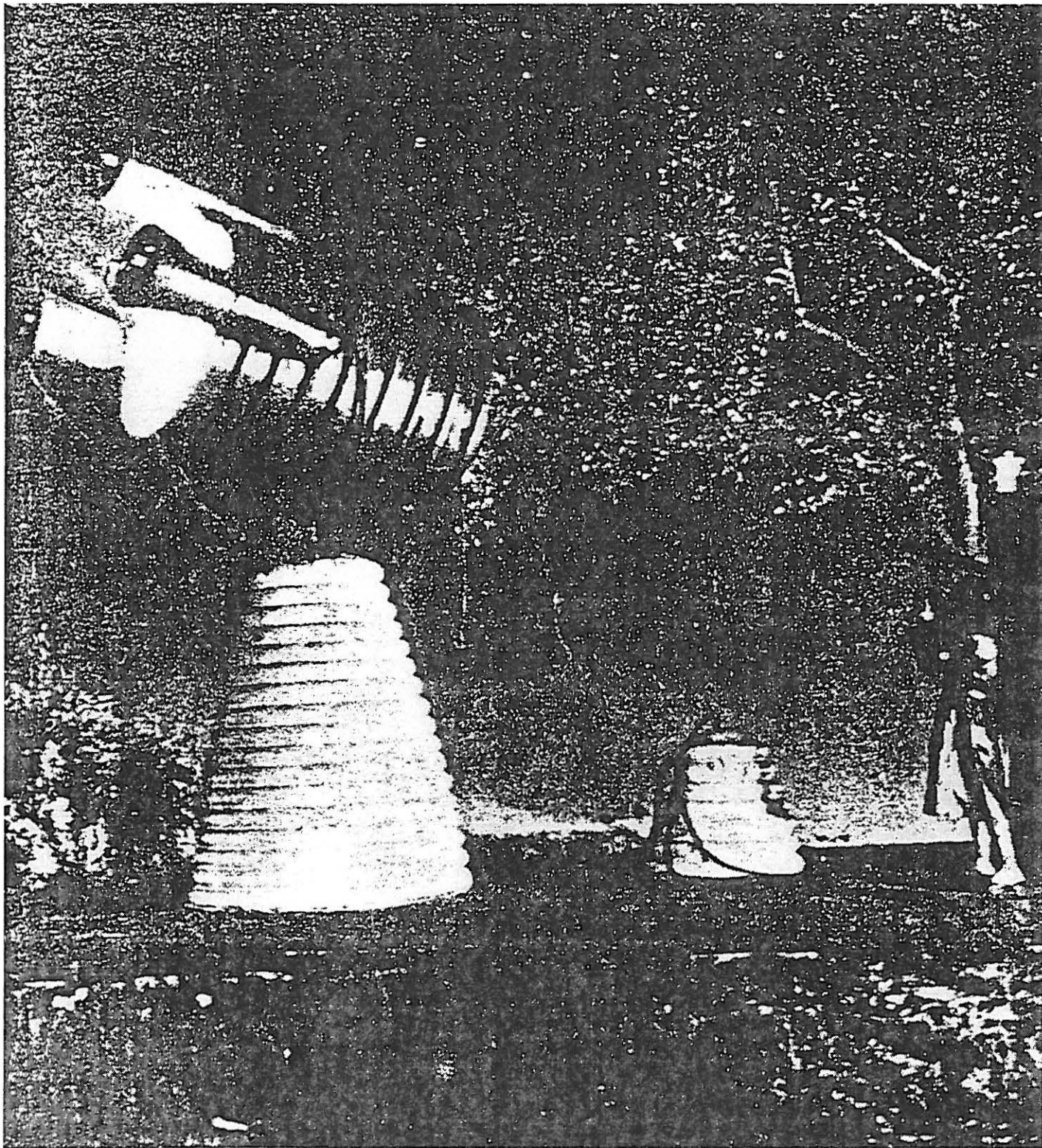
What the outcome of this discovery will be, it is too soon yet to say. Some are of the opinion that it will cause the annihilation of the human race; others think that it will make war so terrible that it will be realized how useless it is. The optimists see in it (and I hope that they are right) the vindication of the man who has through all the discouragement and labor of my work been my inspiration and my greatest source of hope—Nikola Tesla, to me the greatest man on earth today.



from a drawing by Arthur Merrick for POPULAR RADIO

When the World's Motive Power Is Collected by Antennas

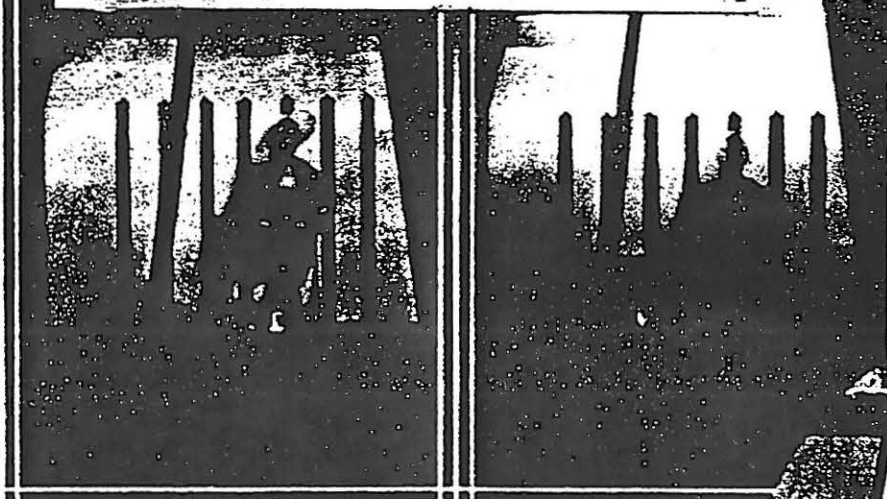
Science may discover a new form of radiant energy and inventors may design machinery that can harness this force and put it to work—to run our factories, to heat and light our homes, and to drive air, sea and land craft at incredible speeds.



Carrier Rays That Kill

A spectacular night-demonstration of the "death ray" apparatus of H. Grindell-Matthews (described in detail by the inventor for the first time in POPULAR RADIO) was recently held on the Island of Flatelme in England. The inventor states that this machine is now capable of projecting its death-dealing powers more than 3,000 feet.

Invisibility At Last Within Grasp

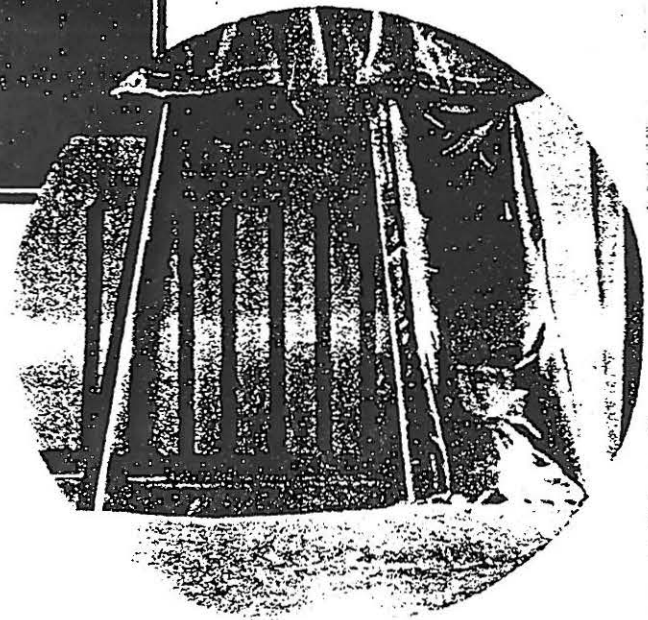


Two Hungarian scientists solve age-old quest with devices worthy of Arabian nights wizards.

Sitting before the beam of the invisible ray this young lady slowly faded out of sight yet her voice was clearly heard by onlookers. At right the photo shows girl completely invisible.

SUPPOSE that out onto a stage come eight chorus girls performing an intricate dance. Gradually something seems to happen, the heads, faces, and upper parts of the bodies of the girls seem to be disappearing. In fact, little by little they do become invisible to the audience until at last only eight pairs of legs are seen gracefully skipping about on the stage in perfect rhythm. You rub your eyes and begin to think you'd better see an oculist right away, but while you are worrying about it, back into your vision come the eight girls, wholly there and dancing gaily as though they had not just given you the shock of a lifetime.

Or suppose again that a girl is sitting atop a piano, singing. The piano begins to fade from sight; finally the girl is left sitting in midair, nonchalantly swinging her feet and blithely singing, as though her perch was perfectly substantial.

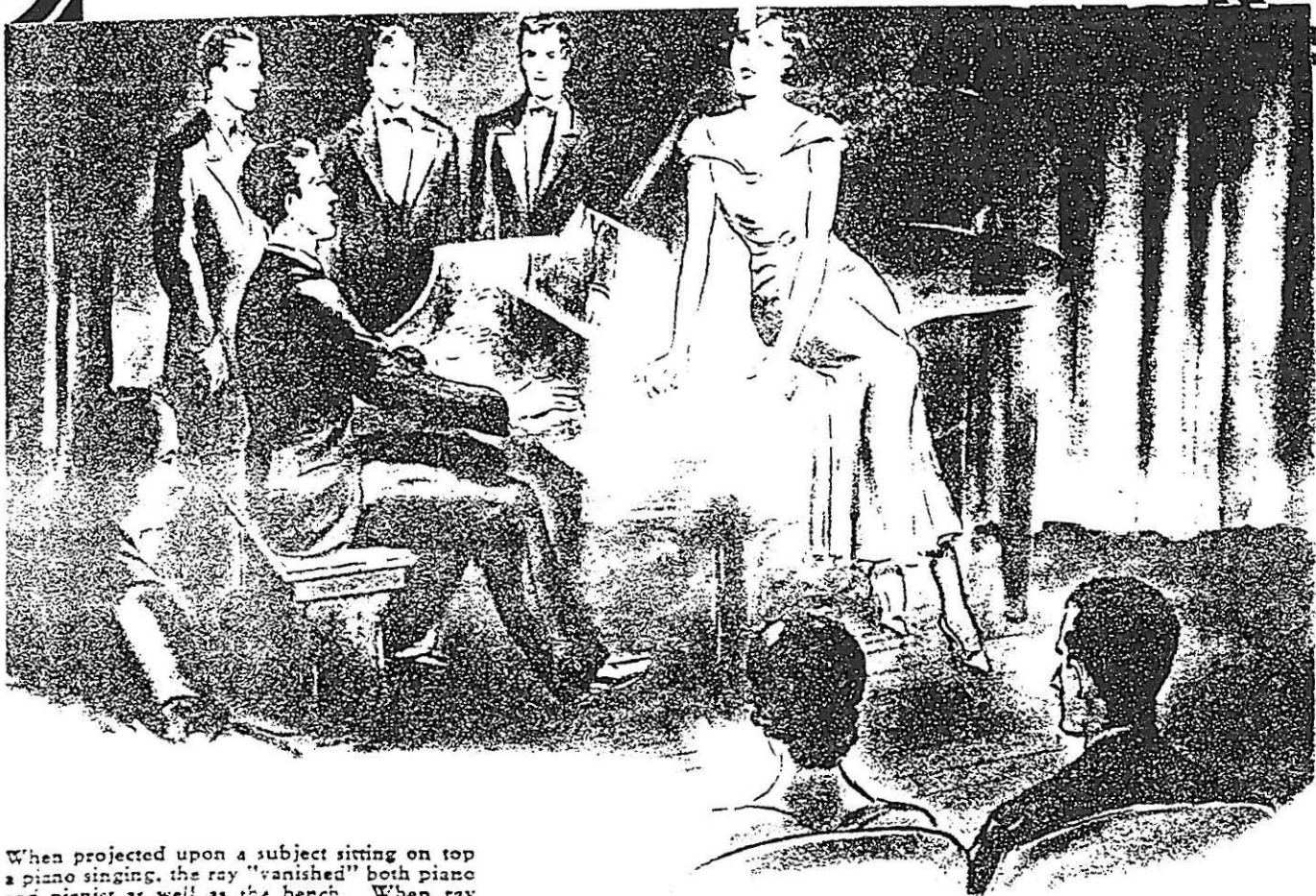


If you did not think that you were just "seeing things," right off you'd say, "Some invisible wires, or anyway, a cleverly arranged set of mirrors." But you would be wrong in your guess. At least so says Mr. Adam Gosztonyi, the inventor of a machine which he claims can accomplish just such disappearing acts as have been described.

In a demonstration of this machine recently the stage was set with a backdrop of wide red



Projecting the ray on this radio had no apparent effect, but in the next picture a change is occurring, the cabinet is vanishing.



When projected upon a subject sitting on top a piano singing, the ray "vanished" both piano and pianist as well as the bench. When ray was shut off they slowly came back into view.

and white stripes. A chair, lifted from among the onlookers so that all could see that it was genuine, was placed in front of this conspicuous background. Then a young man—a very substantial young man—who had been walking around among the onlookers, stepped onto the stage and sat down in the chair. Soon he grew dim in appearance, became sort of thin vapor so that the striped backdrop was visible through the outlines of his body. Then he disappeared completely. But the chair remained, whole and firm, and the young man continued talking to the onlookers as an evi-

dence of his presence. His disappearance, nevertheless, was to all intents and purposes so absolutely real that when the inventor called to the operator of the machine to bring the young man back to sight, one of the onlookers exclaimed: "But suppose you should ever fail to bring him back. What then?"

But the operator did bring the young man back, only to try the experiment all over again, but this time the young man moved about, did a few jig steps with his feet, etc. The disappearing effect began with his head

[Continued on page 147]



The radio cabinet is now merely a faint shadow. The ray increases and at right the cabinet has vanished leaving only chassis.



and slowly worked down over his body until only the feet were left, dancing about.

Modern inventors seem to have found the answers to all the Arabian Nights riddles, with suddenly appearing and disappearing genii and mysterious cloaks that make persons invisible. But according to the modern explanation, this is not magic, it is an application of rays of invisible light. Mr. Gosztonyi says: "It is a combination of lights and shadows. . . . The machine produces rays of invisible light—some rays of great intensity, some of minor intensity. They play one against the other." Anyway, it seems like magic.

Another Hungarian by the name of Stephen Pribil, a professor of optics, has invented a machine producing "invisible rays." This machine has the effect of making parts of an object apparently fade away, leaving the insides exposed.

In a black-curtained cabinet similar to the stage for a marionette show stands a small radio, on which lights were focused. It is obviously and undoubtedly a real, three-dimensional radio. Gradually the outside case of the radio becomes dim, then fades completely away, leaving exposed to gaze the inside works, the tubes and metal parts.

This is no illusion done by some magician, no trick of mirrors, it is asserted, but an actual performance of a new device which produces and projects what, for lack of a better name, may be called an "invisible ray." The apparatus, itself, looks like a long tool box from which cords like telephone or electric cords extend. Lights are projected onto any object placed within the cabinet. The effects of disappearance and re-appearance are obtained, it is explained, by synchronization of invisible rays.

These rays apparently have no effect so far as changing or subduing color is concerned, for in one cabinet was an arrangement of a display of cigarettes. In the background is a brilliantly colored picture of a girl, somewhat on the Spanish type, with a bright yellow broadbrimmed hat, green earrings, and generally vivid coloring. This is a flat picture. In front of the picture is arranged a display of a carton of cigarettes—the actual carton, not a picture—a real cigarette holder, and some small boxes of cigarettes scattered around. When the "invisible ray" is leveled upon this display, the small boxes of cigarettes and the cigarette holder completely disappear, the outside carton falls away leaving neatly packed cigarettes standing alone, and the picture in the background fades and in its place appears another picture of a girl dressed as an airplane hostess with her arm thrown around a large police dog. This combination, in turn, slowly fades, giving place to the original picture with all its brilliant coloring, the complete carton of cigarettes, the holder and boxes.

In order to have no doubt of the genuineness of the displays, the onlookers handled the cigarette holder and boxes. Then on the suspicion that these displays might have been "fixed," they tried their own experiments. A case with eye glasses was placed in the cabinet. This completely disappeared, to reappear gradually in a few seconds.

Someone slipped in his hand. It was distinctly seen for a moment, then disappeared, although the person who had put his hand into the cabinet had not changed his position or withdrawn his hand. While the hand was invisible, the owner of the hand rapped on the carton of cigarettes to prove that it was there. The carton at the time also was invisible. The onlookers could hear the rap on the metal surface but could see neither hand nor carton. Then the hand reappeared, as also did the whole scene of the picture of the Spanish girl, the cigarette carton, and the rest.

This latter device is now being demonstrated for the first time in this country to show its possibilities as a fascinating advertising medium in window displays and the like.

A Ray Gun For Buck Rogers!

Here's one death ray
that has won serious
consideration from the
Army and the Navy. It
kills rabbits at four
hundred yards and more!

CLAIMED to be the first "death ray machine" ever actually to work, an invention of a California scientist, Lawrence E. Riley, of Burbank, is being given final secret tests by Army and Navy experts.

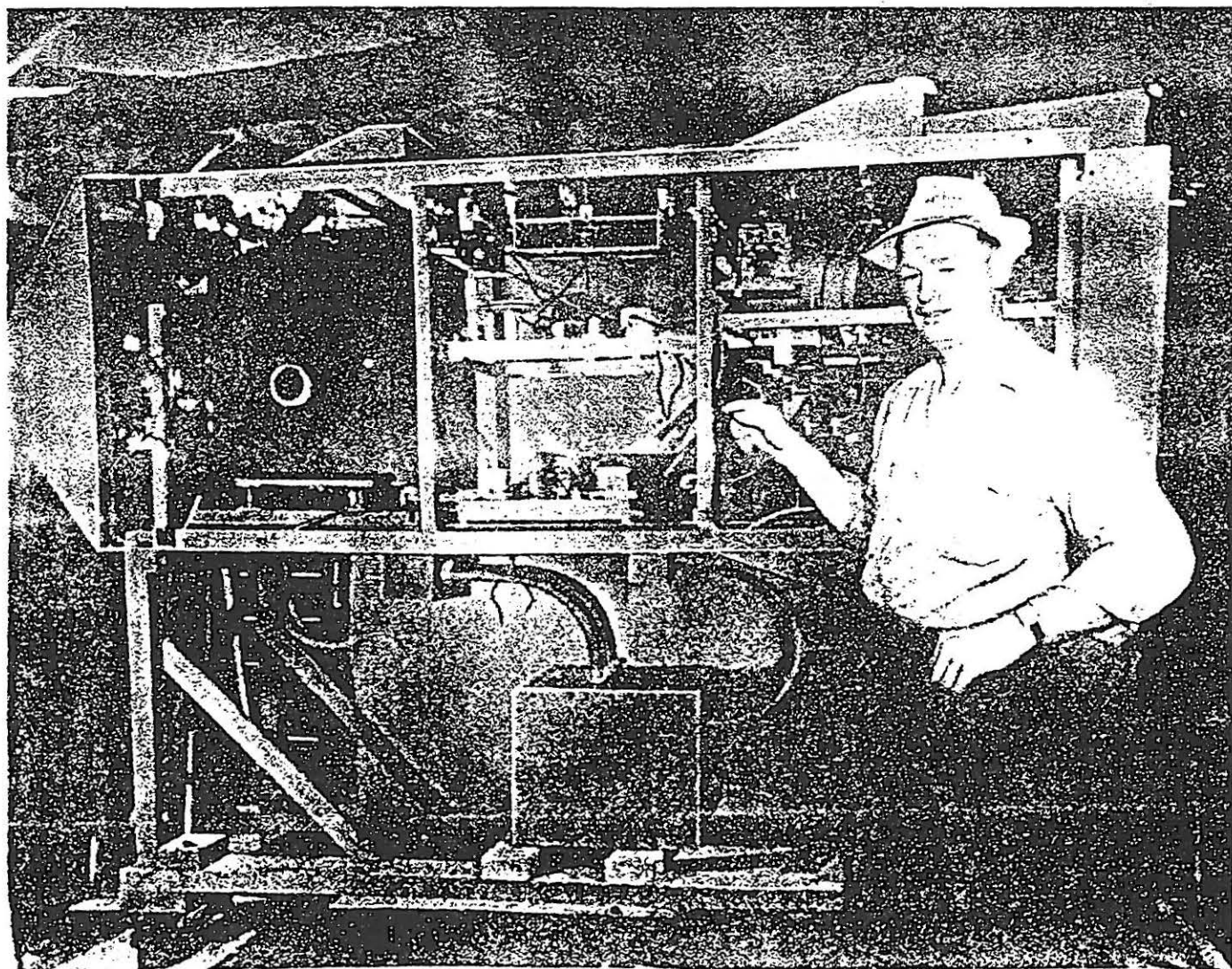
The mysterious electronic ray has killed rabbits at a distance of 400 yards, according to reports of observers. A physician acting as representative of the California State Medical Bureau witnessed a demonstration of the ray machine and gave an affidavit testifying that the ray has killed rabbits at long distance.

The ray, according to the physician's testimony, left no outward sign of scar or wound,

but cooked the rabbit's flesh thoroughly. Rabbits were killed so fast that they did not close their eyes before death overtook them. They appeared to be rooted to the spot, the report said.

More than 100 rabbits have been killed by the ray in demonstrations, and Riley says the machine has killed sheep at a distance of 200 yards.

Riley, who is 39 years old, is married and has four children. He has made numerous trips to Washington and conferred with Army and Navy officials concerning the ray gun, and they have advised him against taking out patents, in order that the mechanism may be



This is the only photograph ever taken of Lawrence A. Riley's new "death ray" machine—and it was taken by Riley's private bodyguard, since the location of Riley's laboratory is a deep secret, known only to Army officials, the bodyguard and Riley.

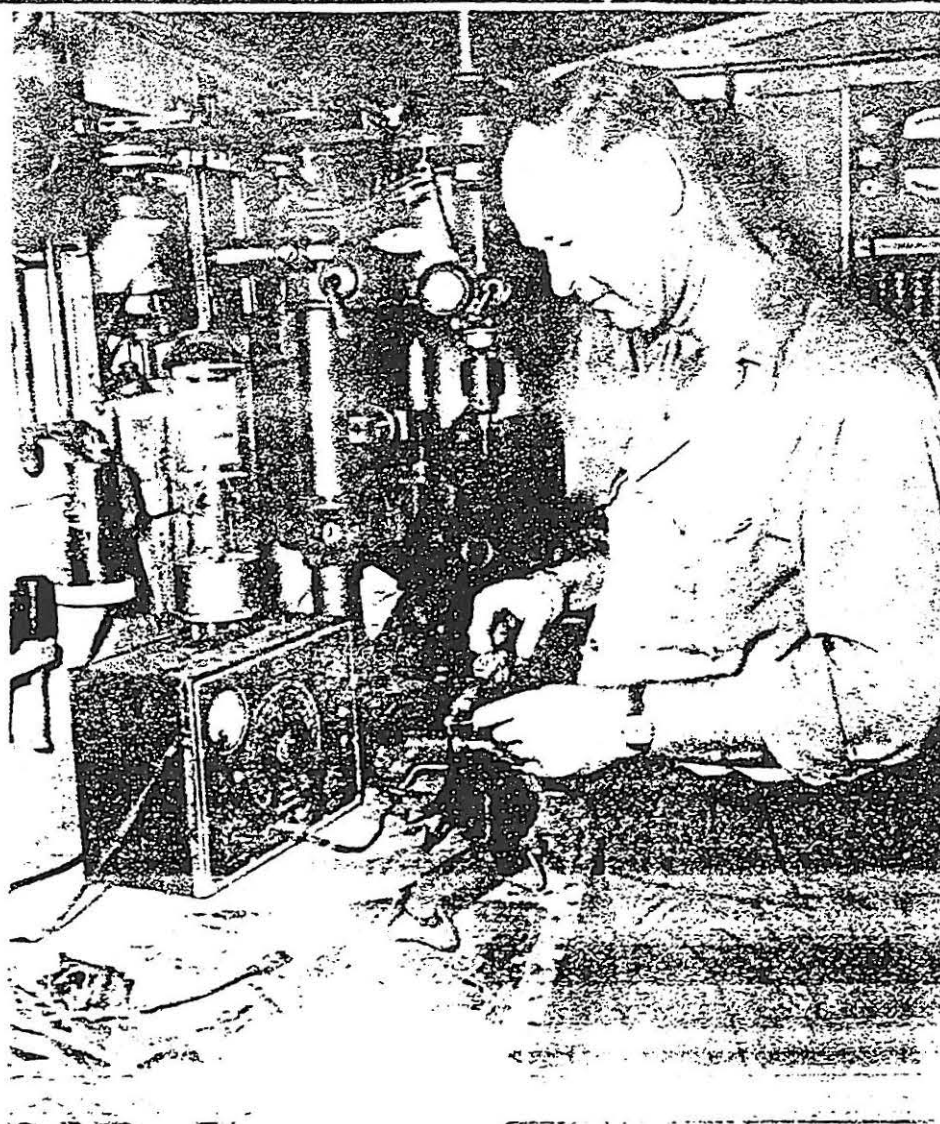


The rabbits shown above are fed well, just like human prisoners in the "death house"—for any meal may be their last. Riley has killed more than 100 of them. Right, Riley is shown in his laboratory.

kept secret. Riley started experimenting in 1926 and patented several improvements in the field of television. He owned a radio shop in Los Angeles and operated an amateur radio station.

It was not until November, 1935, that he realized he had hit on something more important than television. One day, while he was working on an electronic ray model, he accidentally directed his ray machine toward a sheet of metal. The metal became "blue hot" and, instead of melting, crystallized.

Riley raised some money to finance his research. Soon after he had started work, several patents were made.



He moved first to a small building at Roscoe, Calif., where another attempt to steal the machine was made. He removed then to a building at Lake Elsinore, Calif. There, in spite of a burglar alarm system and locks, thieves did manage to carry away his model. Fortunately, they did not get several vital parts, which Riley had hidden.

Thereafter, Riley and his backers hired a private detective to watch the machine and guard Riley at all times. This detective, H. L. Von Wittenberg, of the Von Wittenberg Investigation Bureau, Hollywood, now is with Riley every moment of the day and the ray machine is dismantled at night and the parts are kept in various vaults.

The machine is seven feet two inches long, two feet high and two feet wide. It has two "ports" from which two parallel rays about six inches apart are shot.

Riley says that so far no material has been found which will act as a shield against the rays. The rays will pass through glass, lead, steel, or any other substance.

Riley's chief interest in the invention, aside from its possible military use, lies in his belief that it can be utilized for the wireless transmission of electrical energy. He realizes, of course, that it is exciting interest at the present time principally because of its death-dealing possibilities.

"If I were to mount it in a plane, directed earthward, and were to fly the plane low over a city, it would leave a swath of death beneath it," Riley declares. "I am convinced that it would mow down whole lines of infantry and, also, that tanks would have no defense against it, up to reasonable distances.

Recently, Riley has moved his laboratory to another location which is kept secret and is known only to the government, Riley and his bodyguard. Photographs which accompany this article were taken by Riley, himself, as he refused to lead a photographer to the place where the ray machine is now being kept.

Riley feels confident that additional research will increase the range of the machine—perhaps up to 1,000 yards.

Recently, on a trip to Washington to confer with Navy officials, a car crowded Riley's automobile off the highway near Baltimore and he was injured. He is convinced it was the work of persons who have been attempting to steal his plans.

Many "death ray" machines have been produced in the past, but none has proved successful to date. Most famous of these was one which Nikola Tesla, well known Russian scientist, claimed to have invented in 1935. Tesla's "ray" failed to stand up under tests, however.

Riley expects the Army and Navy will have completed tests on his machine within a few weeks.

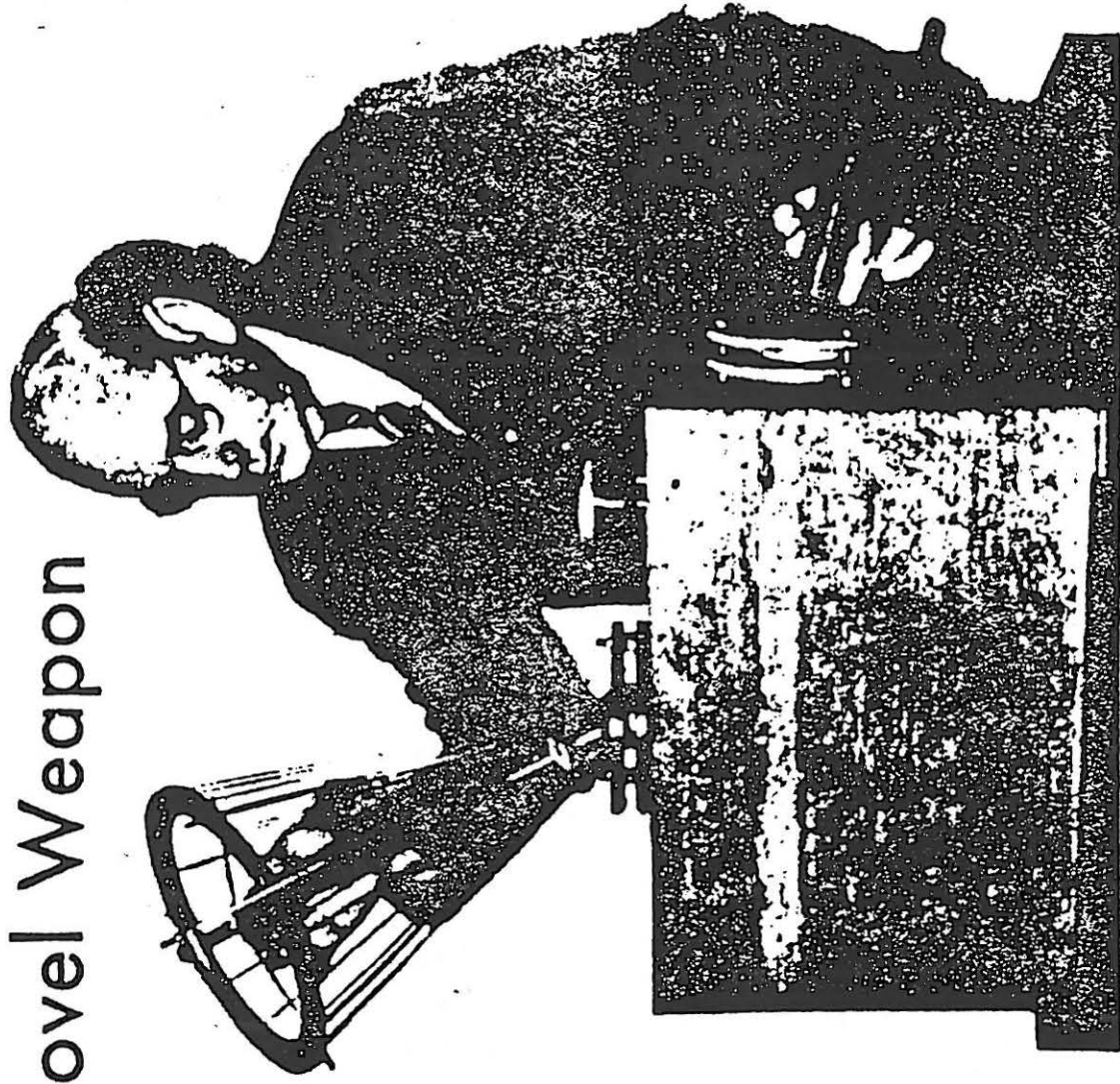
Remote Detonator for Bombs Effective for Two Miles

Claimed to work at distances up to two miles, a remote-control device invented by a Californian explodes bombs or other explosive charges. A directed, or focused, invisible beam, like a radio wave, is said to be the secret of the detonating machine. One anticipated use of the device is the setting off of enemy bombs that fail to explode, thus eliminating the risk of attempting an examination of the explosive. Another use might be in blasting, with the detonator replacing fuses and unhandy electrical equipment.



Ray Gun Is Novel Weapon

SUNLIGHT and electric power are utilized in a new war machine to form a destructive ray that may have vast possibilities for military use, according to its inventor, Otto H. Mohr, of Piedmont, Calif. Machines of this type, he states, could be employed to halt or at least slow down the advance of an attacking army by concentrating their rays on the enemy's ammunition and gasoline supplies, causing them to explode. Although details of the machine's operation have not been revealed, the apparatus was tested recently before a group of U. S. Army officers. Powder poured onto the lids of tin cans was set off by the device at a distance of twenty feet. Mohr is shown at the right with his detonator-ray machine.



Otto H. Mohr with his ray gun that explodes gunpowder at twenty feet

Sun Rays Make Electricity To Light Three Bulbs



Electrical hookup, top and center, uses sun's rays to generate current that will light lamps, bottom

Another step toward the goal of harnessing the sun's power to produce heat and light has been achieved in an invention by O. H. Mohr, of Oakland, Calif., which utilizes rays from the sun to generate sufficient electric power to light three electric lamps. The device consists of a lead-free glass bulb, enclosing a cluster of wires, thermocouples and other electric apparatus. Alternate heating and cooling of this assembly generates electricity in small amounts.

ACCUMULATOR CONE

ANTI-SPRAY
GUARD

HAWSERS LINK UP
NUMEROUS UNITS
TO TOWING SHIP

DETONATOR RAY
TOUCHES OFF
FUEL TANKS AND
EXPLOSIVES IN
ENEMY BOMBER

CONE SHAPED
ACCUMULATOR
PICKS UP AND
RELAYS SOLAR
RAYS TO SECRET
DETONATOR BOX

FOCUS
TUBES

STEERING
GUN

EXPLOSIVES IN
TORPEDO CHAMBER
REACTING TO BEAM

Drafting The Sun for Defense!

SUPPOSE magicians could be stationed at strategic points along the borders or coast of a country at war. Then when enemy battleships, submarines or bombers came within five miles, the magicians could mumble a few magic words, and presto!—the invaders would be blown to bits by their own explosives!

An instrument has really been devised that will perform just such a feat, not by

[Continued on page 144]

hocus pocus, but by utilizing natural physical laws to ignite explosives at a distance without the use of wires or any other direct contact. Otto H. Mohr, inventor of the submarine detector, is the originator of the Solar Mohr Detonator, and has successfully demonstrated it to Army officials.

Recently a group of United States Army experts gathered in the hills near Oakland, California, to witness a test of the Detonator. Several times in previous months they had watched demonstrations of the instrument, and they came prepared to put it to tests of their own devising.

Canvas bags containing charges of powder used to fire a one pound shell were placed in the middle of a field. Twenty feet away Mr. Mohr stood by his model Detonator, a cubical measuring about two-feet. He adjusted a cone-shaped antenna on top until a metal tube in its core pointed to the sun. A gentle buzz from within indicated that it was in exact position, then a dim light appeared in a tube extending from the front of the instrument. The inventor focused this tube in the direction of the bags of powder. Nine minutes later the powder exploded. Other tests devised by the officers convinced them that the Detonator is a remarkable and practical defense weapon, and they recommended favorable consideration by the United States Army.

Mr. Mohr stumbled onto the Detonator Ray by accident. While working on another instrument which utilized solar energy, a small amount of powder nearby exploded. It took five years to discover the secret of this accident and to construct an instrument to command and control the principle of remote detonation.

Did you ever focus the sun's rays to pin-point intensity with a lens and set fire to paper or straw? That, very roughly, is the underlying principle of the Detonator. The cone-shaped antenna on top gathers the sun's magnetic force which has transformed inside the instrument to motivated vibratory currents. These vibrations are synchronized or "tuned" to the atomic vibrations of the explosive substance and sent on a

beam from the focusing tube in the direction of the target.

Four secret essentials control the Detonator, and to safeguard the invention, Mr. Mohr dismantles it after every demonstration.

* A bright, sunny day is not essential to the use of the Detonator, but the brighter days make it possible to gather more solar energy in less time, thus shortening the time it takes to explode the target. But any amount of sunlight is effective. It is possible, too, that a mercury arc may some day be substituted at night for solar energy.

The explosive principle is similar to that causing combustion when two sticks are rubbed together

rapidly; the energy vibrations from the sun's magnetic force which is transferred along the beam, set up a friction with the explosive elements. They become hot, and hotter, then explode.

Explosive substances used in ammunition are always compounds of several elements—gun powder is a combination of potassium nitrate, sulphur and charcoal—but any explosive with a hydrocarbon base is subject to the Detonator Ray.

However, there is one requirement: the atomic vibration of the constituents must be known so that the Detonator may be "tuned" to effective action.

Otherwise the solar vibrations would slide

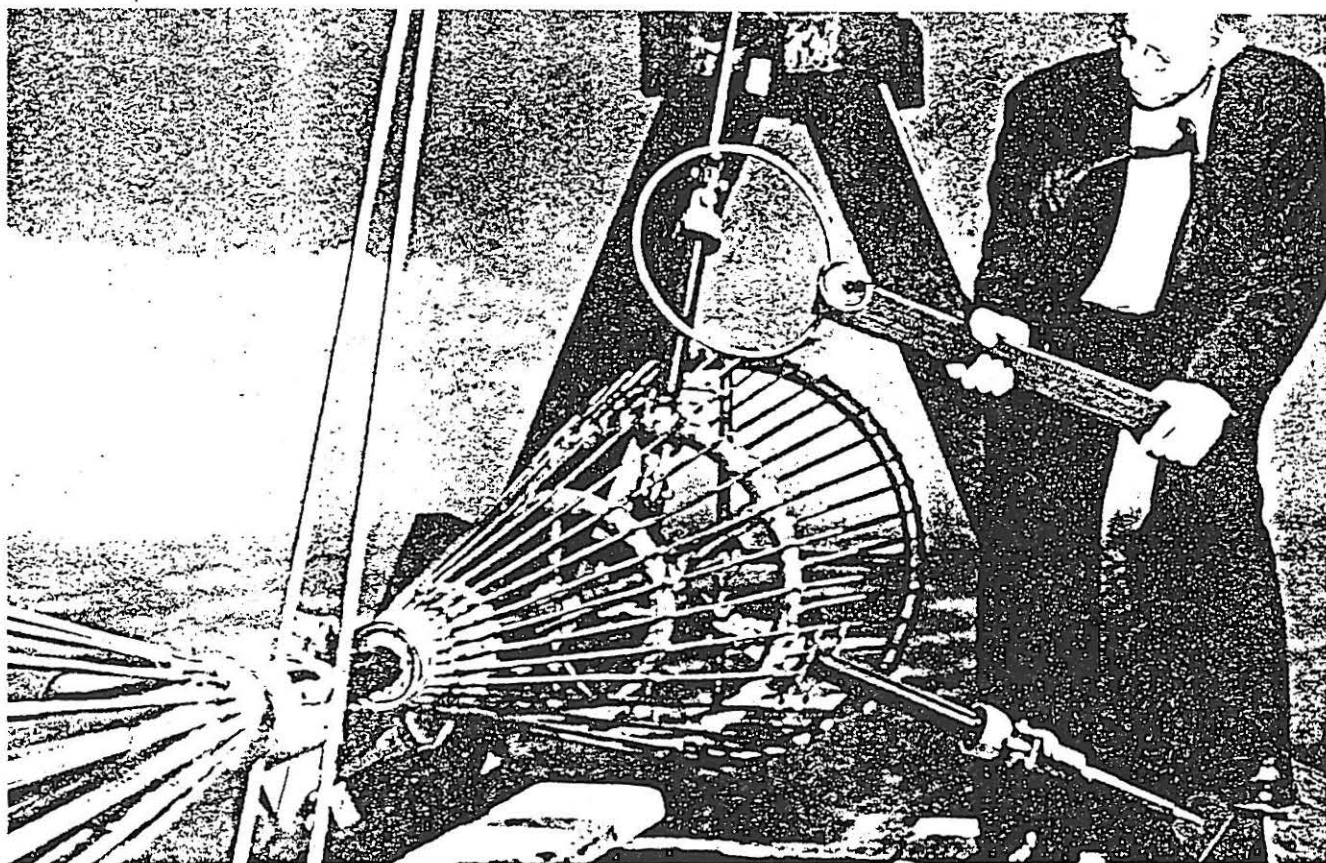
past the explosive's atoms without the friction essential to explosion.

Mr. Mohr has determined the atomic vibrations of some elements, but many types of explosives have not yet been analyzed, and the atomic vibrations of many elements are not yet known. Gun powder, gasoline vapor, and some other explosive substances have been successfully fired by the Detonator. All others will be calculated as soon as time and money will permit, and as fast as further atomic vibrations are formulated, they will be turned over to the Army.

Another improvement that is being worked on is the extension of the distance at which the Detonator will be effective. It is like the projecting of shot from a cannon; the greater the power behind the shot, the farther and harder it will be sent. The inventor believes that the beam of

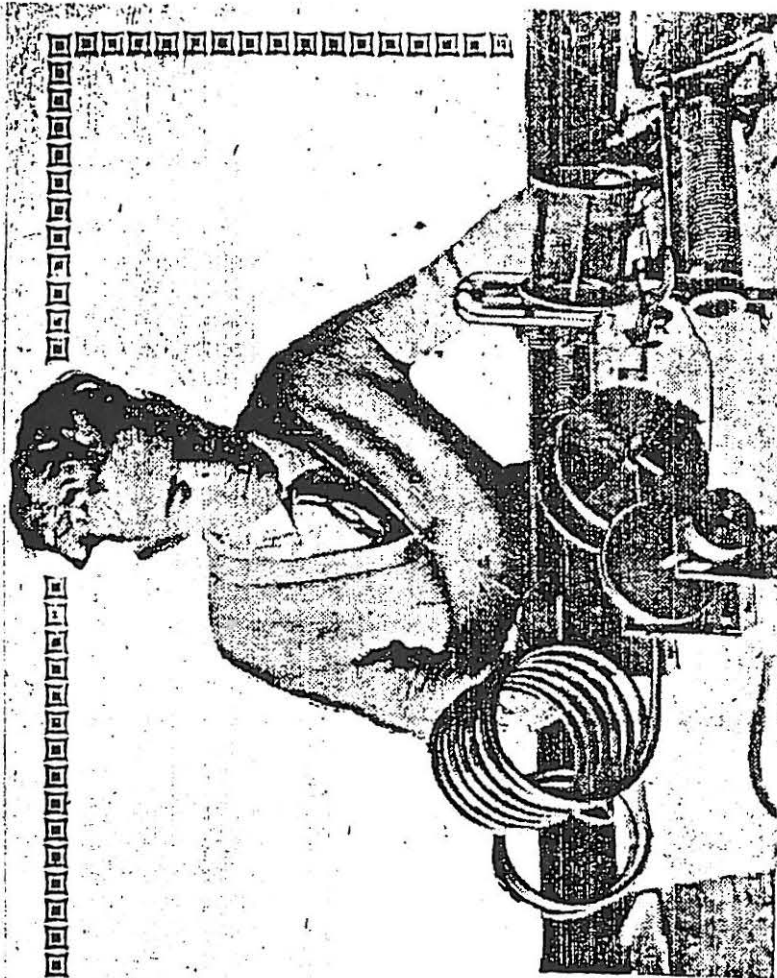
the Detonator may be extended to the reach of light rays; approximately forty miles on a level with the horizon, when sufficient solar energy can be accumulated.

When larger, more powerful models of the Detonator are built, invading machines will have small chance of coming within shooting or bombing distance of the United States. Battleships or tanks would be spontaneously blown up by their own ammunition, and bombers would be destroyed by the very missiles they planned to drop on others.



Basket-Shape Television Antenna Gets Broadcast-Power Tests

ASSUMING the stance of a butterfly collector about to pounce on his prey, the engineer atop the radio tower, above, is up to more serious business. His ring-shaped implement measures the strength of radio waves, and the even queerer-looking object in front of him is the latest in television antennas. By holding the ring in various positions, and reading a meter on its handle, he is testing the amount of power that the cage-like aerial radiates in different directions. Just perfected by General Electric engineers, this conical antenna has been erected at one of the company's stations near Schenectady, N. Y., where it will be used for future picture broadcasts. The photograph also illustrates how a good television site commands a view of the horizon.



Interesting developments are anticipated from the experiments of Mr. W. W. Salisbury, who is perfecting a system of secret communication using very high frequencies. He hopes to be able to direct signals to a given spot within a few miles either way. This photograph shows Mr. Salisbury with his apparatus.

No. 628,352.

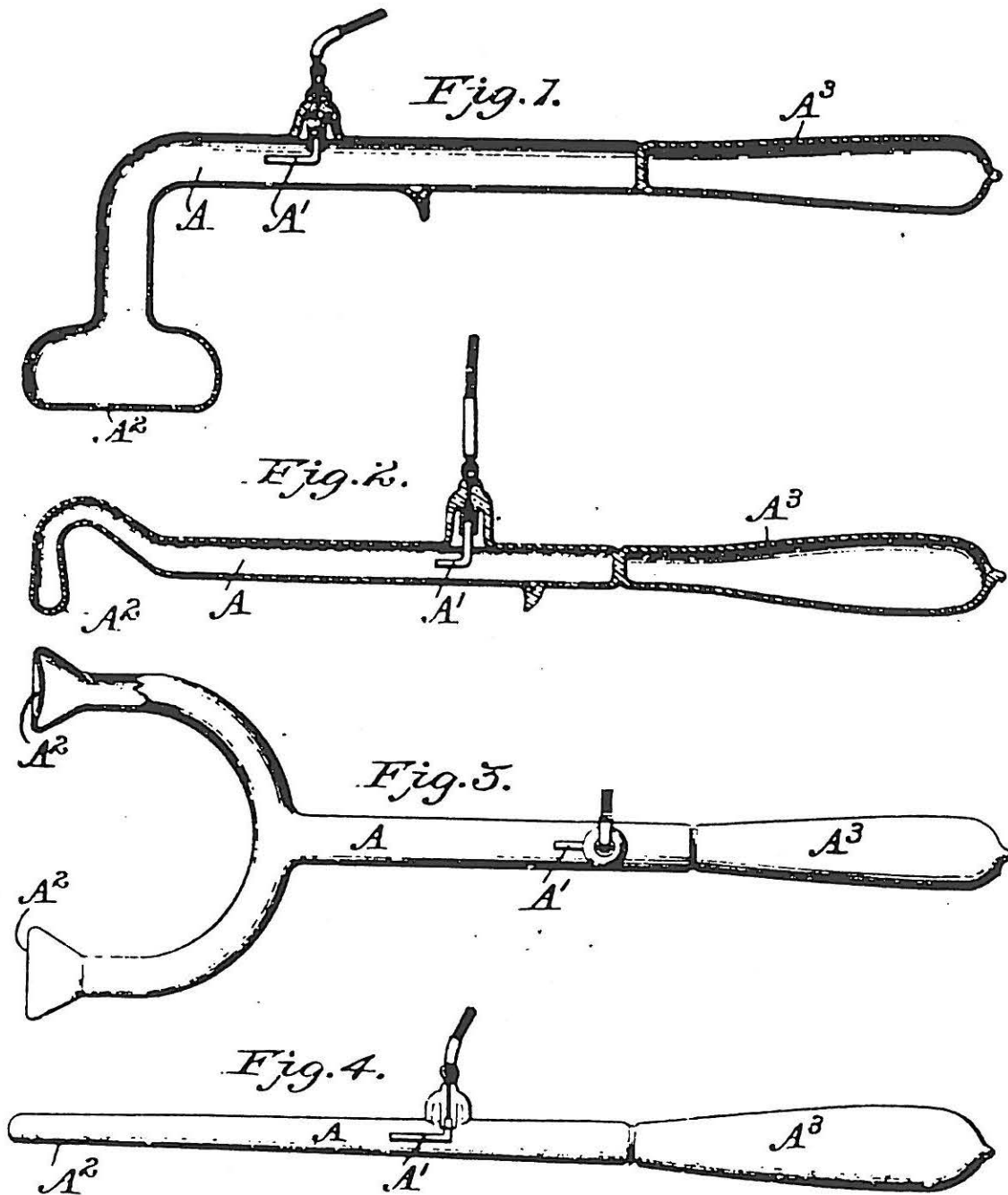
Patented July 4, 1899.

H. G. O'NEILL.

VACUUM ELECTRODE FOR THERAPEUTIC PURPOSES.

(Application filed Oct. 16, 1898.)

No Model.)



WITNESSES:

Edmund J. McKee
Geo. A. Crawford

Henry E. O'Neill

BY
C. W. Anderson
ATTORNEY.

NEW RADIO SET HAS NO VALVES OR INDUCTANCES

"Directed Ray" Is Used by an English Inventor in Transmitting.

A radio transmitting or receiving set which uses neither valves nor coils, in the accepted sense, and which will operate on the short waves by directional methods—such, very briefly, is the invention of H. E. Chapman, a wireless engineer.

In an interview, Mr. Chapman said it was true, in a way, that his device employed no valves, as at present known, but his H. F. relay takes the place of a valve. This is heated by an electric current, though he is at work on a cold emitter. The action of this relay is electromagnetic, and unlike the ordinary valve, two of the electrodes are inductances. For work with very short waves these inductances inside the relay tube are all that are necessary for tuning.

Mr. Chapman does not accept the theory of the "Heaviside layer" against which the wireless waves impinge and are deflected back again to earth. His theory is that the earth is surrounded by a dense electronic field which varies according to the temperature of the earth's atmosphere and its distance from the surface. Also that this electronic field has its orbit in a longitudinal plane, as opposed to the earth's magnetic field, which is in a latitudinal plane. Mr. Chapman's apparatus therefore is designed to concentrate the output or reception into a ray which can be directed by any transmitter to any receiver by aiming it at the correct angle into the electronic and magnetic fields. The accuracy with which it is claimed this can be done is such that reception would only be possible within quite a comparatively short distance laterally each side of the receiver. As the wave lengths would have to be altered to suit the time of day and temperature conditions, a set of relays would have to be used, but probably not more than five. These would have in their electrodes the windings which in combination would give the necessary wavelengths.

It is possible that Mr. Chapman's invention may prove to be an improvement on the Marconi "beam" system and may mean a still further advance toward wireless reception of a message by the individual only for whom it is intended.

UNITED STATES PATENT OFFICE.

HENRY GIBSON O'NEILL, OF NEW YORK, N. Y., ASSIGNOR OF TWENTY-NINE
THIRTY-SECONDS TO JOHN ROONEY, OF SAME PLACE, AND ALEXANDER
ARNOIS, OF PHILADELPHIA, PENNSYLVANIA.

VACUUM-ELECTRODE FOR THERAPEUTIC PURPOSES.

SPECIFICATION forming part of Letters Patent No. 628,352, dated July 4, 1899.

Application filed October 15, 1898. Serial No. 893,882. (No model.)

To all whom it may concern:

Be it known that I, HENRY GIBSON O'NEILL, a subject of the Queen of Great Britain, and a resident of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Vacuum-Electrodes for Therapeutic Purposes; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters of reference marked thereon, which form a part of this specification.

This invention appertains to the art of electrotherapy, and is designed, mainly, to afford a simple and effective means for producing electrical asepsis and stimulation without any of the unpleasant physiological effects incident to the use of electricity for therapeutic purposes. The principle involved in this system of electrical asepsis and stimulation is the production of nascent ozone surrounding and within the diseased surface, thereby oxidizing the micro-organisms or other toxic matter present, while stimulating healthy granulation by molecular bombardment.

The process consists in directing high-tension currents of electricity through a unipolar vacuum-electrode of glass or other vitreous material against the affected parts, thereby decomposing not only the air surrounding but occluded within the same, resolving the molecules of oxygen into their atoms and re-constructing them into a new group represented by O_3 , (ozone.) Ozone in this nascent form is very much more energetic than in a free state and produces instant oxidation of all diseased matter. This form of asepsis is applicable to the entire tract of a wound or diseased surface at any depth. It is fatal to all germ life and affords a means of internal asepsis for which there can be no substitute in the very nature of things.

The manner of carrying out this system is through an electrode of glass, having an interior vacuum and one pole in connection with a source of high-tension currents of electricity.

The specific form of electrode or instrument will vary according to the organ involved or part affected.

In the accompanying drawings, Figure 1 illustrates one form adapted generally to treatment of a wound or diseased surface on the body; Fig. 2, a form for treating catarrh or other forms of diseases of the ear; Fig. 3, a form for certain eye diseases, and Fig. 4 a form where the nose is involved.

While all necessarily vary in form, they embody the same essentials. They are in each case made of glass. The contact-surface of each is characteristic of its function. In each case this contact-surface is exterior of a vacuum.

In the drawings, A designates a vacuum-chamber, and A' a sealed-in terminal entering the chamber A.

A² is the contact-surface, and A³ is any suitable non-conducting handle. I prefer to have it either of solid glass or of glass filled with air.

The one pole or terminal A' is connected with a source of high tension current. The electrode is then brought near or in contact with the diseased surface. The current entering the vacuum-chamber is attenuated, and impelled by its potential passes through the contact-wall of glass to the person softened in its action as to be unfelt, while it produces nascent ozone *in situ* and stimulates healthy action and the reparative processes.

Any current of sufficiently high tension will suffice. I prefer, however, to employ a current having a wave approaching as nearly as possible to the sine curve.

What I claim as new, and desire to secure by Letters Patent, is—

1. A unipolar electrode of glass or other

5 vitreous material, containing a vacuum-chamber, having an exterior contact-surface, and a single sealed-in terminal designed for connection with a source of high-tension electrical current, substantially as specified.

2. The apparatus for electric asepsis and stimulation which consists of an electrode of glass having a non-conducting handle; a contact-surface exterior of a vacuum-chamber,

and one pole connected with a source of high-tension energy, substantially as set forth. 10

In testimony whereof I affix my signature in presence of two witnesses.

HENRY GIBSON O'NEILL.

Witnesses:

G. M. ANDERSON,
GEO. H. PARNELLE

No. 733,343.

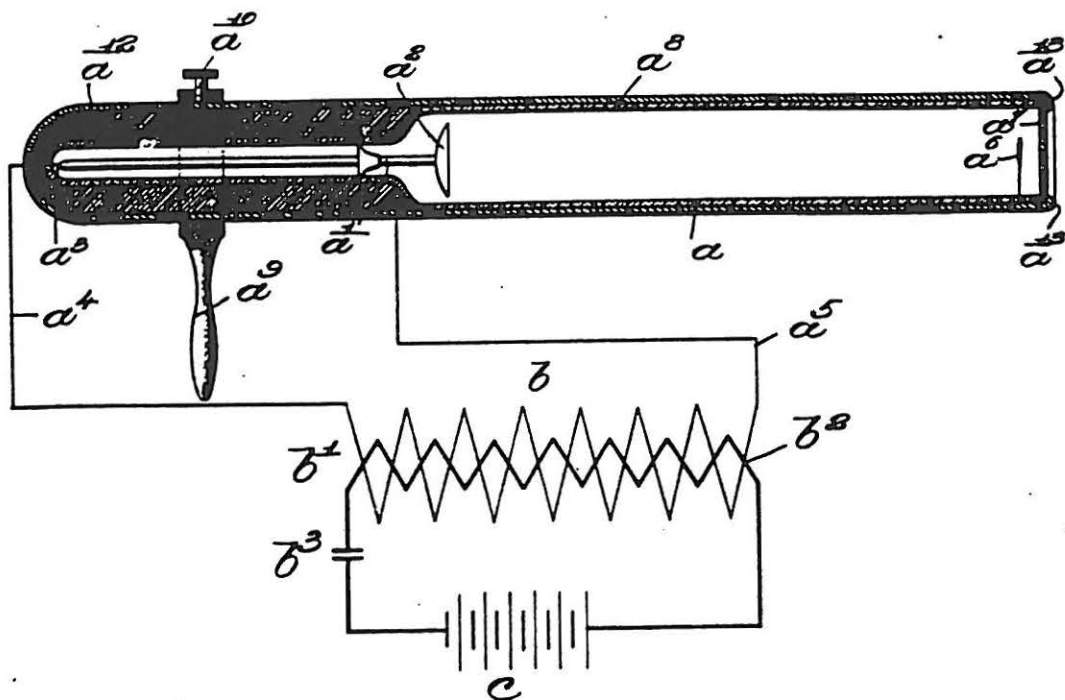
PATENTED JULY 7, 1903.

F. F. STRONG.

ELECTRICAL APPARATUS FOR USE OF ULTRA VIOLET RAYS.

APPLICATION FILED MAY 11, 1903.

NO MODEL.



Witnesses:
Fred S. Greenleaf.
Samuel W. Sutton.

Inventor.
Frederick F. Strong,
By Henry H. H. H. H.

UNITED STATES PATENT OFFICE.

FREDERICK FINCH STRONG, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO
FRANK H. SWEET, OF BOSTON, MASSACHUSETTS.

ELECTRICAL APPARATUS FOR USE OF ULTRA-VIOLET RAYS.

SPECIFICATION forming part of Letters Patent No. 733,343, dated July 7, 1903.

Application filed May 11, 1903. Serial No. 156,565. (No model.)

To all whom it may concern:

Be it known that I, FREDERICK FINCH STRONG, of Boston, county of Suffolk, State of Massachusetts, have invented an Improvement in Electrical Apparatus for Use of Ultra-Violet Rays, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawing representing like parts.

My invention is an improved ultra-violet generator or device for generating and applying to the human body or wherever desired waves of short lengths between the green rays of the spectrum and the Becquerel and Roentgen rays, comprising mainly violet light-rays and ultra-violet rays.

The recent activity following the results obtained by the Far-En light has brought forth a number of different forms of apparatus for this general purpose, which, however, are in the main costly and cumbersome and require connection with a dynamo or commercial service-wire. In endeavoring to devise a convenient portable apparatus for general use adapted to the conditions met with by the country physician as well as the city practitioner I have succeeded in producing the herein-described apparatus, which does not depend in any way upon a commercial service-wire, but is operable by a usual dry battery or other form of comparatively small battery in connection with an induction-coil of the Ruhmkorff kind simply by using a Geissler tube or other convenient vacuum-tube provided with a quartz lens or equivalent device transparent to the ultra-violet waves, as herein set forth. This form of apparatus can be economically constructed and used, is entirely portable, and occupies very little space.

In the drawing I have illustrated a preferred form of my apparatus.

The tube, as herein shown, is cylindrical, this form being best adapted to certain surgical purposes; but it will be understood that any other form of tube may be used, as desired.

Geissler tube a is mounted, in usual manner, an electrode a' , containing a mirror a^2 and connected at a^3 with a terminal wire a^4 , leading from a suitable generator of high-

voltage current, (herein shown as an induction-coil b ,) said terminal a^4 leading from one end of the secondary b' thereof, the other end a^5 of said secondary, when required by the form of apparatus used, leading to an opposite electrode a^6 within the vacuum-tube. At its outer end I provide a lens a^7 , of quartz or other material transparent to the ultra-violet rays, this lens being cemented or ground into place and properly fixed so as not to interfere with the vacuum within the tube. The tube contains a residue of gases or vapors which have the power of giving out large quantities of ultra-violet rays in their spectrum, especially when excited by a high-voltage current with a pressure of, say, about one one-thousandth of an atmosphere, among such gases or vapors being acetylene gas, iodine vapor, mercury vapor, and hydrogen gas. The tube a is preferably incased in a hard-rubber or other covering a^8 . The primary b^2 of the coil b is connected through a suitable interrupter b^3 to a suitable battery c . This apparatus may be inclosed in a small case, so that the entire apparatus is portable, and the rays can be generated independently of any arc-lamp or other electric circuit or expensive high-frequency machine or apparatus.

The tube a preferably has a length sufficient to reach the affected part—e. g., the cervix uteri—and to project conveniently for proper manipulation, and in connection therewith I may use a handle or supporting-stand a^9 , adjustable at a^{10} to suit special requirements. Preferably insulating material a^{12} is filled in at the outer end to give solidity and strength. The incasing part a^8 is preferably sealed around the lens at a^7 , and this also provides means for pressing against and confining the tissue being treated, tending to de-homatize the tissues, thereby rendering them permeable to the ultra-violet rays.

I believe that I am the first to develop for use the rays in question by a vacuum-tube, and in practice I have found that very satisfactory results may be obtained by this simple and convenient form of apparatus.

In use the tube is introduced to the part to be treated, and the quartz lens is pressed against the tissues at the seat of the disease.

The battery-current being turned on through the primary of the coil, causes the high-voltage current to flow through the residual vapor in the vacuum-tube, causing the particles of said vapor to vibrate at such a rapid rate as to impinge upon the surrounding ether and cause ultra-violet rays to fill the tube and radiate out through the lens a' upon the diseased tissue, thereby producing the desired action thereon. The glass a being nearly opaque to these rays, reflects them back from the sides of the tube, concentrating them in a stream which passes freely through the transparent lens a' .

It will be understood that I do not restrict myself to all the constructional details, arrangement, and combination of parts, as shown herein and specifically set forth, inasmuch as many variations may be resorted to within the spirit and scope of my invention, all as will be more apparent from the appended claims.

Having described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. A device of the kind described, comprising a vacuum-tube having a discharge-electrode and a lens transparent to ultra-violet rays opposite said electrode combined with a source of high-voltage current of electricity.

2. A device of the kind described, comprising a vacuum-tube containing a gas, such as described, having large capacity for ultra-violet rays in its spectrum, and said tube having a discharge-electrode, and a lens transparent to ultra-violet rays opposite said elec-

trode, combined with a source of high-voltage current of electricity.

3. A device of the kind described, comprising a vacuum-tube having a discharge-electrode, being inclosed in a protecting covering a'' , and a lens transparent to ultra-violet rays opposite said electrode, combined with a source of high-voltage current of electricity.

4. A device of the kind described, comprising a vacuum-tube having a discharge-electrode, and a lens transparent to ultra-violet rays opposite said electrode, combined with an induction-coil, interrupter, and battery, said induction-coil having its secondary connected to said electrode and its primary connected through said interrupter to said battery.

5. A device of the kind described, comprising a vacuum-tube provided with a discharge-electrode, a lens in one end of said tube transparent to ultra-violet rays and a projecting bearing beyond said lens for resting upon the part being treated by the device.

6. A device of the kind described, comprising a vacuum-tube having a discharge-electrode, a lens in the end of said tube transparent to ultra-violet rays, and a handle adjustably mounted on said tube.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FREDERICK FINCH STRONG.

Witnesses:

GEO. H. MAXWELL,
FRED S. GREENLEAF.

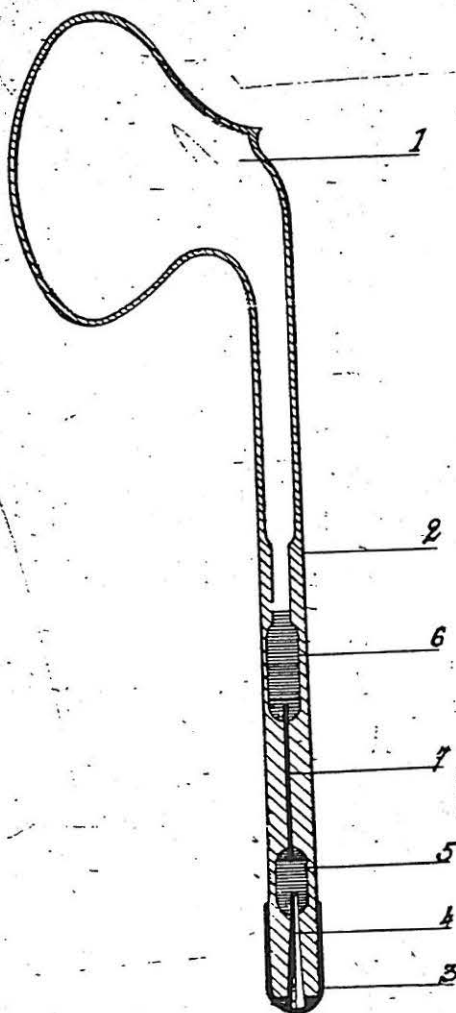
Jan. 10, 1928.

1,655,783

R. GALLOIS

ELECTRODE FOR THE COMBINED THERAPEUTIC APPLICATION OF HIGH
FREQUENCY CURRENT AND OF ULTRA VIOLET RADIATION

Filed Sept. 14, 1926



Inventor
R. Gallois

By *Lawrence Perry, Carl Shaffer*
Att'ys.

UNITED STATES PATENT OFFICE.

ROBERT GALLOIS, OF LYON, FRANCE.

ELECTRODE FOR THE COMBINED THERAPEUTIC APPLICATION OF HIGH-FREQUENCY CURRENT AND OF ULTRA-VIOLET RADIATION.

Application filed September 14, 1926, Serial No. 135,428, and in France October 3, 1925.

Electrodes at present utilized for the therapeutic application of high-frequency currents are composed of tubular glass bodies or members which are sealed when, after exhaustion, they contain only low pressure air.

One of the extremities of these electrodes has a shape which varies according to the part of the body to be treated; the opposite extremity is shaped in such a way as to receive a metallic cap connected to one of the poles of the apparatus generating the high frequency currents, the other pole of which is connected to earth. In these conditions, the electrode is supplied by induction and it is sufficient to touch the patient with it in order that it may be illuminated.

According to the present invention, the electrode composed of transparent fused quartz contains an atmosphere of inert gas (argon, helium or neon) and a small quantity of mercury.

The presence of a gas such as argon, helium or neon in the electrode has for object to facilitate its lighting up. As soon as that has taken place, the tension of the mercury vapor increasing, the electrode works like a mercury-vapor lamp and it emits intense ultra-violet rays.

Silica being transparent to these rays, the physician can thus combine sparking with ultra-violet therapy. The surface of the electrode is sterilized in a continuous and automatic manner by the ultra-violet rays which pass therethrough. Moreover, the quartz being refractory, it is possible, in case of need, to sterilize the electrode in a flame without risk of causing the electrode to break.

Since quartz presents a dielectric coefficient very much higher than that of glass, the electrode offers less risk of perforation than do glass electrodes.

The annexed drawing represents, by way of example, in longitudinal section, one form

of constructing the electrode according to the invention.

1 is a hollow body of transparent fused silica, of a shape suited to that portion of the (human) body to be treated, and which is sealed after a high vacuum has been formed therein and of helium, argon or neon has been introduced thereinto. This hollow body ends in a cylindrical shank 2 of reduced diameter which is fitted at its extremity with the metallic cap 3. This latter is provided interiorly and axially, with a metal rod 4, preferably of invar metal, forming a ground joint inside a central passage in the tube 2.

This rod terminates within a chamber formed in the said tube, which chamber contains mercury in electrical communication with another small quantity of mercury free in the container 1, by means of a wire 7 sealed in the axis of the mass of quartz by means of a narrowing of the bore of the tube 2.

This arrangement for leading in the current allows the energy given off by the electrode to be considerably increased.

The invention is obviously not limited to the shape and to the details presented. In particular, for certain applications, the electrode can be composed of a plain tube of silica not comprising a sealing up and simply capped with a metal cap as usual, but always containing essentially a drop of mercury and the gases above specified.

What I claim is:

An electrode intended for the therapeutic application of high frequency currents, comprising a hollow body of transparent fused silica, containing a rarefied inert gas together with a small quantity of mercury, and electric connecting means on said body.

In testimony whereof I have signed my name to this specification.

ROBERT GALLOIS.

Feb. 1, 1949.

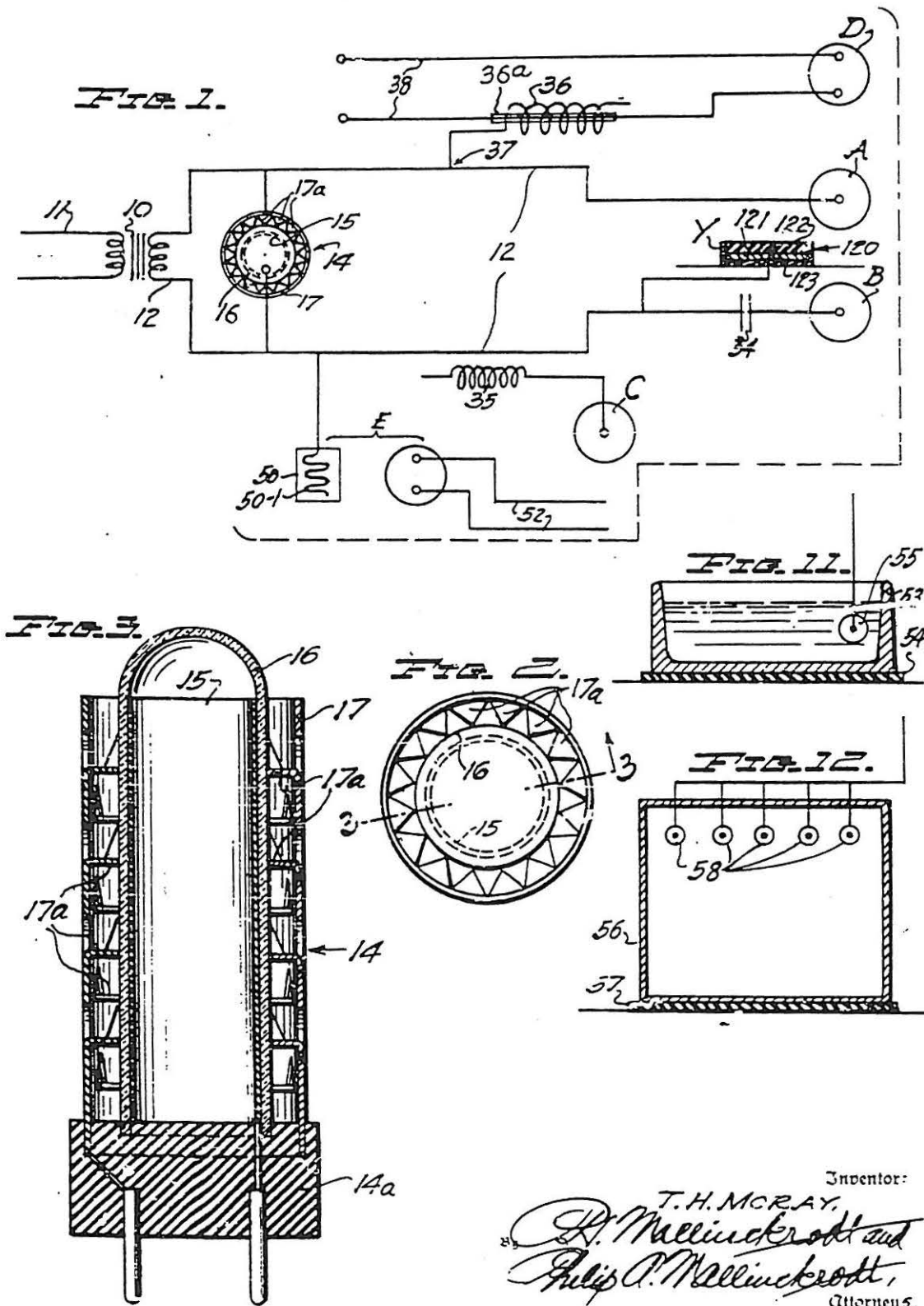
T. H. MORAY

2,460,707

ELECTROTHERAPEUTIC APPARATUS

Filed April 30, 1943

3 Sheets-Sheet 1



Feb. 1, 1949.

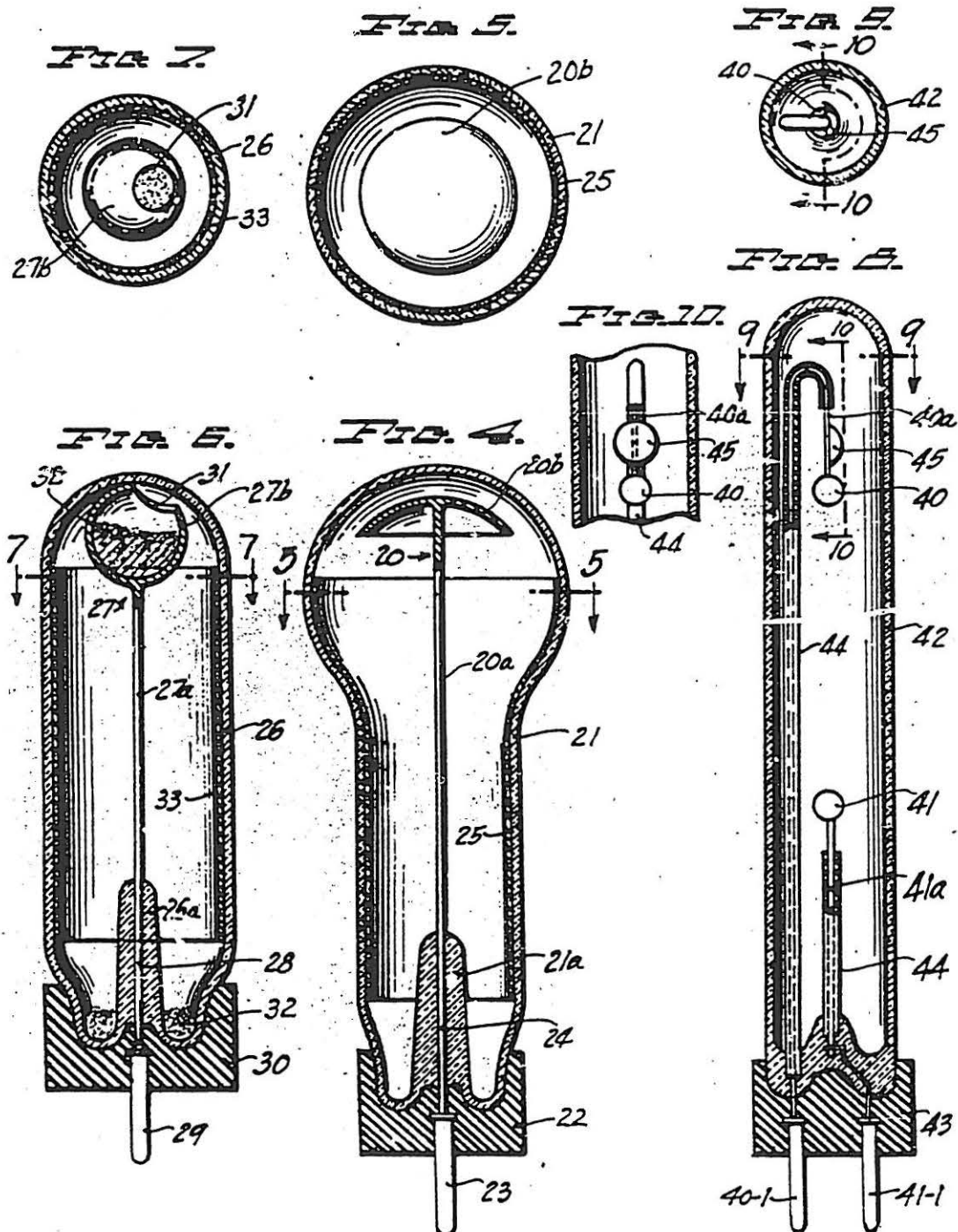
T. H. MORAY

2,460,707

ELECTROTHERAPEUTIC APPARATUS

Filed April 30, 1943

3 Sheets-Sheet 2



Inventor:
T. H. MORAY,
Chas. H. Mallinckrodt and
Philip A. Mallinckrodt
Attorneys.

Feb. 1, 1949.

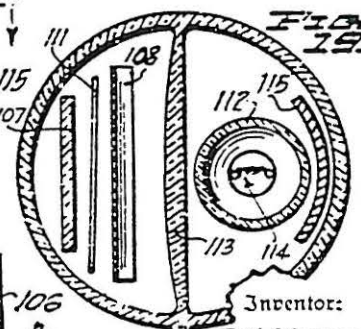
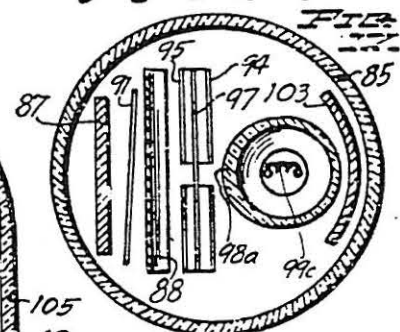
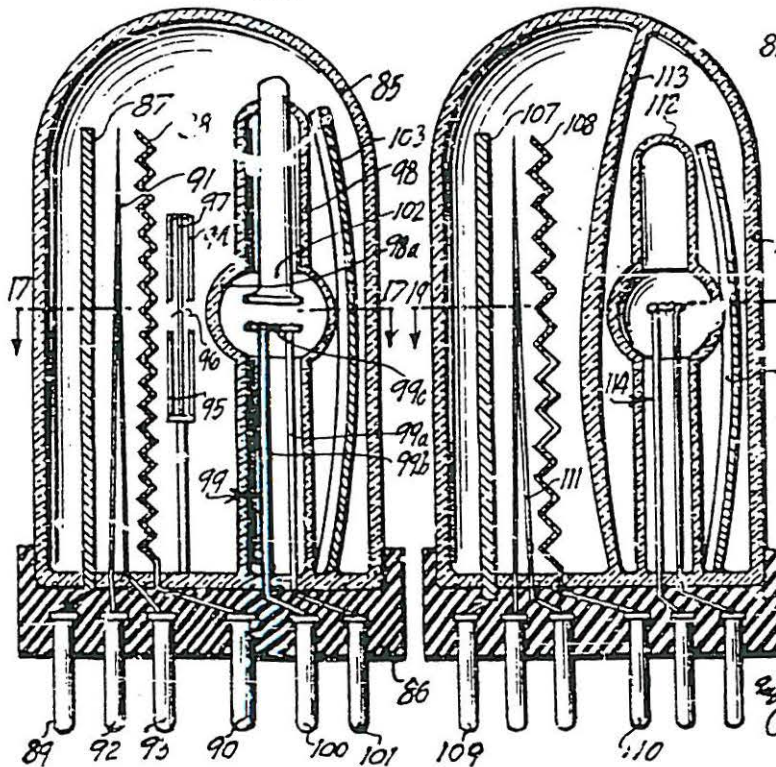
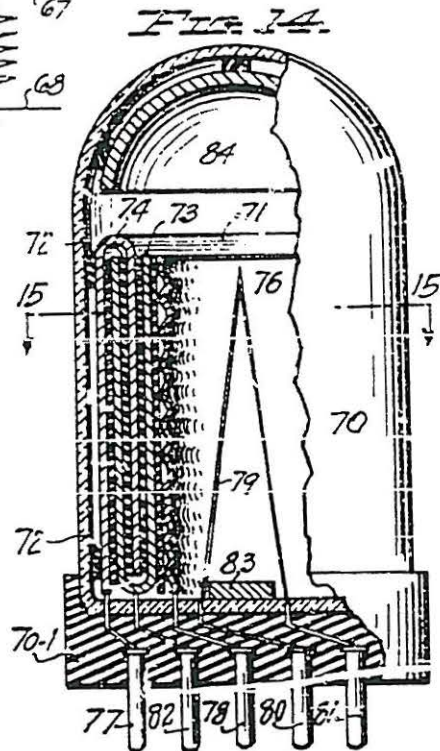
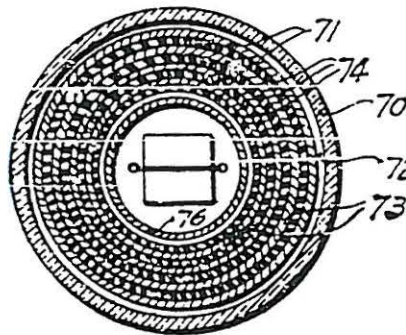
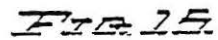
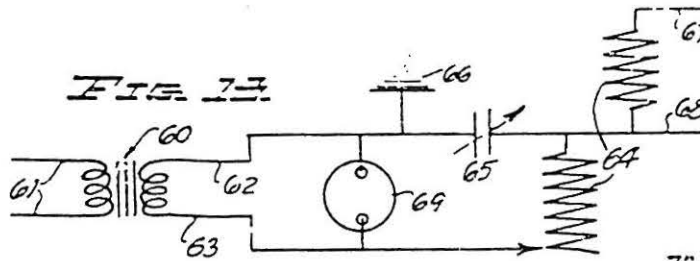
T. H. MORAY

2,460,707

ELECTROTHERAPY CUTIC APPARATUS

Filed April 30, 1943

3 Sheets-Sheet 3



Inventor:

T. H. MORAY.

E. N. Wallingford
Philip A. Wallingford.
Attorneys

Attorneys

UNITED STATES PATENT OFFICE

2,460,707

ELECTROTHERAPEUTIC APPARATUS

Thomas H. Moray, Salt Lake City, Utah

Application April 30, 1943, Serial No. 485,112

8 Claims. (Cl. 128-421)

1

This invention relates to electrotherapeutic apparatus, and to methods of applying electrical, radioactive, and other radiant phenomena therapeutically.

The invention is primarily concerned with the use of high potential, high frequency electricity though not necessarily limited thereto, in conjunction with radioactive and other types of electronic and radiation phenomena, for therapeutic purposes.

Among the objects of the invention are the following:

First.—To render highly effective, from a therapeutic standpoint, radioactive and other types of electronic and radiation phenomena, and, likewise, to render highly effective, from a therapeutic standpoint, high potential, high frequency electricity.

Second.—To augment the therapeutic effect of radioactive and other types of electronic and radiation phenomena by the conjoint use of high potential, high frequency electricity, and, conversely, to augment the therapeutic effect of high frequency, high potential electricity by the conjoint use of radioactive and other types of electronic and radiation phenomena.

Third.—To accomplish the above without danger of burning or of otherwise harming the patient.

Fourth.—To provide apparatus for accomplishing the above, which is relatively simple in construction and operation and relatively inexpensive to produce and operate.

Fifth.—To provide novel electronic and radioactive devices especially adapted for use in conjunction with high potential, high frequency electrical therapy.

I have found that, by enveloping a patient in a high potential, high frequency electrical field in such a manner that no closed circuit is completed through his body, radioactive and other electronic and radiation phenomena can be used therapeutically with considerably greater effectiveness than if used alone. The exact reason for this is not known, nor is it known definitely which, the electric field or the radioactive phenomena, acts upon the other to produce the advantageous results. It is thought, however, that the electric field, permeating the body of the patient as it does, attracts the radioactive emanations or radiations and enables them to penetrate considerably deeper into the tissues and vital organs of the patient than would otherwise be the case. In any event, remarkable therapeutic results have been achieved by use of the invention in the treatment

2

of malignant tumors, arthritis, sinus infections, and various other diseased conditions.

The invention contemplates the use, in therapeutics, of high potential, high frequency electricity to produce diversified forms of radiant energy, such forms being those which have been found best suited, individually, to benefit various human ailments. In accomplishing this purpose, several special discharge tubes have been developed to serve as treatment electrodes, by means

of which correspondingly different curative results are obtained. Throughout the practice of the invention, a prime consideration is that only one terminal of any particular circuit shall be in contact with a patient's body at one time, so there will be no flow of current through a closed circuit of which the patient's body is a part. Such a terminal, too, is usually non-heat producing, so there is no danger of burning. In cases where there is a tendency for a tube to produce X-rays or other injurious rays, these are filtered out.

The present application constitutes a continuation in part of a copending application filed by me November 15, 1940, which bears Serial No. 365,798 and is entitled "Method of and device for the therapeutic application of electric currents and rays," and which has now become abandoned.

In the accompanying drawings, which illustrate several embodiments of apparatus preferred for carrying the method of the invention into practice:

Fig. 1 represents a wiring diagram of a preferred embodiment of apparatus for carrying out the method of the invention in general therapeutic work, several independent treatment stations being provided;

Fig. 2, a top plan view of the novel corona regulator of Fig. 1, employed in the circuit to control and adjust the current and as a governor to safeguard the transformer;

Fig. 3, a vertical section taken on the line 3-3, Fig. 2;

Fig. 4, a vertical section taken centrally through one novel type of discharge tube used as a treatment electrode in the apparatus of Fig. 1;

Fig. 5, a horizontal section taken on the line 5-5, Fig. 4;

Fig. 6, a vertical section taken centrally through another novel type of discharge tube used as a treatment electrode in the apparatus of Fig. 1;

Fig. 7, a horizontal section taken on the line 7-7, Fig. 6;

Fig. 8, a vertical section taken centrally through

a novel discharge tube used as a treating device in the apparatus of Fig. 1;

Fig. 9, a horizontal section taken on the line 8-9, Fig. 8;

Fig. 10, a fragmentary vertical section taken on the line 10-10, Figs. 8 and 9;

Fig. 11, a fragmentary view in vertical section, and drawn to a reduced scale, of a tub bath capable of use as a treatment station in the apparatus of Fig. 1;

Fig. 12, a view similar to that of Fig. 11, but showing a shower or vapor bath arrangement for the same purpose;

Fig. 13, a wiring diagram similar to that illustrated in Fig. 1, but fragmentary in nature, and of a somewhat different embodiment of apparatus;

Fig. 14, an elevation, partly in central vertical section, of a novel tube used in the apparatus of Fig. 13 in place of the corona regulator of Figs. 2 and 3;

Fig. 15, a top plan view, partly in horizontal section on the line 15-15, Fig. 14, of the tube of Fig. 14;

Fig. 16, a vertical section of another novel tube which may be used in place of the tube of Figs. 14 and 15;

Fig. 17, a vertical section taken on the line 17-17 of Fig. 16;

Fig. 18, a top plan view of still another novel tube which may be used in place of the tubes of Figs. 14 and 15 and of Figs. 16 and 17; and

Fig. 19, a vertical section taken on the line 19-19 of Fig. 18.

In accordance with the invention, provision is made for enveloping the patient in a high potential and, in certain instances, a high frequency electric field, and for applying to the patient, while so enveloped in the electric field, radiations and emanations having therapeutic value.

The apparatus of Fig. 1 is capable of administering various specific kinds of treatment, pursuant to the invention, at the several treatment stations provided. The treatment stations are indicated A, B, C, D, and E, respectively.

For supplying the high potential electric field, a suitable transformer is employed. This may be of any type capable of delivering high potential electricity, say from 10,000 to 30,000 volts. It is preferred, however, to utilize a conventional double magnetic circuit type of transformer, indicated at 10 in Fig. 1, having adjustable, laminated, magnetic shunts (not shown), the transformer being connected across an ordinary power line 11 charged with the customary 115 v. The output lines 12 from this transformer advantageously extend to the treatment stations A and B, respectively. The first secondary of the transformer 10 is preferably direct connected to the second secondary thereof. It is noted that this high potential electricity may be applied, without causing injury, direct to a patient who is not grounded. However, in order to safeguard the transformer 10 from damage by sparking across its output terminals, and to render the high potential electricity more suitable for therapeutic purposes, which is believed to include the automatic changing of the frequency to an extent which depends upon electrical characteristics of the patient's body, a governor or control device 14 is shunted across the leads 12.

This governor or control device 14 is a sparking condenser of high capacity embodying a multitude of spark gaps. A preferred embodiment of

this governor or control device 14 is illustrated in detail in Figs. 2 and 3.

As illustrated, the device comprises a cylindrical, electrically conductive plate 15 surrounded by a cylindrical dielectric 16. An outer cylindrical and electrically conductive element 17 surrounds the dielectric 16 exteriorly. It is provided with a multitude (for example, 250) of inwardly extending prongs 17a, which are advantageously formed by stamping out, and inturning, triangular portions of the electrically conductive element 17. The internal plate 15 preferably contacts the interior surface of the dielectric 16, but, in any event, should lie closely adjacent thereto. Likewise, the tips of the prongs 17a preferably contact the outer surface of the dielectric. The several elements are advantageously mounted in a plug-in base 14a, which is adapted to mate with a suitable receiving socket (not shown) carrying the required electrical connections. The internal plate 15 connects with one of the electric lines 12, while the external element 17 connects with the other electric line 12, as shown diagrammatically in Fig. 1.

It is preferable that the dielectric 16 be in the form of a closed tube or envelope, as shown, and be exhausted to vacuum condition. The multitude of sparking prongs 17a produce a brush discharge.

Where the dielectric 16 is not a closed tube or envelope, it is preferred that it be of quartz.

The treatment station A is a discharge tube of a novel type, exemplified by the tubes illustrated in detail in Figs. 4 and 5 and Figs. 6 and 7. Either tube is plugged into the circuit of Fig. 1 at a suitably provided, single-terminal outlet. High potential electricity is, therefore, fed directly into the tube, which serves as an electrode. The tube also embodies radioactive material, which supplies radioactive emanations to the patient simultaneously with the electrical discharge.

As illustrated in Figs. 4 and 5, the tube or electrode may comprise an electrically conductive discharge element 20, having a supporting stem 20a and a major discharge cap or head 20b, which is preferably in the form of a thin, convex-concave plate. The head 20b may be spot welded to the end of the stem 20a.

The discharge element 20 is enclosed within a tube 21 of dielectric material, preferably glass, the stem 20a being fixed in the fused tongue portion 21a of the tube. The tube or shell 21 is fitted to an insulating base 22, provided with a single plug-in terminal 23, and an electrical connector 24 extends from the terminal 23 to the stem 20a.

The inside surfaces of the side walls of the tube or shell 21 are coated with a radioactive material, as at 25. The coating is conveniently made from uranium salts or powdered carnotite or other radioactive ore. The ends of the tube or shell are left uncoated.

Air is evacuated from the tube 21, and a small quantity of mercury introduced. The mercury is preferably triple distilled to insure great purity. It is preferred that argon or like inert gas be also introduced.

Since the tube just described is plugged into the circuit of Fig. 1, the discharge element or cathode 20 is charged with high potential electricity, and, in its capacity of a treatment station in the apparatus of Fig. 1, serves as an electrode to similarly charge the patient. The patient is insulated from the ground, and the tube is applied directly to the afflicted part of his body, preferably in close contact with the body.

Because of the construction of the tube, radiation of a radioactive nature is also directed against the patient through the uncoated top end of the tube. This radiation has been found to differ somewhat from the radioactive emanations discharging from the side walls of the tube, and is thought to comprise rays lying close to X-rays on the radiation spectrum. These rays appear to have a definite healing value, and to lack the injurious nature of X-rays. Where a predominantly radioactive emanation treatment is desired, the side walls of the tube are placed against the body of the patient.

Best results are obtained when the discharge element or cathode 23 is made of an alloy metal compounded from copper, lead, sulphur, and, if desired, aluminum. The relative percentages of the several ingredients may vary considerably, but a satisfactory mixture comprises 5.0% copper, 55.0% lead, 30.0% sulphur, and 10.0% aluminum. Should aluminum not be used, the difference may be made up by additional copper.

In preparing the alloy, the copper and aluminum are heated to a molten state, after which the sulphur is added while stirring the mixture. After cooling, the mass is again melted, and the lead, in a molten state, is mixed with it, the molten mass being thoroughly stirred. This new mass is then cooled, being later reheated, and, while hot, rolled to make it ductile, so it can be shaped into the desired forms.

The discharge tube or electrode of Figs. 6 and 7 is similar to that of Figs. 4 and 5, having an enclosing tube or shell 26 which is evacuated. A cathode discharge element 27 is positioned within the shell, being fixed in the tongue portion 26a. A conductor 23 connects the stem 27a of the element 27 with a plug-in terminal 29, which extends outwardly of the base 30. The cap or head 27b of the element 27 differs from the cap or head 20b of the electrode of Figs. 4 and 5, in that it is spherical in form and hollow. It has an opening 31 formed at its top, contiguous with the top inside surface of the tube 26. A quantity 32 of radioactive material, which may be the same as used for the coating 25 of the electrode of Figs. 4 and 5, is introduced into the tube or shell 26, along with a relatively small quantity of mercury, before the tube is sealed tight. Such material 32 is preferably powdered or granulated, and is shaken into the hollow of the head 27b through the opening 31 before any given treatment is commenced. The mercury is provided primarily as a getter, and does no harm if shaken into the head 27b along with the radioactive substance. The mercury also tends to produce a vapor in the tube, which aids in the operation thereof. As in the case of the electrode tube of Figs. 4 and 5, this tube may have a radioactive coating 33 covering the inner surfaces of its side walls.

The treatment station B of Fig. 1 differs from the treatment station A only in the fact that a condenser 34 is interposed in the electric supply line 12.

The treatment station C of Fig. 1 differs from the stations A and B only in the fact that the high potential electricity is supplied from the supply line 12 through an inductance 35.

The treatment station D utilizes a germicidal discharge tube, a preferred form of which is illustrated in detail in Figs. 8, 9, and 10. The high potential electricity is taken by induction from the particular supply line 12 concerned. For this

purpose, an induction coil 36 is provided, tapping the line 12 at 37. A pair of leads 38 from an ordinary 115 v. supply source extend to a plug-in socket connection for the germicidal tube, one of the leads passing through a glass tube 36a, Fig. 1, which is disposed within and extends along the length of the induction coil 36. Thus, high potential electricity is impressed, by induction, upon the ordinary current flowing through the particular lead 38 concerned.

The germicidal discharge tube of Figs. 8, 9, and 10 has a pair of discharge terminals 40 and 41, respectively, positioned in an evacuated tube or envelope 42, and electrically connected with plug-in terminals 40-1 and 41-1, respectively, by means of stems 40a and 41a, respectively. The tube or envelope 42 and plug-in terminals are mounted in a conventional base 43. It is preferred that insulating material 44, such as a ceramic sleeve, cover the major portions of the stems 40a and 41a. A piece of lithium metal 45, see particularly Fig. 10, is advantageously secured to the stem 40a adjacent the discharge terminal 40 to act as a getter. It may, however, be placed at any other convenient location in the tube. It is preferred that the discharge terminals 40 and 41 be formed of the special alloy previously described. Argon or other suitable inert gas is preferably injected into the tube or envelope 42, as is, also, a small quantity of mercury. The mercury, by vaporizing, aids electrical arcing between the discharge terminals. As will be noted, the high potential electricity induced in the one lead 38 will manifest at the upper discharge terminal 40, and will charge the patient simultaneously with the discharge into his body of germicidal rays from the tube.

The treatment station E embodies the tube of Figs. 8, 9, and 10, as above described, but impresses the high potential electricity directly on the patient instead of passing it first through the tube. For this purpose, a discharge device 50, in the form of a soft, flexible pad in which a coil 50-1 is embedded, taps one of the high potential electric lines 12. This pad 50 is wrapped around the patient's body adjacent the afflicted portion thereof, thus charging the patient. Any other electrode capable of charging the patient with high potential electricity may be used in place of the pad 50. The germicidal tube has its terminals 40-1 and 41-1 plugged into a suitable plug-in socket connected to leads 52 which extend to an ordinary 115 v. source of supply. The high potential electricity with which the patient is charged is induced into the germicidal tube, thereby further activating the discharge therefrom. A certain beneficial discharge from this germicidal tube will be had by induced activation alone, it being unnecessary, in such instances, to plug the tube into the 115 v. line.

Other types of germicidal and discharge tubes may be used in place of the tube of Figs. 8, 9, and 10, as, for instance, the well known infra-red and ultra-violet lamps, to produce results surpassing those ordinarily attained by the use of such infra-red or ultra-violet lamps apart from the apparatus of the invention.

It should be remembered that the patient is insulated from the ground while being treated at any of the treatment stations of the invention.

Figs. 11 and 12 show how a patient is treated, pursuant to the invention, while immersed in an electrically conductive fluid bath. In Fig. 11, a bath tub 53 is insulated from the ground by a

layer of insulation 54. A treatment electrode of the type shown in any of the figure groups 4 and 5, 6 and 7, and 8, 9, and 10 is positioned to charge the fluid of the bath with high potential electricity, as well as to discharge healing radiations and emanations into the patient. The particular electrode illustrated is diagrammatic in form and is designated 55. It may be connected into the circuit of Fig. 1 as shown at any of the treatment stations A, B, C, and D. In Fig. 12, a shower or vapor stall 56 is insulated from the ground by a layer of insulation 57. A plurality of treatment electrodes are designated 58, respectively. These correspond to the treatment electrode 55 of Fig. 11. A water spray or vapor, such as steam, may be admitted to the stall 56 in any well known manner (not shown), thus enveloping the patient during treatment.

Another embodiment of apparatus, pursuant to the invention, is illustrated diagrammatically by the wiring diagram of Fig. 13. While no treatment stations are shown, those provided are identical with the several treatment stations designated A, B, C, D, and E in Fig. 1. The distinction in this embodiment of apparatus resides in the fact that a special generator of high frequency electricity is provided in the system.

A transformer 60 has its input terminals connected across an ordinary 115 v. electric power line 61. Electrical conductors 62 and 63 lead from the respective output terminals of the transformer to a high frequency generator of the Oudin coil type, indicated generally at 64, a variable condenser 65 being interposed in the line 62, and the circuit being grounded at 66. Output conductors 67 and 68, leading from the high frequency generator 64, provide connections for the several treatment stations in the same manner as illustrated in Fig. 1.

The transformer 60 may be any ordinary high voltage type. A governor or control device 69 is shunted across the conductors 62 and 63.

In the illustrated instance, the governor or control device 69 preferably takes the form of a vacuum tube, having the construction shown by Figs. 14 and 15, Figs. 16 and 17, or Figs. 18 and 19. These tubes all possess high capacity, and include elements effecting a brush discharge. They serve, as does the device 14 of Figs. 2 and 3.

The tube of Fig. 14 and 15 embodies an outer shell or envelope 70 of insulating material such as glass, a plastic, or fiber coated with shellac. Inside the shell 70 is a bi-cylindrical element 71 formed of electrically conductive material. Separating element 71 from the enclosing shell 70 are spacers 72 made of rubber, Bakelite, or other insulating material. Inter-fitting with the element 71 is a second electrically conductive, bi-cylindrical element 73, the two elements being separated by a dielectric 74. Inwardly of the element 73, and separated therefrom by a dielectric 75, is a corrugated, cylindrical element 76. The shell or envelope 70 is secured in an insulating base 70-1, provided with plug-in terminals. One of the terminals, designated 77, is electrically connected with the element 71, while another, designated 78, is electrically connected with the corrugated element 75. These two terminals connect with the conductors 62 and 63, as illustrated in Fig. 13, and the brush discharge takes place at element 76.

Under certain circumstances, it is desirable that the outer shell 70 be made of quartz glass, and that a filament 79 be provided, the filament being heated by connection, through plug-in terminals

80 and 81, with a source of low voltage heating current (not shown). Plug-in terminal 82, which is electrically connected with element 72, may be used instead of or in connection with the terminal 77, since element 73 acts in a manner similar to element 71. A getter 83 of suitable material, and an insulating and reflecting shield 84 may be provided, as shown. While the tube may have either a high or a low vacuum condition, or may be filled with an inert gas, I have also found it advantageous to fill the tube with a moist vapor. The tube acts as an oscillator for electric currents, and has an enormous capacity, a capacity many times that of a condenser of approximately equal size.

The tube of Figs. 16 and 17 comprises an outer shell or envelope 85, which may be made of metal, glass, or fused quartz. This shell is mounted in an insulating base 86. Inside the shell 85 is a metal plate 87, and, spaced apart therefrom, a corrugated metal plate 88. A plug-in terminal 89, which extends from the base, is electrically connected with the plate 87, and a second plug-in terminal 90 is electrically connected with the corrugated plate 88. These terminals are adapted to connect, through a suitable socket, with the electrical conductors 62 and 63 of Fig. 13.

Under certain conditions of use, it is desirable to have other elements in the tube. These are provided, and may be utilized or not as occasion warrants. A filament 91 is disposed between the plates 87 and 88. It is electrically connected with the two plug-in terminals 92 and 93, which are adapted to be connected to a source of low voltage heating current (not shown). A slit screen, comprising shields 94 and 95, with apertures 96 extending therethrough, is disposed adjacent that side of corrugated plate 88 which is remote from plate 87. The apertures 96 are in alignment with each other, and the shields 94 and 95 are made of lead or other material capable of screening off X-rays. Between shields 94 and 95 is a sheet 97 of material which is readily permeable to X-rays. Within the shell 85 there is also mounted a shell or envelope 98 of glass, quartz glass, or similar material, having a portion 98a which is ground like a lens and directed toward the slit screen. This shell 98 really constitutes a tube within a tube. A filament or cathode 99, comprising electrically conductive legs 99a and 99b and an electron-emitting portion 99c, is disposed within the shell 98, plug-in terminals 100 and 101 being electrically connected to the respective legs 99a and 99b. A bombardment element 102 is disposed within the shell 98 opposite the portion 99c of cathode 99. Within the shell 85, but outside the shell 98, is a reflector 103 directed toward the slit screen.

The tube of Figs. 18 and 19 is essentially the same as the tube of Figs. 16 and 17, being equipped with a shell or envelope 105, a base 106, a plate 107, and a corrugated plate 108, the two plates being connected to plug-in terminals 109 and 110, respectively, which are adapted to connect electrically with the conductors 62 and 63 of Fig. 13. There is a filament 111 and an inner shell or envelope 112, but no slit screen. Instead of a lens portion being provided on the inner shell 112, a partition 113 of lens formation is disposed between the inner shell and the corrugated plate 108. It is fused to the walls of the outer shell 105. Within the inner shell 112 is a filament or cathode 114, which corresponds to the similar element 99 of

the tube of Figs. 16 and 17. A reflector 115 is directed toward the lens partition 113.

Reverting now to Fig. 1, there is another advantageous way of treating a patient pursuant to the invention. As shown at Y, a foot pedestal 120 may be provided for making the patient a part of a condenser. The pedestal comprises an electrically conductive plate element or electrode 121, connected electrically with one of the high potential lines 12, and covered by an insulating platform 122 upon which the patient rests his feet while being treated at any of the previously described treatment stations A, B, C, D, or E. The electrode 121 and insulating platform 122 are conveniently mounted in a frame 123, which insulates the plate from the ground. The insulating platform 122 is made of a high quality insulating material, such as first grade hard rubber. In certain instances it is desirable that the device be made in other than foot-pedestal form. For instance, it may be of cylindrical formation for use in a bed against any part of the patient's body.

If desired, the patient may be charged with the high potential electricity by direct contact with a metal or electrically conductive electrode in place of the pad 50 of treatment station E, or of the tube electrodes.

The invention has been described in the foregoing with sole reference to its use for therapeutic purposes. It should be noted, however, that inorganic matter may also be treated to advantage pursuant to the method and with the apparatus of the invention. It has been found that metals, for example, lead, have changed physical properties after treatment in accordance with the above. In instances where the invention is not being used therapeutically, it is not always necessary to insulate the subject from the ground.

Whereas this invention is here illustrated and described with respect to particular specific embodiments thereof, it is to be understood that various changes may be made in such specific embodiments and various other embodiments may be utilized by those skilled in the art without departing from the spirit and generic scope of the invention as set forth herein and in the claims which here follow.

Having fully described my invention, what I claim is:

1. Apparatus for applying radiant energy therapeutically, comprising means for producing high potential, high frequency electricity; a high capacity sparking condenser; and a treatment electrode connected in circuit with the foregoing, said treatment electrode including a discharge element adapted to charge the patient with said high potential, high frequency electricity, and radioactive means adapted to discharge radioactive emanations into said charged patient.

2. Apparatus in accordance with claim 2, wherein the sparking condenser is in the form of a vacuum tube of high capacity having mutually spaced capacity elements adapted to produce a corona discharge.

3. Apparatus for applying radiant energy therapeutically, comprising means for producing high potential, high frequency electricity; a high capacity

sparkling condenser; and a treatment device connected in circuit with the foregoing, said treatment device including discharge means adapted to charge the patient with said high potential, high frequency electricity, and radiating means adapted to discharge radiations into the charged patient.

4. Electrical treatment apparatus, comprising a high capacity sparking condenser; a treatment outlet electrically connected to said condenser; and means for electrically connecting said condenser to a source of high potential electricity.

5. Electrical treatment apparatus, comprising a transformer for producing high potential electricity; a high capacity sparking condenser electrically connected across the high potential output terminals of said transformer, and a treatment outlet electrically connected to said condenser.

6. Electrical treatment apparatus, comprising a transformer for producing high potential electricity; a high capacity sparking condenser electrically connected across the high potential output terminals of said transformer; and a plurality of treatment outlets independently electrically connected to said condenser.

7. Electrical treatment apparatus, comprising a transformer for producing high potential electricity; a treatment electrode electrically connected to one of the output terminals of said transformer; an electrical conductor sheathed by insulation electrically connected to the other of the output terminals of said transformer and disposed adjacent said treatment electrode so the subject to be treated may be placed between and in contact with the two; and a high capacity sparking condenser connected across the said outlet terminals of the transformer.

8. In electrical treatment apparatus equipped with means for the supply of high potential electricity and a treatment electrode, a high capacity sparking condenser electrically connected between the said supply means and the said treatment electrode.

THOMAS H. MORAY.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
838,351	O'Neill	July 4, 1899
647,687	Topham	Apr. 17, 1900
755,470	Friedlander	July 19, 1904
950,842	Davis	Mar. 1, 1910
1,156,317	Santos et al.	Oct. 12, 1915
1,193,018	Howard	Aug. 1, 1916
1,466,777	Winkelmann	Sept. 4, 1923
1,590,930	Falkenberg	June 29, 1926
1,655,783	Gallois	Jan. 10, 1928
2,010,018	Hodnette	Aug. 6, 1935
2,073,428	Schmid	Mar. 9, 1937
2,126,070	Wapner	Aug. 9, 1938
2,192,633	Dixon	Mar. 5, 1940

OTHER REFERENCES

Tousey; Medical Electricity and Roentgen Rays (1910), pp. 493 to 498. Copy in Division 55.

United States Patent [19]

Dotto

[11] 3,785,383

[45] Jan. 15, 1974

[54] ELECTROSTATIC WAND

[75] Inventor: Gianni A. Dotto, Dayton, Ohio

[73] Assignee: Alfred A. Anglemeyer, Dayton, Ohio

[22] Filed: Mar. 29, 1971

[21] Appl. No.: 128,813

[52] U.S. CL. 128/414

[51] Int. CL. A61n 1/06

[58] Field of Search..... 128/404, 413, 414,
128/415, 303.13; 313/152

[56] References Cited

UNITED STATES PATENTS

1,570,041	1/1926	Clark	128/414
1,655,783	1/1928	Gallois	128/414
2,286,110	6/1942	Running	128/404

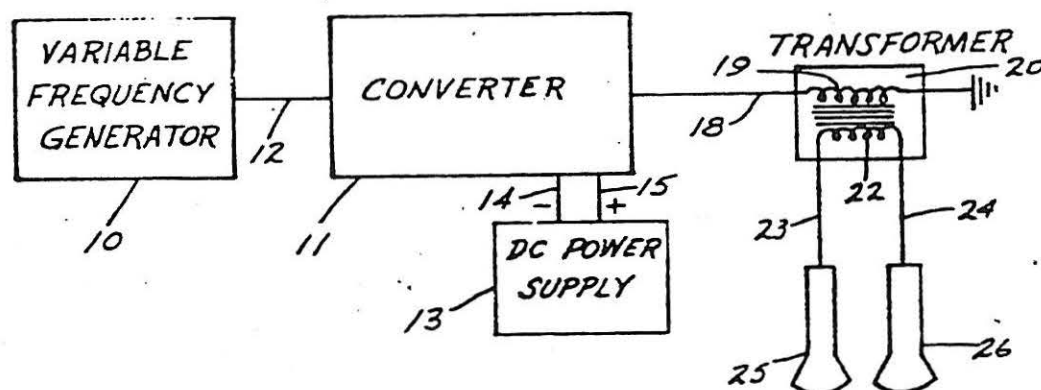
Primary Examiner—William E. Kamm

Attorney—Irvin V. Gleim, Edward M. Tritle and Francis M. Crawford

[57] ABSTRACT

Electrostatic means radiating electrical energy at selected frequencies of the order of megacycles per second is safely and harmlessly coupled capacitively to tissue structure of a human being or of an animal with no significant flow of electrons for reducing sensitivity to pain, at least temporarily. The radiating means may comprise an evacuated glass envelope containing a selected atmosphere of inert gas and also containing an electrode that is intermittently subjected to an electro-positive voltage during certain portions of the cycle to promote positive space charges within the envelope together with a controlled amount of ionization of said atmosphere and the production of selected forms of electromagnetic radiation such as infra red light, ultra violet light, visible light, and mixtures thereof.

4 Claims, 6 Drawing Figures



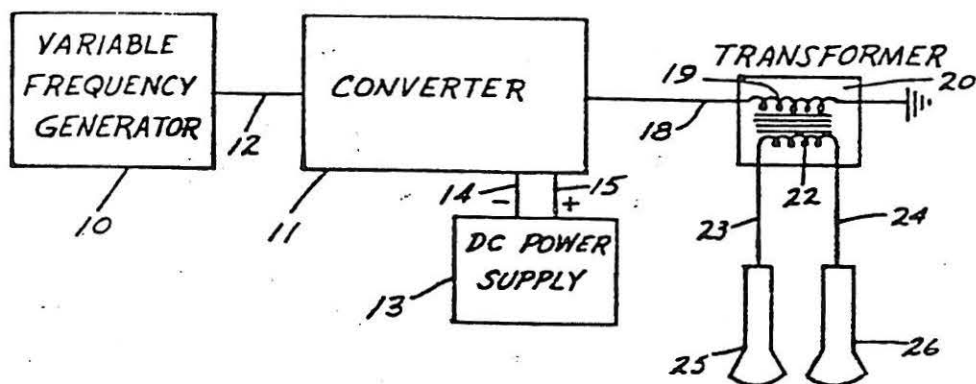


Fig. 1

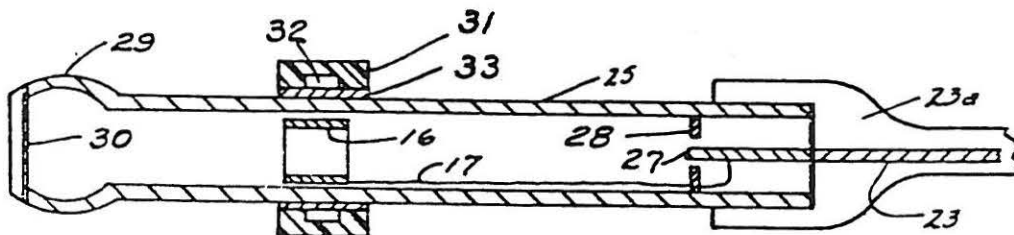


Fig. 2

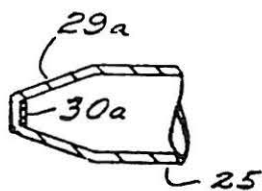


Fig. 3

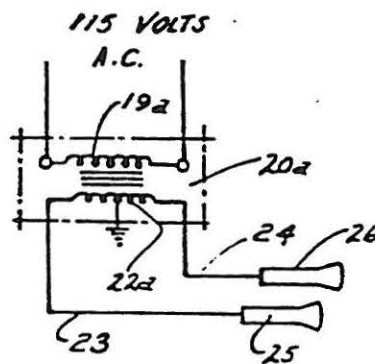


Fig. 4

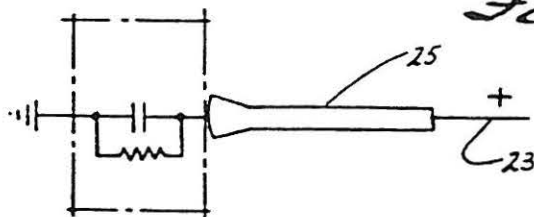


Fig. 6

INVENTOR
GIANNI A. DOTTO
BY *Lawrence V. Seiner*
Edward M. Tittle
Thomas M. Crawford
Attorneys

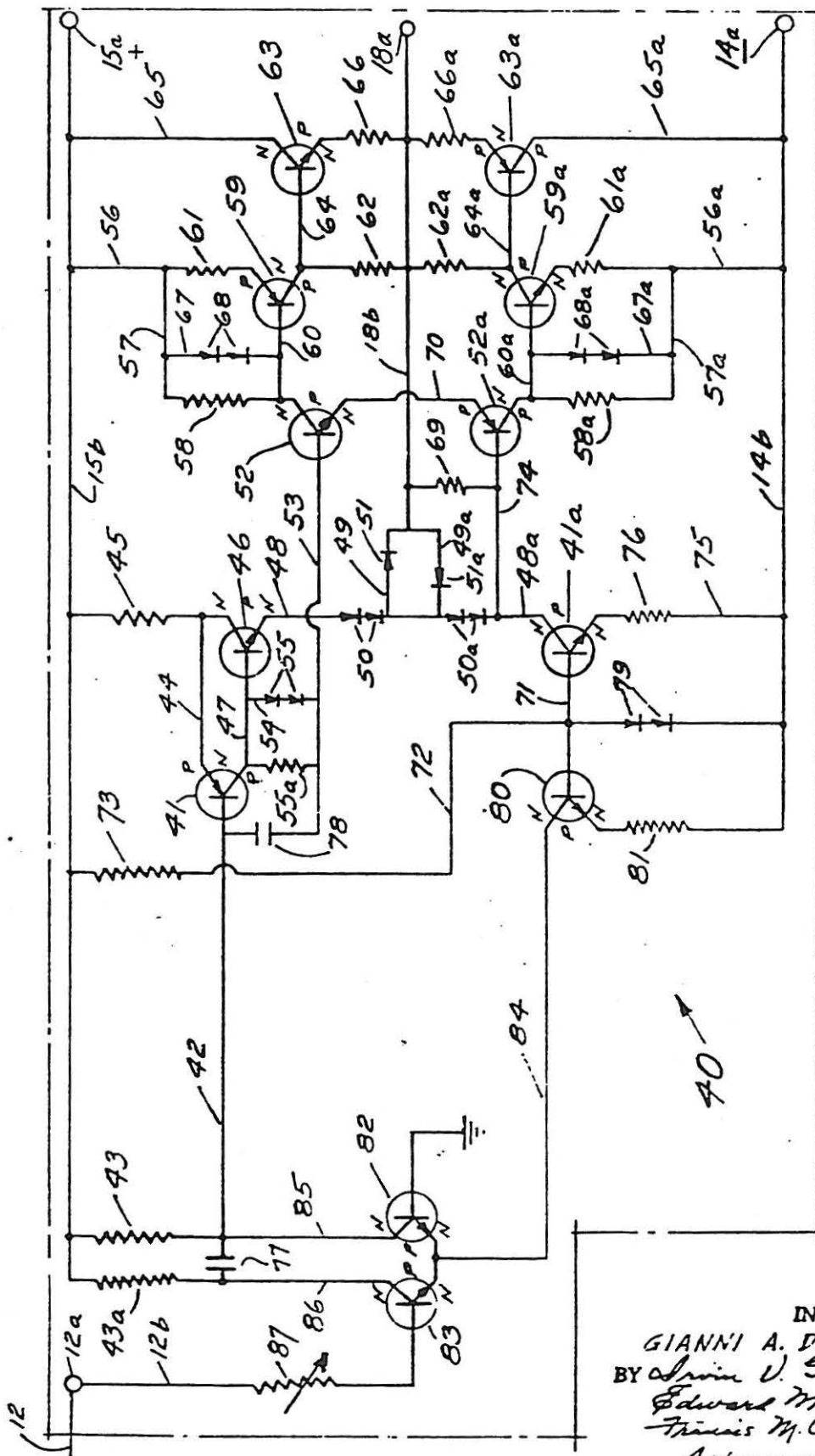


Fig. 5

INVENTOR
 GIANNI A. DOTTO
 BY *Armin V. Seim*
Edward M. Tittle
Thomas M. Crawford
 Attorneys

ELECTROSTATIC WAND

BACKGROUND

There are many known influences that can reduce or augment the threshold of pain reaction as opposed to pain reception. For example, devices employed heretofore for the relief of pain include heating devices such as hot water bottles, hot packs, electrically heated pads and blankets, radiant heating devices, diathermic devices, whirlpool baths and the like. While such devices are generally effective they are subject to certain disadvantages and/or limitations. Conductive heating devices heat only the areas with which they are in contact and are not particularly suited for irregular bodily surfaces. Conductive heating devices, such as the whirlpool bath, heat all immersed areas generally rather than locally.

Additionally, it has long been known that skin or cutaneous tissues are quite sensitive to pain whereas certain organs that are more deeply disposed within the body, such as the viscera, are quite insensitive to pain when judged by criteria applicable to the skin but are sensitive to tissue distension or muscular contraction. For example, a limb muscle can be quite painful if exercised while its blood supply is cut off, and other relatively deep tissues to pain include the periosteum (bone covering). Thus, depending upon the nature and location of the factors causing the pain sensation, analgesic methods and/or devices in many instances need to be applied in particular locations for effective relief from pain.

SUMMARY

Accordingly, the principal objective of the present invention is to obviate the above-noted difficulties and efficiencies. This is accomplished, in accordance with the present invention, by the provision of means establishing electropositive space charges at high frequencies within an evacuated glass envelope with or without accompanying electromagnetic radiation. It can be applied to tissue structure safely and at a desired location for reducing, at least temporarily, sensitivity to pain.

DESCRIPTION

These and other objectives of the invention will become apparent from the following description taken in connection with the accompanying drawings in which:

FIG. 1 is a simplified circuit diagram illustrating one embodiment of the invention including means for producing intermittent electropositive space charges within an envelope or envelopes;

FIG. 2 is a cross sectional view of one of the envelopes of FIG. 1;

FIG. 3 is a cross-sectional view of a modification of the envelope of FIG. 2;

FIG. 4 is a view illustrating a modified embodiment of the invention;

FIG. 5 is a wiring diagram of the converter portion of the embodiment of FIG. 1; and

FIG. 6 illustrates an electrical circuit equivalent to the electrical circuit of human or animal tissue structure.

The human body is known to consist of a composite mass of tissues which have electrical constants like any other substance or matter. In other words, all of the tissues act as conductors of electrical energy to a varying extent. In human tissues, all cells are bathed in lymph

or other intercellular fluid and an electrical current, in order to reach the cells, has to pass through this fluid. The tissue fluids consist of a solution of water, albumin, fibrin, and salts.

An equivalent electrical circuit of human tissue structure is shown in FIG. 6. The electrolyte surrounding the cells is resistive. The cell electrical characteristics are illustrated as being in parallel with the characteristics of the electrolyte. The cell wall or membrane and the cell interior are each equivalent to resistance and capacitance connected in parallel. The values of capacitance and resistance are a function of cell shape radius and volume concentration. At low frequencies (below 300 megacycles) current tends to bypass the relatively high capacitance of the cells through the conductants of the electrolyte which surrounds it. As the capacitive reactance drops at higher frequencies, the current passes into the cell. At higher frequencies of the order of 1,000 megacycles current conducts primarily at the skin surface.

Experimental and clinical work with electrical energy of high frequency has shown that this form of energy can pass through electrically non-conductive surfaces because dielectric permeability or conductivity increases with the increase of the frequency of currents. The flow of an electrical force through the insulating or dielectric medium is known as a current "capacitive" current in contrast to the "conduction" current through an ordinary electrical circuit at 60 cycles per second or with direct current. The unit of dielectric permeability is that of air under normal pressure. Body tissues and fluids transmit electrical field force from 80 to 90 times better than air space.

Such prior experimental and clinical work has also revealed that structures such as fat, bones, and so forth are relatively poor conductors and may have currents conducted through them only if sufficiently high frequency currents are applied to them.

Prior clinical and experimental work has also shown that the various diseases and/or ailments to which tissue may be subjected are sensitive or are resonant at differing frequencies. Accordingly, it is desired both to provide a method and means to supply sufficient numbers of frequencies to meet all of the combinations of reactance and resistance that may be presented by living tissue structure. There are literally an infinite number of electrical circuits within human tissue and they require a range of frequencies to meet the various combinations of reactance and resistance to permit penetration of the electrical energy into the tissue structure. These equivalent electrical circuits of the tissue structure all have a different electrical impedance and they will conduct radio frequency current at a maximum peaking level when the impedances of these many circuits are at resonance with the frequency.

Apparatus embodying the present invention is indicated generally in FIG. 1 and comprises a variable frequency generator 10. Variable frequency generators are previously known and will not be described in detail except to state that they comprise a tunable electrical circuit and suitable means selectively controlling the variable frequency output at a desired frequency.

The variable frequency output from generator 10 is fed through line 12 into a converter 11 which also received the output from a direct current power supply via connecting lines 14, 15. The converter includes a tunable circuit which functions to deliver a converter

output signal with full-wave voltage amplification of the signal received from generator 10 at a desired value of output current, and at a frequency corresponding to that provided by the generator.

The output from the converter is fed through a line 18 to the primary winding 19 of transformer 20. The primary winding 19 is connected to ground through a line 21. The secondary winding 22 of the transformer is connected by lines 23, 24 to a pair of glass envelopes 25, 26. Envelopes 25 and 26 are identical in construction so that the following description concerning one of these envelopes will apply equally to the other.

Line or conductor 23 is connected at one end to the secondary winding 22 of transformer 20 and its opposite end is connected to an electrode 27 which is housed within evacuated glass envelope 25. As shown in FIG. 2, the inner end of glass envelope 25 is silver plated to provide a full mirror surface 28 surrounding the distal end of the electrode. The opposite end of envelope 25 is formed to a ball-shaped enlargement 29 the inner surface of which is provided with about 5 percent silver plating 30.

Envelope 25 also houses therein an annular ring 16 of conductive material that is connected to anode 27 by a flexible connector 17. Ring 16 is smaller in size than the internal diameter of the envelope 25 so as to be freely slidable along the extent of the envelope.

For reasons which will appear as the description proceeds, it is desirable to provide means for adjustably positioning ring 16 at selectable positions along the extent of envelope 25. This is accomplished in accordance with the invention by the provision of a permanent magnet 32 housed within an annular housing 31 of a suitable material such as plastic that will not interfere with the magnetic attraction exerted by magnet 32 on ring 30. Housing 31 is fitted to a sleeve 33 having an internal dimension slightly greater than the external dimension of envelope 25 so that the housing and sleeve are also slidable along the extent of the envelope. As the housing is selectively positioned at various selected locations along the extent of envelope 25, the magnetic attraction exerted by magnet 32 on ring 16 causes the ring to follow such movement of the housing to a selected position of the ring.

In accordance with the invention, the glass envelope may contain an atmosphere which has been evacuated to a pressure of about 28 mm. of mercury prior to adding 1 mm. of mercury of a gas such as helium and also about 1/10 mm. of mercury of another gas such as neon.

During operation of the device, at proper portions of the operating cycle the transformer 20 will drive conductor 23 and the anode 27 to a potential which is electrostatically positive relative to ground. However, since the anode 26 is isolated in an essentially non-conductive atmosphere, no significant electron flow will occur because there is no significant source of electrons which can be moved by the positive voltage, and the electrode 27 merely becomes electrostatically positive. The same is true with respect to the anode contained within envelope 26 when the conductor 24 receives a positive voltage. Accordingly, the respective electrodes contained within envelopes 25, 26 function as intermittent positive electrostatic poles. When the electrode in envelope 25 is electrostatically positive, the electrode housed within envelope 26 is at a negative or ground potential, and vice versa.

The previously described quantities of helium and neon which were introduced into the atmosphere contained within envelopes 25, 26 permit a controlled amount of ionization to occur within said atmospheres.

Such ionization assists in distributing intermittently positive voltage to the ball-shaped enlargements 29 and, as ionization occurs within the envelopes, electrons are drawn toward the electrodes 27, thus promoting positive space charges within each of the ball-shaped enlargements of the respective envelopes.

Such ionization also produces a certain amount of radiant energy in the form of illumination which may pass through the glass envelopes to ground.

Preferably, envelopes 25, 26 are each provided with a shield (not shown) of high capacity with respect to the electrode that it surrounds thus diminishing the electrostatic field strength at the glass which immediately surrounds each of the electrodes. This prevents an undesired arcing which would otherwise result should a grounded conductor be placed in proximity to the exterior of the glass wall surrounding either of the electrodes.

With the device in operation, the electrodes within envelopes 25, 26 function as isolated electrostatic poles that are intermittently driven positive and negative. When one of the electrodes is placed in contact with tissue structure, as indicated in FIG. 6, the electrostatic field which is changing rapidly in the megacycle frequency range becomes capacitively coupled to ground by the equivalent electrical circuit of the tissue structure. The skin tissue will then experience intermittent positive voltages so that electrons in the skin tissue are exposed to active agitation but essentially no current flows between the skin tissue and the glass envelope. The degree of such agitation will be greatly increased when both envelopes 25, 26 are applied to the tissue structure.

By careful pre-selection of the nature of the gases introduced into the glass envelopes and also by careful selection of the optical transmittency of the envelopes, various forms of electro-magnetic radiation can be permitted to accompany such electron agitation. Thus, at the same time the electron agitation is taking place, the tissue structure may also be irradiated with infra red light, or with ultra violet light, or with visible light, or with mixtures of the three.

Regarding such electro-magnetic radiation, it is to be recognized that skin tissue structure will have varying capacities to absorb such radiation and as absorption occurs electrons are freed within the skin tissues. More specifically, for a given frequency and exciting voltage, a certain amount of electron agitation will occur in the skin tissue structure being touched by the glass envelopes. If the skin tissue is simultaneously irradiated with light of a proper frequency, the degree of electron agitation within the skin tissue can be increased, and by controlling the light color, the depth of light penetration can also be controlled.

Obviously, there is a vast range of optical excitations that can be caused to accompany the electrostatic agitation of electrons in the tissue structure. Experiments have shown that beneficial effects from the particular combination of helium and neon, noted heretofore, are obtained. Beneficial results are also observed if the helium and neon are replaced by about 1 mm. of mercury of argon. Beneficial results have also been observed when the glass envelope is so-called "black glass" hav-

ing a high ultra violet transmission and the gas atmosphere within the envelope comprises air evacuated to a pressure of about 28 mm. of mercury to which 1 mm. of xenon has been added. The beneficial results noted include relief from pain from localized cuts and bruises, relief of arthritic pain, toothaches, and the like, sometimes for prolonged periods of time.

Without intending to limit the present invention, it is my present preference to employ a transformer 20 having a secondary designed to provide voltages of the order of 12,000-15,000 volts across their secondaries.

In FIG. 3, there is shown a glass envelope of the same basic construction as that described above in connection with FIG. 2, the principal difference being that in FIG. 3 the glass envelope terminates with a pointed projection having a small end portion 29a. As noted heretofore, the controlled atmosphere within the glass envelope and the presence of certain selected gases therein promotes a positive space charge at the end of the envelope which is opposite the electrode. The relatively pointed shape of the electrode in FIG. 3 functions to concentrate such positive space charge and is sufficiently small in physical dimensions that treatment can be applied to a relatively small and carefully selected portion of skin tissue structure.

Those skilled in the art are aware of the fact that there is a known relationship between frequency and wave length. And it can be shown that the wave length of electro-magnetic energy corresponding to a frequency of 1,000 megacycles per second is about 30 centimeters in length, and that for a frequency of 300 megacycles the corresponding wave length is about 100 centimeters.

In accordance with the present invention the distance between the mirrored surfaces 28 and 30 is chosen to correspond with one quarter wave length of the desired frequency. Thus, by utilizing a distance between mirrored surfaces 28 and 30 of about 25 centimeters, the wave harmonics and the adjustability provided by the selectively positionable ring 16 provides effective utility over a frequency range of from about 300 to about 1,000 megacycles.

A modification of the device is illustrated in FIG. 4. The device shown in FIG. 4 differs from that of FIG. 1 in that a single transformer 20a having a secondary winding 22a provided with a center tap to ground is connected to the glass envelopes 25, 26. Transformer 20a has its primary winding 19a connected to a suitable source of alternating current such as a conventional 115 volt, 60 cycle, source. In this embodiment, the variable frequency generator, the converter and the direct current power supply elements are not employed.

The embodiment of FIG. 4 functions essentially like that of FIG. 1 in that, although the device is supplied with a 60 cycle alternating current, the glass envelopes 25, 26 function essentially as indicated above since the selective positionability of ring 16 between the reflective surfaces of mirrors 28 and 30 enables the device to function at selected frequencies within the above noted frequency range. Thus, the embodiment shown in FIG. 4 is suitable for use by physicians in their offices where the expense and complication of the additional equipment shown in FIG. 1 may not be economically feasible.

Converter 11 comprises terminals 12a, 14a, 15a and an output terminal 18a interconnected by an electrical circuit 40, as shown in FIG. 5. Terminal 12a is adapted

to be connected to line 12 to receive a signal from variable frequency generator 10. Terminals 14a, 15a are adapted to be connected to lines 14, 15, respectively, to receive negative and positive voltages from direct current power supply means 13.

The electrical circuit superimposes the variable frequency signal upon the direct current voltage at differing levels thereof and thereby provides at output terminal 18a a full-wave output signal of desired wave form, such as a square wave, and corresponding to the frequency of the selectable variable frequency input signal. In accordance with the invention, said electrical circuit comprises semiconductor materials such as diodes and transistors of both the p-n-p and the n-p-n type and employs, in a follower type circuit, complementary symmetry to take advantage of the opposite bias and signal polarities of the transistors.

The electrical circuit includes negative line 14b and positive line 15b with output signal line 18b interposed therebetween. Lines 14b, 15b, respectively, are connected to terminals 14a, 15a and each is interconnected with output signal line 18b by complementary amplifier circuits each of which comprises a plurality of transistors. Transistor 41 is of the p-n-p type and is base connected by line 42 in series with resistor 43 to line 15b. Transistor 41 is emitter-connected by line 44 in series with resistor 45 to line 15b. It will be understood that resistors 43, 45 will have differing values of resistance chosen to provide the proper bias voltage for transistor 41. Transistor 46 is of the n-p-n type and is base-connected by line 47 to receive the collector voltage of transistor 41. Line 18b is series connected by lines 48, 49 and diodes 50, 51 to receive the collector voltage of transistor 46.

Transistor 52 is also of the n-p-n type and is base-connected by lines 53, 54, diodes 55, parallel-connected with by-pass resistor 55a to line 47 to receive the collector voltage of transistor 41. Transistor 52 is emitter-connected to line 15b by lines 56, 57 and series-connected resistor 58 to provide desired voltage to the emitter.

Transistor 59 is base connected by line 60 to receive the emitter voltage of transistor 52. Transistor 59 is of the p-n-p type and its emitter is series-connected by resistor 61 and line 56 to line 15b. The collector of transistor 59 is series-connected to line 18b by resistor 62.

Transistor 63 is of the n-p-n type and is base-connected by line 64 to receive the collector voltage of transistor 59. The emitter of transistor 63 is connected by line 65 to line 15b, and its collector is series-connected to line 18b by resistor 66. Connected to lines 57 and 60 and in parallel with resistor 58 is a line 67 including diodes 68.

Transistors 59a and 63a are similarly connected between lines 14b and 18b with corresponding connected lines, resistors, and diodes bearing a like number with the suffix a. However, in the case of the transistors, where transistor 59 is of the p-n-p type, transistor 59a is of the opposite type, that is n-p-n type. Similarly, transistor 63 is of the n-p-n type and transistor 63a is of the p-n-p type.

Additionally, transistor 52 and transistor 52a are of opposite types, the former being of the n-p-n type and the latter being of the p-n-p type. Transistor 52a is base-connected in series with resistor 69 which in turn is connected to line 18b. Line 70 interconnects the collector of transistor 52 with the emitter of transistor 52a.

Transistor 41a is of the n-p-n type, opposite from that of transistor 41, and is base-connected by lines 71, 72 and in series with resistor 73 to line 15b. The emitter of transistor 41a is connected by lines 48a, 74 to the base of transistor 52a. The collector of transistor 41a is series-connected by line 75 and resistor 76 to line 14b.

As noted heretofore, a variable frequency signal is superimposed upon direct current signals. The superimposed signal is received by transistor 80 which is base-connected to line 71 with its collector series-connected to line 14b by resistor 81. Transistor 80 is of the n-p-n type and its emitter is interconnected with the collectors of transistors 82, 83 by line 84.

Transistors 82, 83 are both of the n-p-n type. Transistor 82 is base-connected to ground, and its emitter is series-connected to line 15b by resistor 43 and line 85. Similarly, the emitter of transistor 83 is series-connected to line 15b by resistor 43a and line 86. Transistor 83 is base-connected to terminal 12a for receiving the variable frequency signal from line 12 by line 12b and resistor 87 which may be variable, if desired.

While particular embodiments of the invention have been illustrated and described, various changes and modifications can be made without departing from the invention and it is intended in the appended claims to cover all such changes and modifications that fall within the true spirit and scope of the invention.

What is claimed is:

1. An electrostatic wand for the relief of pain upon contact with tissue structure comprising walls of electrically-insulating material forming an enclosure having therein an elongate evacuated cavity, and an electrically-conducting member extending through said enclosure walls and having one end portion disposed within one end of said cavity and

having a second end portion terminating externally of said walls and adapted to be connected to a source of electropositive electrical voltage pulses of the order of about 12,000 to about 15,000 volts and at variable frequencies in the range of about 300 to about 1,000 megacycles per second, said walls having a tissue-contacting external surface positioned opposite said one end of said cavity capacitively coupling said variable frequency pulses to ground potential when said surface is in contact with tissue structure,

mirror surfaces within said cavity at opposite ends thereof and adjacent said conducting member and said external surface respectively,

an annular member of electrically conducting material slidably disposed within said cavity for reciprocation therein,

means electrically connecting said annular member to said conducting member, and

means slidably mounted externally of said walls for reciprocation thereon and concomitantly selectively positioning said annular member,

wherein said cavity is evacuated to a pressure of about 28 mm. of Hg. below atmospheric pressure and said cavity contains an inert gas at a pressure of about 1 mm. of Hg. absolute.

2. A wand according to claim 1 and additionally including means magnetically coupling said annular member with said externally mounted slidable means.

3. Structure according to claim 1 wherein said mirror surfaces are spaced apart a distance about one fourth of the wavelength corresponding to the frequency at the lower end of said frequency range.

4. Structure according to claim 3 wherein said distance is in the range from about 7 centimeters to about 25 centimeters.

* * * * *

The Home-Treatment of Tuberculosis by High-Frequency Currents

By DR. FREDERICK FINCH STRONG

Lecturer in Electrotherapeutics, Tufts College, Boston

STATISTICS show that one death in every seven is caused by tuberculosis, usually in the form called "Pulmonary tuberculosis." "Tuberculosis of the Lungs," or "Consumption."

Sanitary regulations, isolation of cases and hygienic education are rapidly lowering this high death rate, but tuberculosis is still humanity's most terrible scourge.

Through the ages "The Great White Plague" has done more to retard human progress than all the wars of the centuries—not excepting the present Armageddon.

Fortunes have been spent in the study of the prevention and cure of this disease; countless fortunes have been made by quacks and mistaken enthusiasts who either claimed or believed themselves to have discovered "A Sure Cure for Consumption." The discovery of tuberculin by Koch was widely heralded as the longed-for panacea, but it proved a failure, and up to the present time no "specific" has been found for the cure of tuberculosis.

The importance of the subject is further emphasized when we reflect that even when it does not manifest as consumption, tuberculosis still does its insidious work in undermining the stamina of the entire race. Dr. A. C. Geyser states that "ninety per cent of all children are infected before their twelfth year, and nearly all bodies that come to autopsy show unmistakable signs of previously existing tubercular lesions." That more people do not develop the disease in its active form is due to the natural curative forces that are always at work in the human body.

Disease germs grow only in a suitable soil or medium; healthy human tissues do not furnish this medium. Only when these tissues are weak, inactive or charged with dead matter do they allow disease germs to multiply in their midst and produce their poisonous secretions.

In a previous article in the March, 1917, *EXPERIMENTER*—"Electricity and Life"—the writer called attention to the existence of the "Vital-force," or "Prana," thru the activity of which all life is maintained. This is absorbed from the food, air and water,

and is probably distributed by a circulating system all its own—a subtle "Ethereic Body," which interpenetrates the coarser molecules of the organism and is doubtless formed of imponderable

chemical atoms finer than the gas atom and coarser than the electron. Just as modern physicists find it necessary to employ the hypothesis of "The Ether of Space" in order to account for the phenomena of radiant energy, so the most advanced of our physiologists and biologists are assuming the existence of the "Ethereic Body" in order to explain the phenomena of life in animal and vegetable bodies.

Probably the great sympathetic nervous system distributes the life-carrying matter of the etheric body in much the same way as the heart and blood vessels transmit food and oxygen to the cells and tissues. The latter circulation depends upon the maintenance of the former, for if pressure is made over certain nerve centers the blood stream is retarded or ceases altogether; pressure on another center stops the breathing mechanism and death from syncope follows. Great discoveries will be made in the immediate future thru the study of the nerve currents and their relation to the Etheric Body and to "Vital Force."

It is because this vital circulation is fairly active in the majority of persons that so many recover spontaneously from pulmonary tuberculosis. But in cases of weak "vital resistance," where the Prana is not actively distributed to the lung cells, the tubercular germs grow, multiply, secrete poisons and ultimately make the physical body unfit for its human tenant who is forced to move elsewhere!

This lowered cell vitality results from hereditary weakness, improper food, and above all, from insufficient fresh air and out-of-door exercise. We can prevent this hereditary weakness in future generations by following Eugenic principles and exercising the same care that we now use in breeding blooded cattle and horses.

But meanwhile we have in our midst countless thousands of poor sufferers in whom tuberculosis exists in an active form, and the majority of whom face a lingering death scarcely less horrible

than that resulting from the "poison gas" of the war zone. What can we do for these unfortunates? Those of them who can go to the special tuberculosis sanitariums and

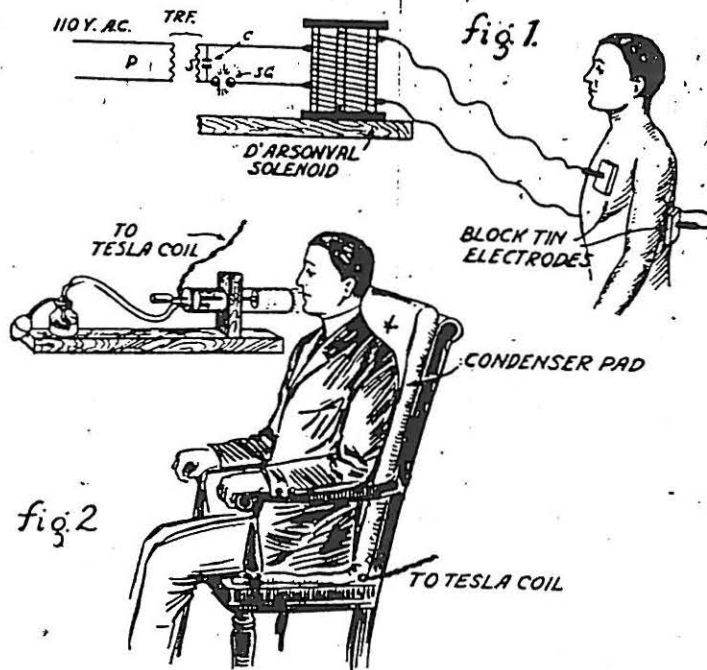
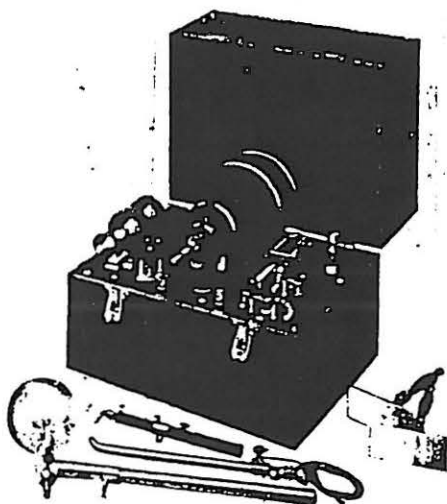


Fig. 1 Shows Treatment of Tuberculosis by "Diathermy." Fig. 2, Treating Tuberculosis by "Ozone Nebula" and Tesla Currents.

have daily treatment under proper surroundings stand a fair chance of recovery, especially when the disease is in the early stages. There are hundreds, however, who cannot go to such institutions.

When we do not use a machine it rusts and falls to pieces; when we do not use an organ or tissue of the human body the life-force and blood supply are diminished and we have a condition where disease germs can find a ready foothold. If certain parts of the lung are not periodically expanded by the inspired air they become "Anaemic" and susceptible to tubercular infection, which afterwards spreads to other parts of the lung. Now if we can find a way of revitalizing these anaemic areas, nature will use the blood and oxygen to start a regenerative process and the bacilli and dead cells will be thrown off in the expectoration. This latter material—the "tubercular sputum"—carries the infection to others; it should always be burned or received in vessels containing antiseptics such as creolin or sulphonaphthol. If this were always done the disease would soon be stamped out.

It is a well known fact that high-frequency currents when past thru the body cause every molecule to vibrate to their particular periodicity, and this vibration produces secondary effects, notably the release of heat in the tissues and the increase of local blood supply. When an acute infection occurs in any part of the



Portable Yet Effective Electrical Apparatus for Diathermy and Tesla Treatment of Tuberculosis.

(Continued on page 718)

body—for example, in acute bronchitis or "cold in the chest"—we have as prominent symptoms—fever, congestion, cough and expectoration. Most people think that by taking medicine to suppress these symptoms they can cure the disease; hence the use of cough-syrups, sedatives, etc. When the patient recovers under such treatment it is in spite of the medicine rather than because of it, for these symptoms are the very means nature is using to throw off the infection. Extra vital force is being wisely directed to the endangered area—hence the fever, heat, congestion and expectoration. Medical science has been working at the problem of "cure" from the wrong end. Instead of suppressing symptoms we must aid nature to throw off the disease-producing germs and neutralize their poisons. In other words we must assist and promote the process of inflammation. It is because the inflammation is not sufficiently vigorous that many cases of tuberculosis do not recover. The infected areas are usually anaemic to start with and after the infection becomes well established the general blood pressure drops and it is still more difficult to establish the healing inflammatory phenomena. Other germs come in and cause secondary infections which greatly hasten the progress of the disease.

Now the D'Arsonval High-frequency current, when applied to certain tissues of the body, produces all the effects of a natural inflammation—they cause "hyperaemia" or increase of blood to the parts, liberate heat and probably promote the circulation of the vital currents. This method is known as "diathermy" or "thermo-penetration" and has been successfully employed in many hospitals and clinics in treating pulmonary tuberculosis. Dr. Albert Geyser, of New York City, reports over sixty per cent of recoveries in cases so treated at his Clinic at Fordham University; others have reported equally good results, yet it is a fact that the State Boards of Health, the Public Sanitoriums and thousands of lung specialists ignore this important method of combating the "Great White Plague."

For those who can make or procure a High-frequency apparatus, such as the writer described in the December, 1917, issue of the *ELECTRICAL EXPERIMENTER*, or any other standard therapeutic high-frequency apparatus giving both Tesla and D'Arsonval currents, the successful home treatment of tuberculosis is easily possible. The technique is exceedingly simple—once daily for twenty-five minutes, the patient is given a D'Arsonval treatment—a block-tin electrode attached to a cord connected with each terminal of the solenoid being held or strapped in close contact with the skin of the patient's chest and the corresponding portion of the back (Fig. 1), so that the infected area of the lung lies in the path between the electrodes. The spark is opened until the patient feels a deep penetrating heat in the tissues between the tin electrodes. If the heat becomes uncomfortable the spark gap should be made shorter. All physicians' machines are provided with hot-wire milliamperemeters in the patient's circuit. When the meter is available the current strength can be adjusted so as to begin with 1,000 ma., gradually increasing this to 2,000 ma., by the second or third week of treatment. A home-made machine operated from a one-quarter K. W. wireless transformer will not give more than 1,200 ma., in Diathermy, but this can be made sufficient by increasing the length of the treatment to forty

minutes. Continued daily treatment will bring about recovery in a majority of consumptive patients. It is scarcely necessary to add that proper dietary and hygienic measures should also be employed. Bulletins giving all needed information on these points can be had gratis from any State Board of Health. A physician should be consulted occasionally so that the progress of the case can be intelligently followed.

The use of the "Ozone Nebula" by inhalation is of great value in treating tubercular cases and when it is given in connection with Diathermy the chances of the patient's recovery are materially increased. A simple home-made apparatus for this treatment is made from a Welsbach lamp chimney mounted in a wooden upright as shown in the drawing (Fig. 2); one end of the chimney is open, from which the patient inhales the nebula; the other end is closed with a disc of wood thru which is past a short glass tube three-eighths inch in diameter; a brass rod $\frac{1}{4}$ " by 8" slides thru a hole in the center of the disc. The inner end of the rod carries a small brass disc $\frac{1}{16}$ " by $1\frac{1}{4}$ "; a small insulating rubber handle being attached to the outer end of the rod. A rubber tube connects the small glass tube with a *Del'ibes Oil Nebulizer* (procureable for a small sum at any large drug store) containing a small amount of "Pinoleum"—a preparation containing oils of pine and eucalyptus.

In treating, the patient sits on the fiber condenser pad which is connected with one terminal of the Tesla coil; the other Tesla terminal is connected to the brass rod in the chimney which is brought up close to the patient's face until a fine purple effluve passes between him and the brass disc. An assistant now alternately compresses and releases the nebulizer bulb, thereby forcing the vaporized oil across the effluve so that it emerges from the open end of the chimney close to the nose and mouth of the patient. The patient, breathing naturally, inhales the chemical combination which is said to form between the oils and the ozone and nitrous vapors formed in the effluve: these are later released in the lung tissues. The action is antiseptic and also carries oxygen into the infected areas. Clinical tests seem to prove that there is a complicated vitalizing effect obtained by the simultaneous use of the ozone nebula and the Tesla currents.

This method was devised some years ago by the writer and differs from all the Ozone and "Oxylene" systems on the market in the above respect; in other words it is a combination treatment of two well recognized healing agents.

It should be given for only a few minutes at a time, and twice daily. If the vapor is too irritating, reduce the effluve by means of the spark gap or by withdrawing the sliding rod in the chimney.

No possible dangerous effects can follow the intelligent use of the electrotherapeutic methods above described, in the home treatment of tuberculosis, and the beneficial results are very marked.

Those interested in using high-frequency currents for the above purpose should obtain the back numbers of the *ELECTRICAL EXPERIMENTER* containing the articles "Electricity and Life," and "Treatment of Disease by High-frequency Currents" by the writer.

It is hoped that this article may be the means of enabling many sufferers from tuberculosis to regain their health.

Health In A Glass Tube

The interesting story of a man "too busy to bother" who appreciated perfect health, energy and vitality only after he lost it—and how he won it back in a startling way

By FRANK HARTLE

YOU probably know dozens of people like my friend John Brainard. Strong, robust, a human dynamo for work, a real bull-dog in business and a real home body in his own home. He regarded sickness as a mild sort of crime and had such faith in his own excellent health that he had about as much sympathy for sick people as, according to Mark Twain, David had for Goliath. If you happened to mention that you didn't feel extra well Brainard would say, as courteously as was absolutely necessary, "T'bad, very sorry"—and you could almost see the entire matter sail out of his other ear. Sickness and suffering were foreign to John Brainard and he couldn't understand it in other people, that was all.

But as Josh Billings once said, "Health is like munny. We never hav a true idee uv its value until we lose it." And quite suddenly John Brainard realized what ill health is. Too much overwork, inconsiderate hours, immoderate meals, and general inattention to his health finally "told on him." One day I went to his apartments and found him in bed with a severe attack of sciatica, but fuming with rage in spite of the intense pain. "Why should I have this?—I've been in health, as a horse all my life. Why should I be sick?—hang it, I won't be sick," and he jerked himself to a sitting posture only to fall back in pain upon the pillow.

For a week John Brainard lay in bed in intense agony. Those of you who have suffered from acute sciatica or rheumatism know what it is. The doctor came and went, but Tuesday and Friday when I called, John only said, with a weak attempt at his former cheerfulness, "Nothing doing, Frank. They haven't pushed the right health button yet. Who was that fellow anyway who said something about 'a man too busy to take care of his health is like a mechanic too busy to take care of his tools'?"

At the ability of my old friend George Conrad, who treated him, I mentioned about John's still being so very ill. "Listen, Frank, old boy," he said, "I don't want to be pre-occupied or anything like that and I certainly believe that the Doc will fix John up fine, but there's a treatment which entirely cured my wife of chronic neuralgia, and now it's bringing total cure to my cousin, another sciatic sufferer. I think if John would give it a trial it might help him some." Ten minutes further conversation with Conrad convinced me and I went right over to John's home to "spring it."

"John," I said quietly, as I tip-toed into his bedroom, "I've got the very thing. Conrad has given me some real facts about what electric violet rays are doing for people and I think—"

"Oh," he interrupted, "I don't know. I don't imagine it can help me."

"Of course you don't know. And you never will until you try. Now don't talk foolish, Johnny, old scout. Won't you even believe your friends? This violet ray treatment has proved what it is."

And then I went on to tell him all I had learned about violet ray treatment—how it had been invented by the great Tesla in 1890, how it was being used with wonderful success by eminent physicians all over the world, how he

could use it on himself and it wouldn't shock him like electricity in other forms, how it would surely at least help his own sciatica and other diseases, and finally I told him how it would bring back to him his old "pep," vigor, and "knock-'em-dead" vitality. Then John rolled over and said, "All right, if it brings me out of this blamed bed a well man I'll swear by it for life. Carl in the dynamo, or whatever it is."

"It's nothing of



"When I ran that glass tube over my 'hide,'" said John, "it felt just like a local anesthetic on a wild tooth."

the sort," I insisted. "It's a handy little tube-shaped thing that attaches to that electric socket right over your head. And you can apply it yourself right to your 'hide' without feeling a bit of a shock."

Three days later I had gotten a violet ray instrument from Chicago and John used it on his legs and thighs. "Say," he cried, after the first treatment, "I thought electricity always shocked a fellow. Why, when I ran that glass tube over me and the violet rays flashed around, it just felt like a local anesthetic on a wild tooth. If this keeps up—oh, boy!"

John Brainard got up for good three days ago for the first time in over two weeks. Five days' treatment with the violet rays put him on his feet.

"Where is your 'rheumatiz,' John," I remarked yesterday.

"Dunno, Frank, I can't find it anywhere. It just 'violet-rayed' itself away, I guess," he said, pointing to the instrument in the bathroom.

"I see you keep it attached."

"Yes, you see my wife discovered that the best beauty specialists in town used it, and she—well, my wife's a woman you know."

Violet rays have brought good results in almost every disease and Violetta, being the most advanced instrument produced and selling many thousands ahead of all others, is certain to bring you the health-giving results you have always wished. But we do not want you to take our word for it. Judge for yourself—try it for ten days in your home before you decide one way or the other.

Now, through the Violetta, you can have in your own home, the wonderful violet-ray treatments exactly as given by eminent physicians for such ailments as: Headaches, Coughs, Colds, Corns, Constipation, Dandruff, Deafness, Eczema, Eye Diseases, Hay Fever, Headache, Gout, Insomnia, Lumbago, Nervousness, Neuritis, Obesity, Paralysis, Piles, Pimples, Pyorrhea, Rheumatism, Skin Diseases, Sore Throat, and many other ailments.

Multiply your bodily health—vitalize your nerves—double or treble your energy and vitality. Sleep better, increase your strength, improve your appetite and digestion. Soothe your nerves, reduce or increase your flesh, tone and strengthen the entire system, beautify your complexion. All with the Violetta.

Trixie Friganza, the famous actress, says, "Cheerfully will I add my praise for Violetta. It's the best 'pain chaser' and 'soother' I've ever had the good fortune to find. It's wonderful. It cured my brother of neuritis. As for myself, I use it for facial treatments and general massage. I cannot say too much for it." Frank Borzone, of Seattle, Washington, says: "I purchased the Violetta for my wife who was suffering from an acute attack of sciatica. From the very first treatment it induced peaceful rest and she is entirely well now." Scores of letters like these are received each day.

The Violetta is not a vibrator. It is not a machine that contracts the muscles—it does not shock—it does not pound the muscles—it is absolutely painless.

Eminent physicians from all over the country apply the Violetta with wonderful results. Dr. Bert H. Rice, of Vinton, Iowa, says: "I have good results with the Violetta. Almost instant relief in Facial Neuralgia." Dr. Daniels, Lisbon, North Dakota, says: "Have used the Violetta in such cases as Goitre, Bronchitis, Pleurisy, Neuritis, Neuralgia and Lumbago, and find it very beneficial. In fact, I would not be without it in my office." Dr. G. B. Duncan, Keewauke, Ill., says, "The Violetta is the finest thing I ever used to relieve congestion in any part of the body, and to relieve pain. Treatments are so pleasant that all of my patients like it."

Write today for a very interesting little booklet explaining fully about the Violetta and how you can try it for ten days before you decide. Read some of the amazing results produced in almost every disease. Read how the Violetta can be attached to any electric socket, and also used where there is no electric light. Read how this little instrument, shaped somewhat like a thermos bottle with a glass tube and bulb at the end, pours electric energy and vigor into every muscle, fibre, cell, and pore of your body, read how you do not have to obligate yourself in any way until the Violetta has proven its value in your particular case.

Write for this interesting booklet now. Fill out the coupon printed below for your further convenience, and mail at once. Address: Bleadon-Dun Company, Dept 2C, 11 So. Desplaines St., Chicago, Ill.

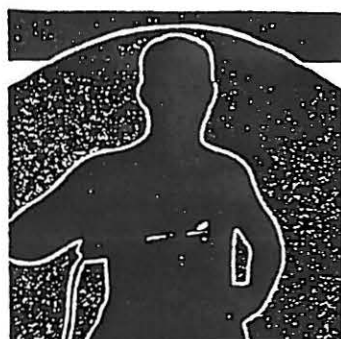
BLEADON-DUN CO.,
Dept. 2C, 11 So. Desplaines St., Chicago.

Please send me your free booklet about the Violetta and ten days' trial offer.

Name.....

Address.....

Revitalize Your Tired Nerves!



Vitality

The Violet Rays send a spray of mild, tiny currents through every part and organ, vitalizing and invigorating every cell. It acts like the refreshing effects of a shower bath—and leaves you with a delightful feeling of bounding health and buoyant energy.



Beauty

Violet Rays purify the scalp and stimulate hair growth—a wonderful aid to beauty. Remove acne, pimples, blackheads, obesity—giving the skin a smooth fine texture, free from blemishes and sallowness.

Magic-Like Treatment For:

This is only a partial list of the many ailments that can be treated successfully with Violet Rays right in your own home.

Asthma	Cold
Barbers' Itch	Insomnia
Bleeds	Lumbago
Blackheads	Nervousness
Burns	Neuritis
Callous	Obesity
Cataract	Pains
Chills	Paralysis
Corns	Prison
Constipation	Pimples
Dandruff	Pyrexia
Deafness	Rheumatism
Derma	Skin Diseases
Eczema	Sore Throat
Eye Diseases	Sore
Falling Hair	Tonsillitis
Hay Fever	Whooping
Headache	Cough

Simple Delightful Treatments Right In Your Own Home

Enjoy wonderful, sparkling health! Feel the thrill of the bounding vitality of youth! Increase your store of energy, revitalize your worn out cells, make every fibre of your body tingle with a new vim and vigor! All this you can have through the magic of Vi-Rex Violet Rays right in your own home!

Violet Rays penetrate to every cell in the body, imparting that stimulating vigor which brings the glow of health, tones up the entire system, putting life into over-taxed and sluggish tissues. As a quick relief from pain Vi-Rex has no equal. Its soothing rays quickly find the source of distress and afford speedy comfort. Headaches, nervousness, skin blemishes and many other complaints vanish as if by magic through this marvelous treatment. You will be amazed at the splendid, quick results through the use of this wonderful new Vi-Rex Violet Ray Machine—right in your own home!

VIOLET RAYS

The Amazing New Source of Health, Energy and Beauty

Vi-Rex Violet Rays are effective for a host of disorders and ailments. Physicians in all parts of the country are adding this scientific outfit to their equipment and recommending its use to their patients. Beauty specialists have long realized its efficiency for inducing a clear and healthful skin. Until recently expense prohibited the use of this remarkable health-building force in private homes. Now the practical, inexpensive Vi-Rex Violet Ray Machine enables everyone to enjoy all the benefits of this marvelous treatment at home.

20 Home Self-Treatments FREE

You don't have to take any risk in giving Vi-Rex Violet Rays a trial. Take 20 treatments in your own home. Use this marvelous machine morning and night for ten days. If you do not find quick relief—if you do not feel better, sleep better, look better, send it back and you will not be out one penny. This special offer is now open but it may be withdrawn at any time so act quickly!

Write for Free Book and Trial Offer

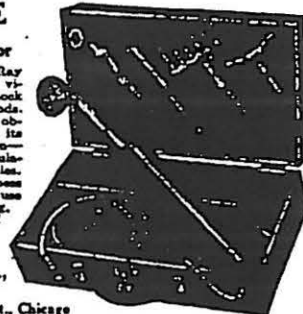
Write to-day for our free booklet describing the wonderful Vi-Rex outfit in complete detail, and particulars of our liberal to-day trial offer. Find out how Violet Rays will help you. Read what hundreds of users say about the Vi-Rex and astonishing results which have been obtained. Learn why it is the most economical and practical machine of its kind available. You may use it to gain health, vitality, beauty! There is no limit to its beneficial powers. Mail the Coupon or send a postal. Do it now.

Vi-Rex Electric Co., Dept. 44
326 W. Madison St., Chicago

The operation of the outfit is simplicity itself. Current from your electric light socket is transformed into an effective healing agent as pleasant to the senses as a ray of spring sunshine. It may be used on the very young and the very old without the slightest discomfort. No shocks or jolts—just a soft steady ray of violet light filled with an abundance of health and energy. (Special equipment is supplied to you at a trifling cost if electric current is not available.)

Not a Vibrator

The Vi-Rex Violet Ray Machine is not a vibrator—does not shock or jar the nerve ends. Its effectiveness is obtained through its power of penetration—not through manipulation of surface muscles. No feeling of soreness or exhaustion after use—only a comforting, agreeable sense of relief.



Vi-Rex Electric Co.,

Dept. 44
326 W. Madison St., Chicago

Please send me without cost or obligation your free book describing your wonderful Violet Ray Machine.

Name.....

Address.....

City.....State.....

Treatments at Home

WHAT USERS SAY

THIS TYPE of Violet Ray instrument makes possible a light, convenient handle and permits large efficient units to be used contained in handsome case.

OUR NEW BOOK

JUST OUT. This latest edition explains in detail, with many illustrations, the uses and benefits of Violet Ray. You should have one. Free for the asking.

SEND FOR BOOK!

COUPON FOR BOOK and Special Information

RENULIFE ELECTRIC CO.,
124 Marquette Bldg., Detroit, Mich.

Please send without obligation, your book "Health," explaining Violet Ray treatments with Kenolife Generators, and give full particulars as to its application for ailments checked below.

TREATS SUCCESSFULLY

- [illegible]

Name

Address

THOUSANDS OF VOLTS

No Shock—No Harm—Simply Great Benefits

Current from your light socket is transformed into the most powerful, effective purifying Health and Beauty giving agency; yet, as painless and pleasant as a ray of sunshine. Made safe for use in any home, on infant or weakest invalid. Attacks the deep seated source of diseases, at the same time relieving the aches and pains which may be the annoying symptoms. Learn how this modern form of electricity—The Violet Ray—so acceptable to the human body actually saturates the whole system with invigorating life-laden forces, bringing back normal conditions. You may treat the local area but results are not confined to that part alone—the blood, nerves, tissues are revitalized, toned and restored.

Send for the Booklet—full of information—that tells the story so you can understand it.

Natures Own Aid

What is the strange relation between electricity and life? Some declare electricity is life. We do not know. But life calls do welcome and respond marvelously to electricity in the form of Violet Rays. It works with nature to restore. And many other methods fail. It treats—fundamentally and therefore is specified by physicians—for a wide range of ailments—for rheumatism, neuritis, nerve and blood disorders—etc., etc.—both chronic and acute. See the list on coupon and ask for full particulars. Blood is brought to area treated—enriched and purified—assimilation and digestion improved—functions restored to normal. Combines the benefits of electricity, vibration, exercise, stimulation, and oxidation. Get the information as to what you may expect from the Violet Ray. Its astonishing low price places it within the reach of all. The Trial Plan proves its value, in actual use. Receive full information by return mail.

Renulife Electric Co., Inc.

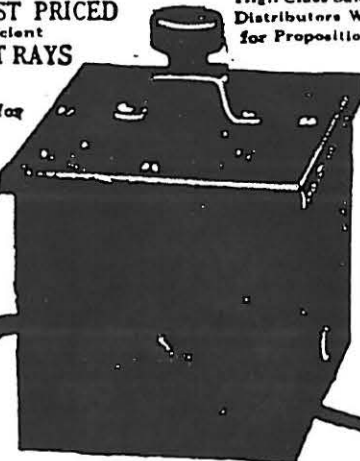
1204 Marquette Building, Detroit, Mich.

Chicago Office, Room 410, 123 West Madison
CANADIAN RENULIFE ELECTRIC CO., LTD.

Toronto Office, 347 Adelaide St., West

LOWEST PRICED
Efficient
VIOLET RAYS

Several Models for Home and Professional Use



High Class Sales Distributors Write for Proposition

OZONE
Labels
from

Pain
and Ache
Radiation—
Without Equal

For
Calarrh.
Throat, / ungr
— also a name.

L.F. MAGNETRON AMPLIFIER

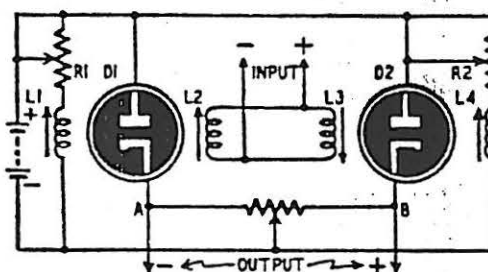
Patent No. 2,546,033

Chester R. Knight, Scotia, N. Y.

(Assigned to General Electric Co.)

This high-gain amplifier uses 2 magnetrons per stage. It eliminates contact potential errors and has high stability. It is effective at low frequencies down to d.c.

A magnetron is a diode with a straight wire cathode surrounded by a cylindrical anode. It requires an external magnetic field parallel to the cathode. Electrons from the cathode are attracted to the positive anode. The electrons tend to move simultaneously in circular orbits around



the cathode. But due to the magnetic field, under the combined effects of the anode and the field, electrons travel along spiral paths which begin at the cathode and terminate at the anode.

If the field is intensified, some electrons assume circular paths about the cathode and do not reach the anode at all. Further increase in flux density reduces the space current because still more electrons do not reach the anode. A typical magnetron characteristic is almost flat up to a critical flux density, then current drops sharply toward cut off.

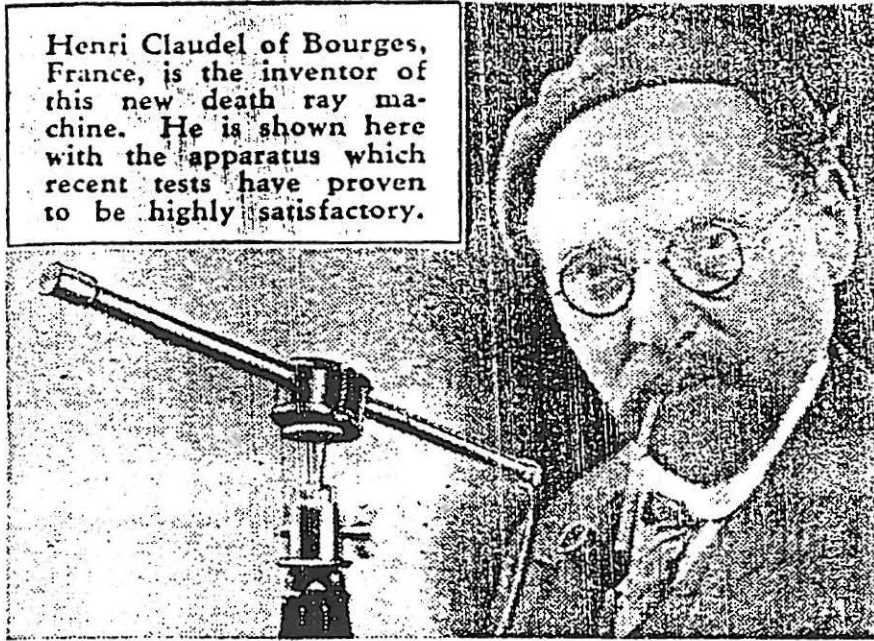
Each magnetron is surrounded by a pair of coils to generate the required field. Coils L1, L2 energize magnetron D1. The arrows indicate that their fields are additive. Coils for D2 have opposing fields.

With zero signal input, R1, R2 are adjusted to bias the magnetrons to a critical operating point. Therefore the space currents are sensitive to either decrease or increase of flux density. The output voltage is initially balanced to zero by R3.

When d.c. (or slowly varying a.c.) is fed to the amplifier, the field of one magnetron is strengthened and the other weakened. For example, if the signal has polarity as indicated, the field acting on D1 is strengthened so this tube passes less current. D2 conducts more freely at this time. The currents through R3 are no longer equal (and opposite) so output appears between terminals AB.

Ray of Death Kills at 6 Miles

Henri Claudel of Bourges, France, is the inventor of this new death ray machine. He is shown here with the apparatus which recent tests have proven to be highly satisfactory.



LATEST of the death rays, designed for modern warfare comes from Bourges, France. Henri Claudel, well known French scientist, is the inventor.

Recent experiments with the delicate apparatus have proved it to be unusually deadly when directed at small forms of life. The inventor estimates that the machine, which he calls "Rays of Death," will kill any living thing at a distance of 10 kilometers, or approximately 6¼ miles.

The rays are projected by means of a slender tube mounted on a tripod, permitting the operator to send them in any direction or at any angle. Details regarding the construction of the death ray machine are being kept a closely guarded secret, only the results of the experiment having been made public.

Death Ray Machine Is Invented by Cleveland Scientist

REPORTED to have tremendous military possibilities, a successful death ray machine is said to have been invented, after lengthy experiments, by a Cleveland scientist.

A partial description of the machine's construction and operating principles was recently offered at a session of the National Inventors' Congress at Omaha, Nebraska.

Privileged witnesses to demonstrations of the machine declared that experiments were successful to a startling degree. Dogs, cats and rabbits were killed instantly, their blood turning to water as the ray was turned upon them. It is reported that the machine has been suppressed by the government until such time as it may be needed as a defensive weapon.

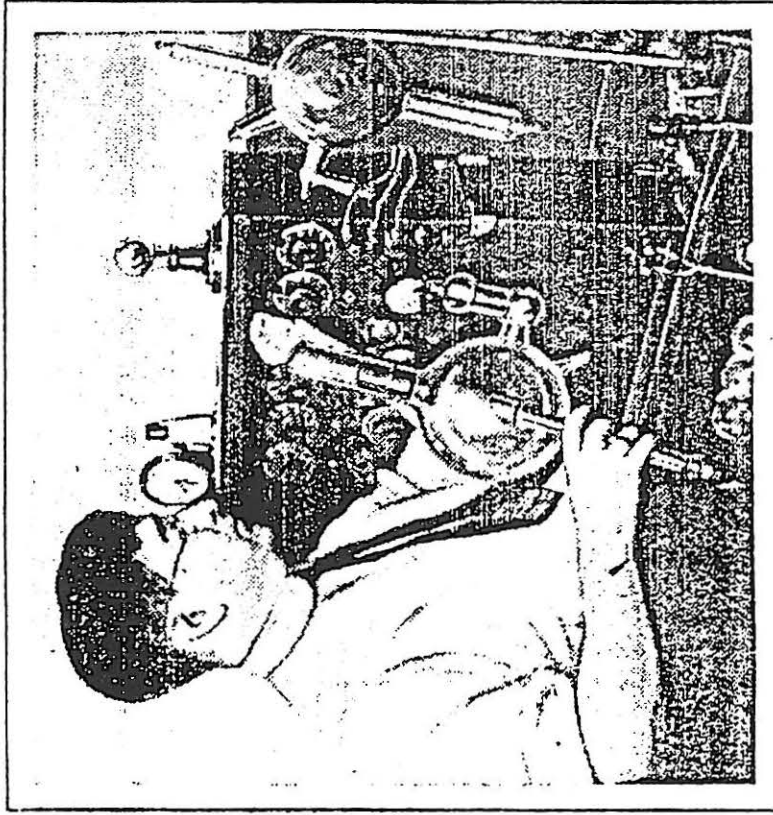


Photo shows Cleveland inventor in his laboratory with death ray machine in early stages of development. This machine is said to have proven successful in practice.

"Death Ray"



Prof. Harry May and his "death ray" machine. He hopes will make nations afraid to start future wars. It is on exhibition at a San Diego, Calif., exposition at this time.

A "DEATH RAY" machine is on exhibition at the California Pacific International Exposition being held at San Diego, Calif. It was invented by Prof. Harry May of London, England.

Prof. May feels that his new lethal weapon will be instrumental in outlawing war. He thinks that nations, knowing that such a weapon for quick destruction is available will hesitate to attack each other.

Tesla Predicts Ships Powered By Shore Beam

Scorns at Normandie's Speed;
Sees Success for His Plan
to Use Stratosphere Ray

Would Light Sea at Night

Says French Liner's System
Copies His in U. S. Boats

Dr. Nikola Tesla, scientist and engineer whose discoveries in the fields of polyphase electrical current and wireless telegraphy place him in the front rank of modern inventors, refused yesterday to be awed by the record speed achievement of the French liner Normandie in crossing the Atlantic in 4 days 15 hours 42 minutes and predicted that enormous ships would cross the ocean at far greater speeds by means of a high-tension current projected from power plants on shore to vessels at sea through the upper reaches of the atmosphere.

In his room at the Hotel New Yorker, dressed in a blue bathrobe, blue socks and red slippers, Dr. Tesla expounded the principles of his fabulous method of power transmission—a method which he has been developing at regular intervals from as far back as 1897. The virtues of stratosphere transmission, he said, lay not only in its potential increase of a vessel's speed but also in its power to eliminate the dangers of nocturnal navigation.

In short, high-tension currents of electricity passing through the stratosphere would light the sky and to a degree turn night into day. With power plants stationed at intermediate posts such as upon the Azores and Bermuda, vessels could cross the Atlantic, propelled and safeguarded at the same time by electricity generated ashore. There would no longer be danger of boiler explosions nor hazards of collisions at sea. Even on moonless, cloudy nights, there still would gleam overhead the faint rays of shining electrical currents, so strong that pilots would be able to distinguish objects miles away.

Normandie Uses U. S. Cruiser System

Dr. Tesla, a tall, slender man with straight, silver hair, lean features and bright blue eyes that belie his seventy-eight years, prefaced his prophecies by pointing out that the Normandie's system of power generation and application was not new—but one which had been adopted long ago by some of the United States cruisers. The principle is one of his own invention.

"The Normandie," he said, "employs an electric drive in which turbines drive generators and generators supply the current to independent motors. In this case the turbines are driven by steam, the generators are of the three-phase type and the motors are of the induction type."

In many respects the machinery installed in the United States cruisers by former Secretary Josephus Daniels is more remarkable than that on the Normandie on account of the limitations of available space. Moreover, while the Normandie develops only 160,000 horsepower, the cruisers each develop 185,000 horsepower. These cruisers employ the most remarkable engine plants in the world, and I believe that this drive would not have been employed on the Normandie had it not been for the pioneering work done in the United States.

In view of the adoption on such a large scale of these inventions of mine, it is interesting to recall that I was violently attacked only a few years ago by a professor of marine engineering at Columbia, who claimed an electrical drive was not feasible and that it was folly to undertake it.

However splendid the machinery on the Normandie might be, the time is not distant when we will have much simpler and better means of propulsion.

Elites Use Force Beam as One Way

Here Dr. Tesla recalled the possibilities of his force beam of particles which he announced last year as a potential defensive weapon of great value. One of its aspects is a death ray capable of destroying airplanes and armies. Another is a means of power transmission which could be used to relay immense voltages of

Not in Arc of Notionality



Herald Tribune photo—Nikola Tesla

power over distances limited only by the curvature of the earth.

The difficulties inherent in using this method as a means of propulsion for oceangoing ships, however, were seen by Dr. Tesla to lie in the necessity of vast outlays of capital and concerted harmonious endeavor by the chief nations of the world. The latter, he said, would be impossible to achieve at the present time. A third difficulty would be the task of keeping a ship at sea constantly in touch with a threadlike beam of particles from ashore.

Dr. Tesla, therefore, suggested that his other scheme of stratosphere transmission of electricity would be a far more feasible means of marine propulsion. The principles of the two plans are entirely distinct. The force beam is a thin barrage of tiny particles discharged at tremendous velocities from a kind of electrical gun. The other invention, which he has not hitherto discussed publicly, is of transmitting high tension currents through the upper air, and receiving them by means of a vertical ionizing beam which would be a sort of invisible electrode. He discussed this yesterday.

AN INVENTOR'S SEASONED IDEAS

Nikola Tesla, Pointing to 'Grievous Errors' of the Past, Explains Radio as He Sees It at Age of 77—He Expects Television

By ORRIN E. DUNLAP Jr.

ATALL, lean inventor in a cut-away walked into his skyscraper parlor thirty-three floors above the sidewalks of New York, laid his black derby on the table, opened the window and then was ready to talk about radio's past, present and future. He was Nikola Tesla, the inventor whose discovery of the rotary magnetic field made possible the alternating-current motor. He described a system of wireless transmission of energy in 1892.

Seven milestones beyond three-score and ten, this electrical wizard, who came to America in 1884, looked back across the years, recalled where theorists often chose wrong paths at the crossroads of science and then turned his thoughts to the future in which television lurks.

A Spectacle That Frightens.

"There is something frightening about the universe when we consider that only our senses of sound and sight make it beautiful," said Mr. Tesla as his furrowed brow indicated he is puzzled with its destiny. "Just think, the universe is darker than the darkest ink; colder than the coldest ice and more silent than a silent tomb, with all the bodies rushing through it at terrific speeds. What an awe-inspiring picture, isn't it? Yet it is our brain that gives merely a physical impression. Sight and sound are the only avenues through which we can perceive it all. Often I have wondered if there is a third sense which we have failed to discover. I'm afraid not," he said after some hesitation in thought.

Looking back to the mauve decade, to the turn of the century when the world was being thrilled with new ideas and discoveries, Mr. Tesla observes a vast change in the art of invention. Man, he finds, in this streamline era of speed, has little chance to think.

* * *

Fruits of Seclusion.

THE big, modern research laboratories are but the incubators of ideas as he has watched them function. Seldom, if ever, he explains, has an original idea of any consequence been born in an elaborate laboratory. The egg of science is laid in the nest of solitude. True, it may later be incubated, hatched and nursed in the million-dollar laboratory.

"It is providential that the youth or man of inventive mind is not 'blessed' with a million dollars," said Mr. Tesla. "He would find it difficult to think. The mind is sharper and keener in seclusion and uninterrupted solitude. No big laboratory is needed in which to think. Originality thrives in seclusion free of outside influences beating upon us to cripple the creative mind. Be alone, that is the secret of invention; be alone, that is when ideas are born. That is why many of the earthly miracles have had their genesis in humble surroundings."

Radio experimenters of this age are following ancient theories, Mr. Tesla believes, and he warns that progress will be more rapid when they discard the old and adopt new ideas. His directions for getting on the right track of radio, television, power transmission by wireless and sundry other branches of science follow:

"The fascination of the electromagnetic theory of light, advanced by Maxwell and subsequently experimentally investigated by Hertz, was so great that even now, although controverted, the scientific minds are under its sway. This theory supposed the existence of a medium which was solid, yet permitted bodies to pass through it without resistance; tenuous beyond conception, and yet, according to some, one thousand times denser than platinum. According to our conceptions of mechanical principles and ages of experience, such a medium was absolutely impossible. Nevertheless, light was considered essentially a phenomenon bound up in that kind of a medium; namely, one capable of transmitting transverse vibrations like a solid.

A Question Tesla Asked.

"It is true," said Mr. Tesla, "that many scientific minds envisaged the theory of a gaseous ether, but it was rejected again and again because in such a medium longitudinal waves would be propagated with infinite velocity. Lord Kelvin conceived the so-called contractile ether, possessing properties which would result in a finite velocity of longitudinal waves. In 1865, however, an academic dissertation was published by Professor De Volson Wood, an American, at a Hoboken institution, which dealt with a gaseous ether in which the elasticity, density and specific heat were determined with rare academic elegance. But, so far, everything pertaining to the subject was purely theoretical."

What, then, can light be if it is not a transverse vibration? That was the question he asked himself and set out to find the answer.

"I consider this extremely important," said Mr. Tesla. "Light cannot be anything else but a longitudinal disturbance in the ether, involving alternate compressions and rarefactions. In other words, light can be nothing else than a sound wave in the ether."

This appears clearly, Mr. Tesla explained, if it is first realized that, there being no Maxwellian ether, there can be no transverse oscillation in the medium. The Newtonian theory, he believes, is in error, because it fails entirely in not being

able to explain how a small candle can project particles with the same speed as the blazing sun, which has an immensely higher temperature.

"We have made sure by experiment," said Mr. Tesla, "that light propagates with the same velocity irrespective of the character of the source. Such constancy of velocity can only be explained by assuming that it is dependent solely on the physical properties of the medium, especially density and elastic force."

* * *

Micro-Wave Possibilities

COMING now to the wireless waves, it is still true that they are of the same character as light waves, only they are not transversal but longitudinal. As a matter of fact, radio transmitters emit nothing else but sound waves in the ether, and if the experts will realize this they will find it very much easier to explain the curious observations made in the application of these waves.

"It being a fact that radio waves are essentially like sound waves in the air, it is evident that the shorter the waves the more penetrative they would be. In 1899 I produced electromagnetic waves from one to two millimeters long and observed their actions at a distance. There has been a great hope expressed by various workers that introduction of these waves will have a revolutionary effect, but I am not sharing the opinion. They will be used, of course, but to a very limited extent. It is manifest that applications of the very short waves will not produce any appreciable effect upon the wireless art."

"Errors" Retard Wireless Power.

What about the possibilities of power transmission by wireless? the inquirer said.

Here again Mr. Tesla blames "a strange misconception of the experts" and "grievous errors" for retarding the idea. He believes that when it is accomplished, the power will travel on long waves and not on the wings of "uneconomically produced" short waves. He said he could vouch that the scheme of wireless power transmission is entirely practical.

"The application of short waves for power purposes," said Mr. Tesla, "involves complicated and expensive apparatus for rectification or frequency transformation, which would make any serious attempt to carry out a project of this kind much more difficult from an economical point of view."

When will television come around the corner? he was asked.

"It ought to be with us soon, and some day it will be on a par of perfection with broadcasting of music." Then with a circular sweep of his arm and added, "There will be large pictures thrown on the wall."

Beam to Kill Army at 200 Miles, Tesla's Claim on 78th Birthday

Death Ray Also Available
as Power Agent in Peace
Times, Inventor Declares

By Joseph W. Alsop Jr.

Dr. Nikola Tesla, inventor of poly-phase electrical current, pioneer in high frequency transmission, predecessor of Marconi with the wireless, celebrated his seventy-eighth birthday yesterday by announcing his invention of a beam of force somewhat similar to the death ray of scientific romance.

It is capable, he believes, of destroying an army 200 miles away; it can bring down an airplane like a duck on the wing, and it can penetrate all but the most enormous thicknesses of armor plate. Since it must be generated at stationary power plants by machines which involve four electrical devices of the most revolutionary sort, Dr. Tesla considers it almost wholly a defensive weapon. In peace times he says, the beam will also be used to transmit immense voltages of power over distances limited only by the curvature of the earth.

As a hors d'oeuvre to this Jules Vernean announcement, Dr. Tesla disclosed that he has lately perfected instruments which fully approve the present theory of the high physicists that the sun is destined to burn itself out until it is a cold cinder



Herald Tribune photo—Stefan
Dr. Nikola Tesla

floating in space. Dr. Tesla stated that he is able to show that all the suns in the universe are constantly growing in mass and heat, so that the ultimate fate of each is explosion.

Dr. Tesla refused to describe specifically the instruments in question in both discoveries, or even to disclose the principles upon which they

(Continued on page fifteen)

Beam to Kill Army at 200 Miles, Tesla's Claim on 78th Birthday

(Continued from page one)

are built. He said that at some date soon he expected to make the full details public in scientific journals or before scientific bodies. Since he considers the beam of force a defensive and therefore a pacifist weapon, he hopes to be able to present it in full for the first time at the disarmament conference at Geneva. He also said that minor parts of each of the discoveries are still in the theoretical or blueprint stage, but he pointed out that his method of work has almost always been purely mental.

The aging inventor, a tall, thin, almost apiritual figure in the sort of brown cutaway suit that older men wore before the World War, received interviewers in one of the public rooms in the Hotel New Yorker, where he lives. Before he would speak of his present work he reviewed his past achievements, which entitle him, more than Edison, Steinmetz or any other, to be called the father of the power age. He has 30 patents to his credit, and 10 of a few of them are for epoch-making discoveries. But over and over again he has been ridiculed as a lunatic. He recalled this and his work together as if to prepare the way for his announcements.

He came to the idea of a beam of force, he said, because of his belief that no weapon has ever been found that is not as successful offensively as defensively. The perfect weapon of defense, he felt, would be a frontier wall, impenetrable and extending up to the limits of the atmosphere of the earth.

Creates Rays in Free Air

Such a wall, he believes, is provided by his beam of force. It is produced by a combination of four electrical methods or apparatuses. First and most important is a mechanism for producing rays and other energy manifestations in free air. Hitherto vacuum tubes have always been necessary. Second is an apparatus for producing unheard-of quantities of electrical current and for controlling it when produced. The current is necessary as power for the first mechanism. Without this no rays of sufficient strength could be produced. The third is a method of intensifying and amplifying the second process, and the fourth is a method of producing "tremendous electrical repellent force."

"These four inventions in combination enable man to loose in free air forces beyond conception," Dr. Tesla remarked mildly. "By scientific application we can project destructive energy in thread-like beams as far as a telescope can discern an object. The range of the beams is only limited by the curvature of the earth. Should you launch an attack in an area covered by these beams, should you, say, send in 10,000 planes or an army of a million the planes would be brought down instantly and the army destroyed."

The plane is thus absolutely eliminated as a weapon. It is confined to commerce. And a country's whole frontier can be protected by one of the plants producing these beams every 200 miles. Nor should they be much more costly than an ordinary power plant.

It Is an Electric Gun

The "beam of force" itself, as Dr. Tesla described it, is a concentrated current—it need be no thicker than a pencil—of microscopic particles moving at several hundred times the speed of artillery projectiles. The machine into which Dr. Tesla combines his four devices is, in reality, a sort of electrical gun.

He illustrated the sort of thing that the particles will be by recalling an incident that occurred often enough when he was experimenting with a cathode tube. Then, sometimes, a particle larger than an electron, but still very tiny, would break off from the cathode, pass out of the tube and hit him. He said that he could feel a sharp, stinging pain where it entered his body, and again at the place where it passed out. The particles in the beam of force, ammunition which the operators of the generating machine will have to supply, will travel far faster than such particles as broke off from the cathode, and they will travel in concentrations, he said.

As Dr. Tesla explained it, the tremendous speed of the particles will give them their destruction-dealing qualities. All but the thickest armored surfaces confronting them would be melted through in an instant by the heat generated in the concussion.

Some Parts Still Unmade

Such beams or rays of particles now known to science are composed always of fragments of atoms, whereas, according to Dr. Tesla, his would be of microscopic dust of a suitable sort. The chief differentiation between his and the present rays would appear to be, however, that his are produced in free air instead of in a vacuum tube. The vacuum tube rays have been projected out into the air, but there they travel only a few inches, and they are capable only of causing burns or slight disintegration of objects which they strike.

Dr. Tesla declared that the two most important of the four devices involved in his force beam generator, the mechanism for producing rays in free air and the mechanism for producing great quantities of electrical current, had both been constructed and demonstrated by actual experiments. The two intensifying and amplifying apparatuses are not yet in existence, but he displayed the most perfect confidence that when they are, they will work as he expects them to do.

"These effects," he said, "are of the kind that can be calculated with the most positive accuracy. Like many other things I have done they require no previous experiment once they are properly conceived. There are a few details to be finished—my calculations

might be perhaps 10 per cent off at present—and then the whole thing will be presented to the world. It has always been my practice to give the world a sort of preview of what I am doing so that a reception is prepared."

"I should also say, and this is perhaps as important as anything else about it, that in this apparatus all limitations as to electric force and the quantity of electricity transmitted have been removed."

It was evident that Dr. Tesla's work on the force beam as a peace-time means of power transmission was far less advanced than his work on it as a defensive weapon. He did not describe the nature of the receiver which will transform the force beam into useful power, though he declared that he had designed one, nor was he able to show just how the dangers of having such death-dealing but invisible beams traveling through the air could be surmounted.

Dr. Tesla was far less definite in his description of the experiments which led to his revolutionary prediction of the future of the sun and its system than he was when talking of the force beam. He had, he said, detected "certain motions in the medium that fills space, and measured the effects of these motions." The results of the experiments had led him "inevitably" to the conclusion that such bodies as the sun are taking on mass much more rapidly than they are dissipating it by the dissipation of energy in heat and light.

"Heat to Kill All Peoples"

He pointed out that his theory means a future for the earth as different from the general belief as the future of the sun. It is generally held that life on the earth will cease when the sun grows so cold that the earth temperature drops to a point where life can no longer be supported. Dr. Tesla prophesies that life on the earth will cease because the planet will grow too warm to support life, and he believes that life will then begin on outer planets now too cold. He said that his discovery not only allowed him to predict a very different future for the heavenly bodies from that now generally expected for them, but also to calculate in a new way their ages.

Nor were these two discoveries, of a force beam and a new future for the universe, the only new things Dr. Tesla had to offer. The completely new and unlimited source of energy which he stated he was at work on is, he said, still under examination by him, since he first spoke of it great strides have been made, and the complete announcement of it is to be expected in a comparatively short time.

...ray. I was fifteen years ahead of other fellows who were asleep. Now no one can take away from me the credit of being the first discoverer of the cosmic ray on earth."

Dr. Tesla's audience stirred as he took up the next phase of his discoveries.

"I have devoted much of my time during the year past," he said, "to the perfecting of a new small and compact apparatus by which energy in considerable amounts can now be flashed through interstellar space to any distance without the slightest dispersion."

To Claim French Award

Explaining that he did not refer to his "universal peace discovery," Dr. Tesla continued:

"I am expecting to put before the Institute of France an accurate description of the device with data and calculations and claim the Pierre Guzman prize of 100,000 francs for means of communication with other worlds, feeling perfectly sure that it will be awarded to me. The money, of course, is a trifling consideration, but for the great historical honor of being the first to achieve this miracle I would be almost willing to give my life."

"I am just as sure that prize will be awarded to me as if I already had it in my pocket. They have got to do it. It means it will be possible to convey several thousand units of horsepower to other planets, regardless of the distance. This discovery of mine will be remembered when everything else I have done is covered with dust."

Reporters questioned Dr. Tesla closely on his report of an interplanetary communication system. He said he had been working in several laboratories, but refused to disclose where they were. Asked if he had a working model of the apparatus, he said "it employs more than three dozen of my inventions; it is a complex apparatus, an agglomeration of parts."

"It is absolutely developed," he declared. "I wouldn't be any surer that I can transmit energy 100 miles than I am of the fact that I can transmit energy 1,000,000 miles up."

A different kind of energy than is commonly employed must be used, however, he said, explaining further that "you must realize it travels through a channel of less than one-half of one-millionth of a centimeter."

"I could undertake a contract to manufacture the apparatus," he asserted.

Dr. Tesla declared that "life on other planets is an infinite probability, a certitude." A difficulty in using his apparatus, he said, would lie in hitting other moving planets with "the needle-point of tremendous energy," but astronomers could help solve this problem.

The point of energy could be aimed at the moon and "we very easily could see the effects, see the splash and the volatilization of matter." He also pictured the possibility of advanced thinkers living on other planets and also experimenting in this field, but mistaking the Tesla energy rays for some form of cosmic rays.

Dr. Tesla provoked a new stir with his next announcement.

"My most important invention from a practical point of view," he said, "is a new form of tube with apparatus for its operation."

Reports Tube of New Type

Recalling experiments with other tubes, he said he had been "rewarded with complete success" and had "produced a tube which it will be hard to improve further."

"It is of ideal simplicity," he said, "not subject to wear and can be operated at any potential, however high—even 100,000,000 volts—that can be produced. It will carry heavy currents, transform any amount of energy within practical limits and it permits easy control and regulation of the same."

Such a Device "Invaluable"

After all, \$2,000,000 would be relatively a very small sum compared with what is at stake. If Mr. Tesla really fulfills his promise the result achieved would be truly staggering. Not only would it save billions now planned for air defense, by making the country absolutely impregnable against any air attack, but it would also save many more billions in property that would otherwise be surely destroyed no matter how strong the defenses are as witness current events in England.

Take, for example, the Panama Canal. No matter how strong the defenses, a suicide squadron of dive bombers, according to some experts, might succeed in getting through and cause such damage that would make the Canal unusable, in which case our Navy might find itself bottled up.

Considering the probabilities in the case even if the chances were 100,000 to 1 against Mr. Tesla the odds would still be largely in favor of taking a chance on spending \$2,000,000. In the opinion of the writer, who has known Mr. Tesla for many years and can testify that he still retains full intellectual vigor, the authorities in charge of building the national defense should at once look into the matter. The sum is insignificant compared with the magnitude of the stake.

Started New Idea in 1887
"There is a method of conveying great power to ships at sea which would be able to propel them across oceans at high speed. This method I conceived between 1887 and 1889. And in Colorado Springs in 1890 I made experiments along this line on a large scale.

"The principle is this: A ray of great ionizing power is used to give to the atmosphere great powers of conduction. A high tension current of 10,000,000 to 12,000,000 volts is then passed along this ray to the upper strata of the air, which strata can be broken down very readily and will conduct electricity very well.

"A ship would have to have equipment for producing a similar ionizing ray. The current which has passed through the stratosphere will strike this ray, travel down it and pass into the engines, which propel the ship.

My Scheme to Light Ocean

"I will confess that I was disappointed when I first made tests along this line on a large scale. They did not yield practical results. At the time I used about 8,000,000 to 12,000,000 volts of electricity. As a source of ionizing rays I employed a powerful arc reflected up into the sky. At the time I was trying only to connect a high tension current and the upper strata of the air, because my pet scheme for years has been to light the ocean at night.

"However, since 1902 I have made many improvements in my method which I know now will assure success. A power plant upon the Azores, for instance, could send a current up into the stratosphere and illuminate the sky sufficiently for pilots to discern objects upon the ocean at a safe distance."

Dr. Teala said that he was working constantly every day to perfect his force beam, his method of stratosphere transmission of power, and a number of other inventions the nature of which he was not ready to disclose. When it was called to his attention that he was working pretty hard for a man who would be seventy-nine years old next month, he replied:

"Why, I'm young. I never think of my age. Really, you know, I'm just a youngster."

TESLA, 80, REVEALS NEW POWER DEVICE

Says His Wireless Invention
Will Gird the Earth With
Energy for Industry.

Nikola Tesla, inventor, who celebrated his eightieth birthday yesterday, foresaw an industrial civilization founded on cheap and unlimited power transmitted from a central point to any part of the globe without wires.

This new system of power transmission will have its first practical demonstration within a year, Dr. Tesla predicted. He said he had perfected the principles which will create the necessary apparatus.

Each year on his birthday the inventor of the principle of the rotary magnetic field, new forms of dynamos, transformers and 700 other devices which have played a leading rôle in technological development plays host to the press. Yesterday he gave a luncheon for fifteen newspaper men and women at the Hotel New Yorker, and while his guests feasted he contented himself with three oranges and a quart of milk.

Recalls Interesting Episodes

Dr. Tesla recalled his first meeting with Thomas A. Edison, relived some of the interesting episodes in his own life, describing his researches into such varied fields as relativity, death rays, psychic phenomena, lightning machines and power development.

Between sips of the warm milk, he eyed the newspaper folk with their Scotch and sodas and confided that if he had not given up drinking alcohol with the enactment of prohibition he would live to be 150 years old.

"As it is, I believe my abstinence from alcohol during the latter part of my life has lopped off fifteen years from my life, and now I expect to live only 135 years," he remarked. "Alcohol is the elixir of life, but when this country passed the Prohibition Law I felt that as a patriotic American I should stop drinking whisky. I have not touched it since."

Meat is another food which he never touches, Dr. Tesla explained. Two quarts of milk a day provide him with all the proteins and calories he needs to remain alive, he said. Although as a rule he does not retire until 5.30 o'clock every morning, he gets up about 10 A. M. and feels full of energy.

The development of wireless transmission of power will overshadow any of his past accomplishments and will usher in a new civilization for mankind, Dr. Tesla predicted. He explained that his system will make it possible, for example, to install a hydro-electric plant at Muscle Shoals and transmit the power generated to England, China, Little America or Alaska with equal ease and at comparatively little cost.

"Death Ray" for Planes

Nikola Tesla, one of the truly great inventors who celebrated his eighty-fourth birthday on July 10, tells the writer that he stands ready to divulge to the United States Government the secret of his "teleforce" with which, he said, airplane motors would be melted at a distance of 250 miles, so that an invisible Chinese Wall of Defense would be built around the country against any attempted attack by an enemy air force, no matter how large.

This "teleforce," he said, is based on an entirely new principle of physics that "no one has ever dreamed about," different from the principle embodied in his inventions relating to the transmission of electrical power from a distance, for which he has received a number of basic patents. This new type of force, Mr. Tesla said, would operate through a beam one one-hundred-millionth of a square centimeter in diameter, and could be generated from a special plant that would cost no more than \$2,000,000 and would take only about three months to construct.

A dozen such plants, located at strategic points along the coast, according to Mr. Tesla, would be enough to defend the country against all possible aerial attack. The beam would melt any engine, whether Diesel or gasoline-driven, and would also ignite the explosives aboard any bomber. No possible defense against it could be devised, he asserts, as the beam would be all-penetrating.

High Vacuum Eliminated

The beam, he states, involves four new inventions, two of which already have been tested. One of these is a method and apparatus

for producing rays "and other manifestations of energy" in free air, eliminating the necessity for a high vacuum; a second is a method and process for producing "very great electrical force"; the third is a method for amplifying this force, and the fourth is a new method for producing "a tremendous electrical repelling force." This would be the projector, or gun, of the system. The voltage for propelling the beam to its objective, according to the inventor, will attain a potential of 50,000,000 volts.

With this enormous voltage, he said, microscopic electrical particles of matter will be catapulted on their mission of defensive destruction. He has been working on this invention, he added, for many years and has recently made a number of improvements in it.

Mr. Tesla makes one important stipulation. Should the government decide to take up his offer he would go to work at once, but they would have to trust him. He would suffer "no interference from experts."

In ordinary times such a condition would very likely interpose an insuperable obstacle. But times being what they are, and with the nation getting ready to spend billions for national defense, at the same time taking in consideration the reputation of Mr. Tesla as an inventor who always was many years ahead of his time, the question arises whether it may not be advisable to take Mr. Tesla at his word and commission him to go ahead with the construction of his teleforce plant.

Pioneer Radio Engineer Gives Views on Power

Tesla Says Wireless Waves Are Not Electromagnetic, but Sound in Nature

Holds Space Not Curved

Predicts Power Transmission to Other Planets

By Nikola Tesla

The assumption of the Maxwellian ether was thought necessary to explain the propagation of light by transverse vibrations, which can only occur in a solid. So fascinating was this theory that even at present it has many supporters, despite the manifest impossibility of a medium perfectly mobile and tenuous to a degree inconceivable, and yet extremely rigid, like steel. As a result some illusionary ideas have been formed and various phenomena erroneously interpreted. The so-called Hertz waves are still considered a reality proving that light is electrical in its nature, and also that the ether is capable of transmitting transverse vibration of frequencies however low. This view has become untenable since I showed that the universal medium is a gaseous body in which only longitudinal pulses can be propagated, involving alternating compressions and expansions similar to those produced by sound waves in the air. Thus a wireless transmitter does not emit Hertz waves which are a myth, but sound waves in the ether, behaving in every respect like those in the air, except that, owing to the great elastic force and extremely small density of the medium, their speed is that of light.

Advances Seen Fantastic

Some of the advances described by him during the last few years as the result of his investigations may appear equally fantastic today, but one has only to know of Dr. Tesla's past performances in order to have faith that given time and money they could be made realities. Forty years ago he was playing with electrical discharges of many millions of volts, while today scientists have difficulty in developing a fraction of these potentials for their atom-smashing and X-ray experiments. Long before the days of Marconi, Tesla girdled the earth with giant electrical waves from his high voltage generators, and on the basis of this work predicted both the "transmission of intelligence without wires" and the "wireless transmission of power." He controlled a vessel at a distance by wireless power forty years before the advent of our present-day man-of-war aerial torpedoes.

They laughed at me in 1897 when I told them about the cosmic day," he said in a recent interview. "Fifty years ago they attempted to discredit my discovery of the rotating magnetic field and my system of power transmission by alternating currents. They called me crazy when I predicted the radio, and when I sent the first impulses around the world they said it couldn't be done."

So with Tesla's latest discoveries and inventions. There may be many who are skeptical, but the world is moving forward rapidly, and man is constantly doing things a short time before considered impossible. Forty years ago Tesla was predicting world-wide radio communication. Today this accomplishment is history. Now he is predicting interplanetary communication.

Jovian Bolts Hit Aim

Dr. Tesla gave assurance that he did not mean just sending weak signals, but veritable Jovian bolts carrying energy of several thousand horsepower which would be able to produce tremendous effects at the receiving end, even though it be infinitely remote. A test of this invention could be made most advantageously on our nearest heavenly neighbor, the moon. Sufficient energy, he said, could be transmitted to render a small spot on its surface incandescent so that it could be easily observed from the earth.

This is a further extension of the announcement previously made by Dr. Tesla that he would be able to transmit over a beam of not more than one hundred inches and the of a square centimeter in cross section adequate amounts of energy for operating all kinds of machinery at distances limited only by the earth's curvature. Such a beam, he pointed out, could be used not only for constructive but also destructive purposes as annihilating military forces or aerial fleets.

While Dr. Tesla is keeping a deep

secret of the mechanism by which he plans to provide unlimited energy. It is apparent he is bent on using natural forces that operate on a vast scale. To be specific, it seems that the energy is coming to us in the form of cosmic rays, but Tesla's theory of these rays is different from those of Dr. Robert A. Millikan or Dr. Karl T. Compton.

He formulated his theory in 1897 when he sought to explain the production of the phenomena of radio activity by some other means than atomic explosions. He held that any energy an atom exhibits is received from its environment and does not come from itself. Accordingly, he explained radio activity as a result of the shattering of atoms by subatomic cosmic particles. Whence did they come? was the question.

"Now, of all bodies in the cosmos," states Dr. Tesla, "our sun was the most likely to furnish a clue as to their origin and character. Before the electron theory was advanced, I had established that radio-active rays consisted of particles of primary matter not further decomposable, and the first thing to find out was whether the sun is charged to a sufficiently high potential to project such particles and produce the effects noted. This called for a prolonged investigation which culminated in my discovery that the sun's potential was 1218,000,000,000 volts and that all such large and hot bodies emit cosmic rays."

Puzzle of Mystery Rays

While the origin and character of the rays observed near the earth's surface had thus been sufficiently well ascertained, the so-called cosmic rays observed at great altitudes presented a riddle for more than twenty-six years, chiefly because it was found they increased with the height at a rapid rate. My investigations brought out the astonishing fact that the effects at high altitudes are of an entirely different nature, having no relation whatever to cosmic rays. These are particles of matter projected from celestial bodies at very high temperatures and charged to enormous electrical potentials.

It might be remarked parenthetically that Dr. Tesla does not accept the concept of the electron presented by physicists as an elementary unit and carrying a unit charge of electricity. He holds that the electron in a well-exhausted tube operated at high potential carries many multiples of this unit charge. The ignorance of this fact is responsible for many errors and fallacies in various scientific investigations.

The effects at great elevations,

Dr. Tesla continued, "are due to waves of extremely small lengths produced by the sun in a certain region of the atmosphere. This is the discovery I wish to make known. The process involved in the generation of the waves is the following: The sun projects charged particles constituting an electric current which passes through a conducting stratum of the atmosphere approximately ten kilometers (six miles) thick enveloping the earth. This is a transmission of electrical energy exactly as I illustrated in my experimental lecture in which one end of a wire is connected to an electric generator of high potential, its other end being free. In this case the generator is represented by the sun and the wire by the conducting air.

Production of the Waves

The passage of solar current involves the transference of electric charges from particle to particle with the speed of light, resulting in the production of extremely short and penetrating waves. As the air stratum mentioned is the source of the waves it follows that the so-called cosmic rays observed at great altitude must increase as this stratum is approached.

Another of the Tesla inventions is a radically new tube which is in-

altitude must increase as this stratum is approached.

Another of the Tesla inventions is a radically new tube which is indestructible and can handle heavy currents up to any voltage that can be produced, even 100,000,000 volts. It will be useful, he promises, in the production of cheap radium substitutes and in the transformation of matter. Still another invention consists in means for the production of a practically perfect vacuum of the order of 1,000,000,000th of a micron.

While Dr. Tesla does not say so, it is assumed that these latter inventions are parts of the system which he would use in the transmission of energy to the moon or other planets. Such an application would be spectacular, but the inventions when described and made public would have applications of some immediate practical value in industrial operations.

He was honored on his birthday by the bestowal of the highest distinctions within the power of Yugoslavia and Czechoslovakia, which recognition touched him deeply. All the more so Konstantin Potich and Vladimir Hurban, ministers of these countries, came from Washington especially for the occasion. Dr. Tesla is now eighty-one and works continuously at his investigations. He has not been halted even by a recent accident in which he was knocked down by a taxicab. It merely caused the customary bruise and upset the digestion a bit, he said.

Inventor Hopes to Use Energy-Transmitting Device to Make Spot Glow on Lunar Surface

Theory Is Traced To '97 Experiments

His Mechanism to Use
Vast Natural Forces,
Possibly Cosmic Rays

By John J. O'Neill

The failure of forecasters to predict the results of scientific discoveries, particularly with respect to their social and economic significance, was emphasized in the recent report on technological trends and their social implications submitted to President Roosevelt by the National Resources Committee. One of the outstanding oversights was radio broadcasting. None of the previewers of coming events saw this development of radio communication.

With this as justification some attention might be given to the recent announcements by Nikola Tesla, the inventor, whose mind has given us a great many of the major developments forming the foundation of our electrical age. Dr. Tesla seldom writes for publication, but back in 1900 he wrote an article for the June issue of "The Century Magazine" which contained predictions that seemed at that time very fantastic. Those who may read it now will be amazed to find how many of the author's prophecies have proved true.

Suggested Short Waves Early

Since waves of this kind are all the more penetrating, the shorter they are, I have urged the experts engaged in the commercial application of the wireless are to employ very short waves, but for a long time my suggestions were not heeded. Eventually, though, this was done and gradually the wave lengths were reduced to but a few meters. Invariably it was found that these waves, just as those in the air, follow the curvature of the earth and bend around obstacles, a peculiarity exhibited to a much lesser degree by transverse vibrations in a solid. Recently, however, ultrashort waves have been experimented with and the fact that they also have the same property was hailed as a great discovery, offering the stupendous promise to make wireless transmission infinitely simpler and cheaper.

It is of interest to know what wireless experts have expected, knowing that waves a few meters long are transmitted clear to the antipodes. Is there any reason that they would behave radically different when their length is reduced to about half of one meter?

Waves Go Around World

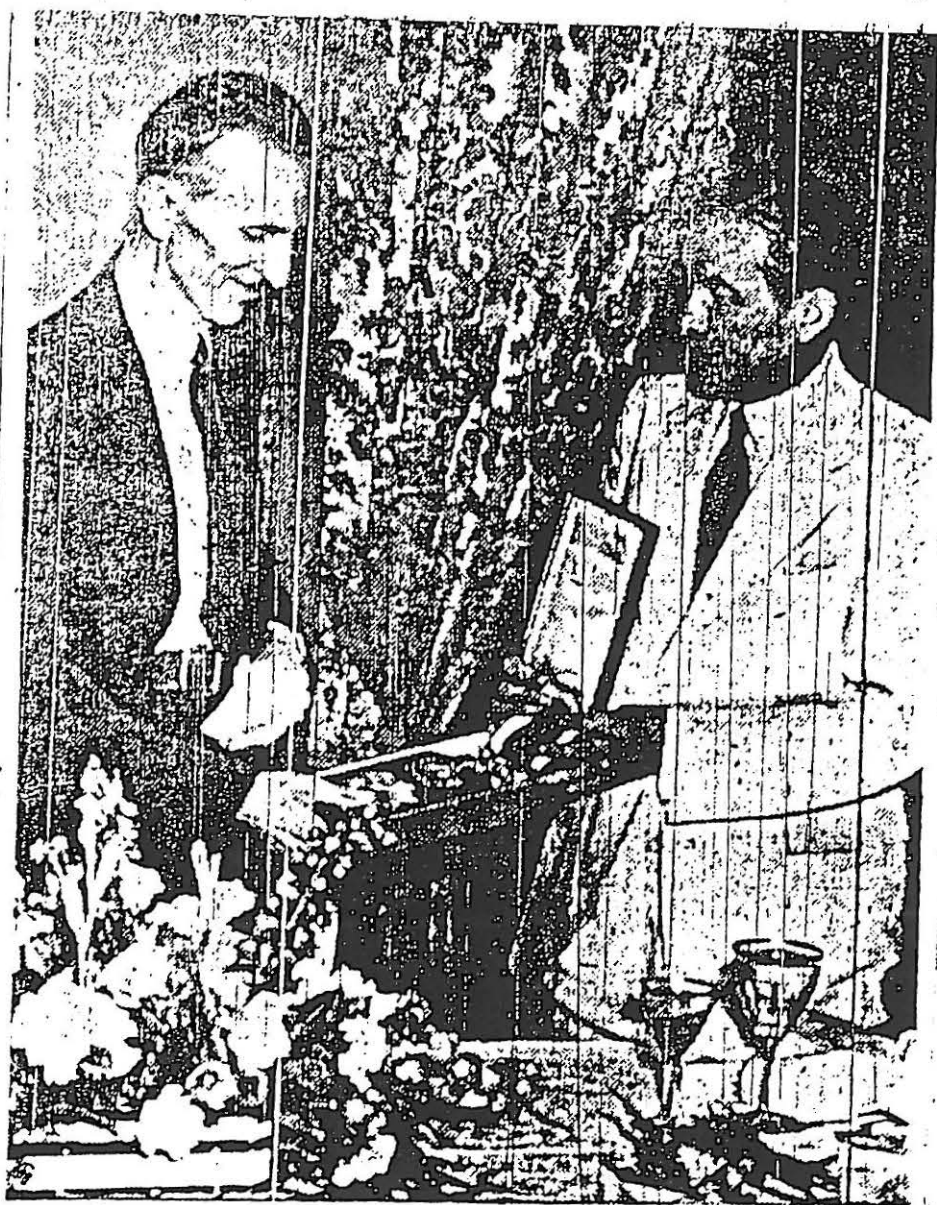
As the general knowledge of this subject seems very limited, I may state, that even waves only one or two millimeters long, which I produced thirty-three years ago, provided that they carry sufficient energy, can be transmitted around the globe. This is not so much due to refraction and reflection as to the properties of a gaseous medium and certain peculiar action which I shall explain some time in the future. At present, it may be sufficient to call attention to an important fact in this connection, namely, that this bending of the beam projected from a reflector does not affect in the least its behavior in other respects. As regards deflection in a horizontal plane, it acts just as though it were straight. To be explicit the horizontal deviations are comparatively slight. In a proposed ultrashort wave transmission, the vertical bending, far from being an advantage, is a serious drawback, as it increases greatly the liability of disturbance by obstacles at the earth's surface. The downward deflection always occurs, irrespective of wave length, and also if the beam is thrown upward at an angle to the horizontal, and this tendency is, according to my finding, all the more pronounced the bigger the planet. On a body as large as the sun, it would be impossible to project a disturbance of this kind to any considerable distance except along the surface.

It might be inferred that I am alluding to the curvature of space supposed to exist according to the teachings of relativity, but nothing could be further from my mind. I hold that space cannot be curved, for the simple reason that it can have no properties. It might as well be said that God has properties. He has not, but only attributes and these are of our own making. Of properties we can only speak when dealing with matter filling the space. To say that in the presence of large bodies space becomes curved, is equivalent to stating that something can act upon nothing. I, for one, refuse to subscribe to such a view.

Need Radio Channels

The chief object of employing very short waves is to provide an increased number of channels required to satisfy the ever-growing demand for wireless appliances. But this is only because the transmitting and receiving apparatus, as generally employed, is ill-conceived and not well adapted for selection. The transmitter generates several systems of waves, all of which, except one, are useless. As a consequence, only an infinitesimal amount of energy reaches the receiver and dependence is placed on extreme amplification.

Sending of Messages to Planets Predicted by Dr. Tesla on Birthday



Times Wide World Photo.

Nikola Tesla, at left, receiving the Order of the White Lion from Vladimir Hurban, Minister from Czechoslovakia, at the luncheon for the former yesterday.

**Inventor, 81, Talks of Key to Interstellar Transmission and
Tube to Produce Radium Copiously and Cheaply—
Decorated by Yugoslavia and Czechoslovakia**

Reports of discoveries by which it will be possible to communicate with the planets and to produce radium in unlimited quantity for \$1 a pound were announced by Dr. Nikola Tesla yesterday at a luncheon on his eighty-first birthday at which he was honored with high orders from the Yugoslav and Czechoslovak Governments.

Dr. Tesla, whose discoveries in electrical science have won for him recognition as the father of modern methods of generating and distributing electrical energy, asserted his "absolute" belief that he would win the Pierre Guzman prize of the Institute of France for his discovery relating to the interstellar transmission of energy.

Following his annual custom, Dr. Tesla played host to a group of newspaper men at his birthday luncheon at the Hotel New Yorker and issued the announcement of his discoveries of the last year. No apparatus or sketches were shown, but Dr. Tesla said in announcing perfection of the principle of a new

tube, which he said would make it possible to smash the atom and produce cheap radium, that he would be able to give a demonstration in "only a little time."

Guests at Dr. Tesla's luncheon included Constantin Fotitch, Minister from Yugoslavia; Vladimir Hurban, Minister from Czechoslovakia; R. Petrovich, first secretary of the Yugoslav delegation; B. P. Stoyanovitch, Yugoslav Consul General in New York; Dr. J. Namecek, counselor of the Czechoslav Legation, and J. Hajny, Acting Consul General in New York for Czechoslovakia.

Presenting to Dr. Tesla the Grand Cordon of the White Eagle, highest order of Yugoslavia, Mr. Fotitch announced it was the first time the order had been granted to an American for civil accomplishments. The honor was bestowed by order of King Peter through the Regent, Prince Paul.

