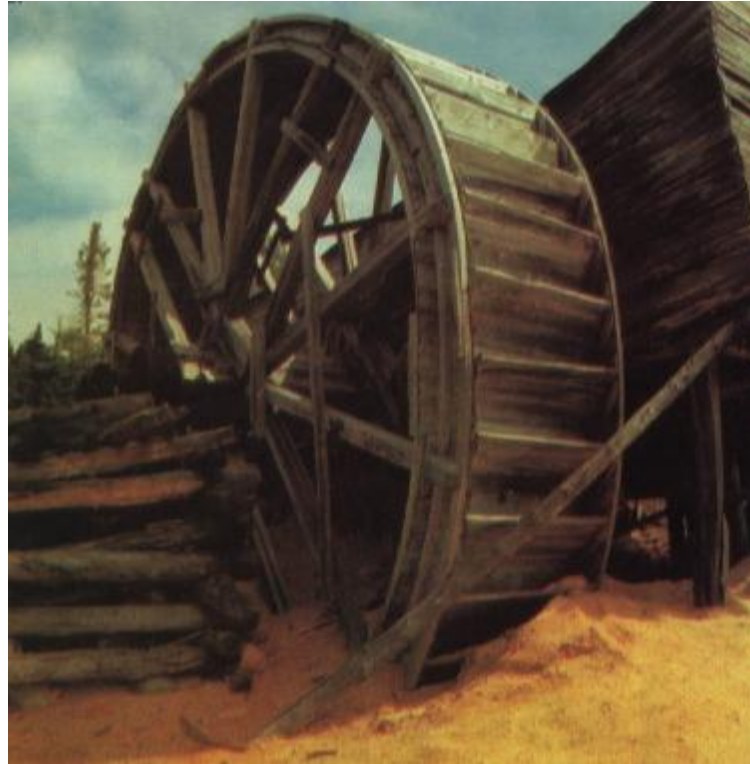


WATER POWER SAWMILLS IN NEWFOUNDLAND



**Written and Illustrated
By
Alexander Robertson**

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PREFACE

This book is mainly the result of a family effort over the past three years. During the summer months the 'research crew' consisted of my wife, Geraldine, our son, Stirling (who was two-and-one-half years old when we began studying old sawmills), and myself. The winter months, when we were confined to the environs of St. John's, offered time for reflection on past summer activities and opportunity for research, writing, drawing and building working models. During our research we travelled extensively throughout Newfoundland and Great Britain and, in the process, we experienced great satisfaction from these wonderful old mills of yesteryear.

The above points are worth noting because it shows that it has a fascination for all ages. I suppose this book might have some merit as an industrial archaeological project - we hope so. But, as a family project, it was all fun and games. The picnics beside the babbling mill brooks amidst peaceful and beautiful forest scenery; the excitement of discovering medieval books in some dusty corner of a library; the pleasures and satisfaction in building a working model sawmill; the acquaintance of many new friends we met on our travels. But perhaps, more importantly, we experienced for ourselves that these dishevelled old mills are not merely useless brutes from the past, like some old stone relic in a glass cage that only experts can appreciate. On the contrary, mills are active places. While adults may marvel at the ingenuity of our ancestors, little children like Stirling in their fantasies see leprechauns and other fairytale heroes behind every cog and wheel; in short, to a child old watermills are great big oversized toys inhabited by all the imaginary friends their active minds can dream of. The fairytale stories of magic wee folk conjured up by a lively, excited little boy gave us the sort of precious memories that all parents treasure. Like hundreds of families, our visits to the old mills are more than just a peek at the past. It is the living experience that strengthens and educates us for greater fulfillment of our role in the future. That is why these old mills are more valuable to us now than they were in the past. That is why this book was written; for, although we have not the resources to buy and restore an old mill, which we would love to do, at least we hope this book will draw attention to a valuable historic resource that will become extinct. Surely there is someone with influence and means to preserve at least one old mill for future generations to enjoy; that we can leave something aesthetic behind that in a real way will help strengthen the moral fabric of family life in our society.

Waterwheels

*Cease from grinding, oh you toilers; women slumber still,
Even if the crowing rooster calls the morning star.
For Demeter has appointed nymphs to turn your mill,
And upon the waterwheel alighting here they are.
See how quick they twirl the axle whose revolving rays
Spin heavy rollers quarried overseas.
So again we savor the delights of ancient days,
Taught to eat the fruits of Mother Earth in ease.*

Antipater of Thessalonica!c. 85 B.C.)

This poem by Antipater of Thessalonica is one of the earliest references to waterwheels. The first water mills were very simple in which the grindstone in grist mills was direct driven by a vertical shaft turned by a horizontal waterwheel somewhat like the 19th century turbines. Later,

in the 1st century A.D., VITRUVIUS, a Roman engineer, described a vertical waterwheel in which the power was transmitted to the grindstone by a series of simple gears. As far as we know these early waterwheels were used only in flour mills and their adaptation to other uses to lessen human toil developed slowly. In fact, the advancement of technology was

frowned upon by the educated and the influential of the Roman Empire as a threat to their status quo. The abundance of slave labour, upon which the Roman economy was based, depressed the inventiveness of craftsmen and technicians. Indeed, so slowly did technology progress in the Roman Empire that large flour mills like one at Barbegal, near Arles in France, which existed in the 2nd and 3rd century A.D. and had sixteen waterwheels that drove thirty-two mills (Moritz, 1958), were a rarity (Plate 1).

At the dawn of the Middle Ages, when Rome lost its mastery, the slave population decreased and labor shortages became a problem. While Rome decayed the 'barbaric' nations on the fringe of the Empire prospered. They prospered because of their resourcefulness which has been depressed by the inequalities of Roman occupation. In fact, it was these so-called barbarians, not the Romans, who laid the foundations of our modern technological society. The 'barbarian' inventors focused on the harnessing of water power by the use of the waterwheel to drive diverse machinery that would ultimately lead to a more equalitarian society in the Middle Ages. In this new order of civilization the respectability of the craftsman and technician rose to new heights. Consequently, a surge of inventiveness ensued heralding the dawn of our modern industrialized society. The waterwheel had as profound an effect on civilization then as our space age technology does now.

By 1000 A.D. almost every hamlet in south western Europe had a watermill. In England, the Domesday Book in 1086 recorded over 5,600 watermills south of the rivers Trent and Severn. They were still mainly flour mills, although by this time water driven fulling mills, forge hammers and bellows had been invented. Waterwheels were also adapted for irrigation using, among other contrivances, an ancient Egyptian spiral, known as the Archimedean screw, for lifting water. The technology of this period was certainly capable of constructing a water-powered sawmill but we have no evidence of such a sawmill in the 11th century.

About 1235 A.D. VILLARD DE HONNECOURT provided us with the earliest record of a water-driven automatic sawmill (Plate 2). Here we see for the first time the **perpetuum mobile** - a wheel with a number of hammers which continuously pushed the log towards the saw. The concept of automation was further extended along the prime mover by trip hammers which pushed down on a movable stake attached to a guide bar on the lower end of the saw. After the trip hammer had completed its downward thrust the saw was pulled upwards by the spring action of a branch attached to the top of the saw.

During the renaissance the waterwheel had become the prime mover **par excellence**. It became an industrial tool of major proportions and "Without it," wrote BIRINGUCCIO in 1540, "you would wear out an infinite number of men". The 15th century manuscripts of FRANCESCO DI GIORGIO MARTINI (1439-1502) and LEONARDO DA VINCE (1452-1519) show a wide variety of water-driven machines. Francesco Di Giorgio Martini's manuscript has a drawing of a workable automatic sawmill with cams, ratchets and rocking shaft. Leonardo da Vinci was the leading hydraulic and mechanical engineer of his time and although there are no drawings of sawmills in his manuscripts he was doubtless familiar with them. One particular invention of Leonardo's was the roller bearing, which he called "those marvels of mechanical genius". Another of his inventions was a turbine identical in principal to the Kaplan turbine. Neither the bearings nor the turbine came into widespread use until the 19th century when, as with many of Leonardo's machines, the sophisticated engineering, tolerances and workmanship of modern technology became sufficiently advanced enough to manufacture them.

Albeit, the 16th century renaissance technology did progress considerably in the art of mechanization. Very large waterwheels, up to 40 feet in diameter, were constructed for the mining industry by GEORG AGRICOLA. In Agricola's book **De re metallica** (1556) we see examples of large complex mine pumps, winches and conveyors driven by waterwheels. But perhaps the most celebrated engineer of the 16th century was Agostino Ramelli whose beautifully illustrated book **Le diverse et artificiose machine...** (1588) is a masterpiece in renaissance technology. Ramelli's book contains almost 200 engraved plates illustrating a wide variety of machines including two stone-cutting sawmills and one

wood-cutting sawmill. One of the stone-cutting sawmills was horse-driven. The other had two waterwheels - a vertical waterwheel as the prime mover and a smaller encased horizontal waterwheel used as a booster for a grindstone to give the mill its dual function as a sawmill and grist mill.

The renaissance was also a period of colonial expansion in the New World - the Spanish in South America, the French and later the British in North America. The French and British fought for mastery of the rich fishing grounds on the Grand Banks off Newfoundland. The Portuguese, too, frequented the Grand Banks for the bountiful cod. But the settlement of the barren coastline was seasonal; the merchant ships which came in the spring returned in the fall to their own lands laden with fish and other bounties of the New World.

In 1610, SIR JOHN GUY established the first English colony in the New World at Cuper's Cove, Newfoundland (Howley, 1908 and Guy, 1972). Among his terms for the new colony he was to have "sawyers to mend boats to supply pine boards, whereas ye shall have plenty when the saw is set up". And so it was that the first recorded sawmill was established in North America. Although we cannot be sure of the design of Guy's sawmill, Plate 3 illustrates the principle of a 16th century renaissance sawmill. In 1611 we read from Guy's letters that his sawyer THOMAS PERCY died of remorse on December 11th, having confessed to committing a murder before leaving England. The main colony was located where the little village of Cupids is now. The sawmill, grist mill-, farm buildings, and several pit saws he built later, were located at South River, adjacent to Clarke's Beach. In 1620 Guy complained that "...great damage was done by certain English fishers to a sawmill and grist mill built by the plantation, not to be repaired for forty pounds". In 1908 archaeologists uncovered the saw-pit, oak beams, grind stones and other remnants of Guy's mill (James, 1910). Unfortunately, I have not been able to locate these artifacts and the site has recently been destroyed by urbanization. When John Guy's colony failed the sawmilling industry in Newfoundland, however rudimentary, was literally non-existent until the 19th

WATER WHEEL SAWMILLS IN NEWFOUNDLAND

At the turn of the 19th century the Rev. John Jones, attempting to build a church in St. John's, complained of the difficulty in buying locally produced lumber, which, even at its best, was inferior (Anonymous, 1975). In those days it was thought wiser and cheaper to import lumber from Halifax than to buy it locally. Although watermills were built at Waterford Bridge Road and Rennie's Mill Road in St. John's during the 19th century (Photos 1 and 2), these were flour mills and I can find no trace or documented evidence of waterwheel sawmills having ever existed in the environs of St. John's. Mills (1968), studying the lumbering community of Shoal Harbour, Trinity Bay, showed that water wheel sawmill operations of several communities in Northwest Arm began in the 1850's. Also during this period waterwheel sawmills were built in other communities around Newfoundland as the population increased.

The design of the water wheel in Newfoundland sawmills was basically the same as those of the 15th century. However, there the relationship ended, for the vertical motion of the 15th century sash saw gave way to the rotary motion of the circular saw; instead of cams, rocker shafts, pawls and ratchets, there were geared pit wheels and counterbalance (jackshaft), drum wheels and mandrels, and push benches and roller bearings.

With the building of the trans-Newfoundland railway at the close of the 19th century the demand for lumber was at a premium. Several large sawmills which were built owed their existence entirely to the railway since most of their produce went into railway construction. These mills were generally powered by steam engines, although at least two were water-powered turbine sawmills. In 1893 an estimated 20,000,000 board feet of lumber was produced in Newfoundland at a market value of \$15.00 per thousand feet (Prowse, 1896). In 1900, according to James (1910) there were 200 sawmills in Newfoundland, employing 2,400 men. These sawmills processed 1,500,000 logs with a market value of \$480,000 for the finished product which would be valued at \$5,000,000 in 1979. Despite the large number of mills there were still very few substantial sawmills like those, for example, at Botwood, Gambo, Terra Nova, Soulis Brook and Gander Crossing, which together produced a total of approximately 5,000,000 board feet annually in the early 20th century. For the many small sawmill operators the old-fashioned waterwheel was the rule rather than the exception and it was estimated that there were more than 150 of these mills in Newfoundland at the turn of the century. In an average season a waterwheel sawmill would produce about 30,000 board feet. This was generally rough-sawn lumber which was bought in bulk by the large sawmill owners and resawn.

Up to 1940 waterwheel sawmills maintained their dominance in some areas of the Province, while co-existing with diesel and gasoline powered sawmills in other areas. The greatest concentration of waterwheel sawmills was undoubtedly in Smith Sound and North West Arm in Trinity Bay. The best known of these were at Popes Harbour Brook, Popes Harbour Pond, British Harbour, Rexton Harbour, Monroe, Maggotty Cove, Pissin Mare, Foster's Point, Shoal Harbour, Milton, Adeytown and Deep Bight. Many of these small communities had several mills each. At Deep Bight there were at least four mills and several more in nearby Adeytown. In 1941 J.R. Smallwood, later to become Premier of Newfoundland, noted that there were three sawmills in Deep Bight and, incidentally, one radio. Some of the mills were associated with ship building like those built by the ship building families of Capt. Stone at Monroe and Frampton's at Gin Cove. The Shoal Harbour sawmill built by the Mills family was associated with cooperage.

Another area with a heavy concentration of waterwheel sawmills was Bonavista North, from Trinity South to Gambo, Glovertown and Clode Sound. Other areas noted for waterwheels were St. Mary's Say, at St. Joseph's, Salmonier and Colinet; Placentia Bay, at Swift Current, Merasheen Island and Little Harbour; and Conception Bay, at Colliers and Maher's Siding. On the Northern Peninsula there were at least three waterwheel sawmills in Bonne Bay, one at Main Brook, which was still standing in the early 1960's; one at Croque and Great Cat Arm.

In 1939-40 there were 790 licensed sawmills in Newfoundland employing 6,500 men (MacKay, 1946). Together they produced 27,250,000 board feet of lumber annually; but of these only 149 mills produced more than 35,000 board feet each. Ironically, the business element in St. John's, complained Mackay, were not forest conscious; which must have had a negative effect on the development of a more substantial sawmilling industry. Nevertheless, according to Mackay, the number of sawmills had risen to 900 by 1946, employing 7,000 men, or 7.4% of the labor force.

It would be difficult to estimate how many of these small sawmills during the 1940's were powered by waterwheels. It is obvious, though, that during this period compact, portable diesel and gasoline engines were dominant and waterwheels were soon to become a thing of the past. The new engines were safer, more efficient, gave constant speed control, and could be operated year round. No longer did the sawyer have to build those cumbersome waterwheels and pit wheel gears, dams and water chutes; nor did he have to rise at five in the morning to open one dam and close another; or be subject to inadequate water supply caused by droughts in the summer and freezing in the winter; in short the age-old

waterwheel had finally outlived its usefulness. As the lone survivor of another age the decayed and dishevelled old sawmill at Deep Bight persists - much to the delight and sympathy of its frequent admirers. The Deep Bight sawmill was built in 1905 by Mr. Wallace Avery of Deep Bight, Trinity Say. At that time there were other sawmills in the area but there is no trace of the others.

TURBINES SAWMILLS

Water turbines are essentially lateral water wheels; having evolved from the ancient horizontal waterwheel as noted earlier. Because of limitations on their size, the ancient versions were never as popular as the huge vertical waterwheels. Until Leonardo da Vinci conducted studies on hydraulics the dynamic forces on horizontal water wheels were never understood. As mentioned previously Leonardo's drawing of a turbine (Codex Atlantic, Folio 258 rb) is identical in principle to the modern Kaplan turbine. The submersed horizontal water wheel designed by Agostino Ramelli (1588) was a variation of Leonardo's turbine and was used extensively in the 16th century. But the principle of blades in a close-fitting case that Leonardo designed was a difficult hydrodynamic problem from a practical standpoint and it was never perfected until much later.

In 1629 GIOVANNI BRANCA proposed an impulse steam turbine. The idea, of course, was an extension of the steam turbine invented by HERO of Alexandria (c 1 B.C. - 75 A.D.). The theoretical works of EULER in the 1750's (Klem, 1954) resulted in a commercial turbine, but it was not generally successful. Although Branca's and Euler's concepts were basically workable the high speeds, which involved close fitting and fast moving parts, required the kind of accurate workmanship and precision that were not achieved until the 19th century.

In 1823 the **Societe d'Encouragement pour l'industrie Nationale** in France offered a prize to anyone for the perfection of the turbine. The prize was awarded to CLAUDE BURDEN and BENOIT FOURNEYRON in 1827. Fourneyron's first turbine was only 6 h.p.; but later he built a 50 h.p. turbine. Thereafter, water-driven turbines became commercially successful and by 1855 larger turbines, capable of producing 800 h.p., were manufactured. About this time the Kaplan and Francis (American reaction wheel) turbines were introduced. Towards the end of the 19th century the Kaplan and Francis turbines were adapted to generate electricity rather than as prime movers for other industrial uses such as sawmills. Until recently the Francis turbine was still considered a valuable industrial tool. Unfortunately, there is no record of where or when it was first used in sawmilling. At least two Francis turbines were introduced to Newfoundland about 1885. Both were used exclusively for sawmilling in many parts of Newfoundland; for example, one at Whitbourne and another at Avondale. The turbine at Whitbourne was bought by the late Mr. Brown of Trinity, Bonavista North, about 1908 and is still in the possession of his descendants at Trinity who kept it in use until 1967. The turbine at Avondale was installed by a Mr. Clarke. The mill, now derelict, was maintained in its original condition and last operated in 1971.

The Avondale sawmill is probably the oldest existing sawmill in Newfoundland. There may have been an earlier sawmill on the same site built by a Kennedy family, but of this there are no records. The original Avondale sawmill was built in 1870 by William Lewis Clarke from Bristol, England and was powered by a water wheel. In 1892, the same -year the Great Fire destroyed most of St. John's, the mill and Mr. Clarke's house was burned to the ground. Shortly after a new mill was built and was powered by a Francis turbine. A shingle saw, manufactured by Charles

Smallwood of Truro, Nova Scotia, and a planer survived the fire and are still in good working condition. William Clarke's son Harold operated the mill until 1948 when he sold it to John Power, who later sold it to the present owner John Mason of Avondale (Mercer, 1970).

DEEP BIGHT SAWMILL

The Deep Bight sawmill was constructed entirely from local materials. Black spruce lumber was used almost exclusively, except for working parts, such as gear teeth, bench rollers, and bearing blocks, which were made from white birch. The roof covering was fashioned from flattened oil drums, and the counterbalance (jackshaft) and cog were salvaged from a ship's derrick winch.

When construction began on the Trans-Canada Highway in 1957 it seriously affected the watercourse; consequently, it was no longer possible to control the water by dams and chutes to drive the waterwheel. Shortly after the water wheel ceased to operate a diesel engine was installed as an alternate prime mover.

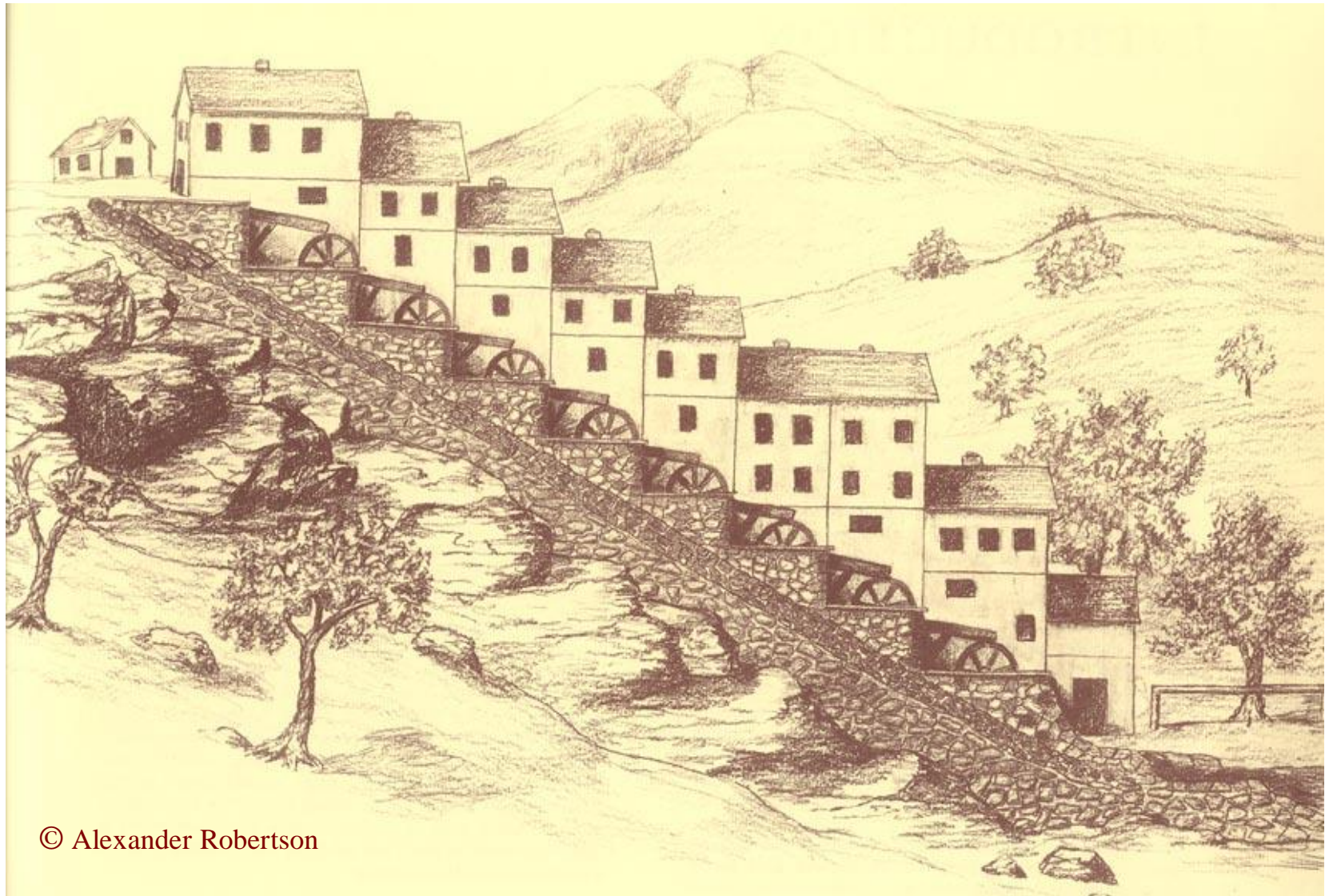
AVONDALE WATER TURBINE SAWMILL

The turbine and most of the workings of the Avondale sawmill were in excellent condition in 1978, but the building was badly deteriorating and parts of it had collapsed. Parts of the dam and sluice are still intact but most of the boards have rotted. A unique feature of the power train are the large wooden pulley wheels which were hand-made from local black spruce and white birch.

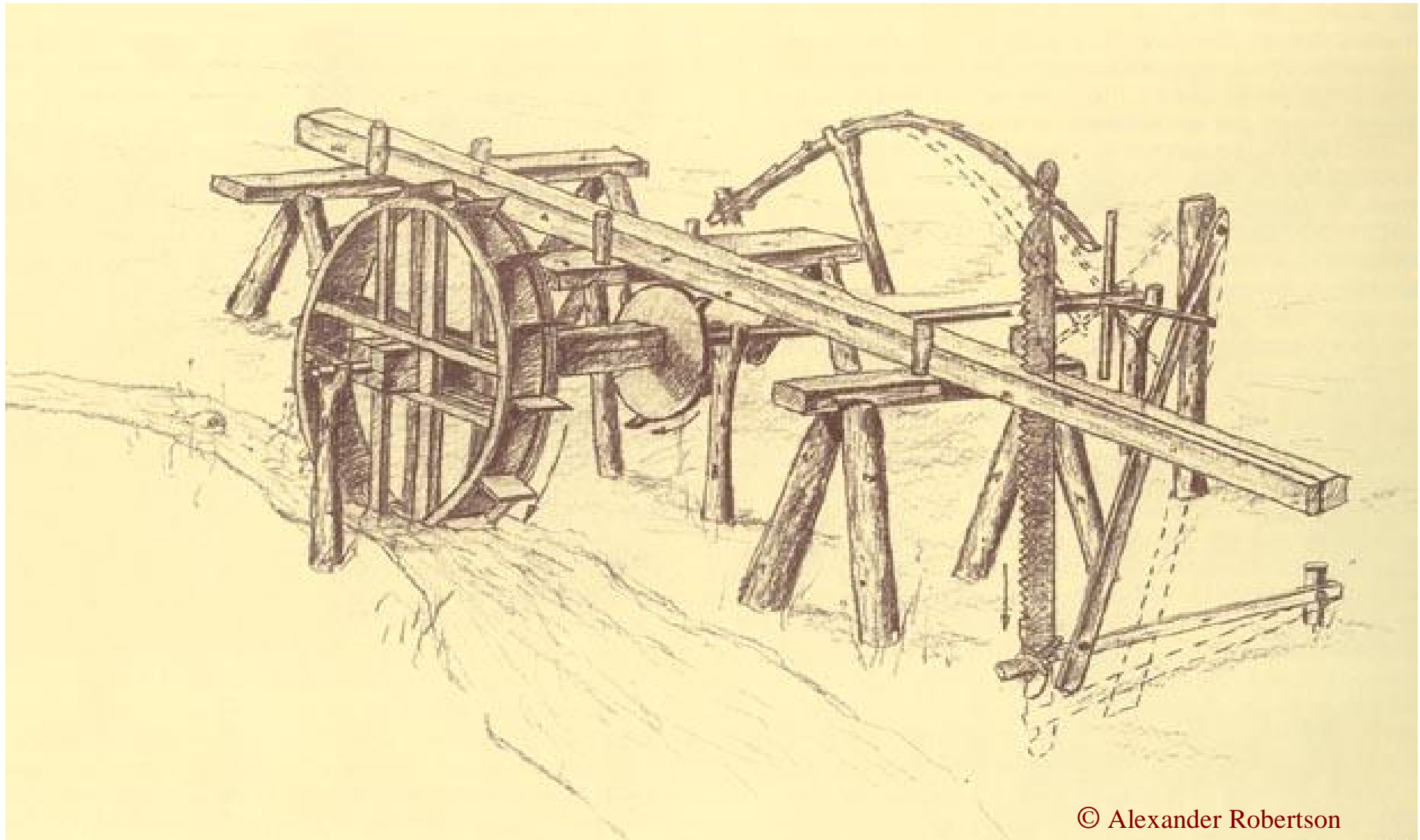
As a medium-sized sawmill the Avondale mill was capable of producing 1,000,000 board feet in one season. In addition to the production of studs, posts and planks, the mill also produced shingles, clapboard and matched lumber. Depending on the head of water a Francis turbine was capable of generating up to 120 hp, but at Avondale the maximum power generated was 50-60 hp when the river was high and under normal conditions at 30-40 hp. An unusual and original feature for controlling the vanes in the turbine, to control turbine speed, was the adaptation of an automobile pinion and crown gear set. Obviously the original control had broken and was replaced by the gear set. The following notes on plates and drawings explain the mill in more detail.

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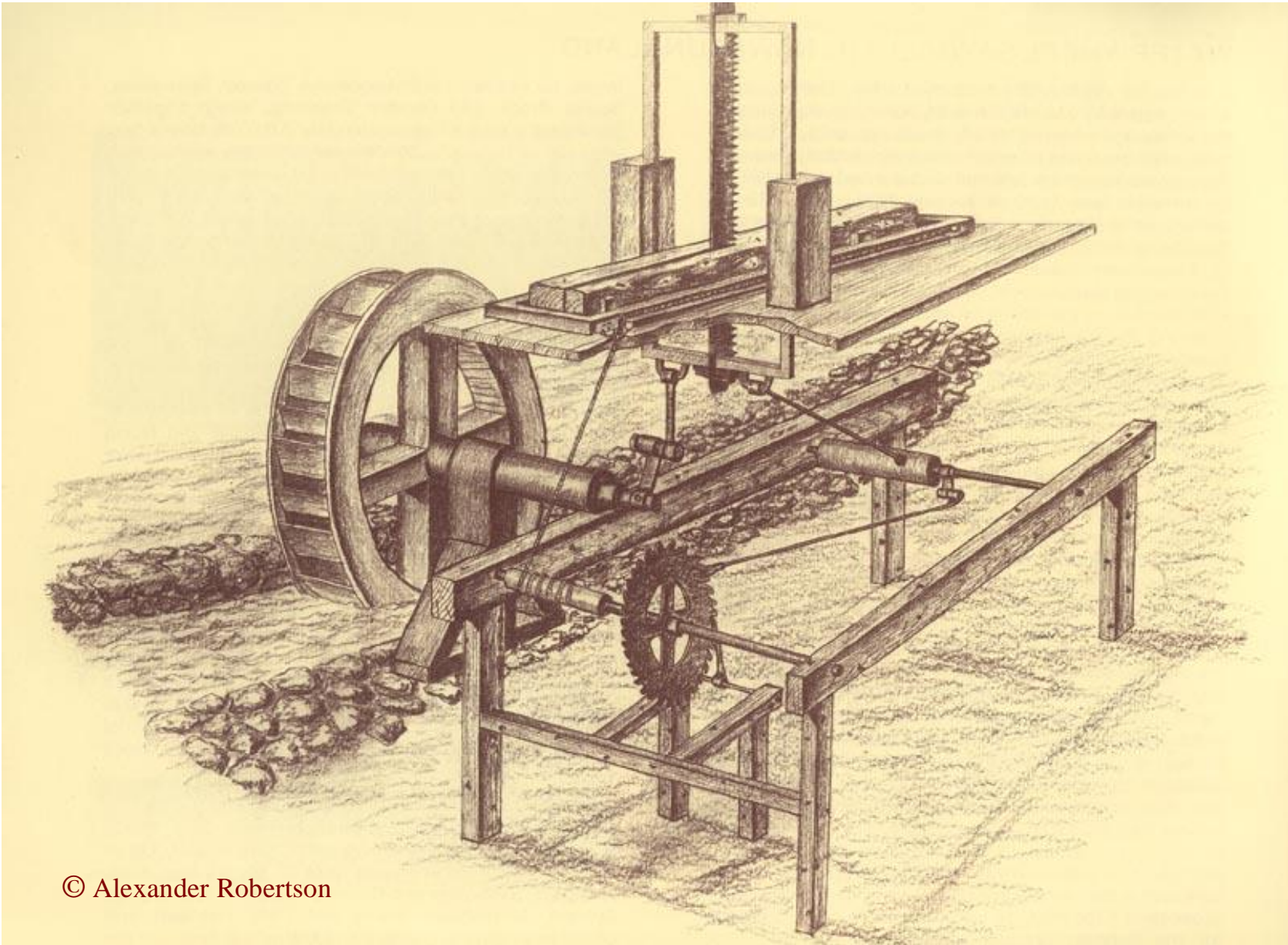
Historical Water Power Mills



Gallo-Roman Flour Mill (2nd Century AD) Barbegal near Arles,

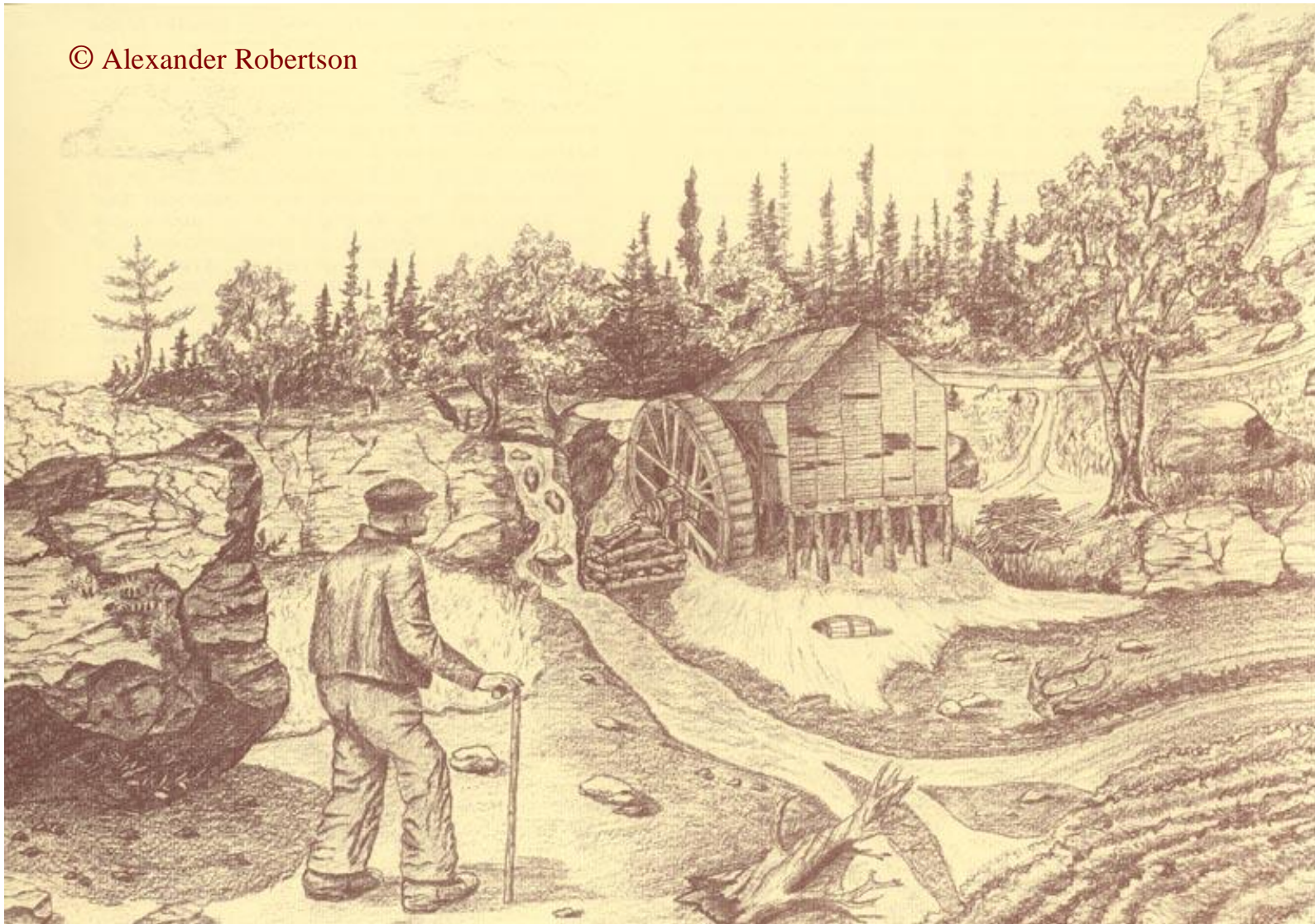


Villard de Honnecourt's concept of an automatic pit saw - c 1235 AD

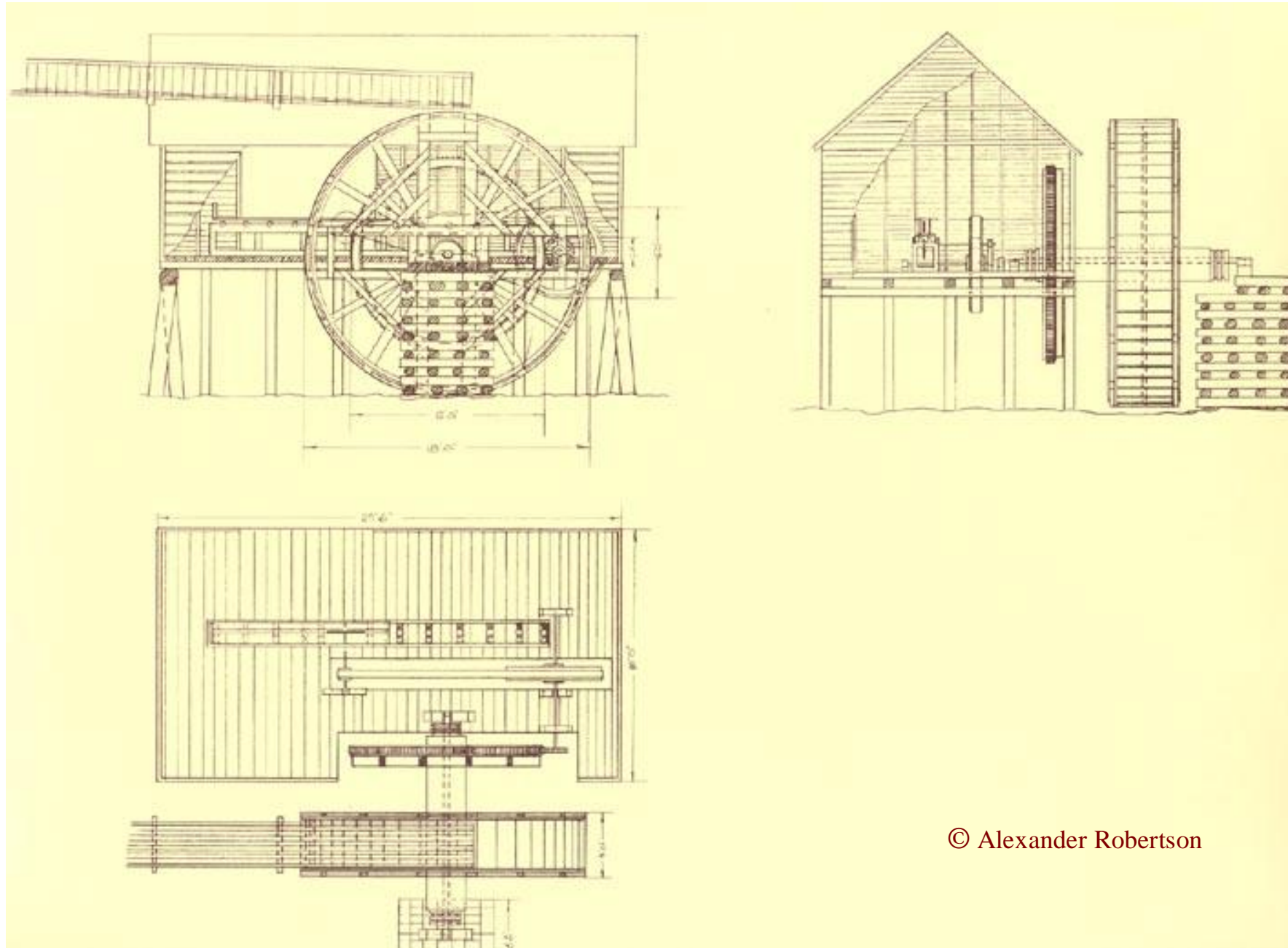


Concept of a typical 16-17th century water powered pit saw

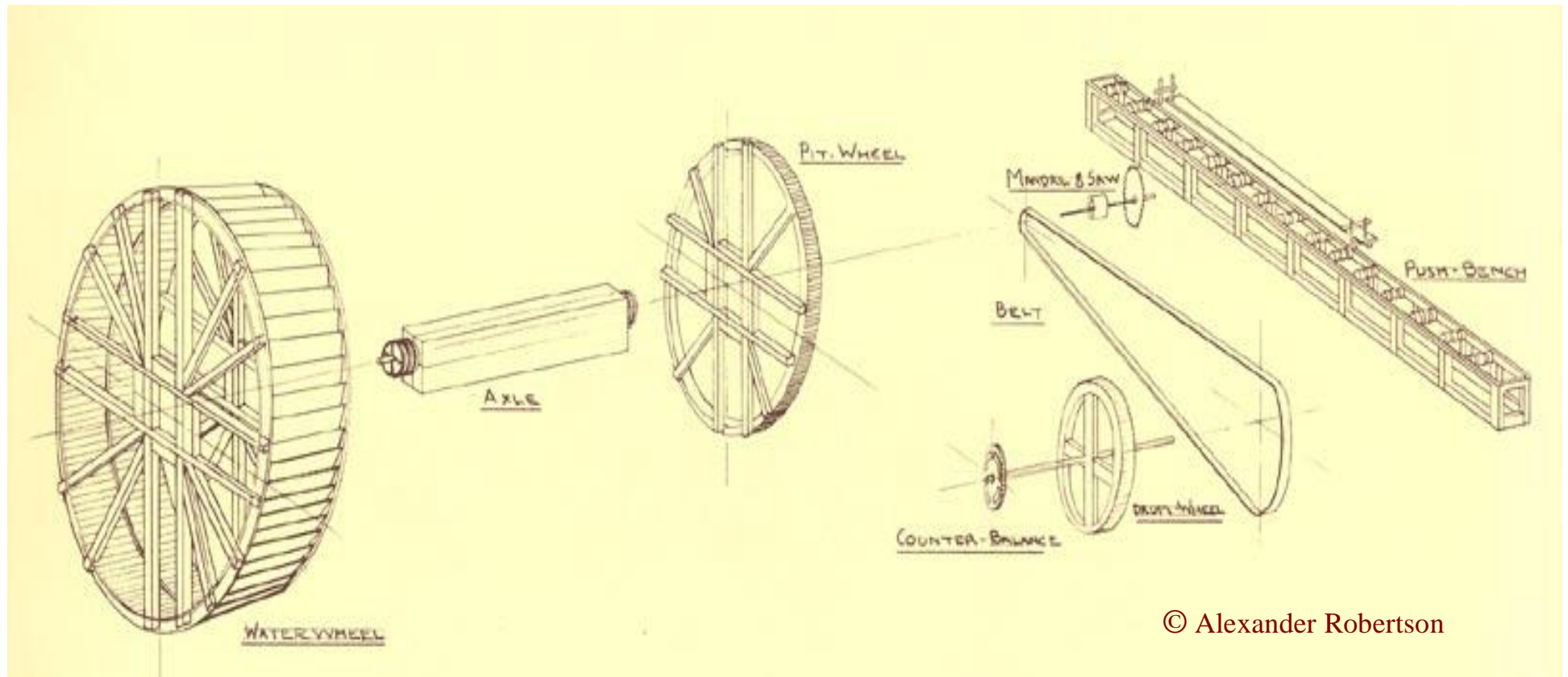
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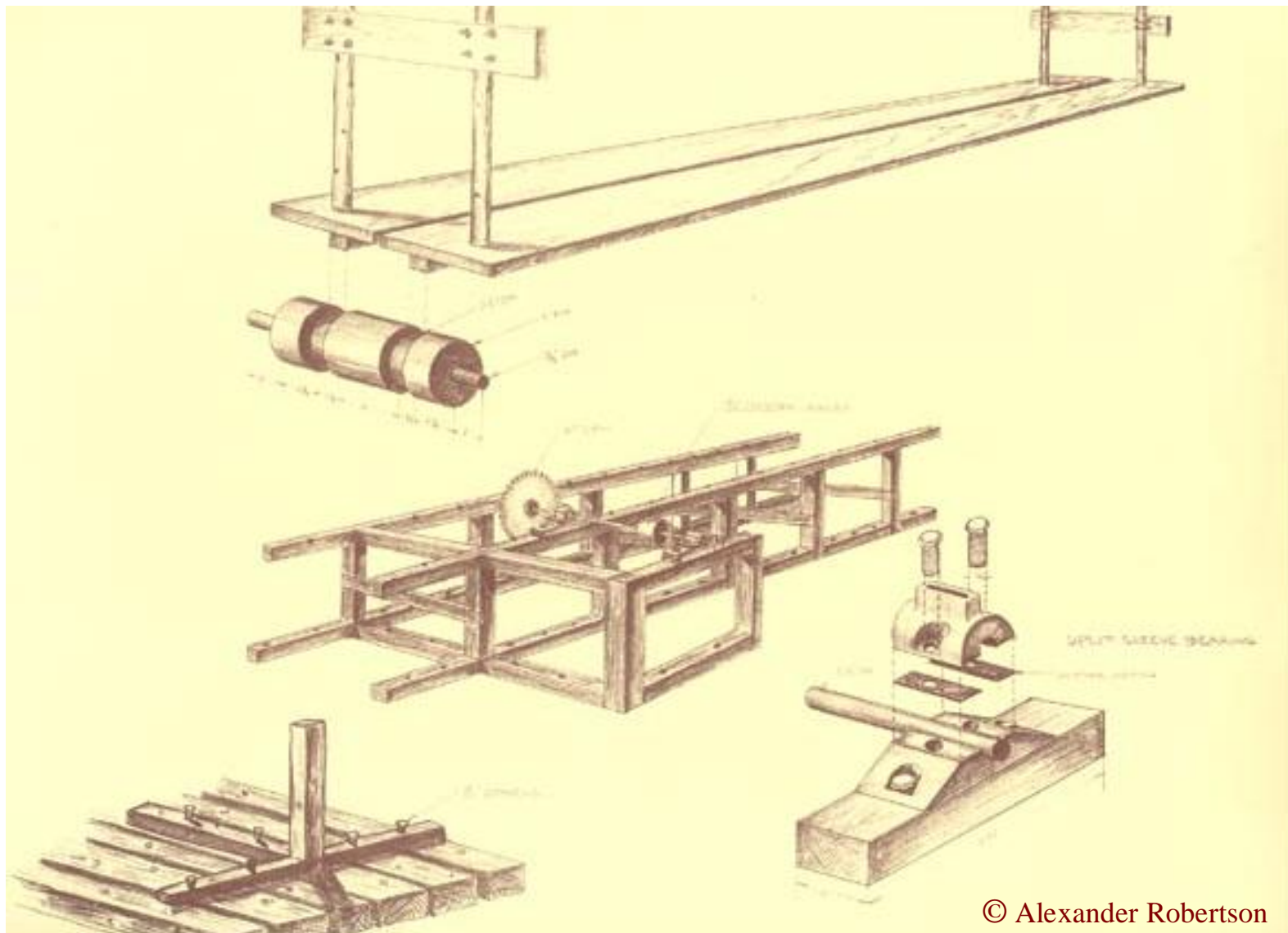
The landscape setting of the Deep Bite water wheel sawmill



Elevations of sawmill this drawing includes a plan, side elevation and rear- end elevation of the complete structure. part of the water chute is shown.

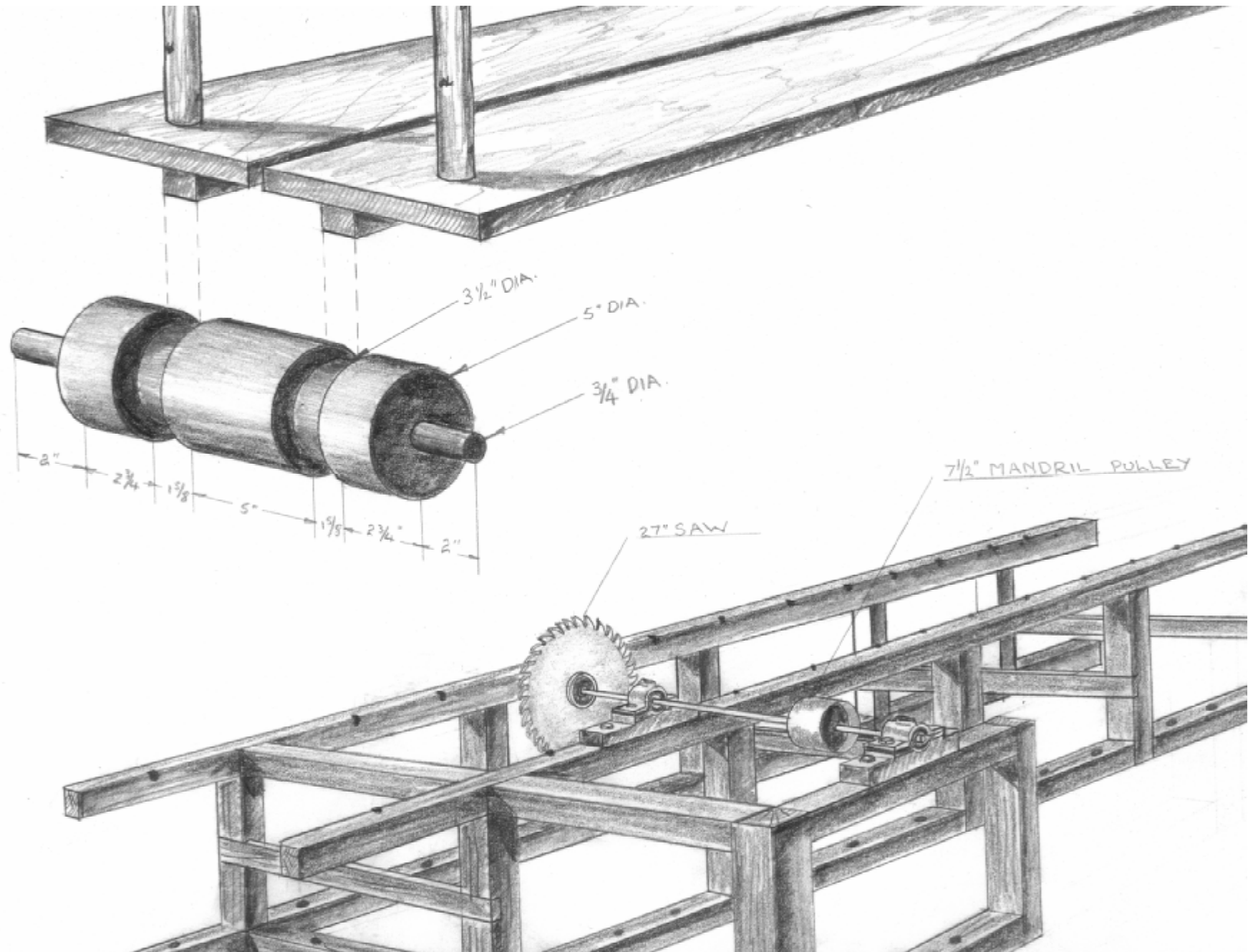


Exploded diagram of the main components of the sawmill

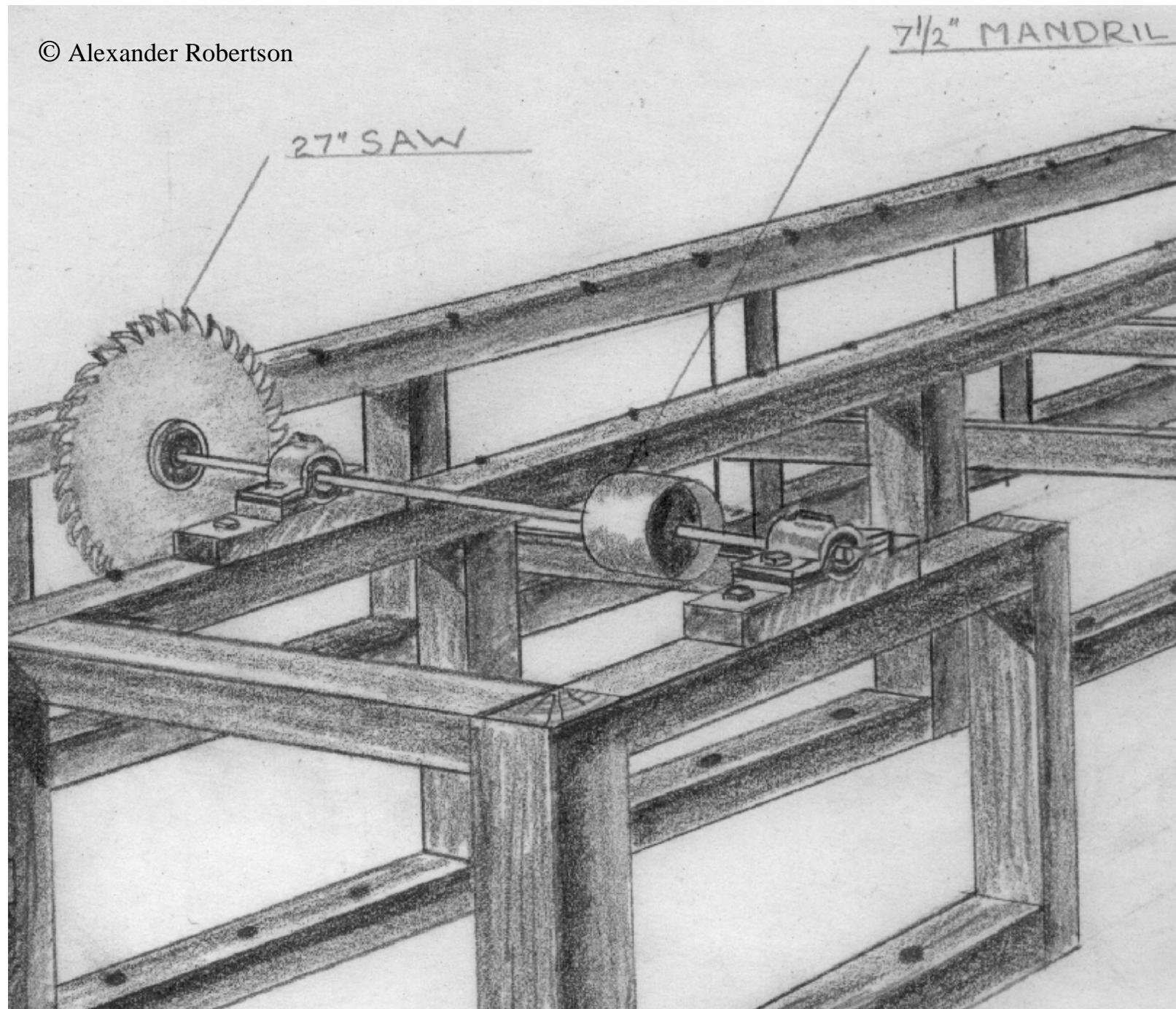


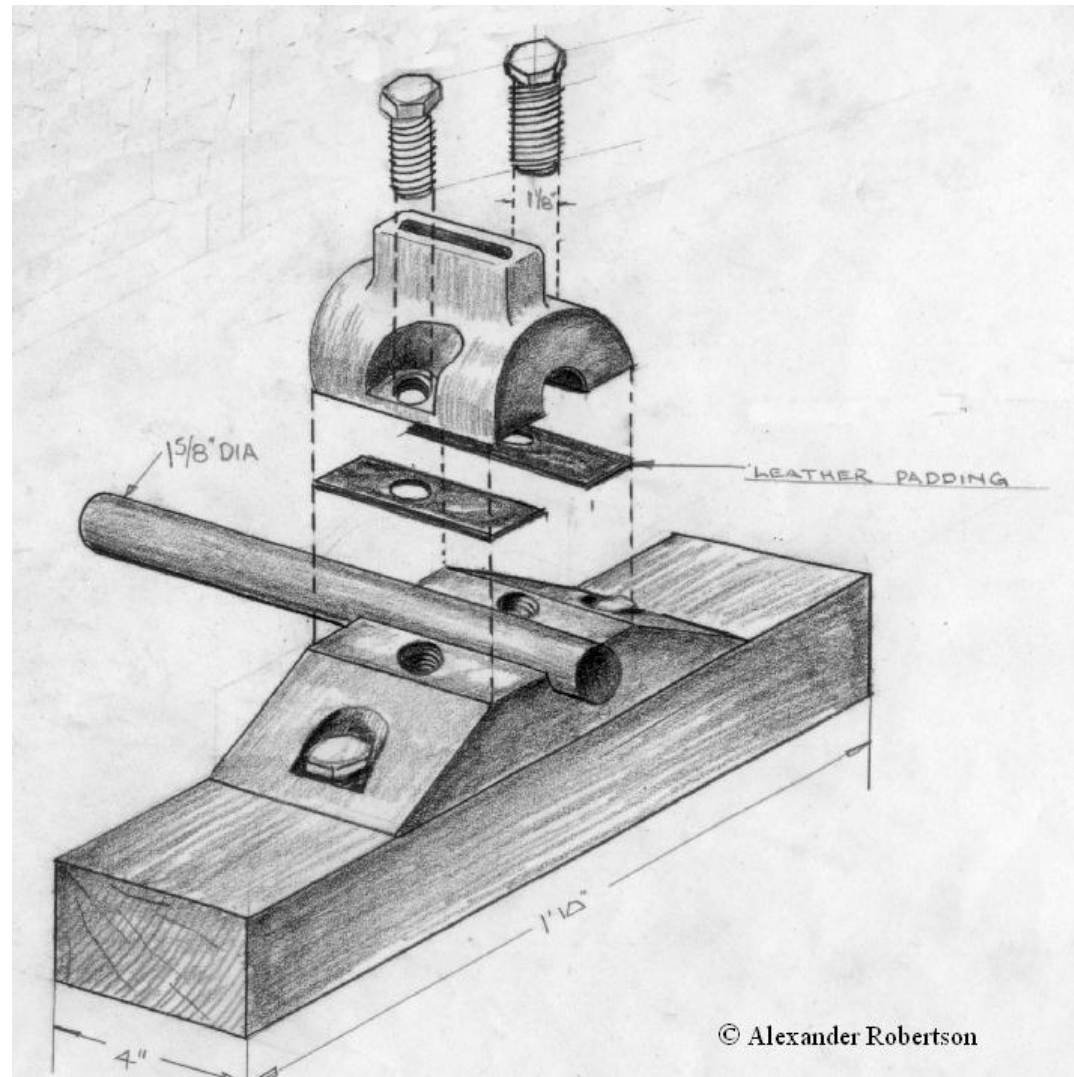
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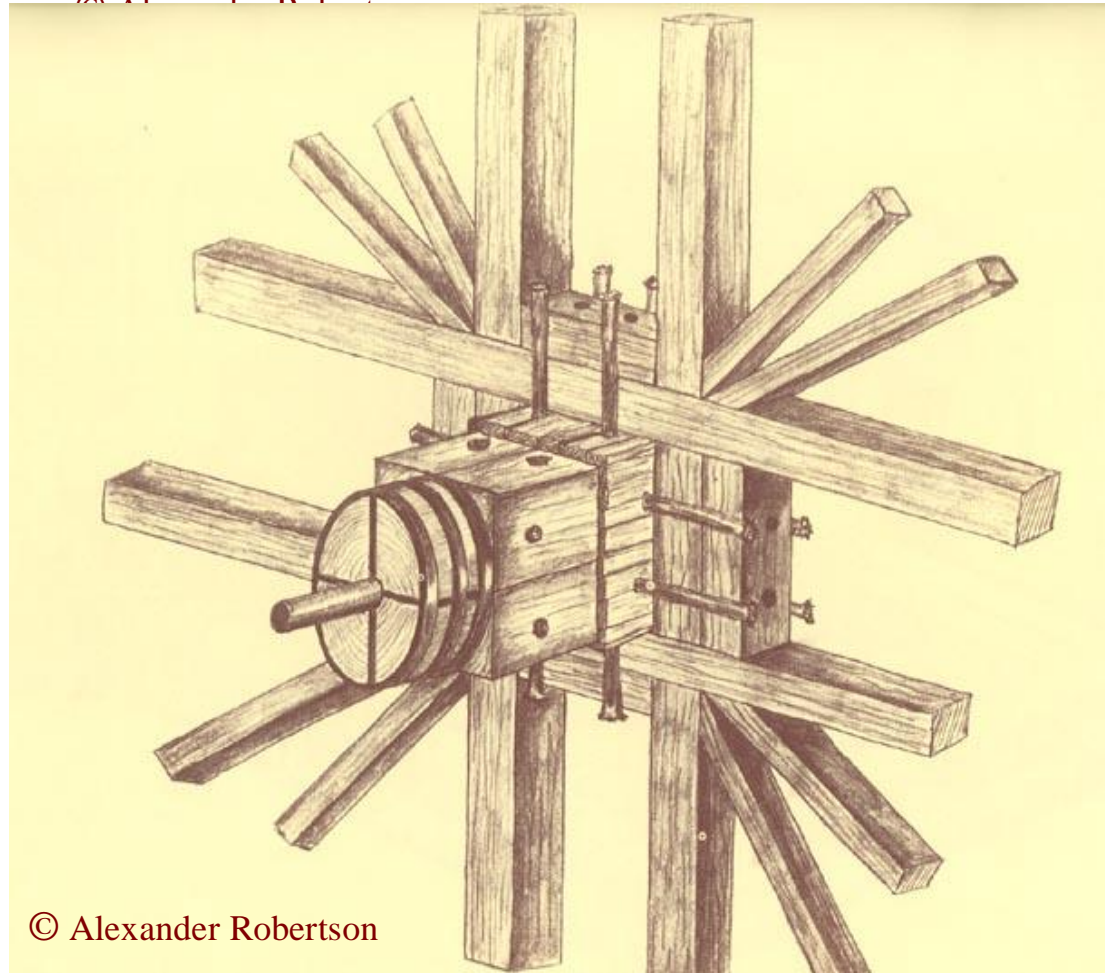
Exploded diagram of saw and bench This traditional arrangement of saw and bench is still widely used in small sawmills in Newfoundland. The bench is fastened to the floor by wooden dowels. Vibration in the split-sleeve bearings is reduced by leather padding between the top and bottom part of the bearing. The slot on top of the bearing is for lubricating with oil. The mandril and 27 inch circular saw are fairly standard equipment. The roller bearings and bearing blocks are made from local white birch. All other wooden components are made from black spruce.



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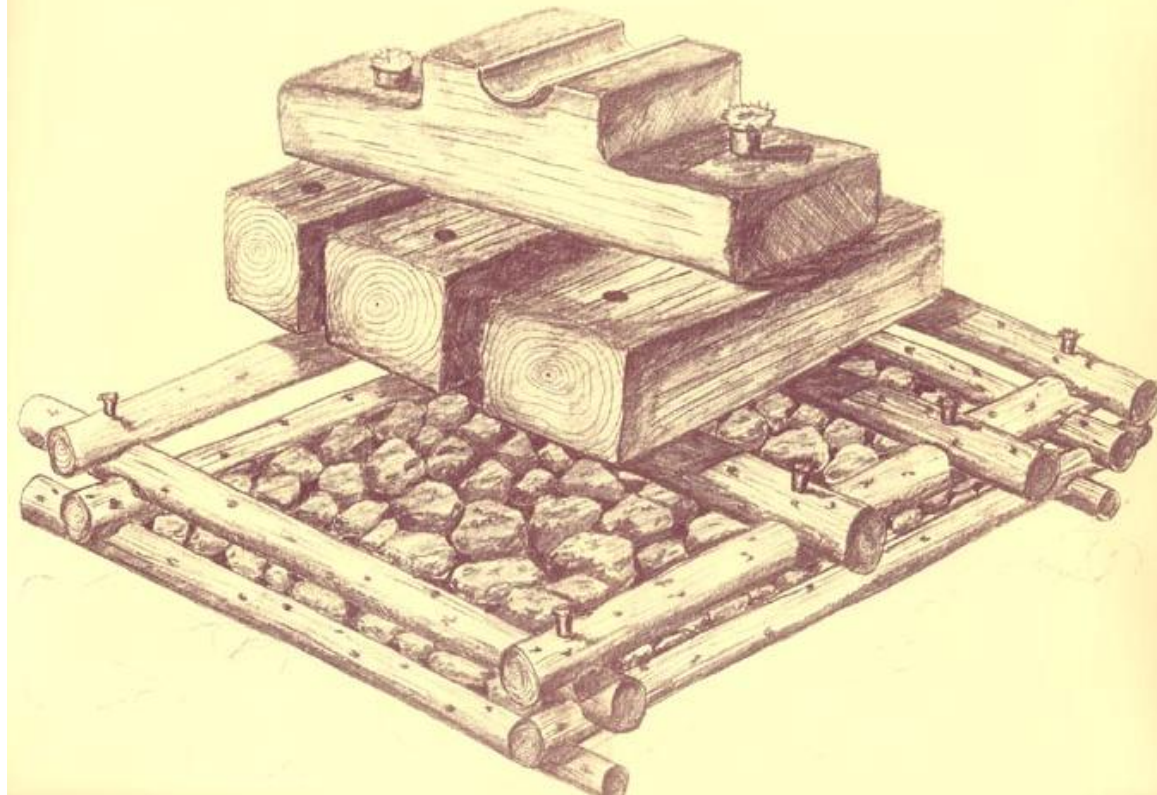




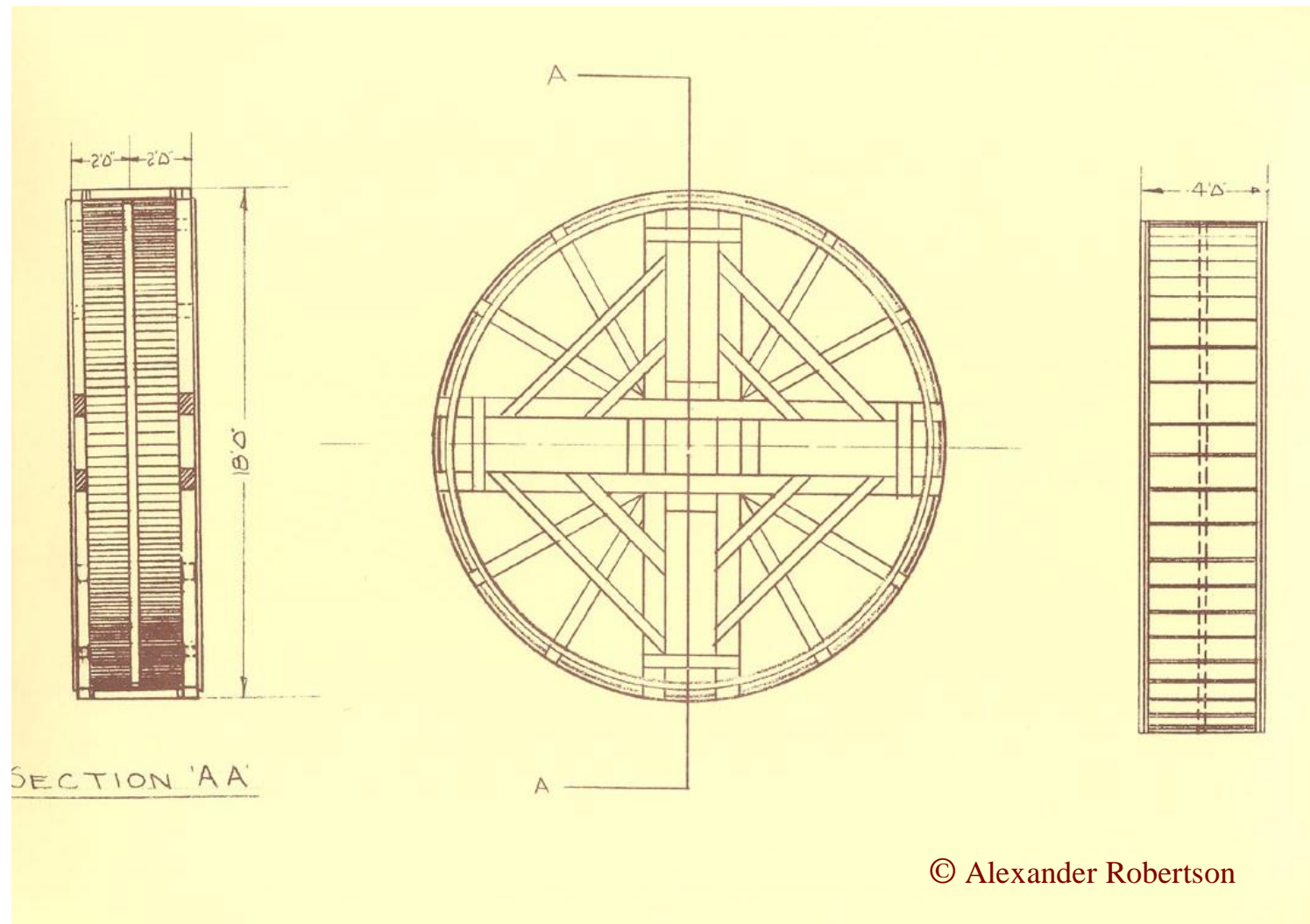
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ASSEMBLY OF AXLE AND WATER WHEEL The object of this perspective drawing is to show how the water wheel was kept in place on the axle by dowels and wedges. It was a simple process and, fortunately, resulted in few changes, so that although the mill continues in use the original structure and workings remain intact. The conversion simply entailed removing the counter-balance and drum wheel, and locating the engine driven drive pulley in its place. The saw, mandril, roller bearings and push bench date from 1908 and are still in excellent condition. Of the original power train the pit wheel, axle and block bearings are in reasonably good condition, but the waterwheel and cribbing are disintegrating. The building too, was sagging badly and the shores on which it rests are decaying in 1978.

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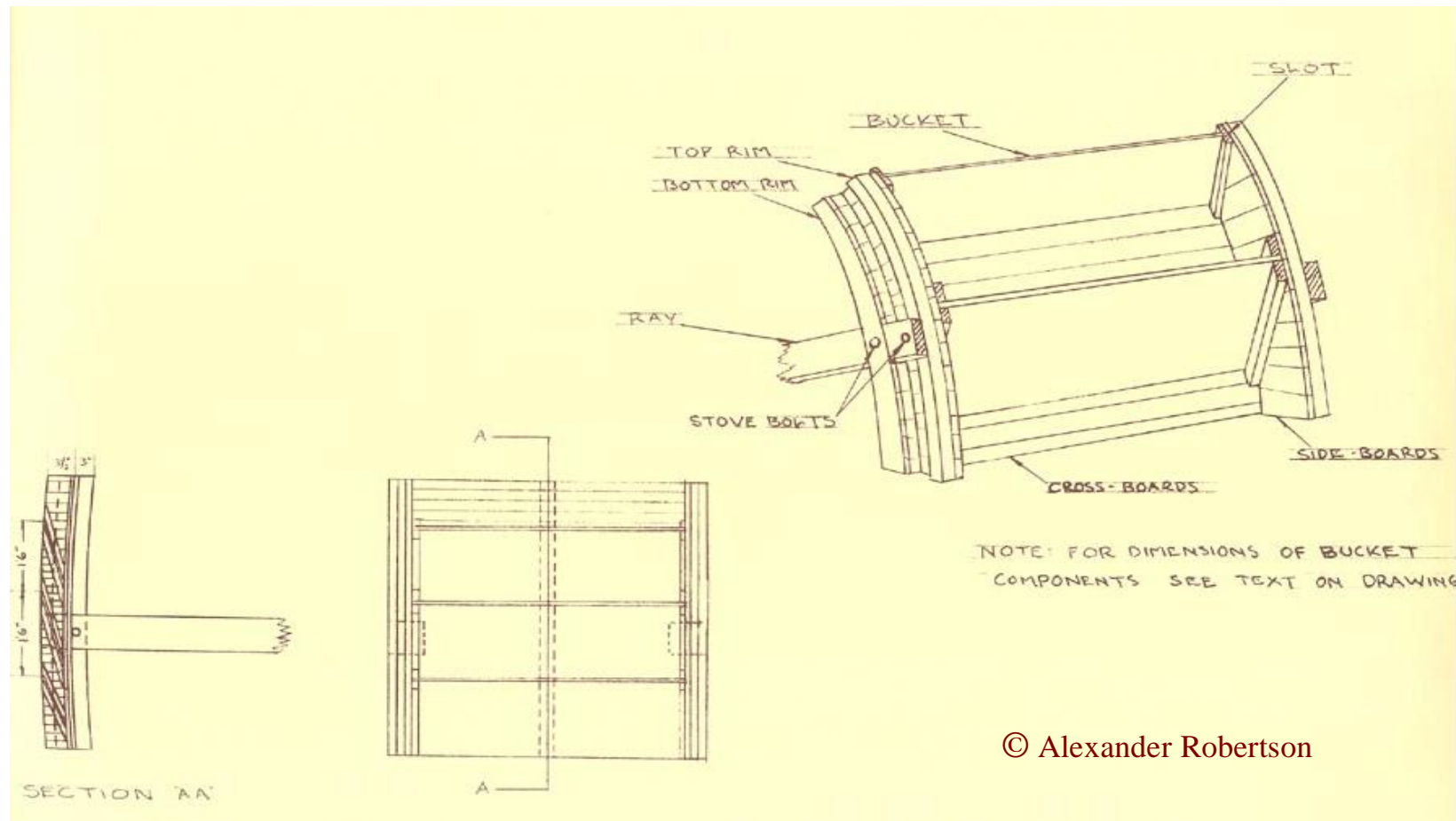


BEARING BLOCK AND CRIBBING The bearing for the large axle shaft is a brass cup that was well lubricated with oil. With extended use it wore out the groove in the bearing block. To extend the life of the block leather padding and birch wedges were placed between the cup and block. The cribbing was built with logs fastened by dowels as shown. Rock ballast was used to give added strength and stability to the cribbing.



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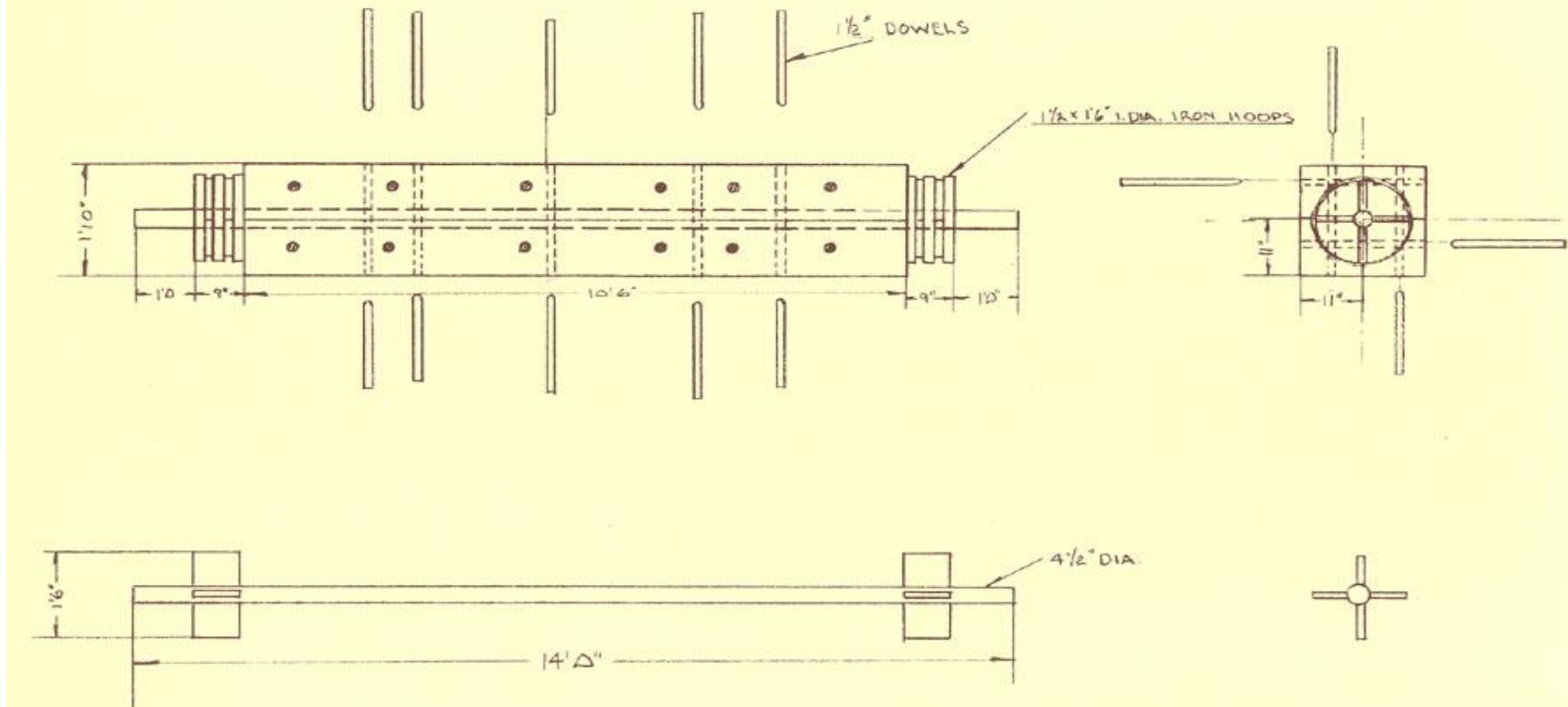
WATER WHEEL Black spruce was used to construct the waterwheel. The rays, i.e. the cross-beams, were made from 7"x7" squared timbers. Supplementary rays were made from 4 1/2"x4 1/2" squared timbers. Braces were made from 3/4"x4" strapping. An allowance of 3/4" was made for the axle to slip in easily.



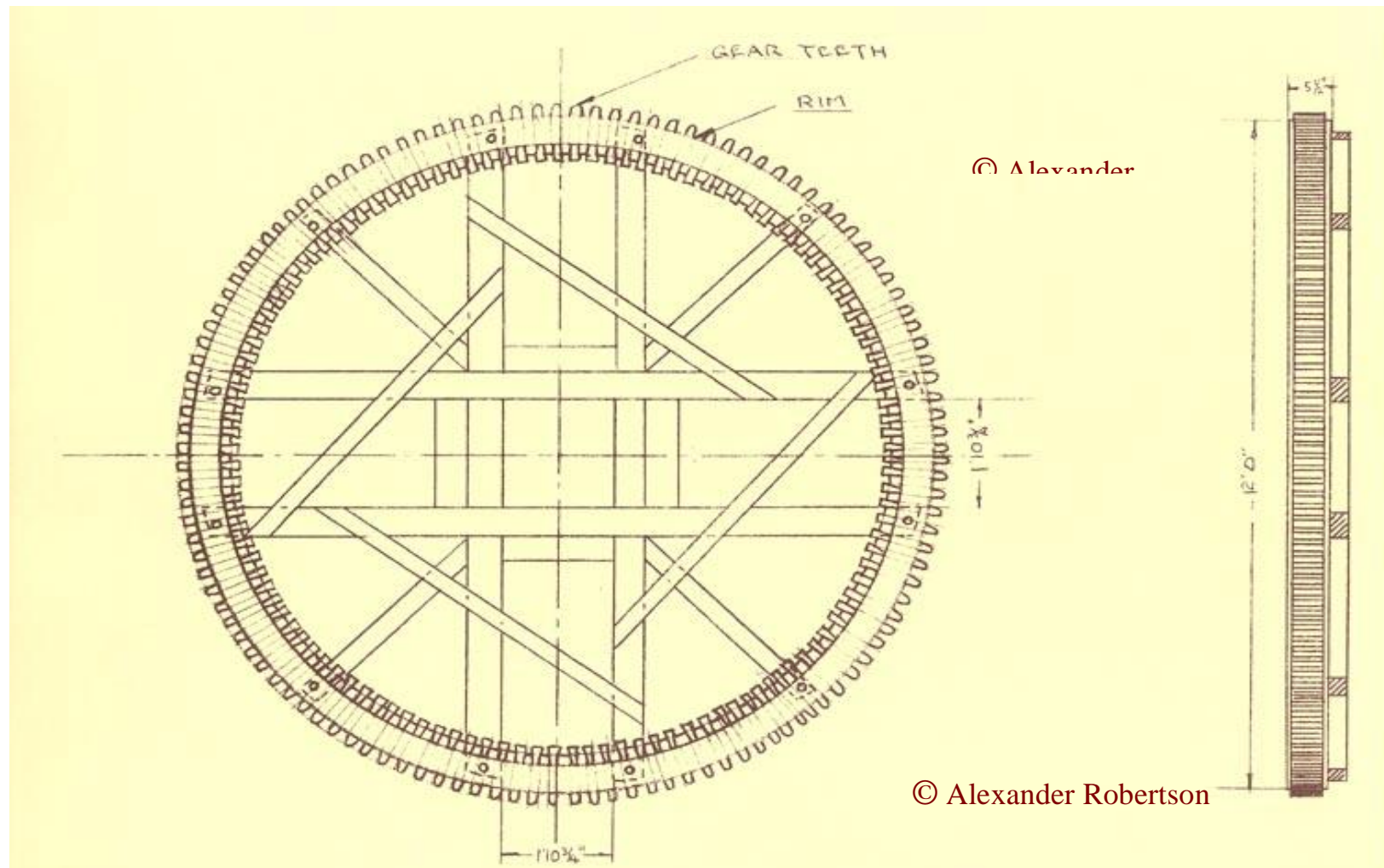
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WATER WHEEL BUCKET This drawing shows a perspective, front and side elevation - note the top and bottom rim. The top rim (1 1/2"x2") is flush with the inside surface of the ray, and the bottom rim (1"x3") is flush with the outside surface of the ray. These are fastened to the ray by stove bolts. The cross boards (3 1/4"x4"x4") were installed first, and the side boards (3/4"x4") are wedge-shaped and trimmed to suit the curvature of which the wheel, were installed next. Not shown in the drawing is a piece of molding (1 1/2"x1 1/2") on the outside of the side boards. This molding was nailed to the cross boards to keep the side boards in place. The bucket (3/4"x14"x4 3/2") fitted snugly into a pair of slots (3/4"x3 1/4"x14"). The buckets and slots were arranged flush with the top rim at approximately 18" between centres.

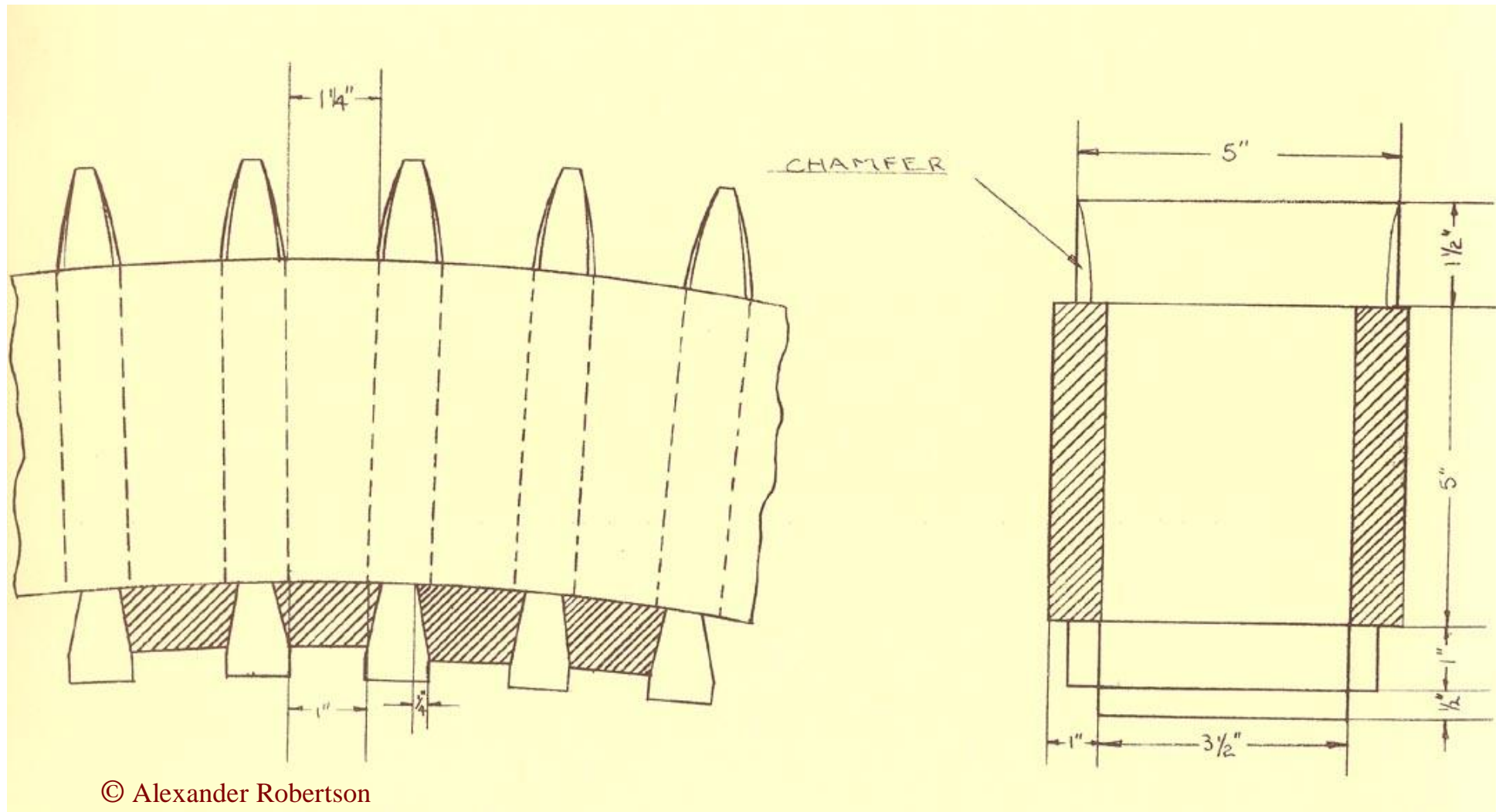
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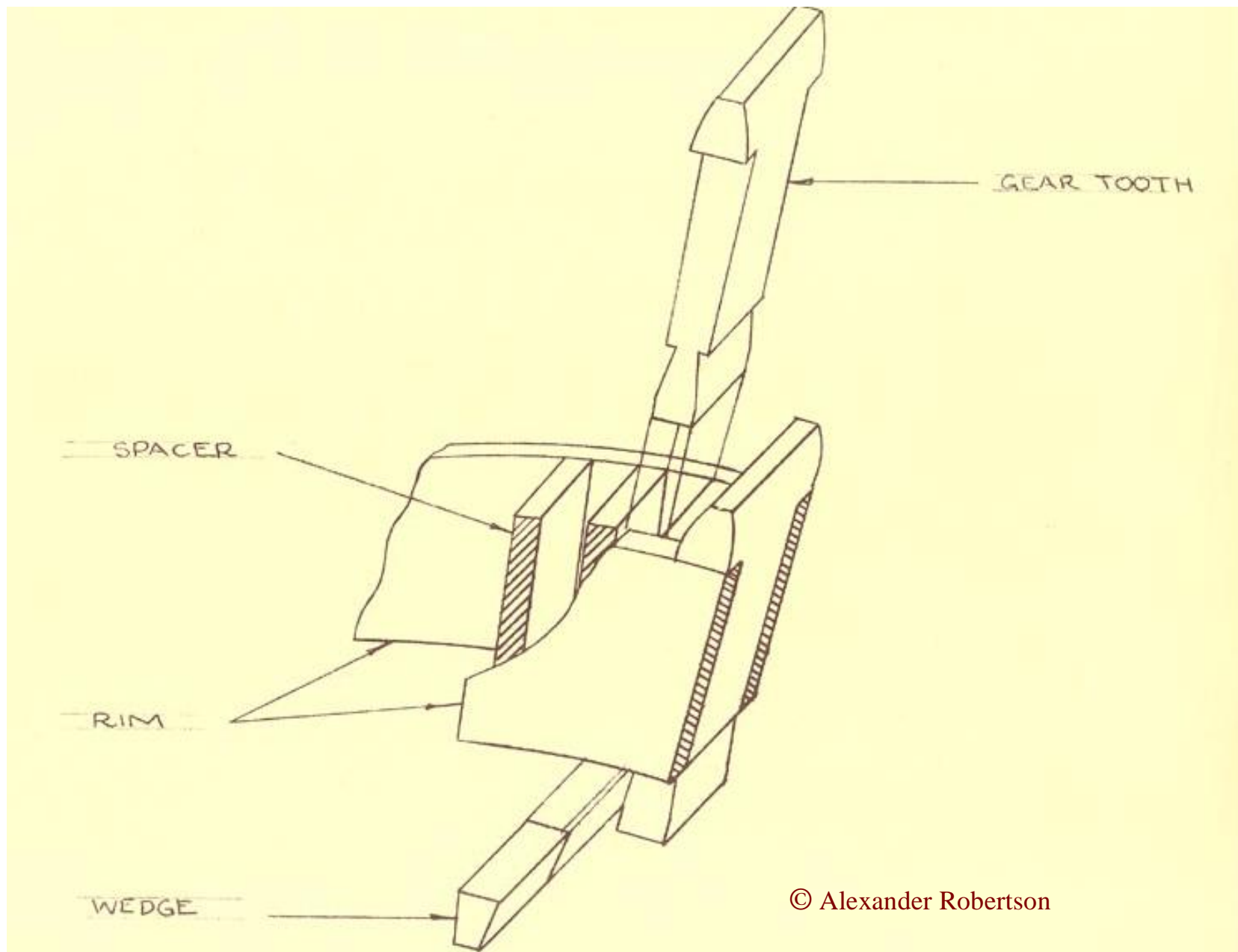
AXLE The axle consisted of a 4 1/2 " diameter steel shaft and four wooden beams. The shaft had four 9" flanges located 7 1/2" from both ends. The four 11"x11" beams were fitted snugly around the shaft and kept in place by dowels and iron hoops as shown.



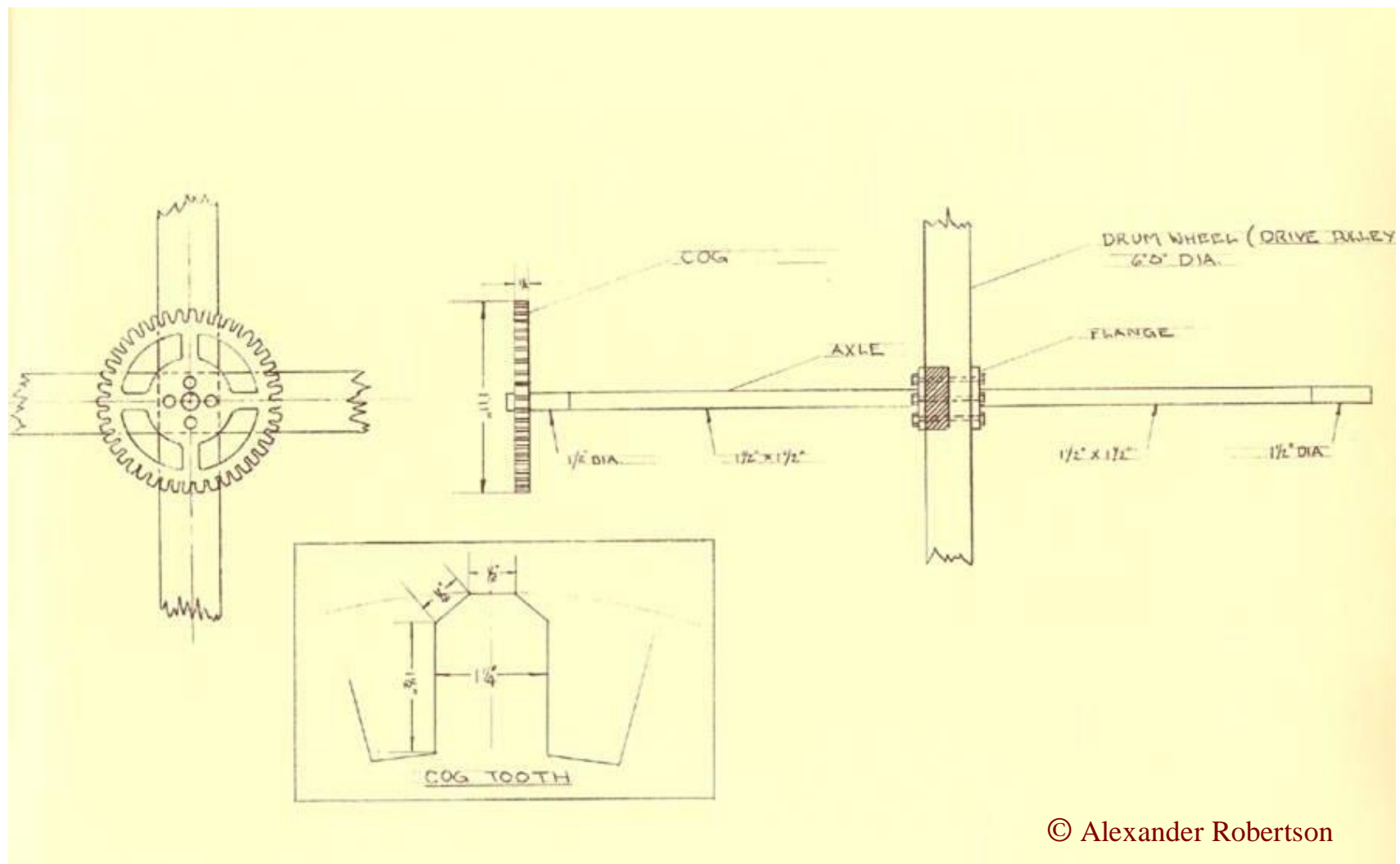
PIT WHEEL The main rays of the pit wheel were made from 6"x6" beams. The rims were made from curved 1"x5" stock. The birch spacers are slightly wedge-shaped and were spaced at 1 1/4" intervals on the outside curvature and 1 " on the inside curvature. The rim and spacers were assembled first and were bolted onto the rays by stove bolts. The pit wheel was fitted onto the axle by wedges and dowels in the same manner as the waterwheel. The birch gear teeth were not installed until after the pit wheel was fitted onto the axle.



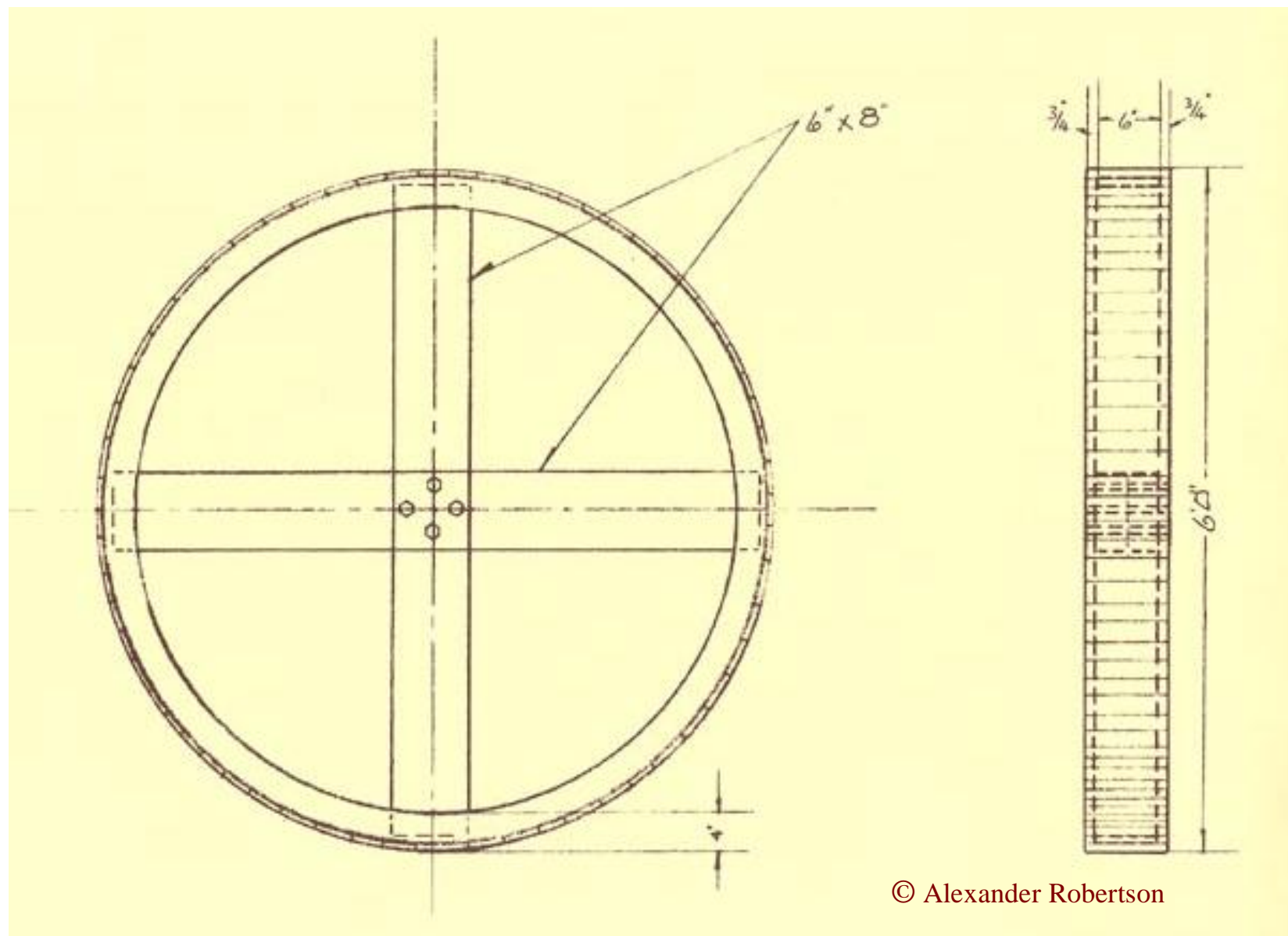
GEAR TOOTH AND PIT WHEEL ASSEMBLY This drawing shows in more detail how the gear tooth was assembled on the pit wheel.



GEAR TOOTH AND PIT WHEEL RIM This drawing gives the dimensions of the gear tooth and pit wheel rim. Note the chamfered corners of the gear tooth.



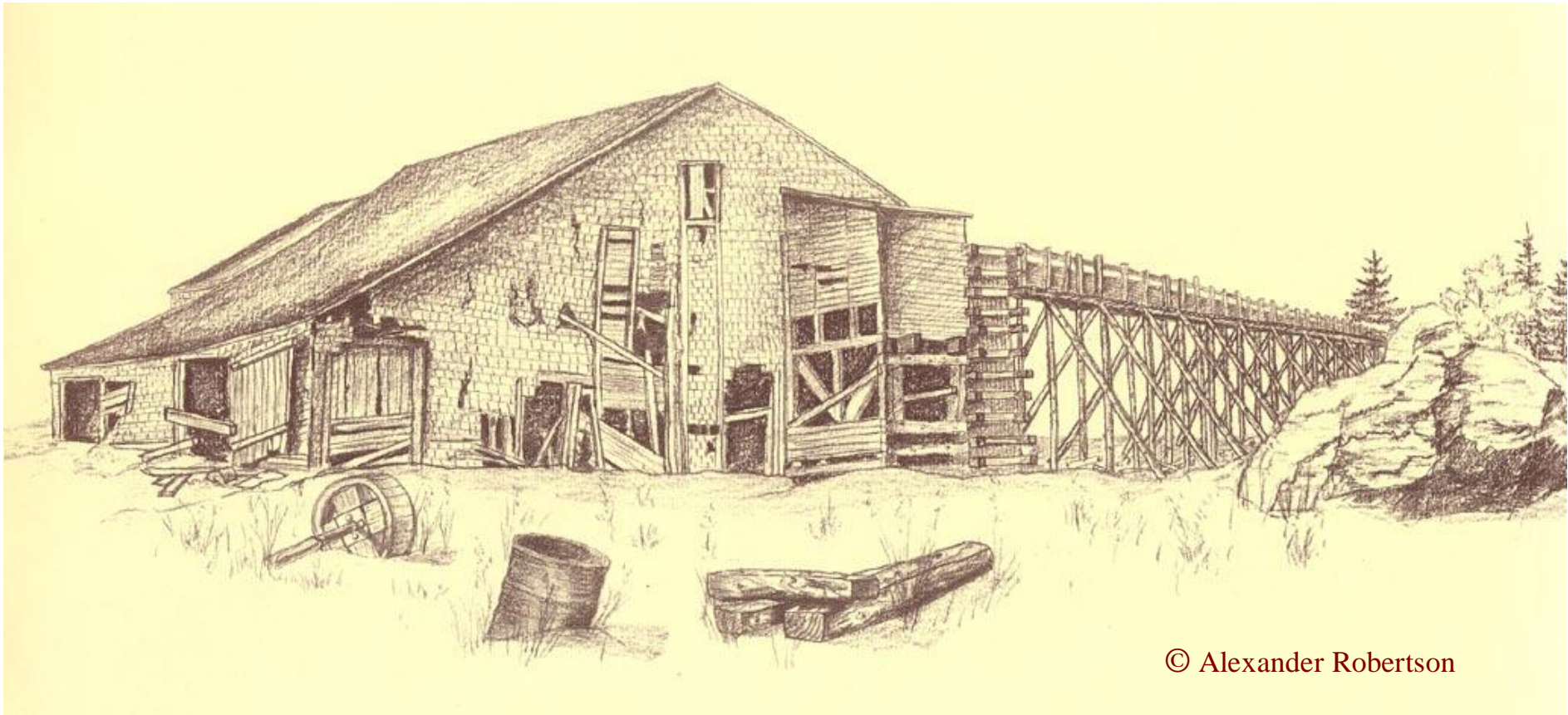
. COUNTERBALANCE (JACKSHAFT) There are three parts to the counterbalance; cog, shaft and drum wheel (drive pulley). Detail of the drum wheel is shown in Drawing #13. The cog is 23" in diameter and is obviously a very old one, probably manufactured around 1850 or earlier, because the gear teeth have flat planes as opposed to the rounded bevels of modern gear teeth. The cog was wedged onto the shaft by iron spikes. The shaft is in two parts, one on either side of the drum wheel each with a flange for bolting onto the drumwheel.



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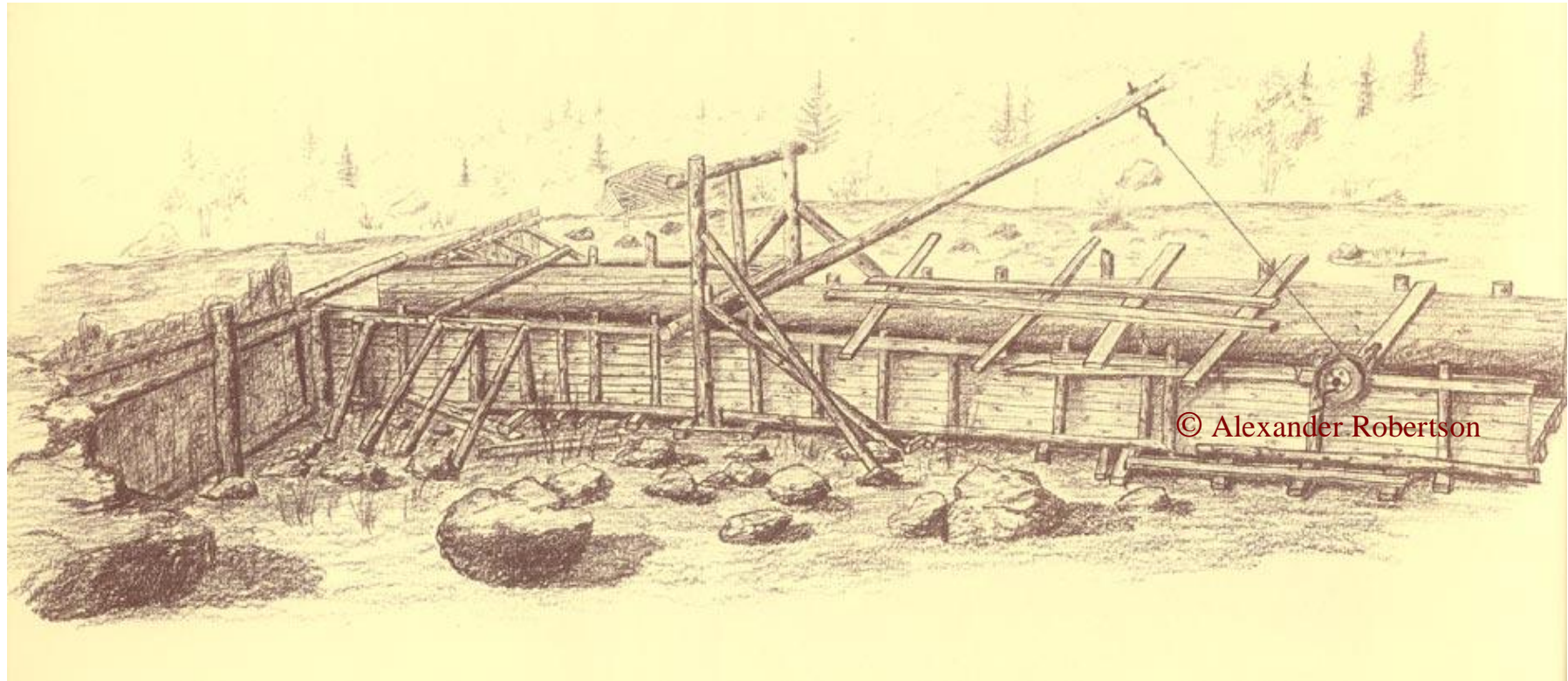
DRUM WHEEL The rays of the drum wheel were made from 6"x8" squared timbers and were lap jointed. The rims were made from curved 3/4"x4" stock and cross boards from 1/2"x4 1/2" strapping.

AVONDALE SAWMILL

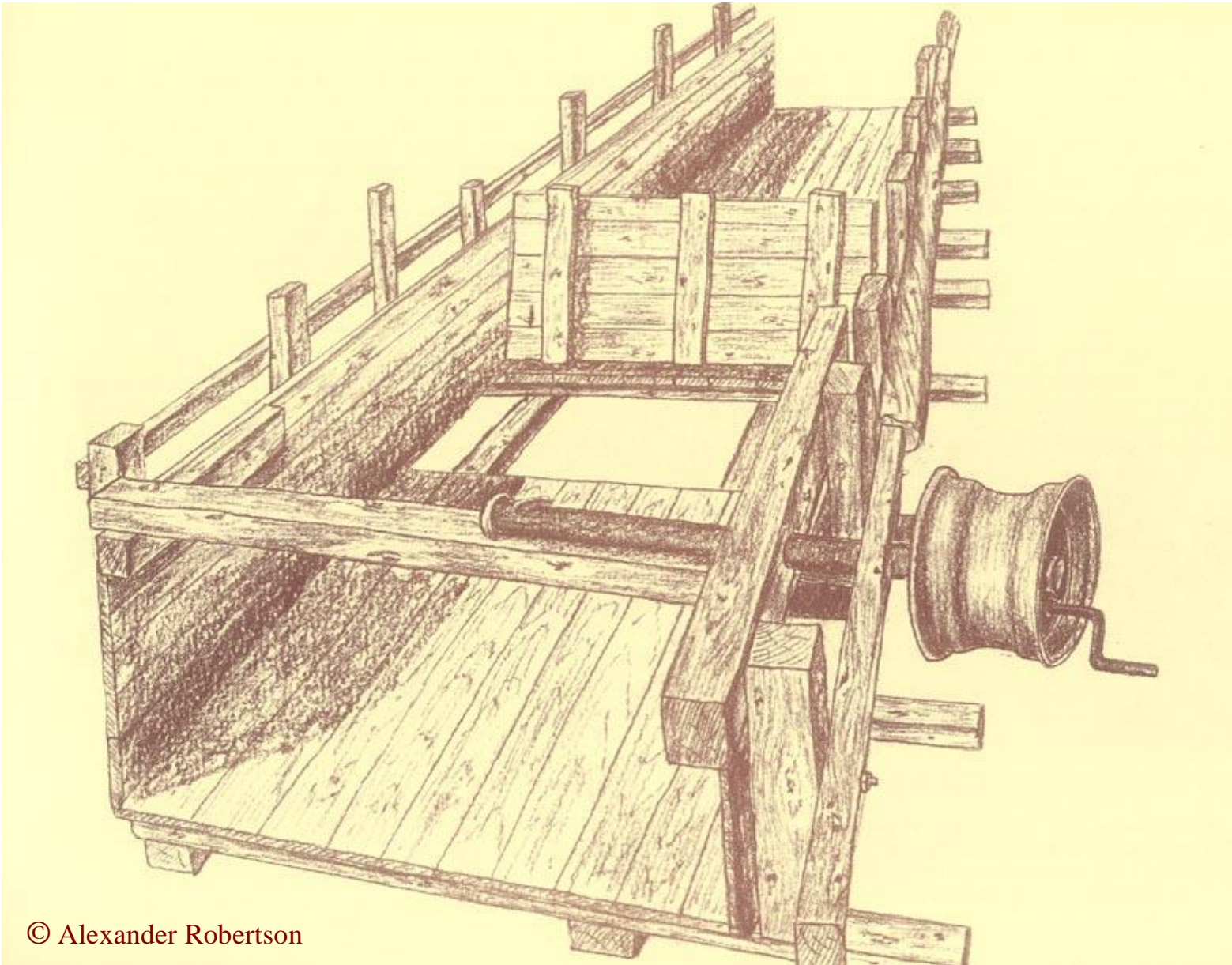


on

On-site sketch of the TURBINE SAWMILL AVONDALE illustrating the condition of the building in 1978. To the right of the building is a sluice. The cribbing next to the sluice is a shaft, and the small annex next to it houses the turbine and drive shaft. The water flows down through the turbine past the building in a channel hidden from view. A small stream was diverted through the building to wash out the sawdust and chips into the channel. The cleaning ditch was located at the opening beside the turbine annex.

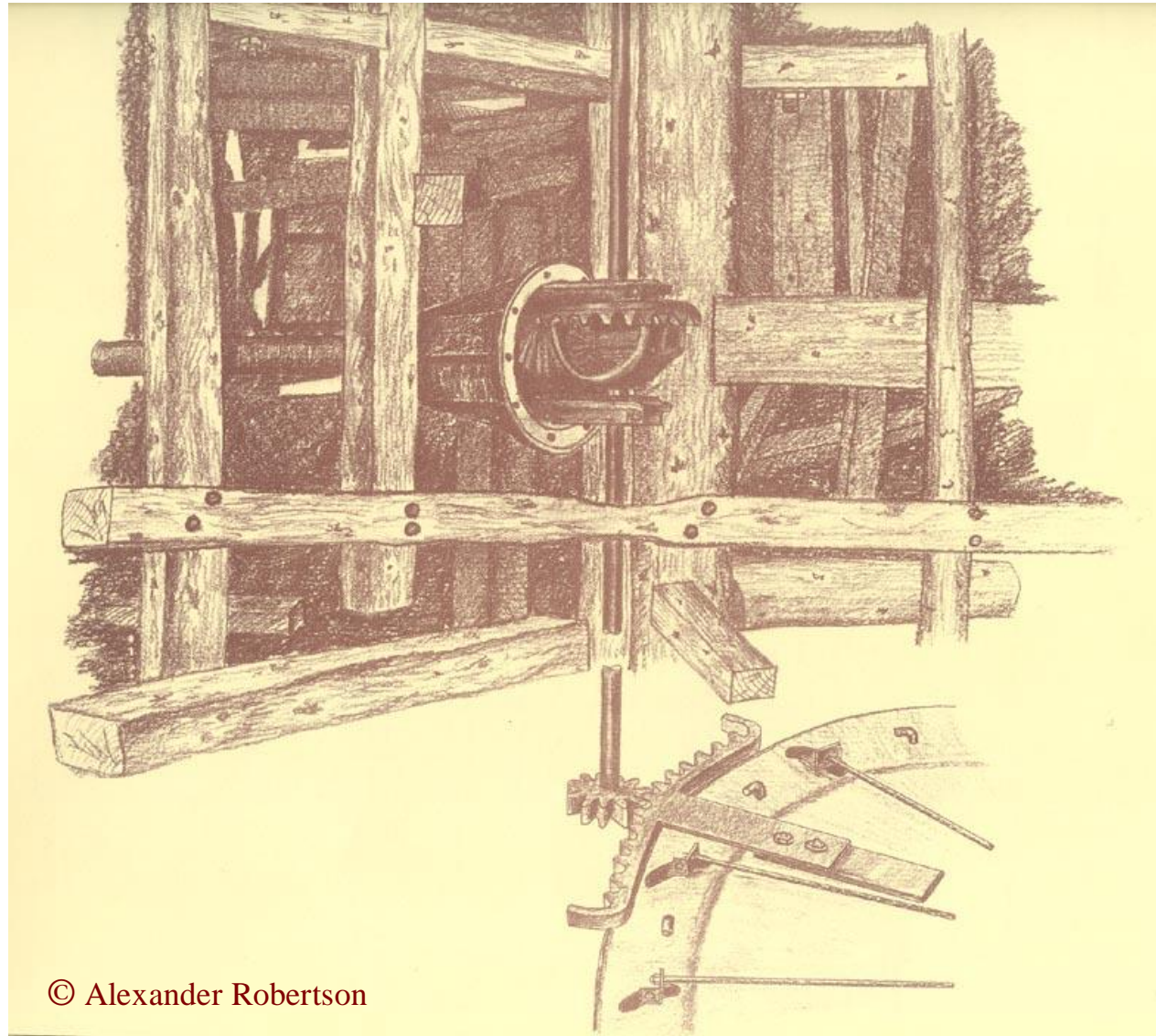


SLUICE GATE This illustration shows part of the dam and sluice gate as it existed in 1978. The water was controlled by a gate on the end of a lever that was winched up and down. The winch, crudely fashioned from an automobile tire rim, was adequate. The sluice was of simple post and rail construction.



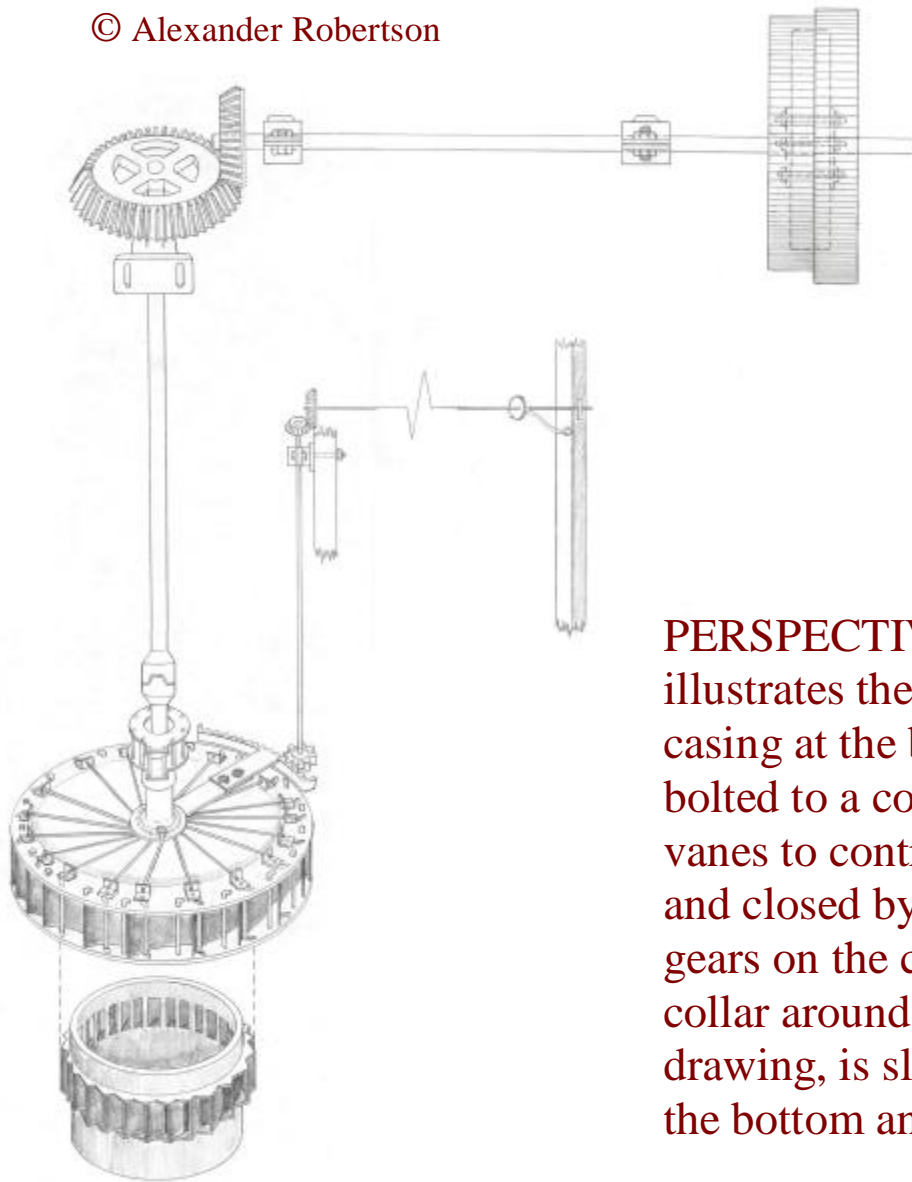
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BY-PASS TRAP GATE This was located just behind the winch and was used as a safety by-pass to cut off the water.



AUTOMOBILE PINION AND CROWN GEAR SET This is an original improvisation to control the vanes. It is of fairly recent vintage, 1948-50. The lower part of the drawing shows a section of the turbine.

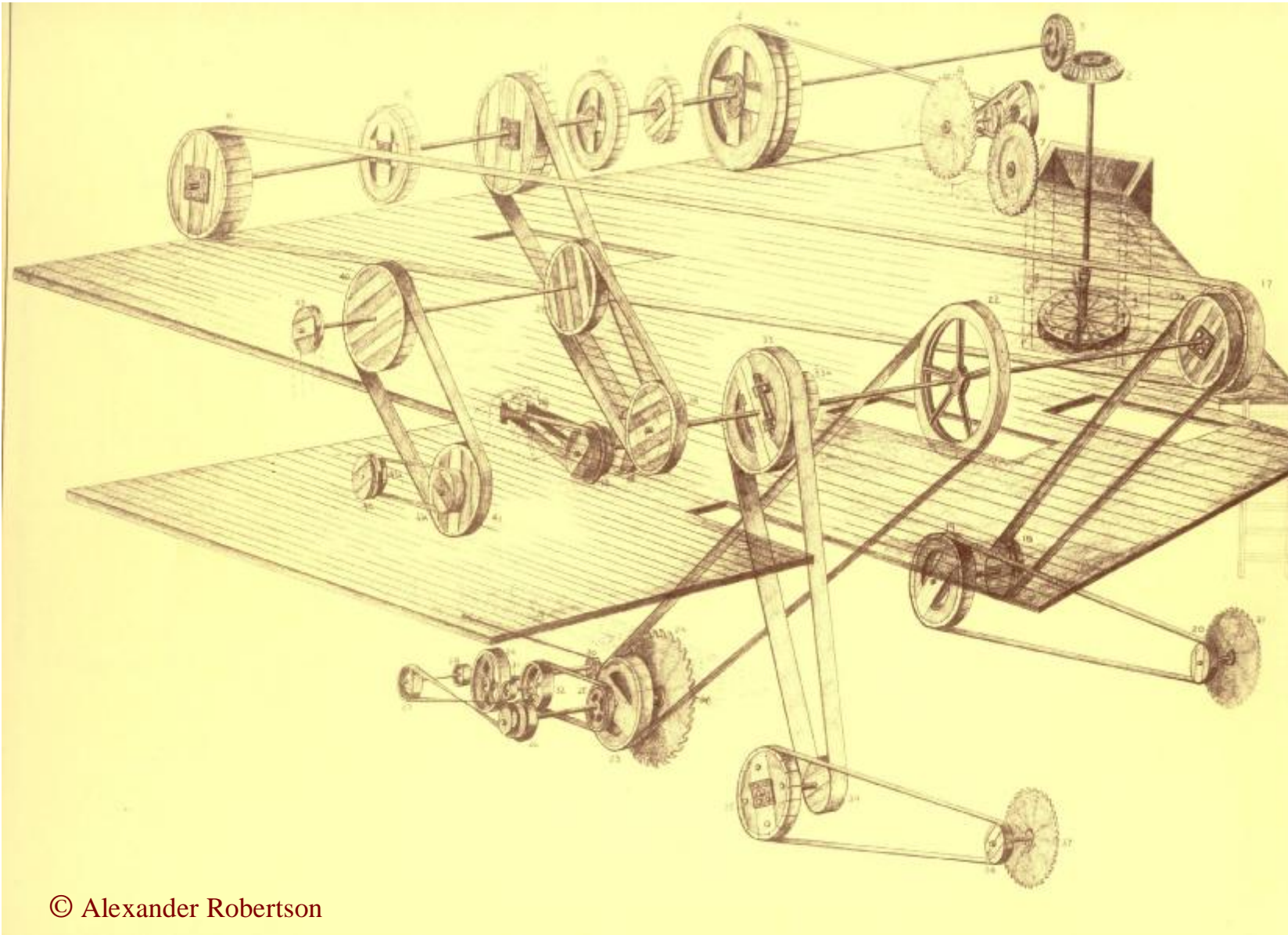
© Alexander Robertson



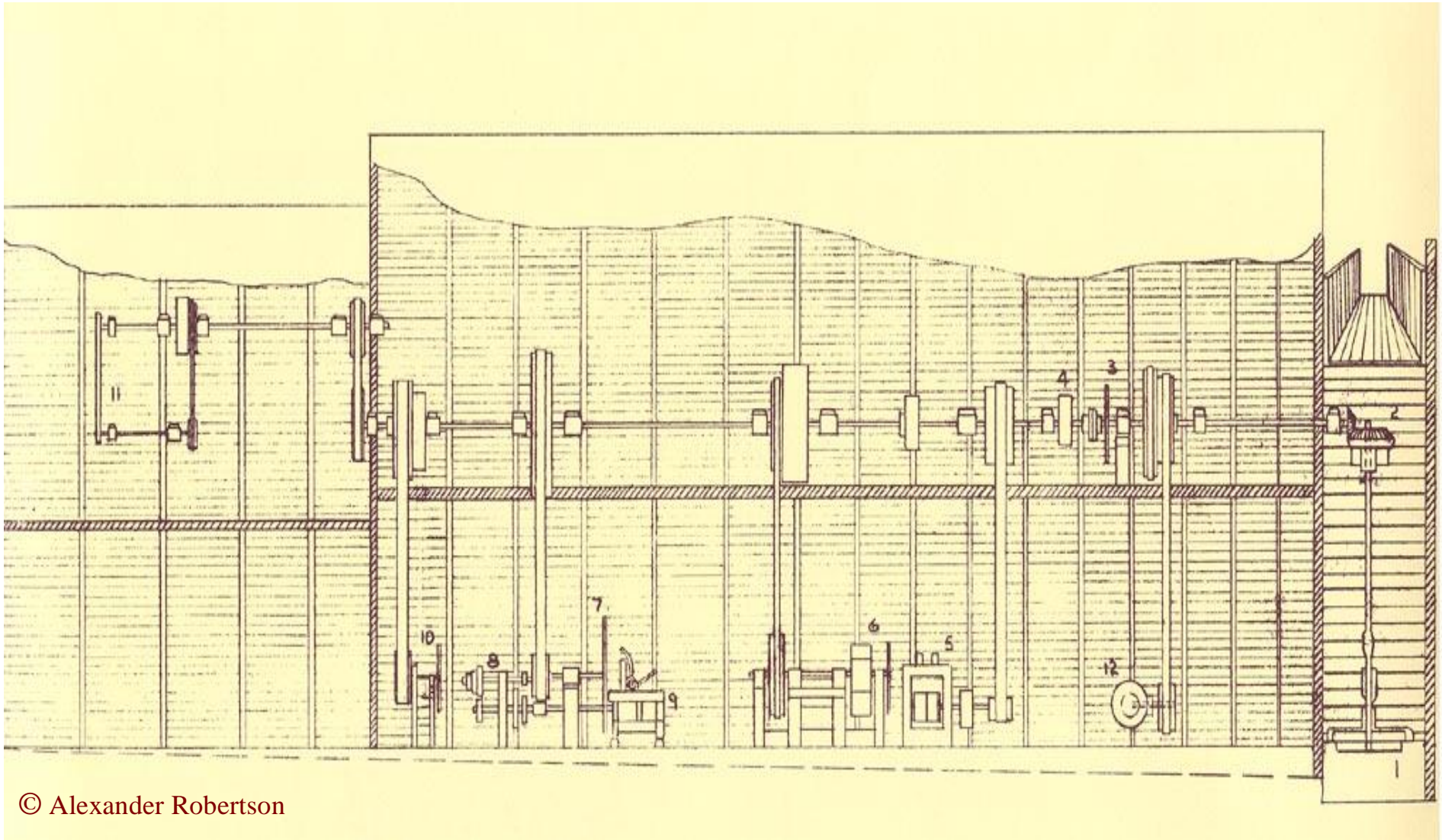
PERSPECTIVE OF FRANCIS TURBINE This drawing illustrates the principle of the Francis turbine., The circular casing at the bottom of the shaft remains stationary and was bolted to a concrete footing. The casing also housed the vanes to control the flow of water. The vanes were opened and closed by the push- pull action of the rack and cog gears on the connecting rods radiating from a moveable collar around the shaft. The runner, detached in the drawing, is slipped onto the keyed shaft in the casing from the bottom and held in place by a lock nut on the shaft.

[illegible]

PLAN OF THE AVONDALE WATER TURBINE SAWMILL The plan shows the main dimensions and location of machinery on the top and ground floor. Note the cleaning drain running from left to right through the building.



Perspective of the power train showing the arrangement of drum wheels some machinery. See appendix 1 for dimensions of various drum wheels.



CROSS-SECTION OF AVONDALE SAWMILL This is a cross-section of the mill looking from the front entrance showing the location of drive pulleys and machinery. The turbine is on the right (see appendix for key to numbers).

APPENDIX

KEY TO NUMBERS

No.	Component	Dimensions	Comments
1	Francis turbine	20" I. D. (50 teeth)	Turns counter clockwise
2	Bevel gear	10" I.D. (26 teeth)	
3	Bevelgear	42" D.	Shingle saw
4	Drive pulley	39" D.	Not in use
4A	Drive pulley	7" D.	Shingle saw
5	Mandril pulley	17" D	"
6	Drive pulley	24" D.	"
7	Sprocket	30" D.	"
8	Saw	15" D.	Not in use
9	Drive pulley	21" D.	
10	Brake drum	31" D.	Planer
11	Drive pulley	13" D.	"
12	Mandril pulley	10" D.	"
13	Double pulley	3"D	"
14	Rotary knives	23" D.	
15	Brake drum	25" D.	
16	Drive pulley	27" D	
17	Drive pulley	22" D	End saw
17A	Drive pulley	12" D	"
18	Drive pulley	20" D	"
19	Drive pulley	6" D	"
20	Mandril pulley	21" D	"
21	Saw	27" D	Rotary saw
22	Drive pulley	62" D	"
23	Mandril pulley	21" D	"
24	Saw	48" D	"
25	Drive pulley	12" D	Log carriage
26	Drive pulley	10" D., 9" D., 6" D	"
27	Drive pulley	9" D	"

28	Roller (clockwise)	5 ½ " D	“
29	Forward and reverse	20" D.	Pulley
30	Rope pulley	8” D	(counter clockwise)
31	Roller	4” D	“
32	Drive pulley	20" D	“
33	Drive pulley	42” D	Clapboard saw
33A	Drive pulley	17" D	“
34	Drive pulley	18" D	“
35	Drive pulley	20" D	“
36	Mandril pulley	6” D	“
37	Saw	27" D	“
38	Drive pulley	19" D	Lathe shop*
39	Drive lley	20" D	“
40	Drive pulley	26" D	“
41	Drive pulley	17" D	“
41 A	Drive pulley	8” D	“
42	Drive pulley	6" D	“
42A	Drive pulley	4” D	“
43	Drive pulley	9” D	“

**Note: Lathe shop badly deteriorated - details on lathe assembly non-existent, therefore the power train is incomplete.*

REFERENCES

Anonymous 1975. The Dissenting Church of Christ in St. John's. 1775-1975. St. David's Presbyterian Church, St. John's.

Antipater of Thessalonica c. 85 B.C. In The Oxford Book of Greek Verse. Transl. by W. Marris, Oxford University Press, Oxford.

Agricola, Georg Bauer 1556. De re metallica. Basel.

Biringuccio, Vannoccio 1540. De la pyrotechnia. Venice.

Francesco di Giorgio Martini 1432-1502. *Tratta di architettura ingegneria e arte militare*. Transcript of Livia Matlese, Ed. Corrado Maltese, Milan.

Guy, Raymond W. 1972. John Guy - Newfoundland's first legal settler and governor. Mimeo of Lecture, Newfoundland Historical Society.

Honnecourt, Villard de c. 1235. In *The Sketchbook of Villard de Honnecourt*. Ed. by Theodore Bowie. Indiana University Press, Bloomington & London.

Howley, J.P. 1908. The first English colony in Newfoundland. *Evening Telegram* (Dec. 26), St. John's.

James, Rev. T.H. 1910. Newfoundland: Its resources and discovery and settlement of John Guy at Cuper's Cove, C.B. *Evening Telegram* (Supplement), St. John's.

Klem, Friedrich 1954. *Technik: Eine geschichte ihrer probleme*. (A history of western technology. Trans. by D.W. Singer, 1964). Mass. Inst. of Technology, Cambridge, Mass.

Leonardo da Vinci 1452-1519. In 'Leonardo da Vinci'. Institute Geographico de Agostini. Reynal, New York.

MacKay, R.A. 1946. *Newfoundland: Economic, diplomatic and strategic studies*. Oxford University Press, Oxford.

Mercer, Max 1970. 100 years old and still going strong. *Evening Telegram* (Jan. 16), St. John's.

Mills, David 1968. the evolution of Shoal Harbour as a lumber community. *Newfoundland Quarterly*.

Moritz, L.A. 1958. *Grain mills of classical antiquity*. Oxford University Press, Oxford.

Prowse, D.W. 1896. *A history of Newfoundland*. Eyre & Spottiswoode, London.

Ramelli, Agostino 1588. *Le diverse et artificiose machine...* Paris. Engi. Trans. 'The various and ingenious machines of Agostino Ramelli.' By M.T. Gnudi and E. Ferguson (1976). John Hopkins University Press, London.

Smallwood, J.R. 1941. *Handbook Gazetteer and Almanac: Newfoundland 1941*. Long Bros., St. John's.

Vitruvius, Marcus Pallio c. 4 A.D. *Ten books of architecture*. English Trans. by M.H. Morgan and A.A. Howard. Harvard University Press, Cambridge, Mass.