Jigging

by Neil S. Coventry and Bond Coleman

June, 1908

Submitted to the School of Engineering of the University of Kansas in partial fulfillment of the requirements for a course in Mining Engineering

Mining Thesis

M I N I N G   T H E S I S

\- - - - - - - - -

J I G G I N G.

\- - - - - -

SUBMITTED AS REQUIRED IN THE COURSE IN MINING

ENGINEERING

THE UNIVERSITY OF KANSAS.

\- - - - - - - - -

BY

NEIL S. COVENTRY

BOND COLEMAN.

\- - - - - -

JUNE 1908.

\- - - -

\- - -

\- -

\-

P R E F A C E .

Our thesis work is jigging in general, that is, the construction of a miniature jig in the laboratory, operation of the same, discussion of jigging principles, and a description with drawings of the jig constructed.

Most of our time was spent on the mechanical construction of the jig which we leave to the Mining Department.

We desire to acknowledge our indebtedness to Professors C. M. Young and F. E. Ward for their suggestions in the construction of the jig.

University of Kansas, N. S. C.

Lawrence Kans. B. C.

June 1908.

J I G G I N G .

Jigging is one of the processes of ore concentration, and depends upon the action of two currents of water, an upward and a downward, alternating with each other in quick succession, upon a bed of fine ore supported by a screen. For concentration by jigging it is essential that the desired concentrates and waste be of two different specific gravities, and then in jigging they will arrange themselves according to the law of hindered settling. Dry jigging has been attempted in an experimental way. Ores subject to jigging are of several size classes ranging from one and a third inches in diameter, down to one twenty-fifth inches.

The old shaking sieve operated by hand developed years ago into the mechanical jigging sieve and this has now been supplanted almost everywhere by the piston jig by sole reason of its better wear. Of the various forms of piston jigs, the jig ~~proper~~ pump, the jig with the jarring sieve, the under piston jig, etc, there remains but one type, namely, the side piston jig. The side piston jig is one in which the piston and sieve are placed in adjoining compartments of the jig box, with free communication beneath them, so that the water can be forced in rising currents through the sieve by decending stroke of the piston. This type answers best to requirements of good sorting, little wear, and simple executed repairs. The other forms of machines may be seen as historical curiosities or in actual use sometimes for the careful treatment of middlings from the regular jigging work.

Automatic jigs with a continuous discharge, both of concentrates and of barren product or tailings are very widely used. In the semi-automatic jigs, concentrates are removed by hand. A few are still in operation. Their quality of sorting is more perfect than that of the other jigs. The difference in favor of intermittent jigs is however very slight, and never able to compensate for the evils of small output and increased mineral loss which accompanies the semi-automatic type of jig.

The concentrated product of the jig either collect on the sieve to be removed automatically or they pass through a bed of coarse mineral and then through the sieve, to collect in the hutch box below. For jigging ore of fine size the discharge through the sieve is doubtless advantageous. The additional power required to raise the mineral bed is offset by the increase of motive power, which the other mode of jigging would absorb in order to force water through an extremely, fine sieve, and by the difficulty which is always experienced and the time consumed in sieveing through a very fine mesh; the abrasion of the ore bed in one case is balanced in the other by the rapid wear of fine sieves, whereas there remains for advantages for the "through sieve" system for fine work an easy control of the sorting by changing the thickness of the bed, and the fact that jigging through a bed to obviates , to a certain extent, the necessity of very close sizing.

Of two different sized grains brought together, as equal falling bodies by continuous water current, the smaller one will be aided by its smallness in working its way through the mineral bed of a fine jig, which the larger one fails to penetrate, and thus a separation may sometimes be easily effected when in jigging on a sieve it would have proved very difficult. The superior limit to which jigging through sieves and beds can in some cases be carried to advantage has as yet not been determined. The light ore and gangue product obtained in each division of a multiple sieve jig passes with a current of water over the dividing dam from one sieve compartment to the nextone and finally the tailings are carried over the last dam, and on an incline draining screen. When water is to be economised, the tailings are mechanically discharged, particularly those of the coarsest jigs, which would require a considerable volume of water to flow them over the last dam.

For very fine jigging a large quanity of water is required on the sieves, and also a great number of short piston strokes per minute in order to keep the fine material from packing. To economise in the use of water and to prevent the fine material being carried off the jig to quickly, the water in such fine jigs is almost always stayed — that is the tailings are discharged through a long slit in the end-board of the jig, beyond and immediatelly adjoining which there is a stay-box. The latter may have the form of a small hydraulic classifier which delivers the heavier material through the bottom and the lighter stuff as overflow.

Ore jigs are gererally built of wood and are found to last in good condition from eight to ten years. The water used in mills is frequently pumped from neighboring mines and is apt to be slightly acid; this precludes the use of iron for jigs, but when such objection does not exist thin plate iron covered with a heavy coat of paint is recommended by large builders of dressing machinery. Experience has shown that iron jigs shake to pieces in a few years if not constructed in the very best manner, particular care being taken to strenghten the corners with angle iron. The piston area is made three fourths as large and some times fully as large as that of the sieve. The advantage of the large piston is that the jigging is performed with a short stroke an d a regular evenly distributed movement of water through the sieve. This is held of particular importance in the system of jigging through a sieve and a bed of mineral to prevent the water from forceing its way with great disturbance through certain parts of the bed and the ore charge while other portions of the fine material may be packing. For fine jigs the width of sieves is not over eighteen inches but for coarse machines this dimension increases to about twenty two inches. The usual lenght of sieve is from twenty-eight to thirty-six inches dependent on the difficulty of sorting.

A jig box with rounded bottoms aids the regular movement of the water, and is sometimes used with fine jigs, even though applied in coarser ones. In iron jigs a semi-circular bottom, which gives to the cross-section of the whole jig box the form of an inverted stilted arch can easily be introduced. The piston always has a half inch of play on all its vertical sides; its upper face when in its highest position is not more than an inch or two above the level of the sieve, so that it is always covered with water and is never in danger of drawing air.

In using the Hartz method of jig discharge the concentrates passing beneath and the tailings over a dam, it is found necessary to place each successive sieve two and one half inches lower than the preseeding one, in order to prevent back currents of water and ore being drawn beneath the apron of the dam, which is at the head of each sieve. With jigs having other dischargeing devices, there is no fixed and necessary height betwenn the levels of the several sieves. In coarse jigs each sieve is usually placed from one to two inches below the preseeding one, and the top level of the successive dams between the sieves is lowered in the same degree. In fine meal jigs the difference in levels is less — sometimes two thirds inch between first and second sieves, and one third inch between second and third, and nothing between third and fourth. The object of several sieve levels being only to facilitate the movement of water and light ore, the drop will of course be very much reduced or disappear altogether, as just observed when very fine material is treated, for this must always be jigged with a large quanity of water on the sieves, and the flow has to be stayed rather than advanced.

The advantage of a short rising flow through the sieves succeeded by a state of quiet water on the sieves or at most by a gentle descending current, was reconized at an early date. Though experience has since modified ideas regarding actions of the jig, and it is now well known that the rising current which is directly due to the piston stroke can effect but very little sorting, on account of the hindering influence which each grain exerts upon its neighbor, yet a strong quick upward movement is today none the less importance than formerly. The piston jig in its action upon the ore is very similar to the old moveable jigging sieve. A strong rising current with a sharp well defined beginning and end, lifts the whole mass of ore almost bodily and unbroken from the sieve and then follows the fall of the material, but not as frequently stated with the velocity of bodies in quiet water or in a slowly decending current. Upon the momentary supposition that the water on the jig sieve is perfectly quiet, the lowest grains in the mass of suspended ore begin to fall and displaceing the water beneath them, they create numberless upward flowing currents which act upon and are reproduced by the succeeding grains, working in this way through the the whole thickness of ore bed, effectually disintegrating it, and affording the bodies a chance to sort themselves in rising currents.

After this period the ore and the water have exchanged places — the ore, as just explained has fallen and the water evidently has risen. With the next stroke of the piston and a renewed rise of the ore bed the surface will over flow the jig dam, and carry off some of the ore tailings. Two influences interfere with the efficiency of this sorting and make it necessary to repeat the operation a number of times; first the action of each individual grain upon its neighbor, and secondally the disturbing effect of the downward flow of a portion of the water. Although the ore becomes thoroughly loosened in falling it can easily happen that a large heavy grain follows immediately upon a small light one, hindering for the time being the rise of the latter, or that a small heavy grain becomes wedged between two large, specifically lighter bodies and prevent it from falling past them. The decending water current caused by the return stroke of the piston can be entirely avoided by the use of a piston with valves in an apparatus such as the jig pumps, but practice has shown that the practice thereby gained in sorting , is as already stated more than counter-balanced by the evils of wear and repair which such machines undergo.

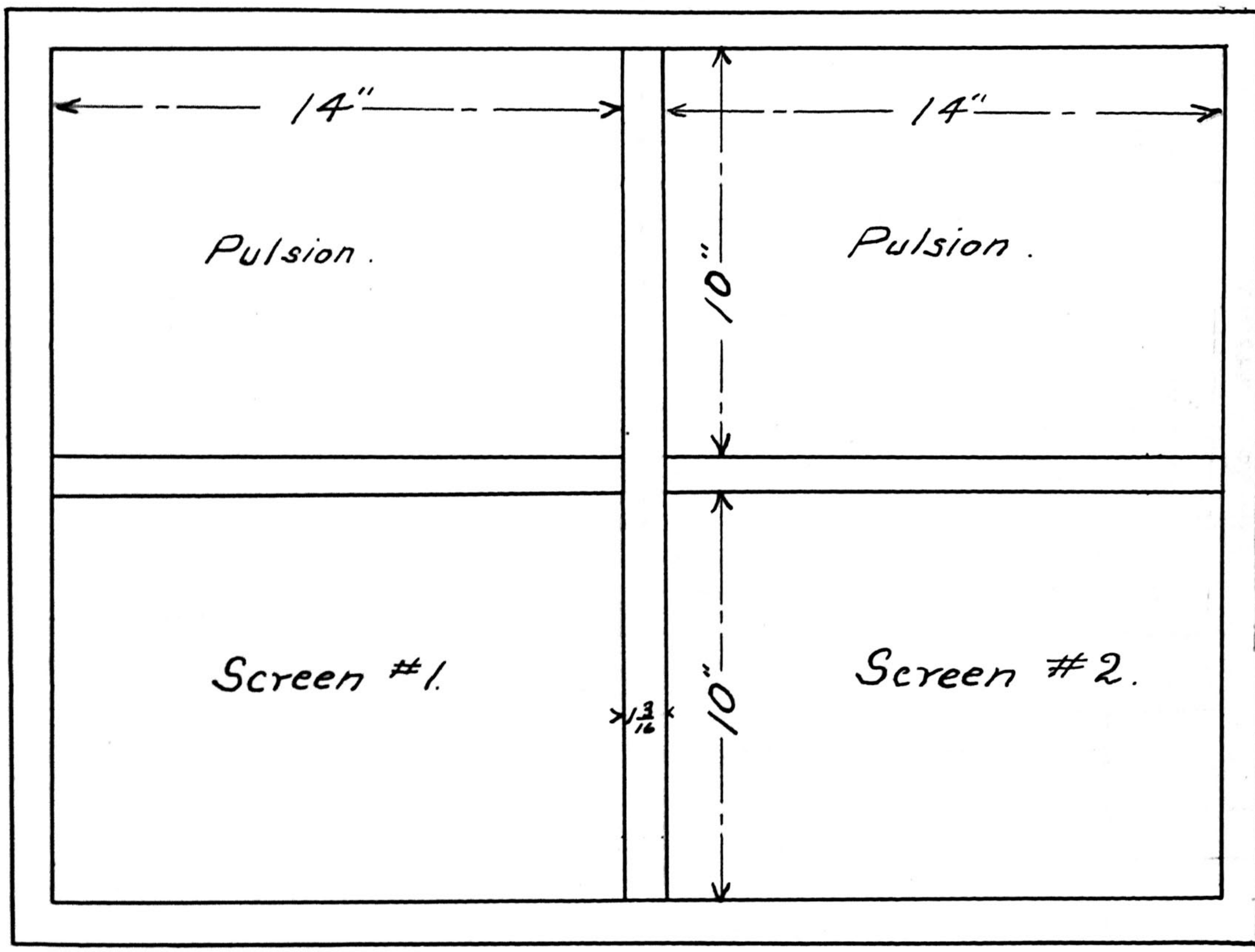
The harmful effect in the ordinary jig can be minimized by giving to the piston a slow return stroke, and by admitting above it an abundant supply of water. The greater the volume of feed water the less appreciable will be the descending current. But the proper amount of feed water also depends upon the quanity of ore that is treated so that it is incidentally inferred that a jig should perform the best kind of sorting when worked to full capacity — that is when there is a continuous stream of tailings passing over the overflow dam; and this in turn involves a provision of ample discharge of concentrates, capable of adjustment for all variations of richness of the ore.

The speed at which jigs are run increases as the lenght of stroke dimishes; it is never less than seventy-five revolutions of the driving shaft, (i.e. that is seventy-five jigging movements) per minute for the coarsest work, and it increases for the successively finer jigs by five to ten revolutions per minute, till a speed of hundred and fifty or a hundred and sixty double strokes is reached in the jigging of material finer than three milli-meters; one hundred and eighty-five double strokes are sometimes used for meal jigging, and two hundred half inch strokes for the cleansing jigs which separate fine mineral from pea and nut ore. Higher speeds —, reaching three hundred revolutions of the driving shaft per minute are advocated for fine jigging by specialists in ore dressing, because the jig capacity is thereby increased. To perserve good sorting this fact must be duly considered in determining the various proportions and adjustments of the machine; neglect in this respect will account, it is claimed for several failures that have been announced as a result of speed exceeding two hundred double strokes per minute. Whether there is really an advantage in such speeds for any kind of fine ore ~~it~~ is not yet a matter beyond dispute and investigation.

It is well understood that the sorting action of a jig depends upon the lenght of stroke, the number of strokes per minute, the supplies of ore and of water, the discharge of concentrates and tailings, and when working through sieves upon the thickness of the mineral bed. After a suitable stroke and speed have once been selected there are usually maintained without variation. Only a radical change in the character of the ore call for an alteration in respect to these points.

DRAWING OF JIG.

Screen and plunger area.



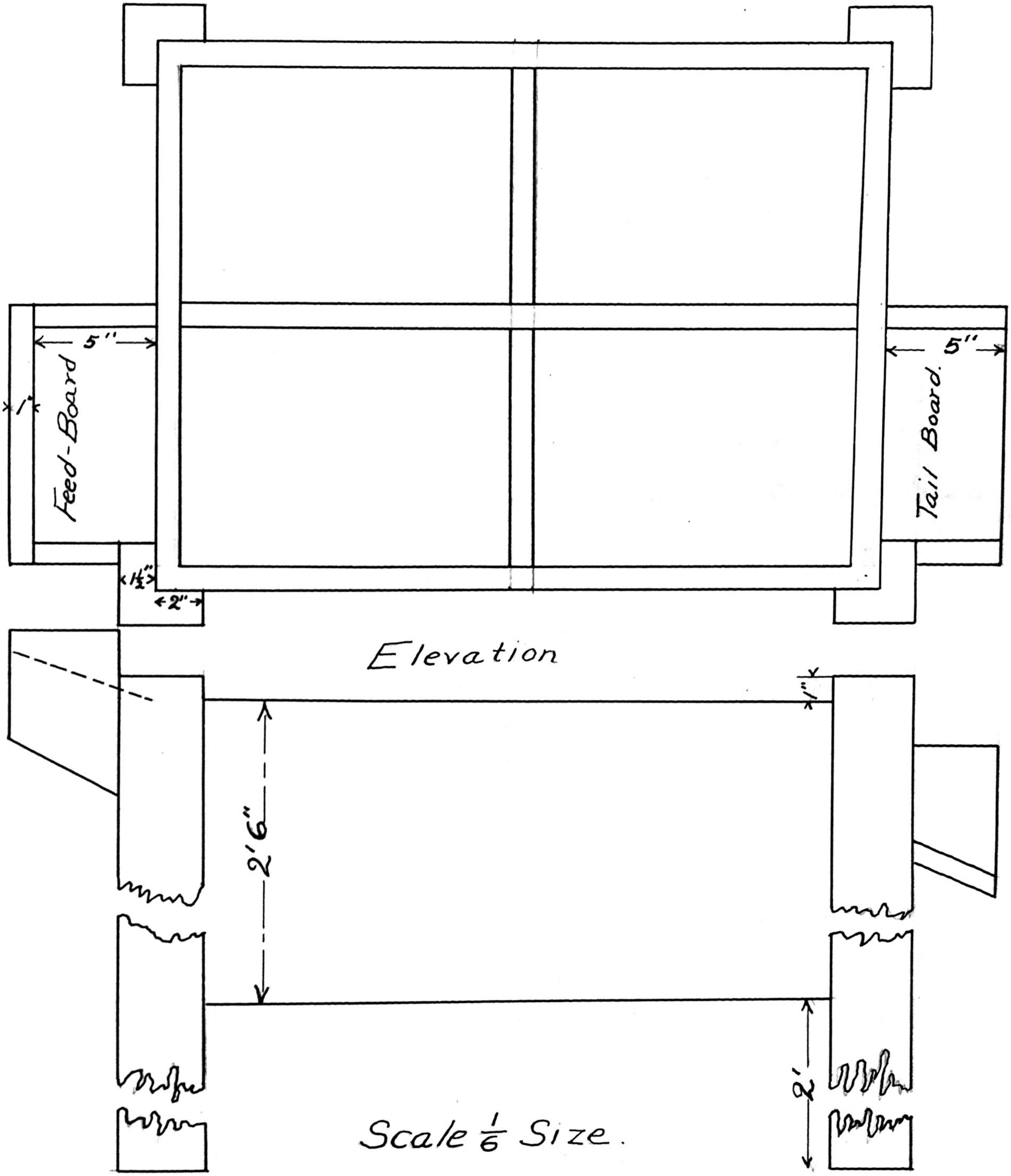
Screen Area = 140 sq. in.

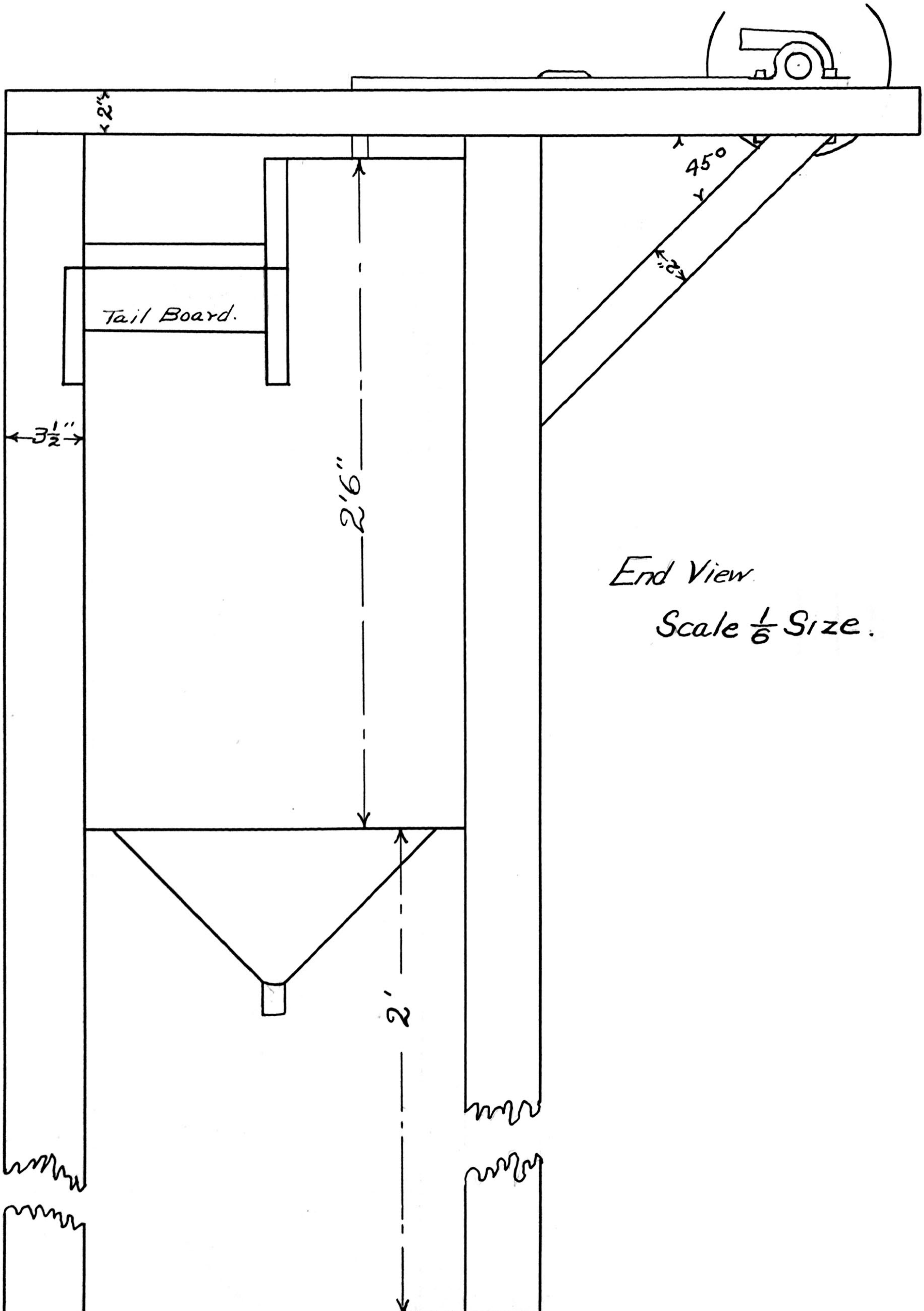
Pulsion Area = 140 sq. in.

Scale $\frac{1}{5}$ Size.

Plan.

Showing Corners, Tail-board and Feed-board.

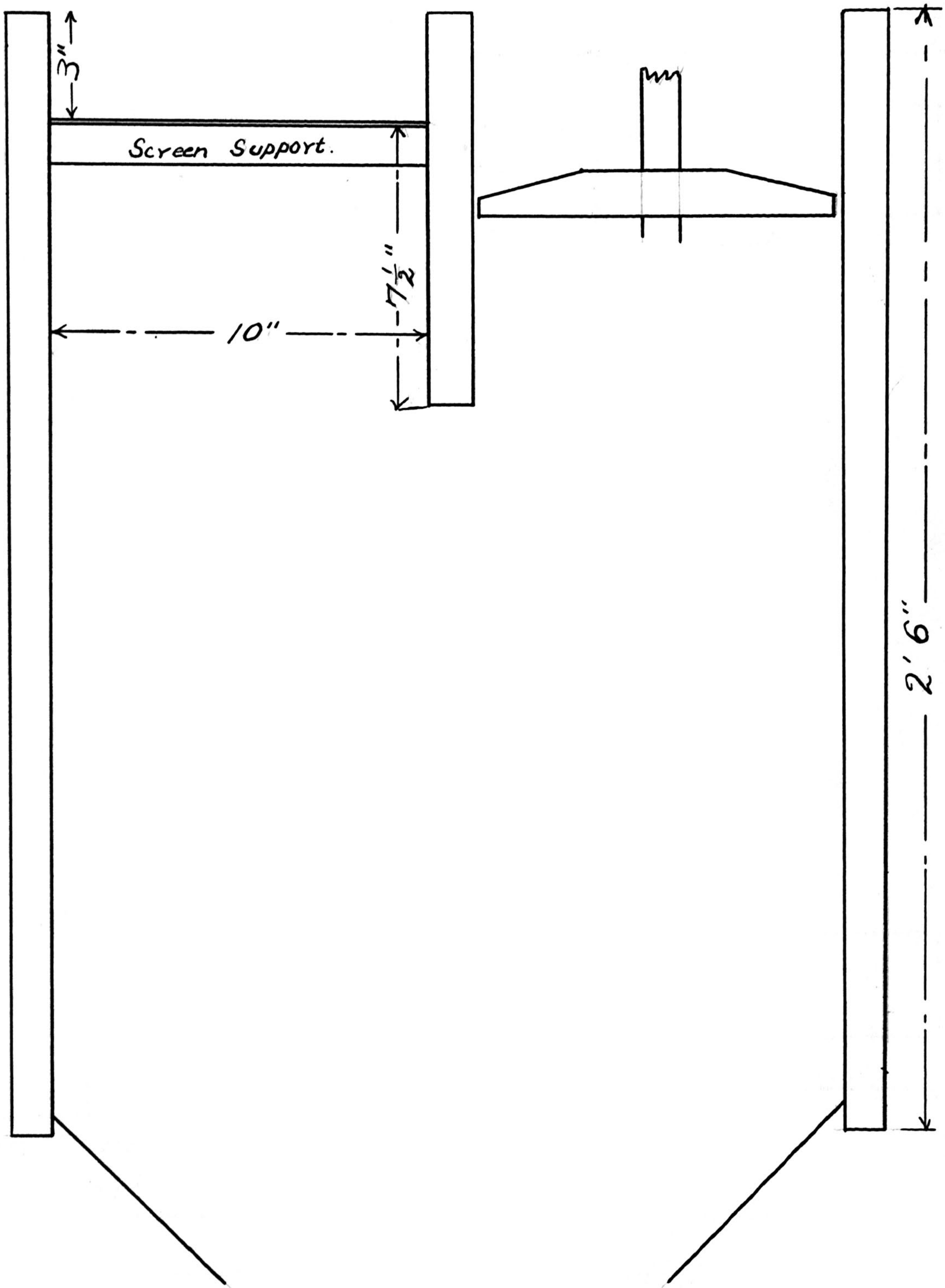


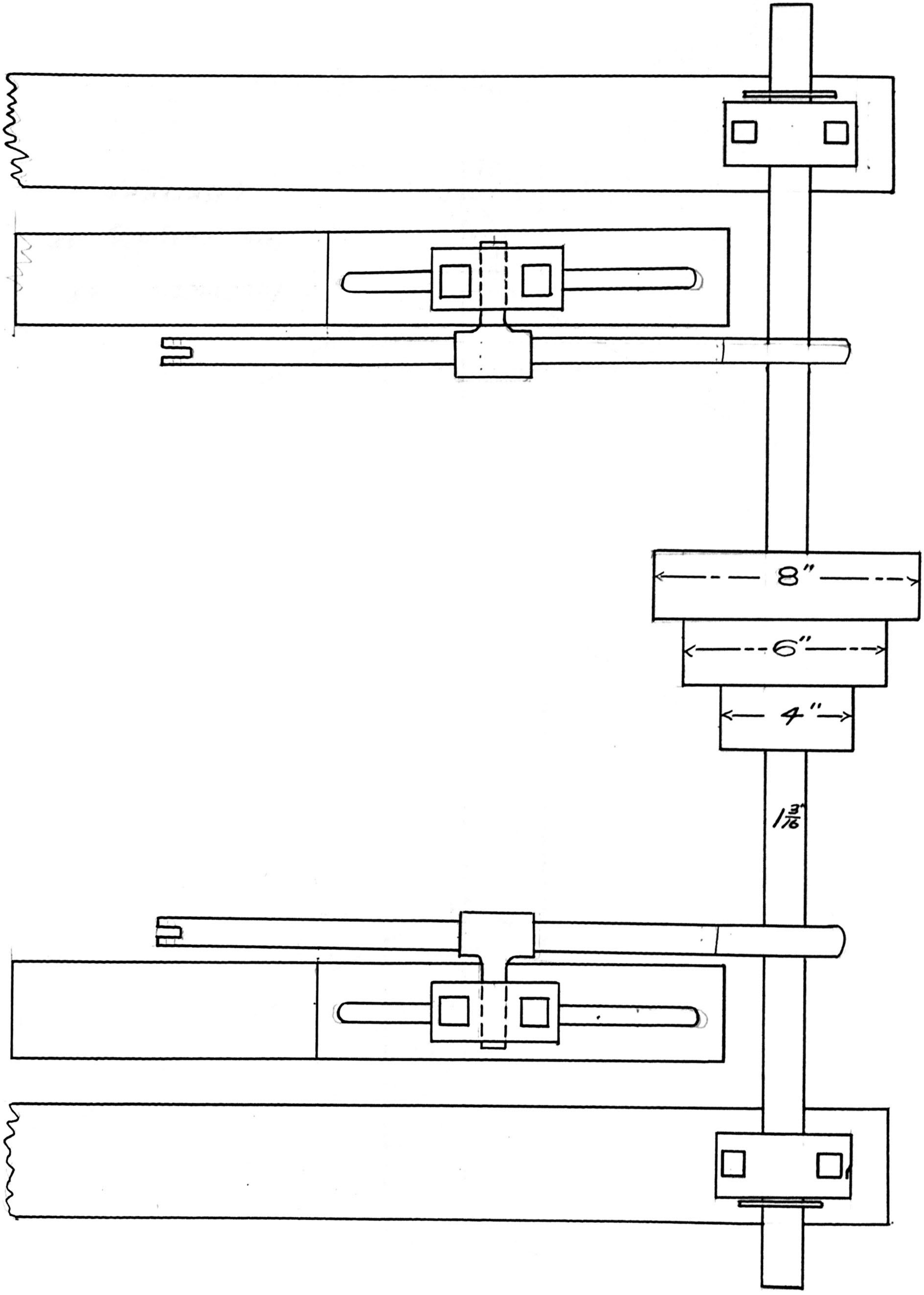


End View

Scale 1/6 Size.

Section Across Screen #1.




8"
6"
4"
1 3/16"

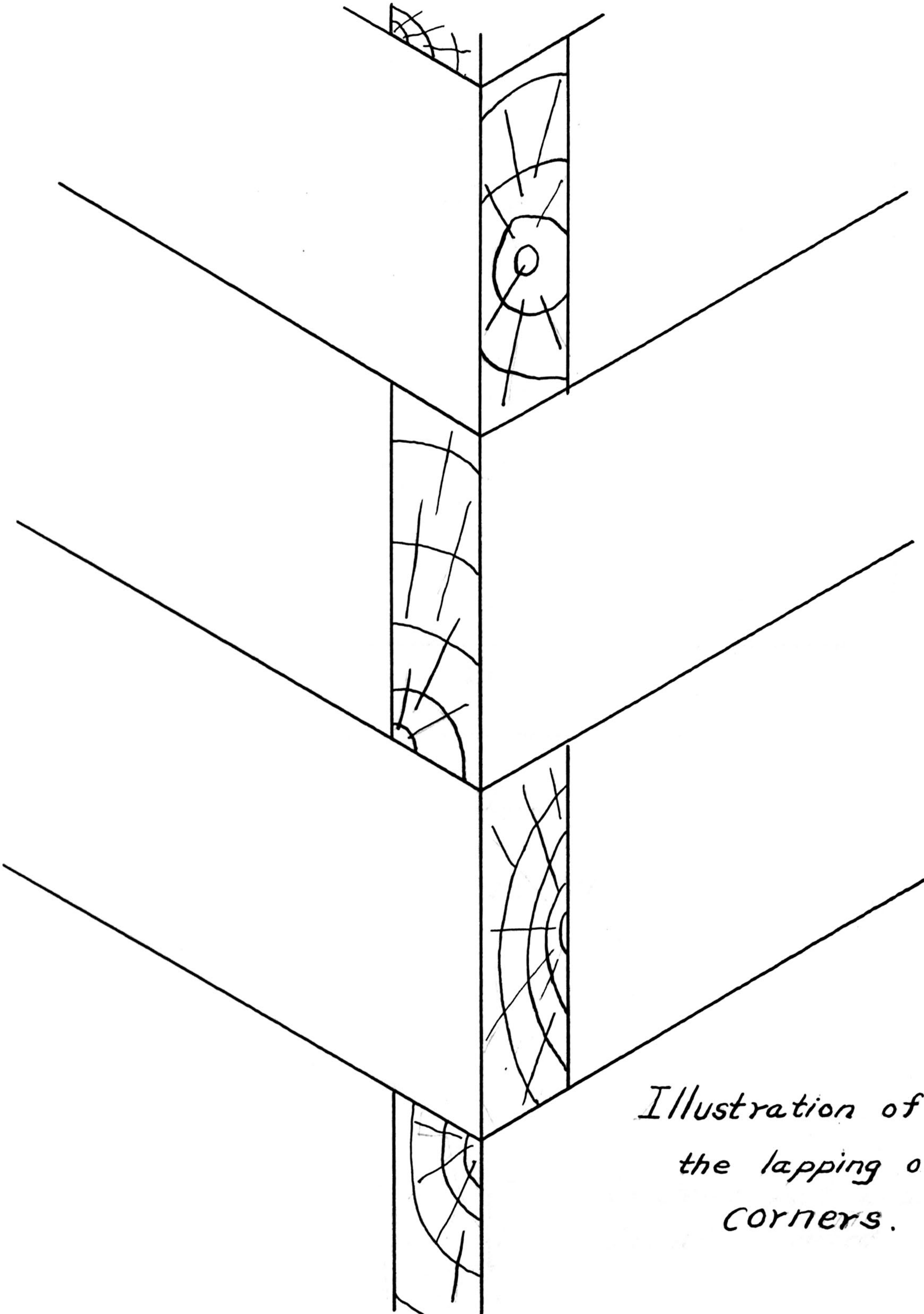
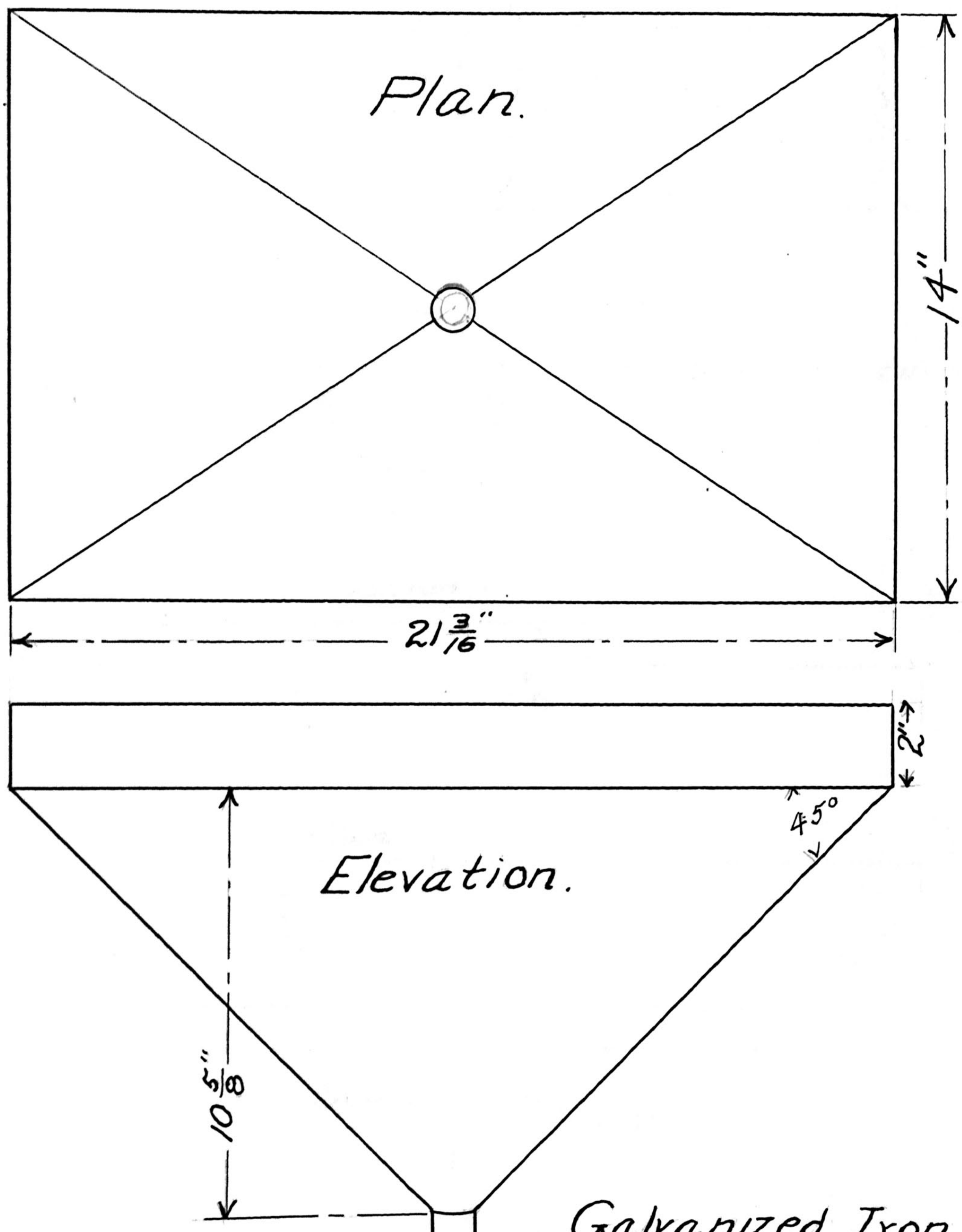


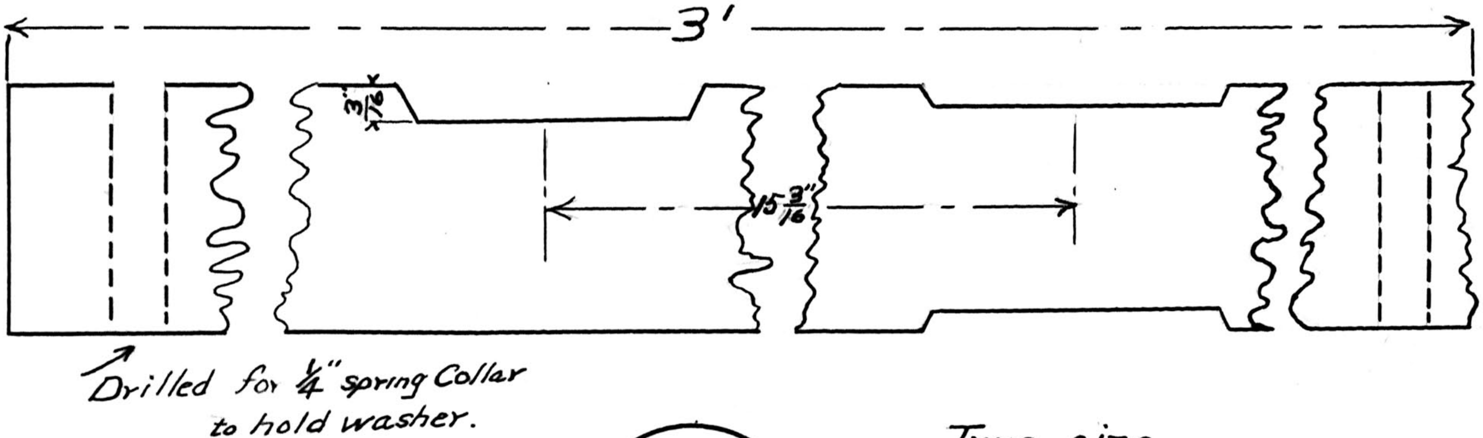
Illustration of
the lapping of
corners.

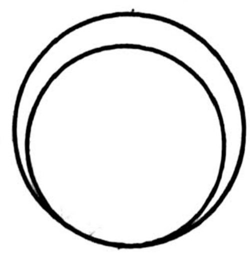
Hoppers.



Galvanized Iron
Joints Riveted and
Soldered
Scale 1/4 Size

Shaft

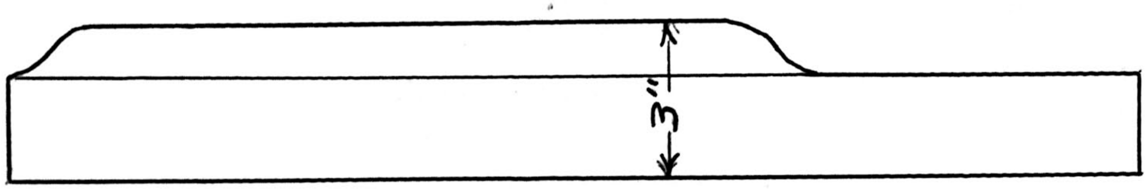




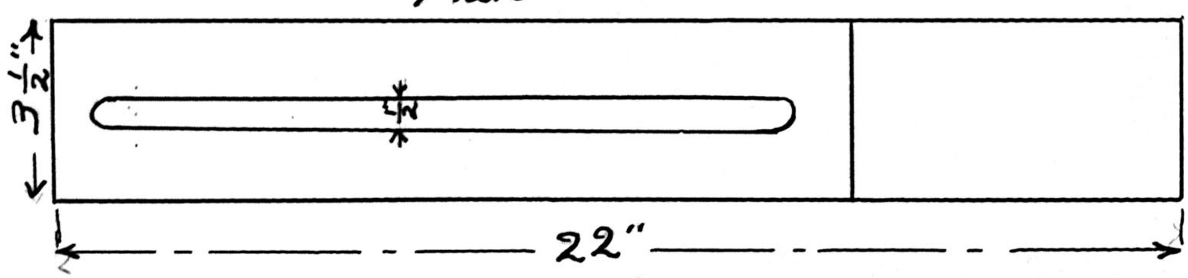
True size.

Manner of turning, for eccentric.

Elevation.

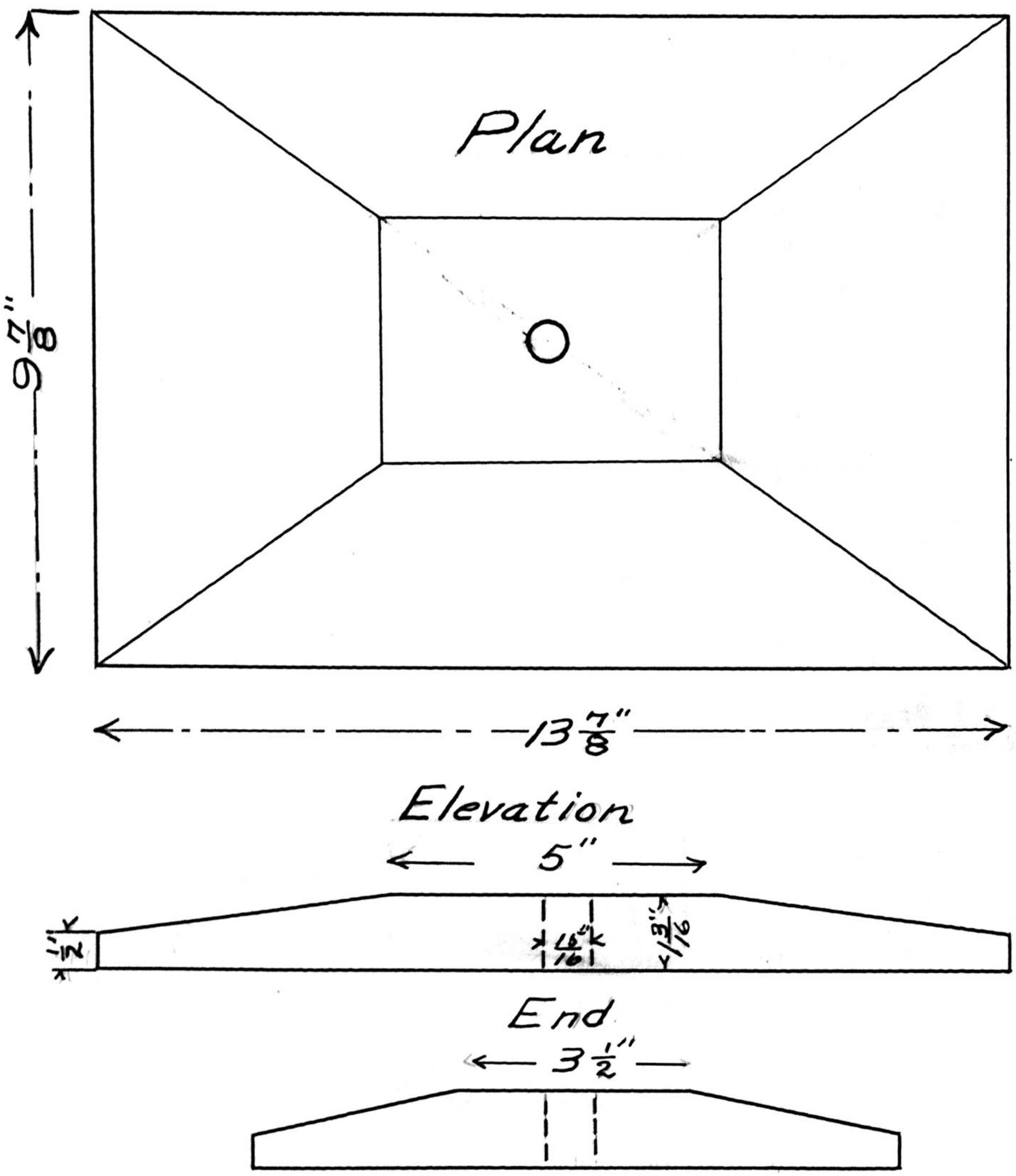


Plan



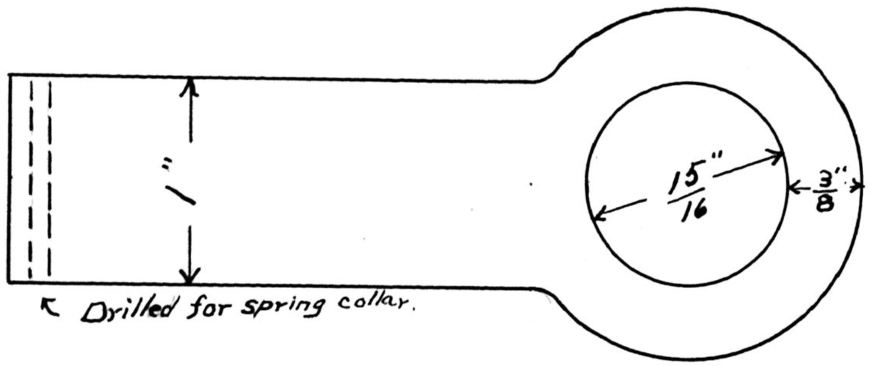
Scale 1/4 Size.

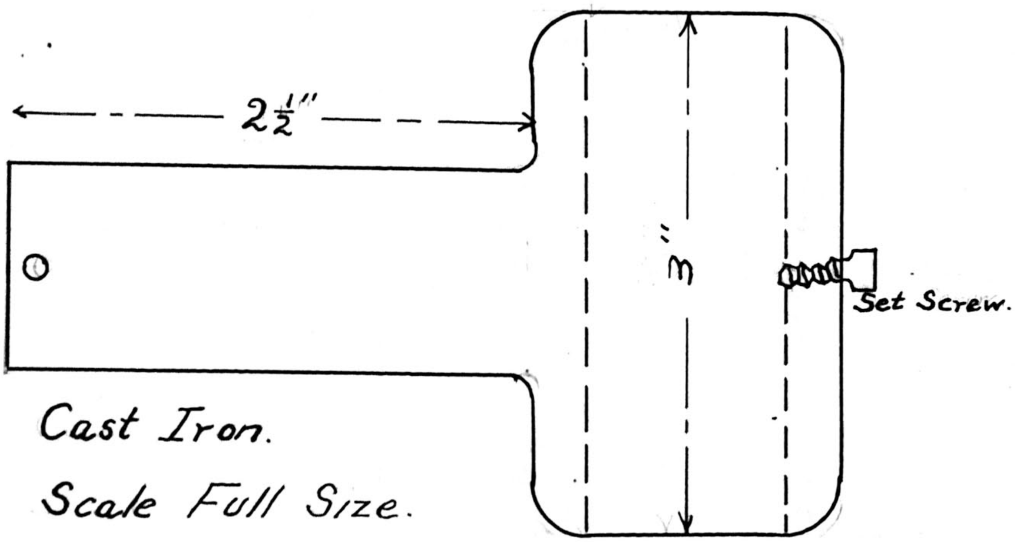
Plunger.



Made of White Pine
Scale 1/3 Size.

Lever Supporter.

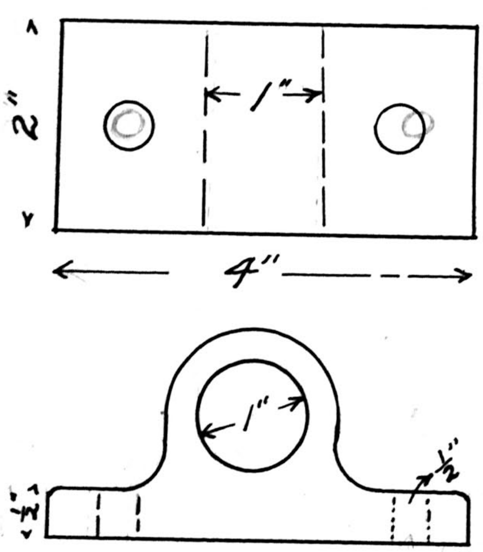




Cast Iron.

Scale Full Size.

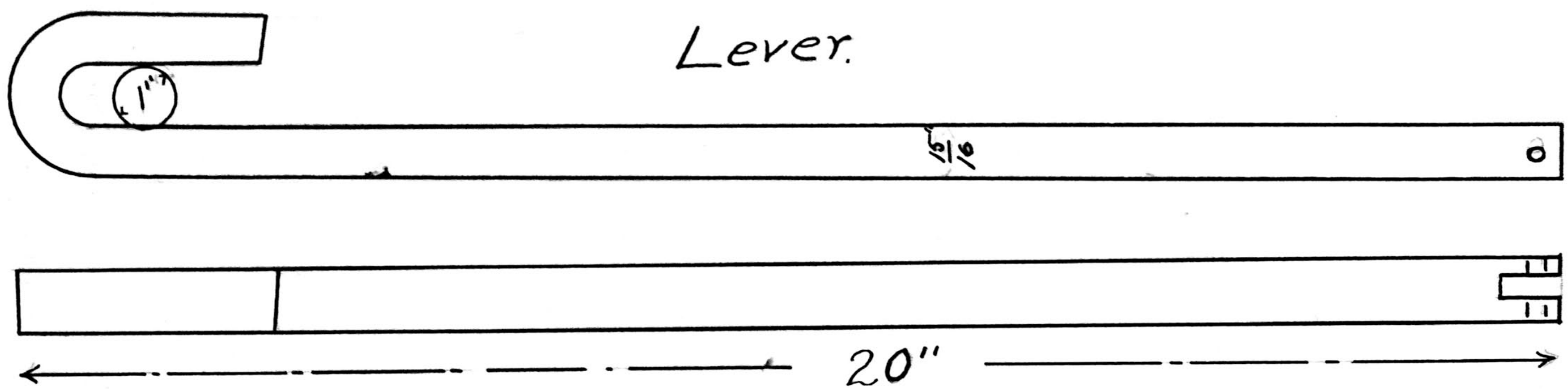
Fulcrum.



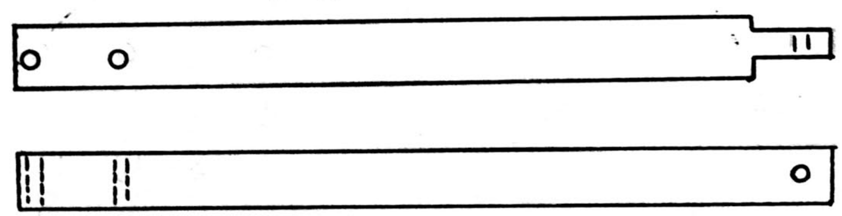
Wrot Iron

Scale 1/2 Size.

Lever.



Pulsion Rod



One 8" long, one 10" long.

We decided to make a miniature jig, of such a size to suit the capacity of the rolls in the laboratory. The jig that has been used in the laboratory is too large . Our object was to make a small jig, study its operation, and to do some testing.

The screen area and pulsion area are equal in size, each measuring I40 square inches. These areas were chosen equal on account of the ease in constructing the jig. Of the screen area as given nothing is deducted for the room taken up by the supports. The kind we decided on is a two compartment jig, stationary sieves, and has both a variable speed and throw. The lumber chosen is white pine for the boxing and yellow pine for the corners and braces. All lumber is cleared. The white pine measures one and three sixteenths. Each tier in the construction of the box was cut to the proper lenght and clamped together before planing, so as to give uniform thickness. The manner of lapping the corners is illustrated in the drawings? The construct- of the corner posts is also shown.

All the joints were painted and tightened with clamps before nailing firmly in place. This gave good water tight joints and proved satisfactory in every respect. The partitions were likewise painted before putting in place, both to insure against leak and decay.

The eccentric was obtained by cutting the shaft, so that with a heavy bar bent over the shaft, an up and down motion would be given to the bar, when the shaft is rotated. The shaft was cut by turning so that three sixteenths was cut off of one side, which gradually diminished to no cut a hundred and eighty degrees from the deepest cut. The two cuts are made ninty degrees from each other, so that when one plunger is up and practically stationary the other is in motion. In other words it is to make the strain on the shaft as even as possible. This shaft is one and three sixteenths inches in diameter and after turning there is still an inch of steel which is plenty strong. The three sixteenths inches give a throw of three eights of an inch. The bar or lever as it could be called is turned over the shaft. This was done by forgeing, to a scant measurement and then filed so as to give a flat surface to prevent wear. This lever passes through the fulcrum as shown, and connects with the plunger rod by a pin joint. This joint is a turn of a right angle and made a pin joint to allow for the little play at this point.

The plunger rod passes through the plunger and holds the latter in place by pins and heavy washers. The plungers are an inch below the level of the screens for their respective compartment. They are made of one piece of white pine, trimmed so as to be light. A good bit of trouble was caused by the swelling of the soft wood.

The partitions crosswise of the jig extend down to the bottom of the boxing. The longitudenal partition extend three fourths the width of the sieve below its level, or in each case seven and a half inches.

Screen number one is set three inches below the level of the box top, and screen number two is two inches lower. The dams for each screen can be adjusted to heights over one inch.

The frame that supports the fulcrum is made so that by loosening the bolts that hold the fulcrum in place a variable throw can be obtained. One objection arises to this form, and that is the one sided pressure on the support.

The fulcrum consists of two parts, first, a piece of wrot iron turned and cut to form shown from a bar, and which can be moved along the frame, secondly, a casting which fits in the wrot iron piece and which holds the lever by means of a set screw. This casting is held in place by a spring collar. Half inch bolts are used to hold the fulcrum to place. The set screw insures the throw to be up and down.

The jig is provided with a feed box and tail board. The tail-board prevents the water from running down the side of the jig and makes it easy to catch the tailings. The feed box should be longer so as to give a more even feed.

The shafting is provided with only two journals, as the bearings are not far apart and the shaft is extra heavy.

The hoppers were made in a tin shop. The material is extra heavy galvanized iron. All joints are soldered and riveted at intervals of two inches. The slope of the ends is forty- five degrees. In placing them in place, oakum was tamped behind the edge of the hopper and a water tight fitting was obtained. At the apex of the hopper an inch pipe was put in to withdraw the hutch products. The pipes are short and give ample room to catch any material in boxes.

The largest screens for the jig have openings two tenths inches or it is a twenty-five inch mesh screen. They grade downward in the approximate proportion of the square root of two.

After completeing the construction of the jig, it was set up in the mining laboratory. As the jig was built high above the ground it was top heavy and bracing to one of the pillars was necessary. Our greatest handicaps were the lack of good lead sulphide ore and the time to do the proper testing. No assay tests could be made along with the running of the jig.

The ore from the crusker in the laboratory was fed to the coarsest screen. The diameter of the ore pieces varied from a half inch in diameter to dust. With the estimated flow of water, the sorting on the screens was very good, but part of the fine pure chert would pass through the screen. This could be remedied by entering water by means of a faucet below the plungers. The screen sorting showed the largest pieces of ore which were high in zinc sulphide to be next to the screen, as well as rare pieces of galena. The large pieces of chert which were entirely free from sphalerite were carried over the tail-boards. The above description of the working of the jig pertains to it when running at the highest speed. With the medium speed the throw had to be increased to give the same working capacity. The slowest speed was to low to make satisfactory sorting. Products from the laboratory rolls were treated on the smaller mesh screens. The jigging here proved more successful with the high speed. Tests were made by panning, and it was found that there was a high degree of concentration, but still the trouble of the fine chert going through the screen. The remedy for this was mentioned above.

For the best work we would recommend the introduction of water below the plungers. If in the future a greater throw of the plunger was necessary, the shaft cut be cut deeper in the same manner and still be sufficiently strong. Larger commercial jigs call for more loosely fitting plungers. This could be easily given. Probably too much of the screen area is taken up by the support. The remedy of this is to fasten the screen on a frame that just fits that portion of the jig.