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Design and construction of the experimental mine

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DESIGN AND CONSTRUCTION OF THE EXPERIMENTAL MINE.

BY

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A

THESIS

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Approved by C. R. Forbes

Professor of Mining.

TABLE OF CONTENTS.

LIST OF DRAWINGS.

FOREWORD.

The following is a report of the work done at the experimental mine from May 1921 to May 1922. Credit is given to Professor C.R. Forbes under whose direction this work was done.

The mining laboratory and experimental mine at the Missouri School of Mines was opened in 1913. At a suitable location, on the site of an old dolomite quarry, one and one half miles southwest of town a tunnel was started into the hillside and the necessary plant erected. This plant consisted of a fifty horse-power Erie Iron Works boiler of the modified locomotive type, and an Ingersoll Rand type 10 single stage, duplex, air compressor of a capacity of one hundred cubic feet of free air per minute. This plant was in operation during the fall months of each year when mining laboratory work was given, and in the summer of 1918 a special training detachment of the army carried on experimental work there. The plant admirably met the requirements of these earlier years but as the classes increased in size the air capacity was found to be insufficient, that is only one large or two small drills could be operated at a time. This was not sufficient to allow the students to complete the course in the allotted time, so the present plant was planned and constructed.

POWER PLANT.

The present plant was constucted during the summer of 1921 and its operation during the fall term was in general, satisfactory. A 72"x16' return tubular boiler was set in a specially designed brick setting. Two interesting features of this setting are that the entire weight of the boiler is carried on a timber frame work and that an extra high fire box and combustion chamber are provided. The boiler sets 48" above the grate bars and the bridge wall is carried to within 16" of this shell. This gives a fire-box 72"x 12"x 48" and a combustion chamber 72"x 120"x 48". To date no test run has been made but heavy loads have been carried with an apparent low fuel consumption. A Ladiaw-Dunn-Gordon 13"x 71/2"x 8"x 8" air compressor of a capacity of 150 cubic feet of free air per minute was installed to furnish air for the drills. This machine discharges into a common receiver with the Ingersol-Rand machine described above, giving a total capacity of 250 cubic feet of free air per minute compressed to 90 pounds pressure. The cooling water from these compressors is fed directly to the boiler without further heating by either a duplex pump or an injector. A suitable structure housing the equipment was erected on the site of the old power house.

HOISTING AND CRUSHING.

During the summer of 1918 the service men had raised an opening to the surface some hundred feet from the portal for ventilation. This makes a shallow shaft which was concrete lined and is now used for hoisting. A Joplin type head-frame was constructed from native sawn timbers. With this type of head-frame the engine is located on the dumping deck and in such a shallow shaft hoisting is accomplished without bells, the operator simply watching the bottom. Hoisting is done with an 8"x 7" English Iron works geared steam hoist. This type of hoist uses a single vertical, non-reversing engine of 7" bore and 8" stroke. A 24"x 26" can carrying about six hundred pounds of rock is used. These are dumped by an ordinary tail rope, the material passing thru a grizzly into a five ton ore pocket.

The present crushing plant was to include both coarse and fine grinding. The coarse material is used for concrete and roads and the fine for an agriculture line. Mine run thru a five-inch grizzly runs by gravity to a 7"x 9" Blake crusher which gives the following product set with a discharge opening of 13/4"

% retained one

Mesh	%
2 inch........	.5

% retained ore - continued.

Mesh	%
11/2 in. ...	9.6
1 in........	30.2
3/4.........	21.4
1/2.........	20.5
1/4.........	13.4
1/4.........	25.2

The crusher discharges into a bucket elevator and the material is carried to a 100-ton storage bim from which it can be loaded into trucks and wagons. The equipment is belt driven from a 10"x 12" Erie Iron works, center crank engine. Steam is piped to this engine and to the hoist by an elevated steam line.

SWING HAMMER TESTS.

The problem has been to secure a product suitable for agriculture lime, that is 75% thru 35 mesh, which can be secured from a machine of relatively high capacity with a reasonably low power requirement. A combination jaw crusher and swing hammer machine known as a #2 Jeffery lime crusher has been tried for this work. This machine consists of a 6"x 7" jaw crusher of the Blake type under which is mounted the swing hammer machine. The hammer mill consists of a number of manganese steel hammers mounted on a rotating cylinder. The material is fed from the crusher discharge into this circular chamber, the lower half of which is lined with grate bars. When the material is reduced in size, it passes thru the openings in these bars. The power is transmitted to the crusher shaft by a short belt from the main or cylinder shaft. Grate openings are 1/16 of an inch.

Following is a screen analysis from this machine.

SCREEN ANALYSIS HAMMER MILL PRODUCT
500 gram.
sample

On mesh	G rams on	Per cent.	Cumulative per cent.
6	7	1.4	1.4
8	36	7.2	8.6
10	66	13.2	21.8
14	53	10.6	31.4
20	38	7.6	39.0
28	43	8.6	47.6
35	34	7.8	55.4
48	34	7.8	63.2
65	44	8.8	72.0
100	53	10.6	82.6
150	40	8.0	90.6
200	25	5.0	95.6
-200	24	4.8	100.4

It will be observed that from a standpoint of crushing this machine is satisfactory but its power requirements are high and its capacity low. Twenty horse-power is required to drive this machine at a capacity of one and one half tons an hour. Considerable difficulty was experienced in running the moist material as it comes from the mine thru this machine. The grate bars would become clogged and the hammers would throw material back into the throat of the jaw crusher and cause it to stick. In general the machine was not satisfactory.

BALL MILL TESTS.

Some experimental work was dome on dry ball mill grinding but the material was so moist that no satisfactory results were secured. The results from one of these tests may be taken as typical.

Ball Mill Test No. 1.

25# - 3/4" mine dolomite.

175 # Balls 3/4" to 2" in diameter.

Moisture in material estimated 5%.

Run 20 min.

Power consumed 5 amp. 220 volts above friction load. (1.47 horse-power)

Product.

4# - 1/2 Lumps.

Rest of material ground but remained sticking to mill and could be removed only by washing.

The machine in the ore dressing laboratory was used for this work. The tests showed conclusively that a ball mill of trunion type of discharge, grinding dry is out of the question for this work.

SCREENING TESTS.

Tests of the rock for concrete purposes has shown that when used with a good grade of river sands, much higher values of compressive strength are secured than with the native gravel. Experiments have shown that the highest strengths are secured when all the material thru 1/4 inch mesh is removed. This was a laboratory test, however, and the screening nearly 100% effective, so it was decided to use a 36"x 6' trommel fitted with a 1/2" punched plate. This trommel is to be located on top of the present ore bin, the oversize going into the loading bin and the undersize into the recrushing bin.

The results of these tests follow.

ROLL TESTS.

The most satisfactory results for handling the moist mine material for fine crushing was with the 12"x 12" laboratory rolls. A surprising fact was noted in connection with this work that with the rolls surfaces in contact and with a moderate pressure on the tension springs, a much finer and more uniform product was secured when the material was moist than when it was dry. These results continued up to a point where the feed became so wet that the material would cling to the roll surfaces, causing them to open up allowing oversize to pass thru.

The screen analysis shown are for the two classes of material and were secured with both rolls running at a speed of 160 r.p.m. or 505 feet per minute.

ROLL PRODUCT. DRY.

3/4" thru 12x12 Rolls.

200 gram sample.

Mesh	Grams	%	Cum. %.
6	65	32.5	32.5
8	35	17.5	50.0
10	32	16.0	66.0
14	18	9.0	75.0
20	10	5.0	80.
28	9	4.5	84.5
35	5	2.5	87
48	4	2.0	89
65	2	1.0	90
100	3	1.5	91.5
-100	15	7.0	99.0

ROLL PRODUCT. WET.

3/4" thru 12"x 12" Rolls.

200 gram sample.

Retained on mesh	grams	%	cum. %
6	14.5	7.2	7.2
8	17	8.5	15.7
10	27	13.5	29.2
14	23	11.5	40.7
20	17	8.2	49.2
28	18	9.0	58.2
35	12	6.0	64.0
48	11	5.5	69.5
65	15	7.5	76.0
100	45	22.5	98.5

By taking a sample of this material and giving it a rotap screening for thirty seconds to determine the effect an impact screen would have upon it, the following results were secured.

No. 1.

Sample. 400 grams.

On 8 mesh 85 grams. 21 per cent.

Thru 8 mesh 315 grams. 79 per cent.

No. 2.

Sample	400 grams.	
On 10 mesh	126 grams.	31.5 per cent.
Thru 10 mesh	274 grams	68.5 per cent.

CONCLUSIONS OF TESTS.

It would seem as if this would be the best proposition:- taking 1/2" material from the crushers and feeding it to the rolls running in closed circuit with an impact screen with a ten mesh cloth.

The equipment was not available to make tests to determine the effect of different roll shell penphial speeds, but it would undoubtedly produce a finer product. The rolls should also be fitted with spring scrapers so as to keep the surfaces clean and in as near a contact as possible.

If the slower roll runs at a speed of 500 ft. per minute, and the distance between the shells is 1/16 inch, the theoretical capacity per hour will be:-

$$\frac{1/16 \times 12 \times 500 \times 12 \times 60}{1728} = 156.2 \text{ cubic feet.}$$

Taking 1 cubic foot = 100 pounds.

$$\frac{156.2 \times 100}{2000} = 7.31 \text{ tons per hour.}$$

Taking the actual capacity as 1/3 this which is a safe rule, gives a capacity of the rolls alone of $\frac{7.31}{3} = 2.44$ tons per hour.

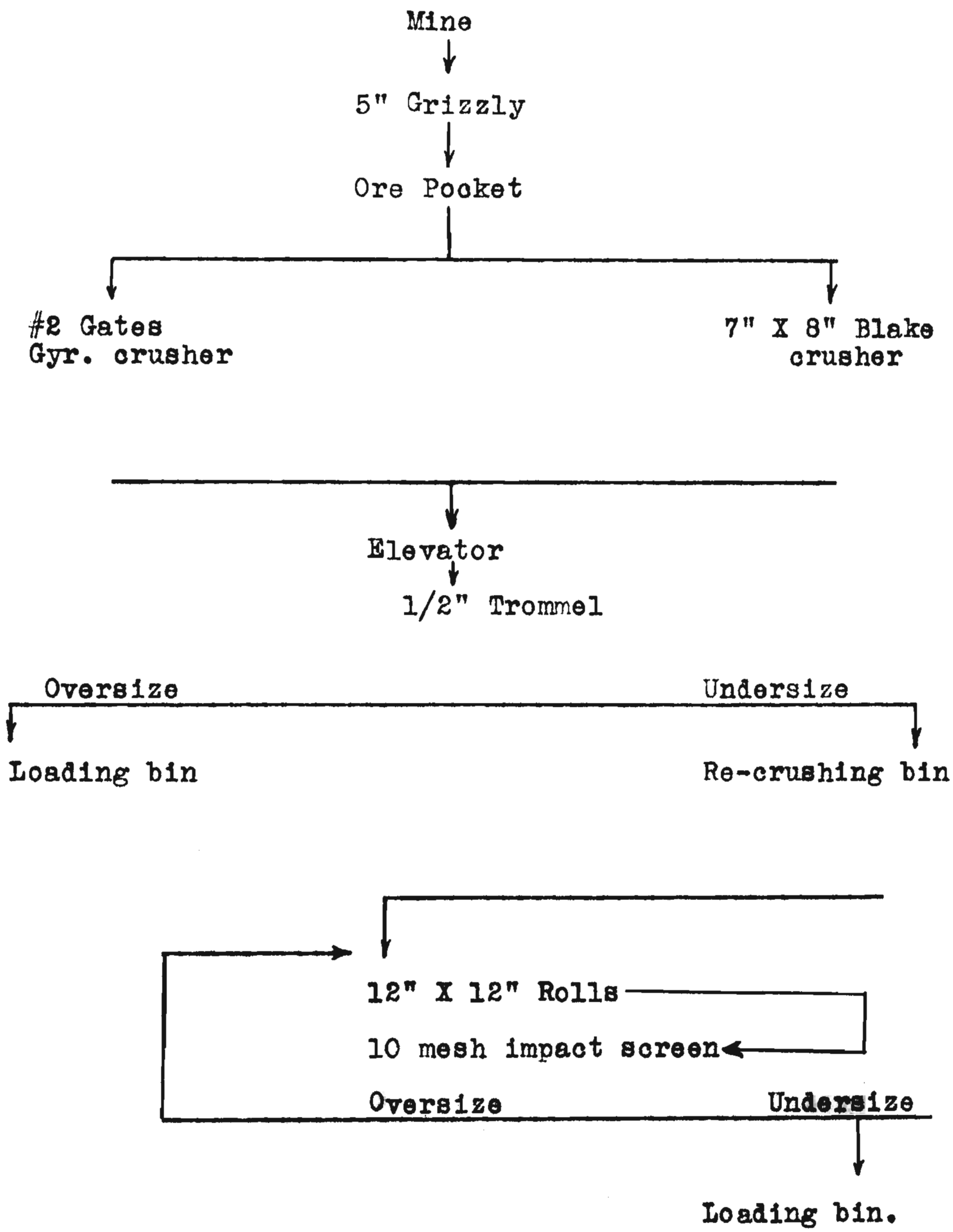
A small extension will be built on the present ore pocket and directly in front of this will be placed the #2 Gates gyratory crusher from the ore dressing laboratory. This machine will discharge into a common chute with the Blake crusher, and into the elevator. Both machines are by no means needed to handle the output but they are duplicated simply for the purpose of instruction. A screen analysis from this machine when in operation in the ore dressing laboratory running on mine rock, is as follows:

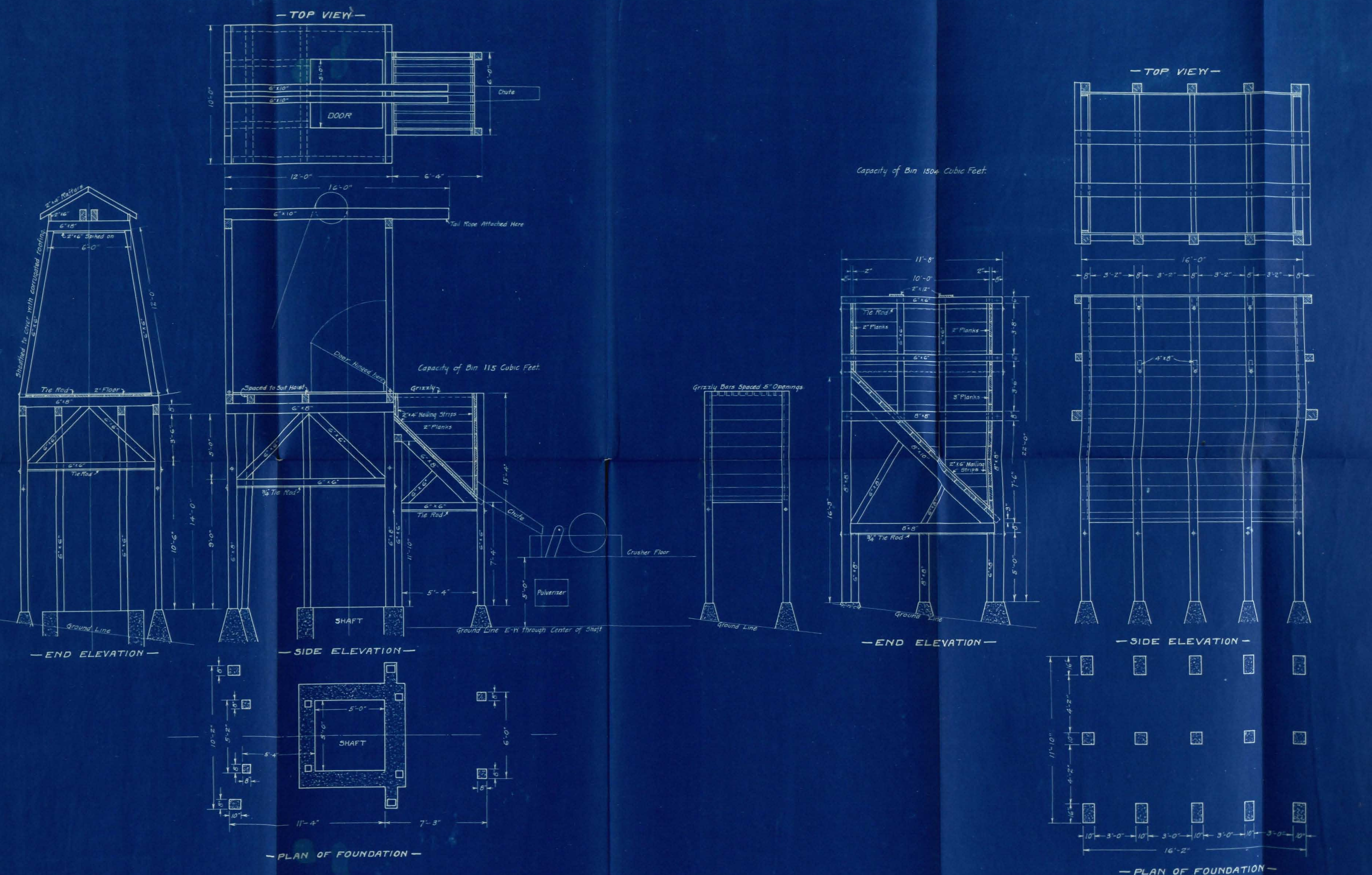
SCREEN ANALYSIS.

Gyratory Product. 11/2" opening.

Screen opening	weight	Per cent	Cumulative per cent.
1.	51.0	17.24	17.24
.742	94.3	31.03	48.27
.525	67.4	22.41	70.68
.371	31.0	10.34	81.02
.263	15.6	5.17	85.19
.185	10.2	3.4	88.59
6 mesh	10.5	3.5	92.09
8	3.9	1.29	93.38
10	2.6	.86	94.24
14	2.6	.86	95.10
20	1.6	.53	95.63
28	1.5	.52	96.15
35	1.2	.37	96.52
48	1.4	.48	97.00
65	1.6	.53	97.53
100	1.3	.43	97.96
-100	1.6	.52	98.48

PROPOSED FLOW SHEET.





SCHOOL OF MINES AND METALLURGY

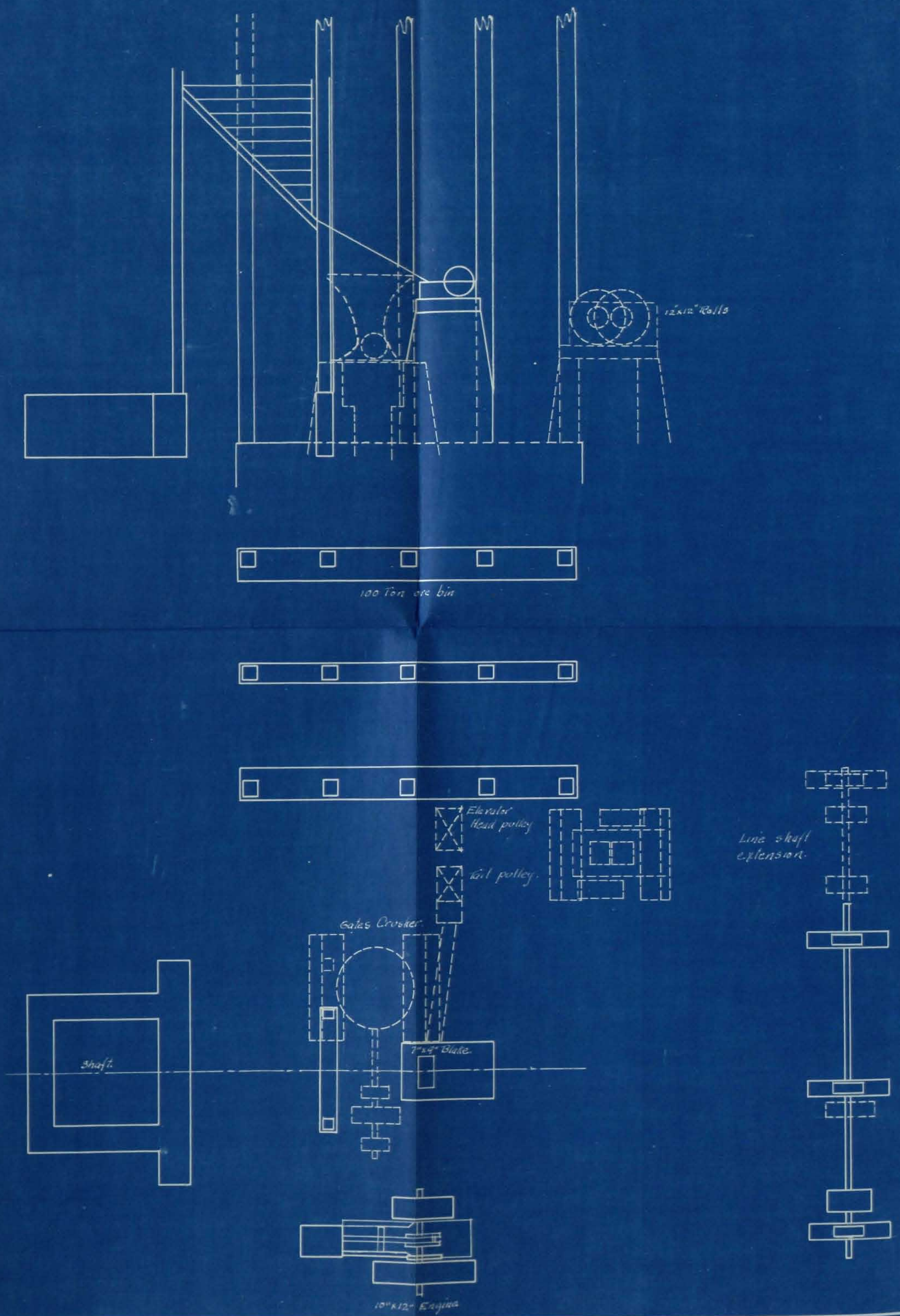
UNIVERSITY OF MISSOURI

DEPARTMENT OF MINING

HEADFRAME AND ORE BINS

DESIGNED FOR SCHOOL MINE PLANT

Rolla Mo. Scale 1/4"=1' May 2, 1921.



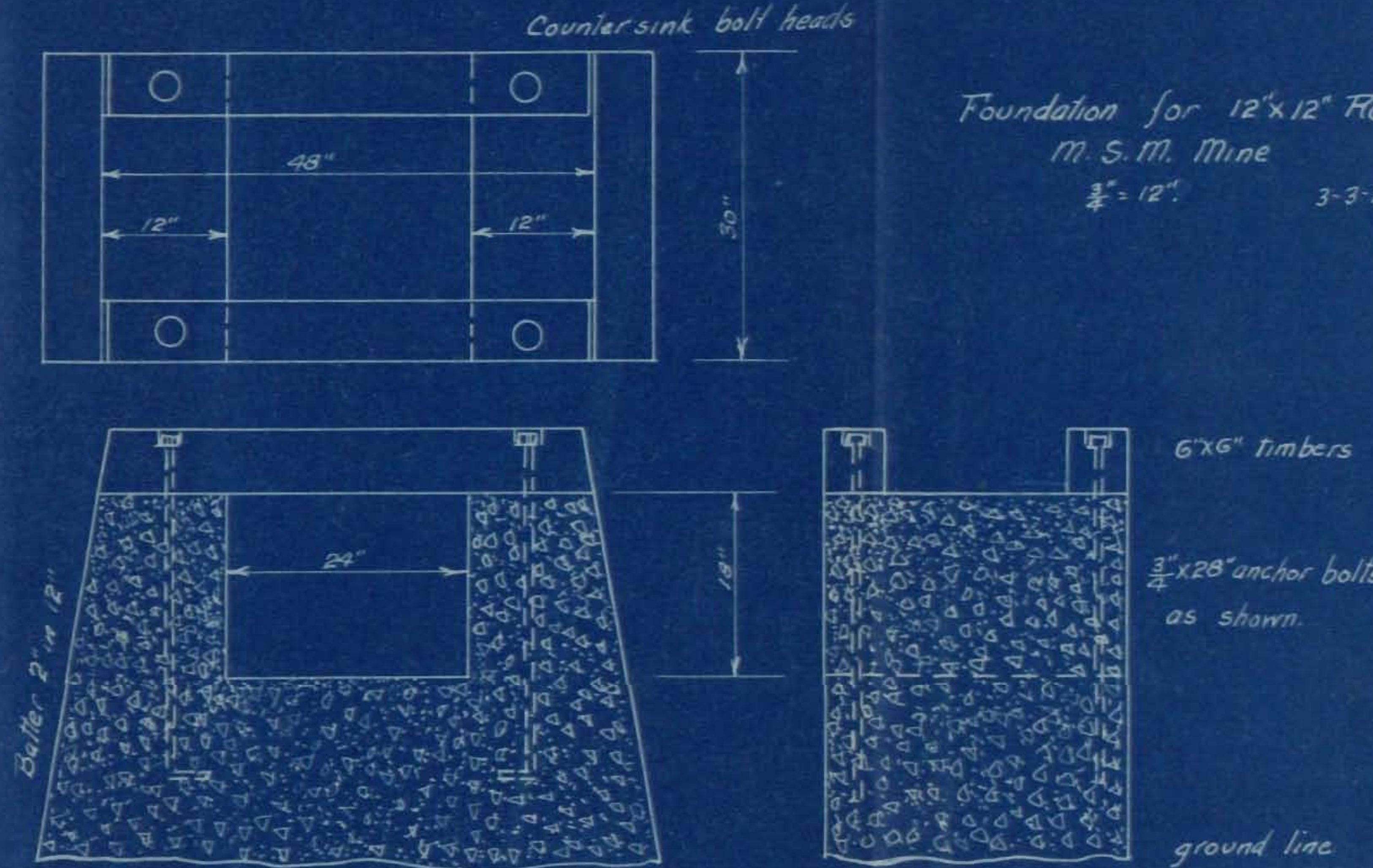
PROPOSED CHANGES
IN CRUSHING PLANT.
M.S.M MINE

Scale ¼" = 1'0"
March 5-1922

Note:- Dotted lines show location of machines to be installed or changed.

Foundation for 12"x12" Rolls
M.S.M. Mine

$\frac{3}{4}$" = 12" 3-3-22

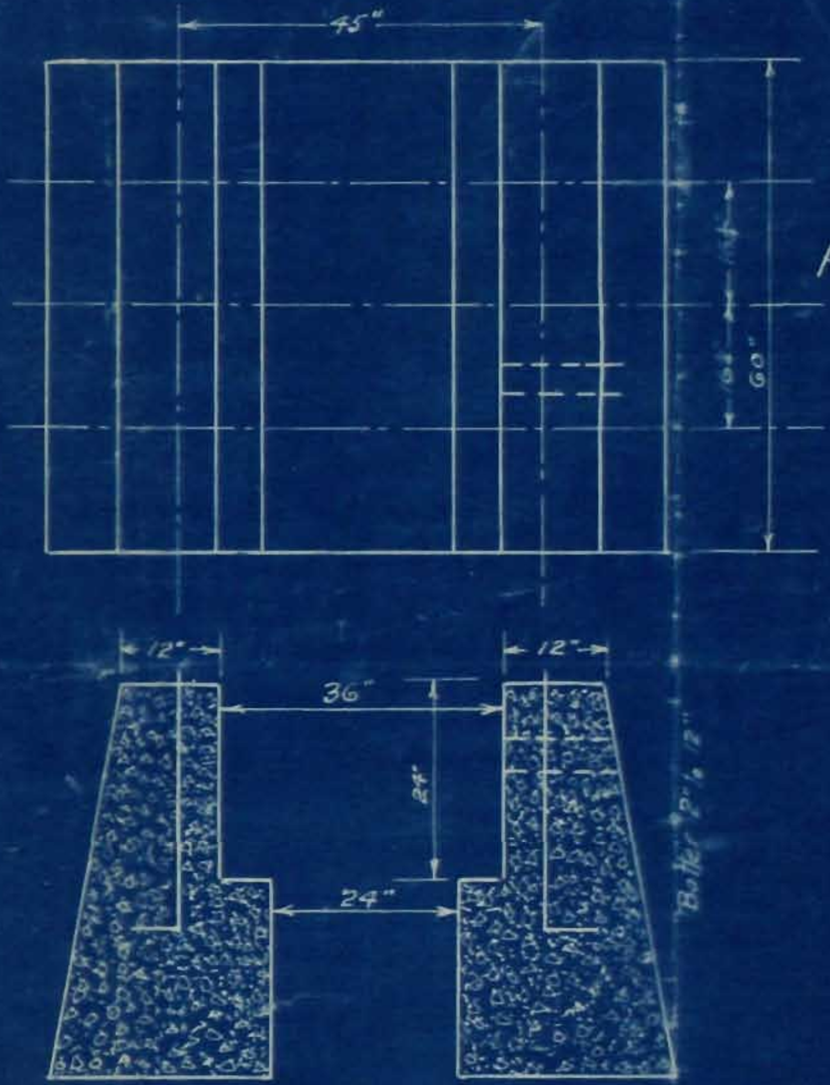


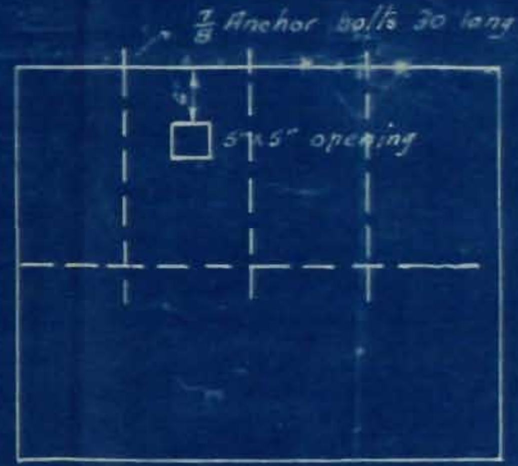
Make top of concrete 42" above north side of ore bin foundation.

Foundation for #2 Gates Crusher

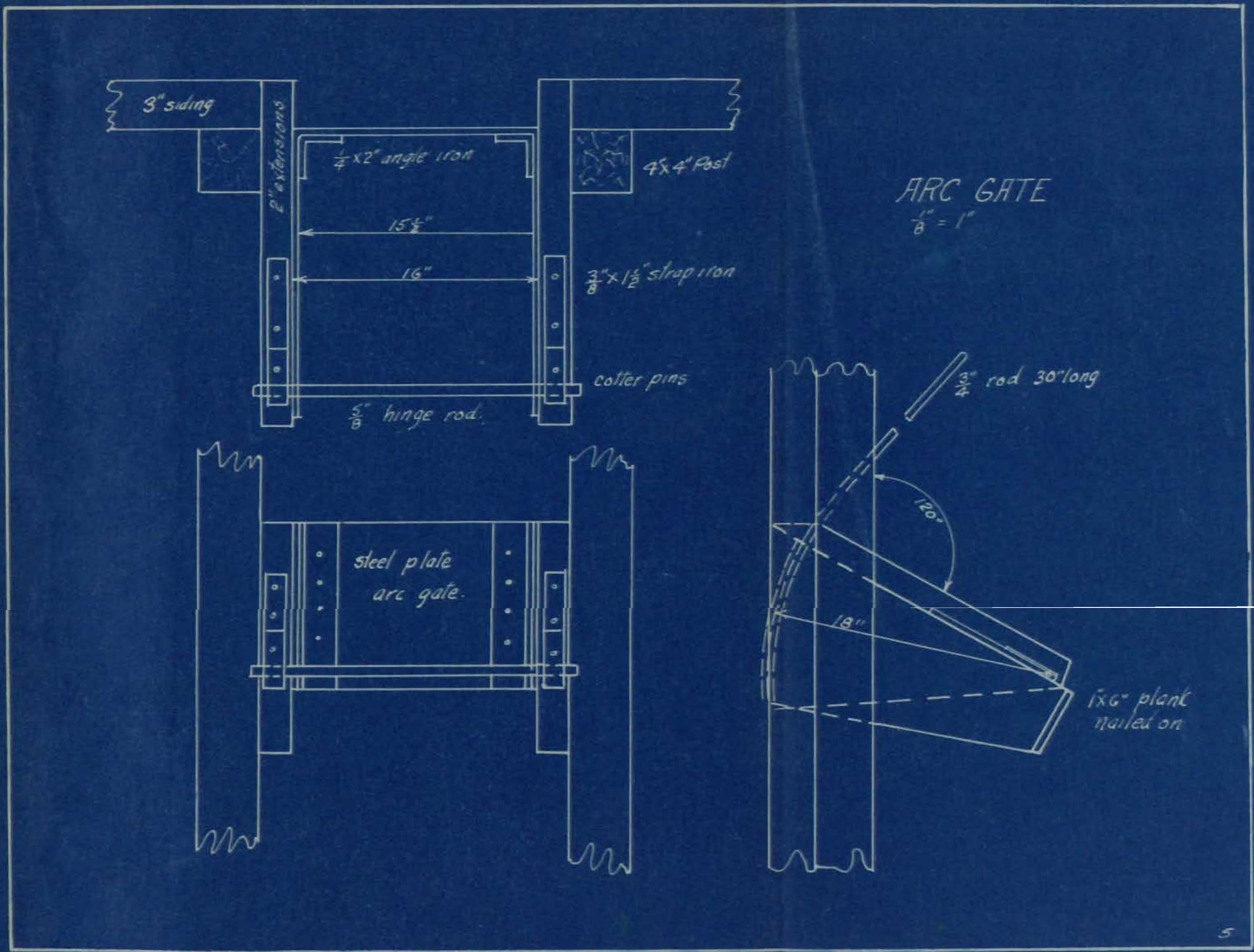
M.S.M. Mine

Scale 1/2" = 1'-0"





Note:- Make ℄ foundation 24" west and 16" above ore pocket foundation. Carry to solid rock.



ARC GATE
1/8" = 1"
3" siding
2" extensions
1/4 x 2" angle iron
4"x 4" Post
15 1/2"
16"
3/8" x 1 1/2" strap iron
cotter pins
5/8" hinge rod.
steel plate
arc gate.
3/4" rod 30" long
120°
18"
1x6" plank
nailed on
5