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The design of a sampling mill to treat a south east Missouri lead ore

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THE DESIGN OF A SAMPLING MILL TO TREAT A SOUTH EAST MISSOURI LEAD ORE.

by

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and

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A

THESIS

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THESIS SUBJECT

THE DESIGN OF A SAMPLING MILL TO TREAT A SOUTH EAST MISSOURI LEAD ORE.

The purpose of the work that was undertaken in preparing this thesis was to provide plans and specifications for a sampling mill to be erected by the St. Louis Smelting and Refining Co. at their plant near St. Francois, Mo.

The conditions existing at this plant are as follows: The ore treated is mined and hoisted from a two compartment shaft shown at A in Plate 1. From this shaft the ore, which will average at present about five per cent of lead in the form of disseminated galena, is carried by electric cars to the crushing plant, shown at C in Plate 1. Preliminary crushing is done at this point by passing the ore through two No. 6 gyratory crushers, the products of which are received on two trommels 8 feet long by 39 inches in diameter. The over-size products from these trommels pass by gravity to four No. 3 gyratory crushers, set to 1.25 inches, the products of which, together with the under-size from the trommels, drop to a conveyor belt 225 feet long running on a slope of 21 degrees. At present this conveys the ore to the belt conveyor G, which delivers it to bins holding

600 tons, shown at H. From these bins the ore is tapped through hand operated gates to a third conveyor, which delivers it to the mill bins of 20 tons capacity situated at I. The mill at present treats about 1800 tons in 24 hours.

The ore, as previously mentioned, contains about five per cent of lead as galena. This galena is rather finely disseminated in a limestone or dolomite gangue. In general the grade of ore is very uniform, thus presenting little difficulty in the way of obtaining a true sample.

Until a few months ago no mechanical sampling plant was operated in connection with this mill, but at the time of the Summer trip of the Junior class in 1910 it was learned that the management of the plant was considering the proposition of providing a suitable sampler to check the operations of the mill. This problem suggested itself as a suitable one for a thesis of this kind, and was accordingly selected.

It was intended at the outset to design the plant completely and to provide full working drawings and specifications for all parts of the mill. On account of the lack of time, however, it has been found necessary to somewhat reduce the amount of work. As a result only general plans and specifications with a few of the more important details are contained in the finished thesis.

It is proposed to erect the sampling mill at the point marked E in Plate 1. The building will occupy a space of 50 feet by 34 feet and will be 60 feet high. This will allow sufficient space for a sample finishing room, if it is desired. The sampling mill will be so placed as to have the conveyor D enter the building on the east side at an elevation of 23 feet and run along the south wall. This will lengthen the conveyor by 30 feet and thus make the total length of the conveyor 255 feet instead of the original 225 feet. This, together with the shortening of the belt conveyor G so as to allow the belt conveyor D to pass, will be the only change necessary in the existing conditions.

The incoming conveyor delivers the ore to an elevator and from that point it is carried through the samplers and on to the conveyor marked G entirely by mechanical means, as shown in flow sheet form by Plate 2 and the explanation of it below. In deciding on the cuts to be taken by the samplers we referred to the table found on page 47 of Hofman's Metallurgy of Lead. This table is based upon the size of the ore, the specific gravity of the richest particle, and the ratio of the grade of the richest particle to the average grade of the ore. The richest grade of the ore received by this mill is that of pure galena, 86 per cent lead, and the average grade is 4 per

cent lead which gives a ratio of about 22 to 1. From the table, by interpolation, it was found that the minimum sample allowable under such conditions is 12,960 pounds. Receiving the ore in a two inch size two cuts of 1/15 each are taken without further crushing. This gives a sample amounting to 1/225 of the total ore received or 16,000 pounds, which is a larger amount than that required by the table and is consequently safe.

Furthercutting down of this 16,000 pound sample cannot be safely accomplished without further crushing. The crushing of this material might be done continuously. However, since the rolls required to effect the proper reduction in size of this material are necessary large, it is thought that a more economical operation may be seoured by storing this preliminary sample and recrushing and resampling it during a small part of each day. Accordingly a 20 ton bin is provided, as shown by the flow sheet, into which each days sample is placed. Then at any convenient time it may be removed, re-crushed, and re-sampled according to the following method.

It was desired to obtain approximately an 80 pound sample of 3 millimeter size. This is done by first crushing from 2 inches to 9 millimeters with 30 inch by 10 inch belt driven rolls, which are set at 1/2 inch. The product from these is passed over a 9 millimeter station-

ary slot screen,from which the over-size is returned to the rolls and the under-size is passed through a four foot Vezin sampler,which takes a 1/14 sample. This sample amounts to 1/14 of 16,000 pounds or 1136 pounds. The table in Hofman's Metallurgy of Lead calls for a minimum sample amounting to 137 pounds under these conditions. Therefore the sample actually taken is sufficiently large.

The further reduction to 3 millimeters is done by a pair of 12.5 inch by 12 inch rolls. With this ore at 3 millimeter size it is safe to take a 13 pound sample according to the table previously referred to. The sample actually taken amounts to 1/14 of 1136 pounds or about 82 pounds. This amount is,of course,sufficient under the conditions. From this point the further reduction of the sample is accomplished by hand crushing and sampling.

The following is an explanation of the flow sheet of the sampling mill,the numbers of which correspond to the numbers found on Plate 2.

1. Ore received on belt conveyor is 1800 tons per 24 hours from the crushing plant.
2. Belt conveyor 20 in.wide and 255 ft.long running 300 ft.per minute.
3. Power and Mining Machinery Co.elevator,20 in.belt with 18 in.by 13 in.No.12 buckets

4. Vezin sampler, 9ft. in diameter, 1/15 cut, and making 15 R.P.M. Rejects to 16 and sample to 5.

5. Mixer, 5ft. by 18in., 35 R.P.M., slope 1 in. to 1 ft.

6. Vezin sampler, 7 ft. in diameter, 20 R.P.M., 1/15 cut. Rejects to 16 and sample to 7.

7. Ten ton bin made of 3/8 in. sheet steel with hopper bottom.

8-9. Automatic feeder from bin to Allis Chambers Co. style B, 30 in. by 10 in. rolls set to 3/4 in. and having a speed of 400 ft. per min.

10. Power and Mining Machinery Co. elevator. It has a 10 in. belt and elevates the material 45 ft. and has a speed of 300 ft. per minute.

11. Plane screen set at 45 degrees with 9 mm. slot holes. Over-size to 9 and under-size to 12.

12. Vezin sampler, 4 ft. in diameter, 1/14 cut, and 30 R.P.M. Rejects to 16 and sample to 13.

13. Allis Chambers rolls, style C, 12.5 in. by 12 in., making 150 R.P.M.

14. Mixer, 4 ft. by 18 in., 35 R.P.M., and slope of 1 in. to 1 ft.

15. Vezin sampler, 3 ft. in diameter, 1/14 cut, making 35 R.P.M. Rejects to 16 and sample of 82 lbs. to sample room

16. Combination elevator-conveyor consisting of 20 in.

buckets mounted on two chains. Delivers the ore to belt conveyor marked F in Plate 1.

The sampling mill is to be run by two main shafts, one of which is to run continuously,and the other approximately an hour each day. The continuous running shaft is driven by a 55 horse power Westinghouse direct-current 500 volt motor. The shaft that is to run intermittently is driven by a 70 horse power Westinghouse direct-current 500 volt motor. The first mentioned shaft is to drive the machines of the following Nos.2,3,4,5,6,and 16,see Plate2. The other shaft is to drive the machines numbered 8,9, 10,12,13,14,and 15. For details of the shafts see purchasing lists and Plates 3 and 4.

The plant receives 1800 tons of ore every 24 hours. To allow for increase in capacity,the sampling mill was designed to sample this amount in 16 hours.

PURCHASING LISTS WITH SPECIFICATIONS
NOT INCLUDING STEEL WORK

The following contains complete lists with the necessary specifications of machinery, materials for erection and construction, power transmission, belting etc., excepting nails and other small supplies, which may be purchased from the local dealers.

Crushing Equipment.

Number.

1. Set of 30-inch by 10-inch rolls. Allis-Chalmers Co. style "B" or the equivalent.

1. Set of 12.5-inch by 12-inch rolls. Allis-Chalmers Co. or the equivalent.

Samplers.

1. Vezin type sampler, nine feet diameter across the two cutting segments, to cut a 1/15 sample. The sampler is to be constructed of No. 6 U.S. gage sheet steel. The sampler is to be hung by a 1 15/16-inch shaft or spindle of cold rolled mild steel, which is to project 6 feet 8 inches above the top of the sampler and to be supported by two rigid, wick oiling, vertical bearings. The sampler is to be driven by a bevel gear attached to the above shaft, which in turn is to be driven by a pinion gear on a shaft of 1 15/16-inch in diameter by 6 feet 9 inches long; this shaft is to be supported by two wick oiling, rigid, pillow-block bearings and provided with a pulley 40-inch diameter

by 4inch face,at the outer end. The ratio of the above mentioned gears is to be five to one.

In addition to the above,the sampler is to be provided with a sheet steel housing,which is to be constructed of the same material as the sampler. The housing is to enclose one-half of the sampler and is to be so constructed that it may be hung from the framework which supports the sampler.

1. Vezin sampler,7-feet diameter across the two cutting segments,with housing. The supporting shaft is to extend 5 feet 3 inches above the top of the sampler and is to be driven by a shaft 4feet 6 inches long with a pulley 54-inch diameter by 4-inch face,at one end. The two shafts are to be 1 15/16-inch diameter and are to be connected by bevel gears of ratio 5 to 1. In all other details this sampler is to conform to the above specifications.

1. Vezin sampler. This sampler is to be the standard two winged,four foot,Vezin sampler as manufactured by Allis-Chalmer Co.or the equivalent thereof. It is to take a 1/14 sample. The supporting shaft is to project 5 feet above the top of the sampler. It is to be driven by a horizontal shaft 3 feet 5 inches long with a pulley 24-inch diameter by 4-inch face,at one end. The ratio of the gears is to be 4 to 1.

1. Vezin sampler. This sampler is to be the stan-

dard two winged, three foot sampler as munufactured by Allis-Chalmers Co. or the equivalent thereof. It is to take a 1/14 sample. The supporting shaft is to project 3 feet 2 inches above the top of the sampler. It is to be driven by a horizontal shaft 5 feet 2 inches long with a pulley 24-inch diameter by 4-inch face, at one end. The ratio of the gears is to be 4 to 1.

Mixers

These machines called mixers are to be used for mixing the smaple taken by one sampler before delivering it to the next sampler. They are to be constructed in a manner similar to the ordinary internal shaft trommel, except that where a punched plate or screen is used in the trommel the mixer will be provided with a solid plate. Each mixer is to consist of the following parts, a shaft 2 3/16-inch diameter length specified below, two spiders with split hubs and bands like those used on trommels, and a third spider with a cast iron band in shape of a frustrum of a cone to serve at the upper end of the mixer as a feed sole. In addition to the above items each mixer is to be provided with two bearings for the shaft, two sets of steel shells or wearing surfaces, and drive mechanism according to the specifications below.

1. Mixer 5 feet long by 2 feet in diameter constructed as above and provided with the following:

One. Shaft 8feet 6 inches long by 2 3/16-inch diameter.

Two. Bearings,solid,rigid,pillow blocks,cup oiling.

Two. Sets of shells of rolled manganese steel 3/8-inch thick for outer surface of mixer.

One. Dodge universal coupling for connecting shaft of 2 3/16-inch diameter to shaft of 1 15/16-inch diameter.

One. Shaft 4 feet long by 1 15/16- inch diameter with pulley 21-inch diameter by 4-inch face.

Two. Bearings,rigid,wick oiling,pillows blocks.

1. Mixer 4 feet long by 2 feet in diameter constructed as above and provided with the following:

One. Shaft 7 feet long by 2 3/16-in.diameter

Two. Bearings solid,rigid,pillow blocks,cup oiling.

Two. Sets of shells of rolled manganese steel 3/8-inch thick for outer surface of mixer.

One. Dodge universal coupling for connecting shaft of 2 3/16-inch diameter to shaft of 1 15/16-inch diameter.

One. Shaft 3 feet long by 1 15/16-inch diameter with pulley 6-inch diameter by 4-inch face.

Two. Bearings rigid,wick oiling,pillow blocks.

Elevators

1. Standard bucket elevator of 120 tons capacity per hour as built by the Power and Mining Machinery Co.,Milwaukee, Wis. It is to be gear driven,the R.P.M. of the pinion

shaft being151 and the R.P.M. of the head shaft 23, as in their catalog No.4. The distance between the head and foot shafts is to be 28 feet 6 inches. The driving shaft is to be 4feet 9 inches long with a pulley 30-inch diameter by 8-inch face.

1. Standard bucket elevator of 30 tons per hour capacity as built by the Power and Mining Machinery Co., Milwaukee,Wis. As in their catalog No.4 the R.P.M. of the pinion shaft is to be 171 and the R.P.M. of the head shaft 32. The distance between the head and foot shafts is to be 44 feet. The driving shaft is to be 4 feet long with a pulley 21-inch diameter by 5-inch face.

1. Combination elevator-conveyor,to be installed as shown in Plate 4. The conveyor is to have a capacity of 120 tons per hour and is to be gear driven by a motor of the proper size at the head end. The motor is to be a Westinghouse,General Electric,or Bullock machine for a 500 volt direct current circuit and is to be supplied by the manufacturer of the conveyor.

1. Conveyor belt 60 feet long by 20 inches wide, four ply 32 ounce duck,with a 0.094-inch extra rubber cover on oneside and is to be spliced on to the conveyor marked D in Plate 1. The same head and foot shafts are to be used as before. This conveyor is to be driven by a bevel gear on the head shaft which in turn is to be driven

by a pinion gear on a shaft 1 15/16-inch diameter and three feet long with a pulley 14-inch diameter by 10-inch face on the other end. This shaft is to be supported by two rigid,wick oiling,pillow block bearings. The ratio of the above gears is to be 4 to 1. This is to be accompanied by 7 carrier idlers and 3 return idlers.

Bin.

1. Ore bin of 20 tons capacity,the dimensions of which are 9 feet by 9 feet by 7 feet deep with a hopper bottom with a slope of 45 degrees. The bin is to be constructed of sheet steel 3/8-inch thick and is to be supported on I beams and angle columns as shown in Plate 5.

Feeder.

1. 10-inch by 12-inch standard bottom discharge bin gate as manufactured by Allis-Chalmers Co.,Milwaukee,Wis., shown in their bulletin No.1411.

Screen

1. 9 mm.,stationary,slot,screen,6feet long by 30 inches wide and 1/4 inch thick with a blank margin 1 1/2 inches wide left on all four edges.

Lumber.

This list contains the dimensions and amount of all lumber necessary for the construction of floors,frameworks, and all other parts of the mill which are to be constructed of wood.

The following lumber is to be grade No.1,clear yellow pine,finished smooth on four sides.

No.of pieces.	Size in inches.	Length.
10	12 x12	22 feet
5	12 x 12	20 "
4	12 x 12	18 "
2	12 x 12	16 "
16	10 x 10	20 "
4	10 x 10	18 "
6	10 x 10	16 "
1	8 x 8	22 "
4	8 x 8	16 "
5	8 x 8	20 "
5	6 x 6	24 "
1	6 x 6	22 "
5	6 x 6	20 "
6	4 x 4	20 "
80	4 x 10	10 "
162	4 x 10	20 "
120	2 x 10	12 "
120	2 x 10	18 "
15	2 x 8	16 "
100	2 x 6	20 "
65	2 x 6	10 "
80	2 x 6	18 "

The following lumber is to be the best grade, yellow pine, free from knots and other imperfections, and smooth on two sides.

No. of pieces.	Size in inches.	Length.
120	2 x 10	16 feet
120	2 x 10	16 "

The following lumber is to be the best yellow pine, vertical-grain, matched flooring in the quantity and sizes shown.

Quantity.	Size.	Length.
3400 square feet	7/8-inch thick by four inch face.	Commercial

Lag Screws.

40 Lag screws, with square heards and gimlet points, 12 inches long by 1/2 inch in diameter.

75 Lag screws, with square heads and gimlet points, 11 inches long by 1/2 inch in diameter.

75 Lag screws, with square heads and gimlet points, 7 inches long by 1/2 inch in diameter.

Tie Rods.

50 Tie rods, threaded at both ends, with washers and nuts, 4 feet long by 5/8-inch diameter.

Doors and Windows.

64 Window frames 60 inches high by 36 inches wide complete with double sliding sash and weights, with four

equal window panes.

64 Window frames 56 inches by 56 inches complete with four equal panes.

1 Door frame for a double door, each door being 4 feet 6 inches wide by 8 feet high.

1 Door frame for a single door 4 feet wide by 8 feet high.

Bearings.

5 Adjustable, ring-oiling, pillow blocks for 5 5/16-inch shafting, to be provided with bolts, nuts and washers for fastening to 8-inch timbers.

5 Adjustable, ring-oiling, pillow blocks for 5 3/16-inch shafting, to be provided with bolts, nuts and washers for fastening to 8-inch timbers.

Collars.

All of the collars in this list are to be solid and to be of the safety type, having no projecting set screws or knobs of any description.

2 Collars for 5 7/16-inch shafting.

2 Collars for 5 3/16-inch shafting.

Couplings.

1 Dodge-Collins compression coupling or equivalent for a 5 7/16-inch shaft.

1 Dodge-collins compression coupling or equivalent

for a 3 5/16-inch shaft.

Pulleys.

All of the pulleys in the following list are to be of solid cast iron with single arms. All are to be finished and accurately bored to shaft size. All are to be C.I.C.K.S.K. which means, cast iron with crowned face, key seated and provided with a key. The keys are to be of standard cross-section and all set screws are to be on the keys.

All of the following pulleys are to be double belt and of 3 7/16-inch bore.

Number.	Diameter in inches	Face in inches.
2	14	4
1	15 3/4	8
1	12	4
1	14	10
1	54	6

All of the following pulleys are to be double belt and of 3 5/16-inch bore.

Number.	Diam. in inches.	Face in inches.
2	14	4
1	54	6
2	27 1/4	8
1	10 1/4	10
1	25 3/4	10

Number.	Diam.in inches.	Face in inches.
1	18	5
1	12	4

Shafting.

All of the following shafting is to be cold rolled mild steel and key seated as shown in Plate 3.

No.of pieces.	Length.	Diam.in inches.
1	19 feet 6 inches	3 3/16
1	12 feet	3 3/16
1	20 feet	3 7/16
1	11 feet	3 7/16

Belting.

The following belting is to be the best grade of rubber belting for power transmission in lengths,widths, and weights specified.

No.of pieces.	Length.	Width.	Ply.
1	120 feet	10 inches	6
1	65 feet	8 inches	3
1	85	6 inches	5
1	42 feet	5 inches	3
1	190 feet	4 inches	3

Belt lacing.

200 Feet of 1/2-inch cut leather belt lacing.

200 Feet of 1/4-inch cut leather belt lacing.

SPECIFICATIONS.

The following contains general specifications for steel structure and steel covering of the sampling mill.

The contractor undertaking this work is to erect only the shell of the building,that is,the skeleton steel work with its covering of sheeting and corrugated iron, and is not to erect any floors,partitions.or other parts of such nature. For this work the contractor is to supply the structural steel parts of the building and the corrugated iron cover with all other items as herein after specified.

The building is to be constructed according to Plates 3 and 5. All details such as the position of windows etc.,are to be obtained from these drawings.

Specifications for Steel Work.

Workmanship:

All workmanship must be first class in every particular. Due regard must be had for the neat appearance of the finished structure,and details of an unsightly character will not be allowed.

Rivet holes must be accurately spaced,and must be clean cut,with out torn or ragged edges. Diameter of punch shall not exceed by more than 1/16-inch the diameter of the rivet to be used.

The use of drift pins will be allowed only for bringing the several parts together,and they must not be driven with such force as to disturb the metal about the holes.

The rivets,when driven,must completely fill the holes,have full heads concentric with the rivet,of a height not less than 6/10 the diameter of the rivet,and shall be in full contact with the surface,or countersunk when so required.

The several pieces forming one built member must fit closely together,and when riveted must be free from twists,bends,or open joints.

All abutting surfaces of compression members must be planed or turned to even bearings,so uniform contact may be obtained over all bearing surface.

All surfaces in contact shall be painted before they are put together.

Quality of work:

All metal in the structure ~~in the structure~~ shall be steel unless specified otherwise. Steel made by the open hearth process shall contain not more than 0.08 per cent of phosphorus,and if made by basic process,not more than 0.06 per cent of phosphorus. The steel must be uniform in character anf shall contain not more than 0.05 per cent of sulphur.

All tests and inspection of material shall be made at the place of manufacture pryor to shipment.

Specimens for testing shall be standard, cut from the finished material, and be at least of 1/2 square inch section.

Rivet steel shall show an ultimate strength of from 48,000 to 58,000 pounds per square inch. Elastic limit, not less than ½ the ultimate strength. Bending tests, 180 degrees flat upon itself without fracture on the outside of the bent portion.

Structural steel, the same as above, except ultimate strength, from 58,000 to 65,000 pounds per square inch.

Corrugated steel used for roof and sides of building shall have 2 1/2 inch currugations. The gage of corrugated steel shall be number 22 for roof and number 24 for sides.

Details of construction:

All connections and details shall be of sufficient strength to develop full strength of the member.

The pitch of rivets shall never be less than three diameters of rivet.

The distance between the edge of any piece and the center of a rivet hole must never be less than 1 1/4 inches, except in angles having a two inch leg, where it shall

be 1 1/18 inches.

The distance between connections of lacing bars to the flange of a channel shall not exceed two times the depth of the member nor shall they be inclined to the axis of the same less than 45 degrees. Thickness of lacing bars to be not less than 1/50 the distance of center of rivets connecting the same to channels. The width of lacing bars shall not be less than 2 1/2 times the diameter of the rivet used.

Columns shall be anchored to the foundations by means of four anchor bolts not less than one inch in diameter, placed as wide apart as practicable. The anchorage shall be calculated to resist the bending moment at the base of the column.

All steel work shall be covered before leaving shop with one coat of graphite paint thoroughly mixed with pure boiled linseed oil.

Structure shall have one coat of same paint after erection.

Covering: The sides and roof are to be covered by galvanized corrugated steel. In both cases, it is to lay upon 2-inch by 10-inch sheeting. On the sides, the sheeting is to lay upon 2-inch by 6-inch yellow pine studs which are to run horizontally 18 inches between centers and be securely fastened to the columns of the

building. On the roof,the sheeting is to lay upon 4-inch by 10-inch yellow pine studs,18 inches between centers,which are to run across the truses and be securely fastened to them. The sheeting and the studs are to be furnished by owner.

The corrugated steel shall be laid with two corrugations side lap and 6 inches end lap when used for roofing,and one corrugation side lap and 4 inches end lap when used for siding. The corrugated steel shall be fastened by clinch nails spaced 8 to 12 inches apart. Bolts,nails and rivets shall always pass through the top of corrugations. Side laps shall be riveted with copper or galvanized iron rivets 8 to 12 inches apart on the roof and 1 1/2 to 2 feet apart on the sides.

Windows are to be spaced as shown in Plate 3.

Doors are to be furnished by owner and are to be located as shown by Plate 3.

Flashing shall be provided above doors,windows and underneath cornices.

Ventilators shall be provided and located so as to properly ventilate the building.

Erection:

The contractor shall furnish at his own expense all necessary tools,staging and material of every description required for the erection of the work,and

remove the same when the work is completed.

The contractor shall assume all risks from stones or accidents,unless caused by the negligence of the owner,and all damage to adjoining property and to persons until the work is completed and excepted.

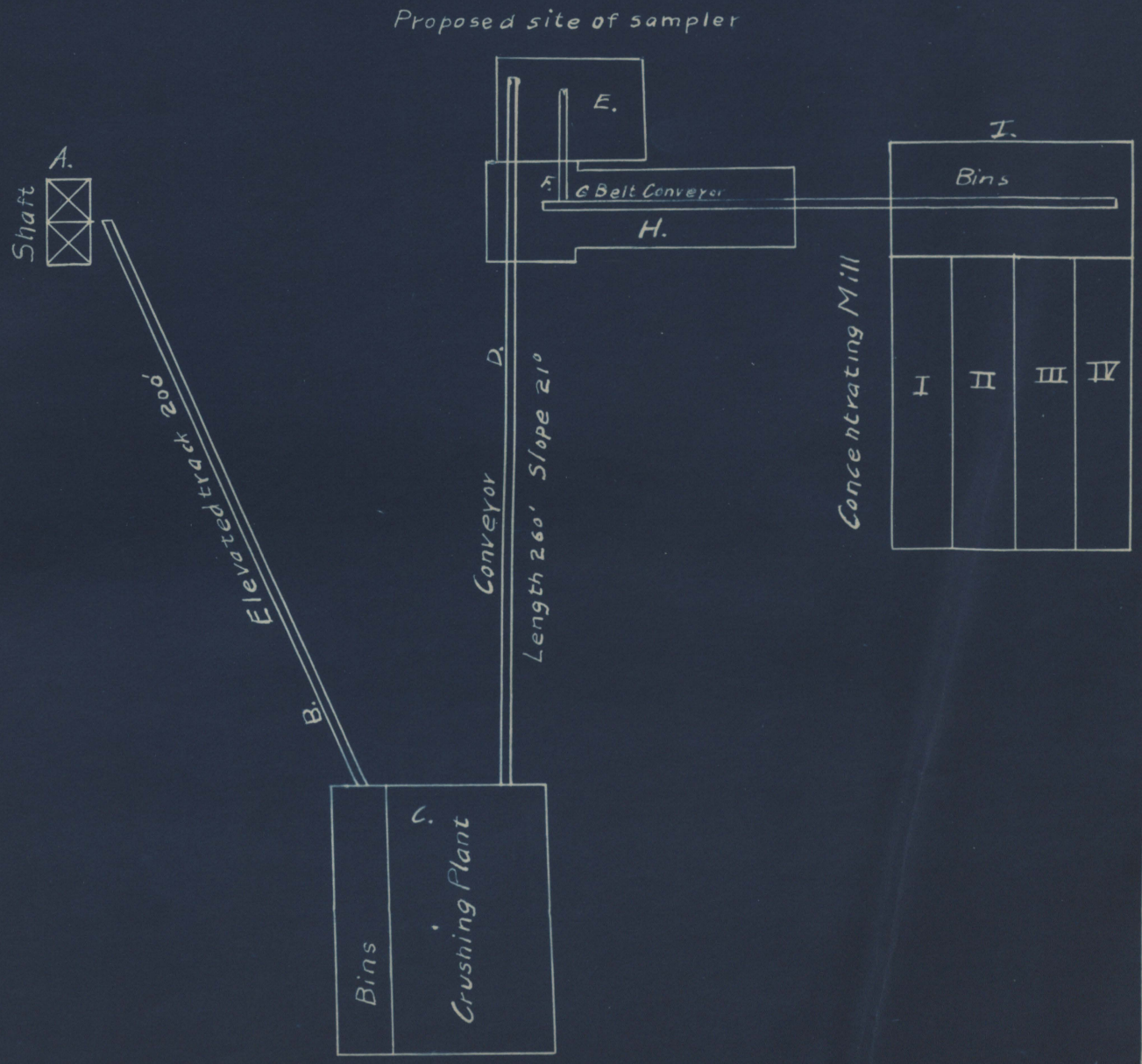
The contractor shall comply with all the preceding specifications of workmanship,details of construction etc.

The erection must be carried forward with diligence and must be completed promptly.

Proposed Sampling Mill for St Louis Smelting and Refining Co.

Proposed Site of Sampler.

Plate I



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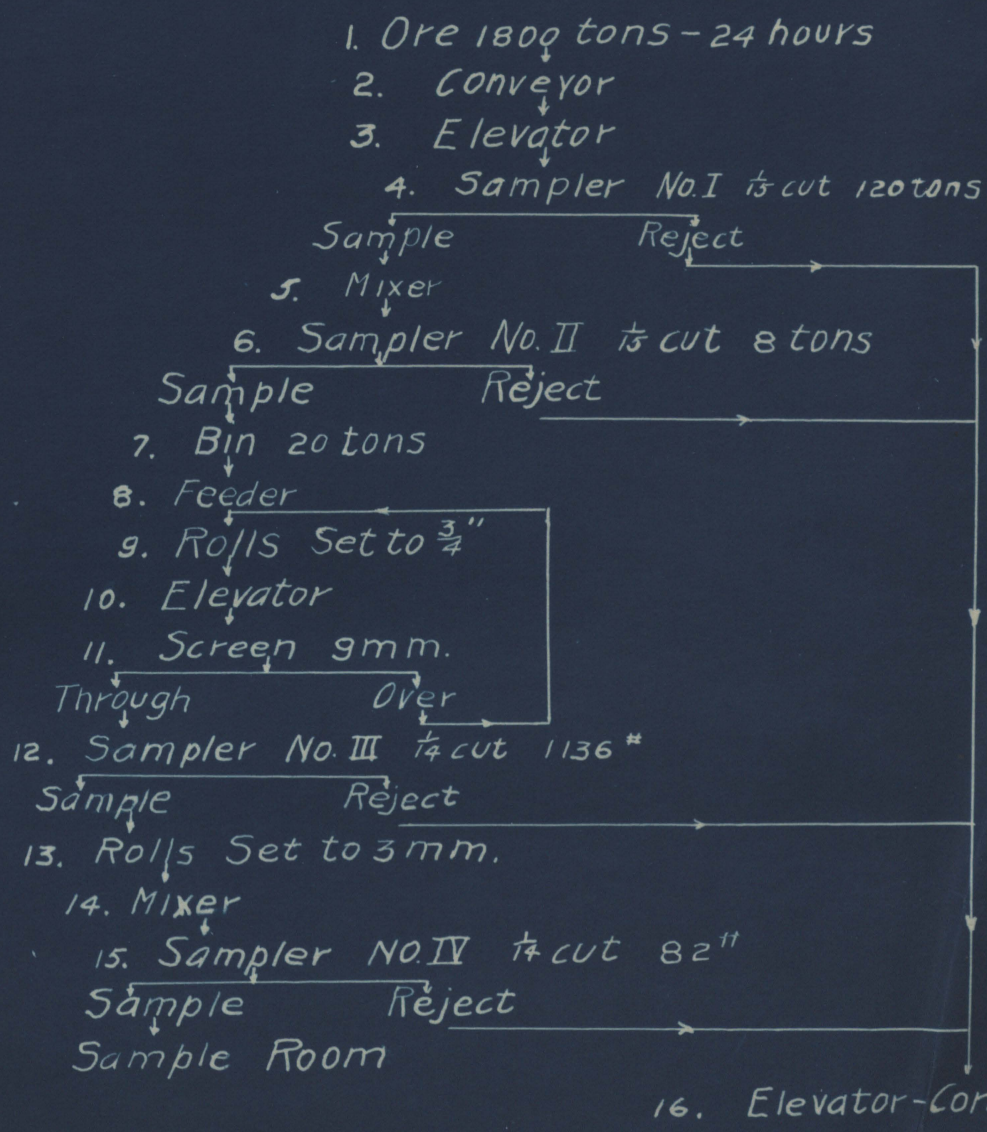
Proposed Sampling Mill for St. Louis Smelting and Refining Co.

Flow Sheet. Plate II



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