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Design of a 100 ton asbestos concentrator

Walter Gammeter

DESIGN OF A 100 TON ASBESTOS CONCENTRATOR.

BY

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A

THESIS

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LIST OF ILLUSTRATIONS.

DESIGN OF A 100 TON ASBESTOS CONCENTRATOR.

Asbestos:

The word "Asbestos" as herein used refers to chrysotile, the fiberous variety of serpentine, and not to the fiberous forms of amphibole (actinolite and tremolite) that are popularly referred to as asbestus, or asbestos. Chrysotile is a finely fiberous variety of serpentine, a hydrous magnesium silicate.. Its chemical formula is $3MgO:2SiO_2 \cdot 2H_2O$, the water of crystalization ranging from 12 per cent. to 14 per cent. Its specific gravity is between 2.2 and 2.3 and the hardness from 2.5 to 3.

The chemical formula for asbestus, the amphibole varieties, is given as $CaMg_3(SiO_4)_3$. When the magnesium is partly replaced by ferrous iron as in actinolite, $Ca(Mg\ Fe)_3(SiO_4)_3$ it is of a greenish color. The specific gravity is given as 2.5 to 3 and the hardness is something over 5.

Chrysotile is much more valuable than asbestus because it has greater tensil strength and can be spun and woven into fabric. These properties are probably due to the lack of calcium and to the water of crystalization of the chrysotile. It is also more finely fiberous or silky than the amphibole varieties. Chrysotile fibers are also classed relatively as to their fineness, the finer varieties being referred to as silky and the coarser or more brittle fibers as being harsh. The silken varieties are more valuable than the harsh, although the term harsh does not truly state the physical condition of the fiber so called, and while somewhat more coarse than the silky variety, never-the-less permits of being spun.

Properties of Asbestos:

Asbestos is of value by virtue of the following properties: noncombustibility, nonconductivity of heat and electricity, chemical inertness, fiberous structure, flexibility and tensil strength. Of these properties the first four determine it's field of usefullness while the latter three determine it's commercial forms, and establish it's use. The fact that it is fiberous, flexible and has good tensil strength permits it's being spun and woven into cloth, or twisted and braided into ropes. This allows a wide range of commercial forms that cannot be obtained from otherwise equally good nonconductors and insulators- and these properties really determine the value of asbestos. The fineness, tensil strength, and fiber length also determine relative values of different fibers, as fibers vary greatly in these properties.

Of the three foregoing properties which determine the value of asbestos fibers, only fiber length is in any measure controllable by the producer. As fiber length has a great deal to do with spinning possibilities, and a long fiber is decidedly better than a short one, it must be given a great deal of consideration in the preparation of the product. Any scheme of concentration, or machine for classifying fibers which materially injures or shortens the fibers is to be avoided.

Types of Asbestos Mills:

There are at present at least two methods in use for concentrating and classifying asbestos fibers, each of which is satisfactory when used to handle ores for which it was designed. The processes can be referred to, conveniently, as the pneumatic and gravimetric processes, deriving their names from the chief factors used in their schemes of operation.

The pneumatic process, or more correctly called the suction process, usds for its scheme of operation the fact that the fiber is readily fluffed. In that state it can be removed from the gangue by air suction methods because of it's much greater surface area than that of the gangue. The range of fiber separation by this method depends on the various strengths of suction used. Therefore, the range of fiber lengths, or classification, by this method is high. Besides the large range of fiber lengths obtained the method is also desirable because of the clean product obtained.

In the gravimetric process separation is partly made by reason of the lower specific gravity of the ore than that of the gangue. However, it depends more on the inelasticity of the fiber, compared to the harder and more compact gangue, which has, relatively speaking, good properties of elasticity. Sizing of the fibers, or classification, in this process is done by screening methods.

The suction process mill is best adapted to large deposits which are favorably located, and where the smaller fibers and by-products can be disposed of successfully. The cost of installation of the mill, as well as the operating cost, is greater than for the gravity or mechanical type.

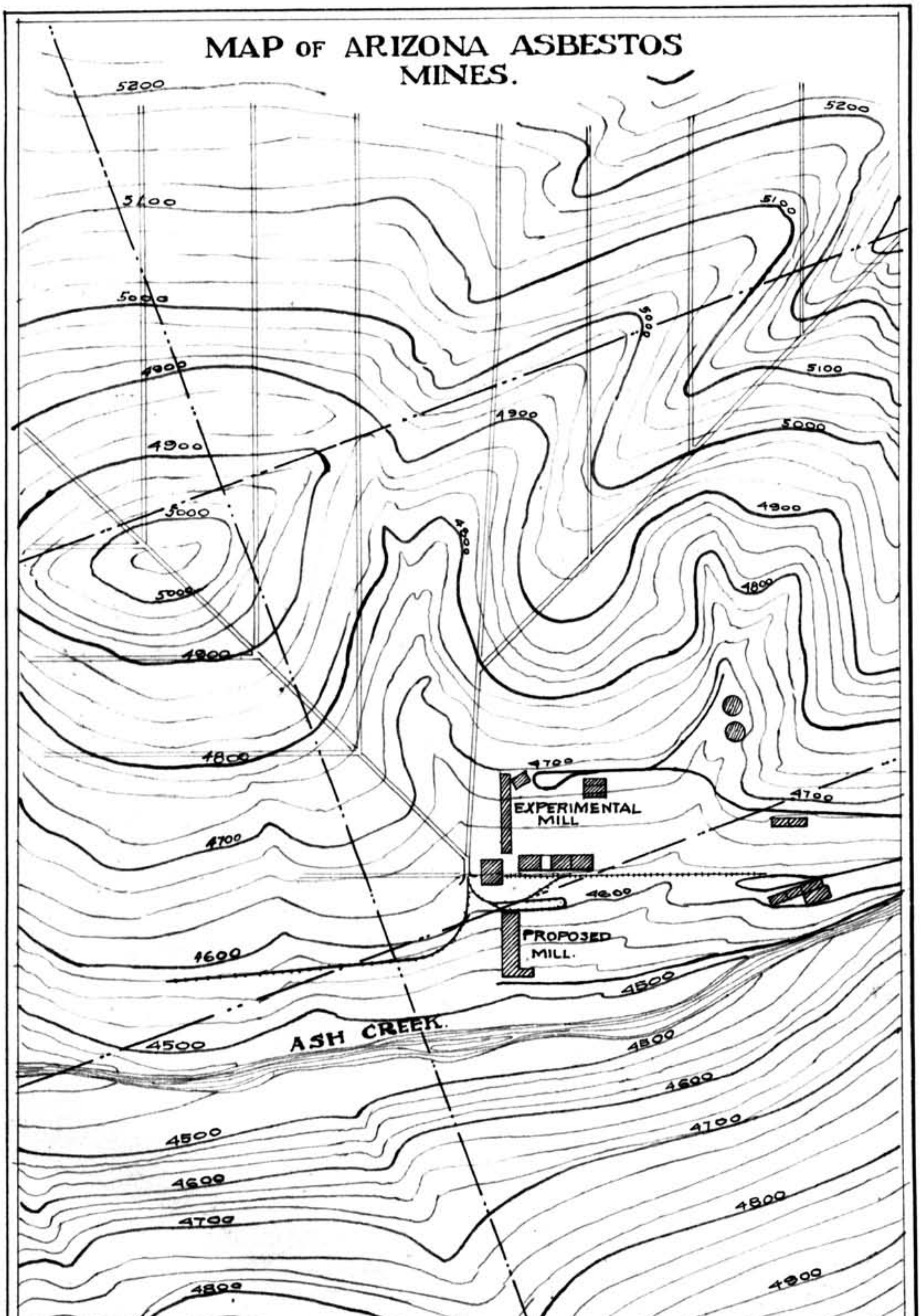
The gravity type lends itself better to isolated deposits where the smaller fibers, dust and general by-products are disregarded because of high transportation costs in getting the products to market. The cost of instsallation of this type of mill, as well as the operating cost, is materially less than the other type. Simplicity of design and process reduces both power consumption and labor. This is a strong point in it's favor for isolated districts. Less skilled labor is required and repairs are fewer and more easily made.

Types of Mill Selected:

The design of the mill submitted here is of the mechanical type, and was designed to meet the requirements of an important deposit, which is so located that it is necessary to discard the shorter fibers and general by-products because of excessive transportaton charges to market. Aside from isolated location and high transportation charges this type was also selected because of the scarceness of good labor, the type being more simple to operate and less liable to breakdowns. Power is expensive here, owing to the fact that fuel in the form of fuel oil must be transported to the mill, and this fact again favors the mechanical type of mill which uses materially less power per ton of ore than the pneumatic type.

Style of Mill:

After selecting the mechanical type in preference to the pneumatic type as being better adapted to the existing conditions, the style of mill, hill-side or flat, was considered. Examining the map on the following page, which is a topographical map of the ground available for mill site in immediate proximity of the extraction tunnels from the main deposits, it is clearly seen that conditions here were ideal for the hill-side type. At a distance of about fifteen hundred feet from the portals of these extraction tunnels a flat site was available, but the matter of cheaper building for the flat type was disregarded in view of the other facts which were in favor of the hill-side type. The facts favoring this selection were: power saved by using gravity flow, elimination of some troublesome elevators, rock in place on the hill-side requiring little retaining wall, and the fact that some of the special apparatus used in this type of mill required considerable head room.



BUILDINGS
ROADS.
CLAIM LINES
UNDERGROUND WORK.
TRACK
CONTOUR INT. 25'-0"
SCALE 1"-200.

Mill Location:

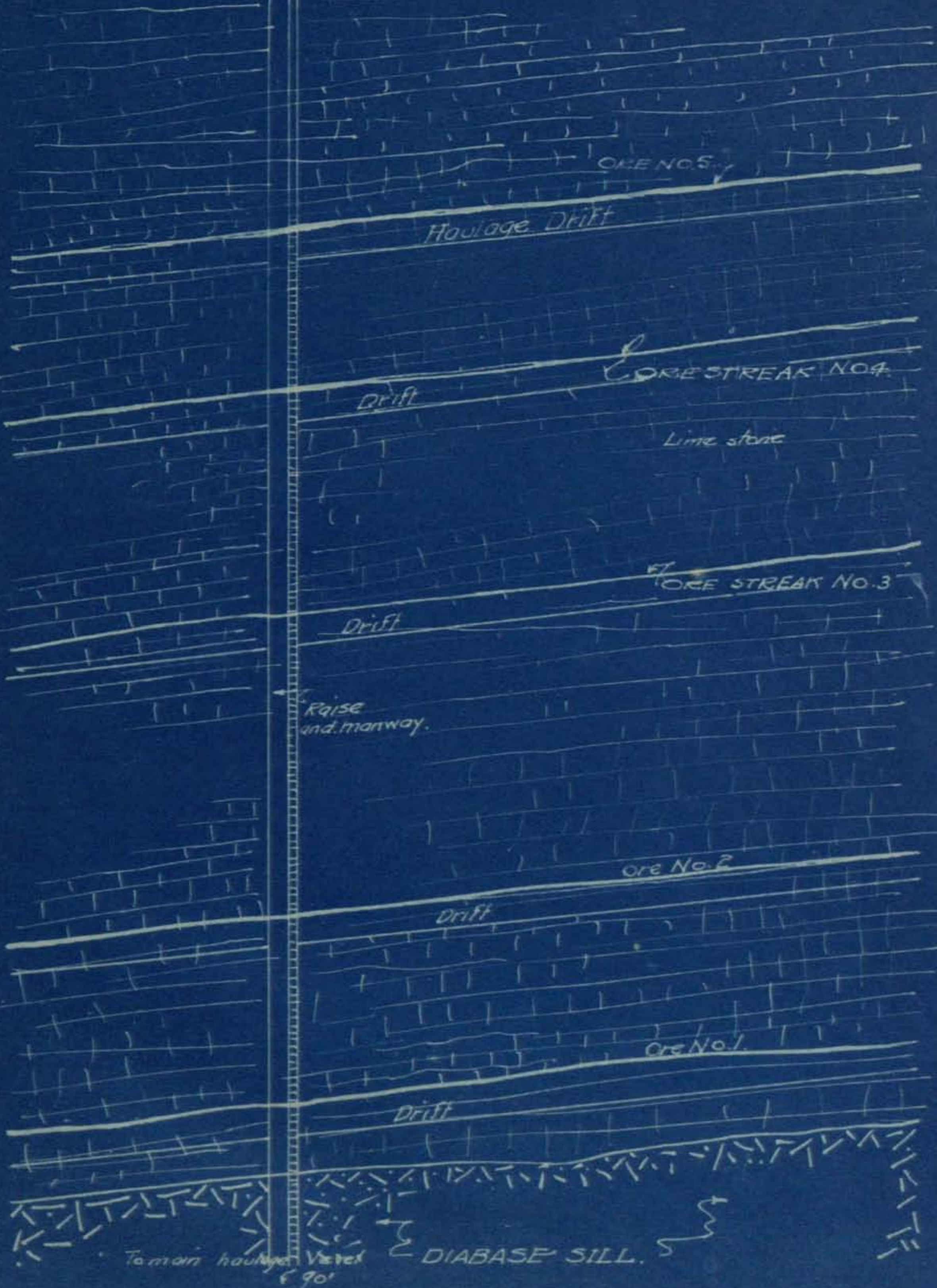
Referring again to the map it will be noted that two mill locations are given. The one higher up on the hill-side is in operation. It is located above the extraction tunnels. This is due to the fact that the mill was built before these tunnels were driven. It is so located that the top of the bin is practically on a level with the ore deposits, at which level all of the ore is being extracted. As the ore is in blanket veins with a slight dip towards the hill it was soon discovered that extraction at this level was undesirable because of the up-hill tram and because of the water encountered. This prompted the driving of the extraction tunnels which will drain the ore deposits for a distance of about three thousand feet under the hill. Extraction of ore at this new level, of course, required the moving of the mill, or of rebuilding one. The old mill was inadequate in tonnage, handling only about forty tons, and also showed many imperfections, both as to process and mechanical apparatus, so that it was decided to re-design a mill capable of handling the required tonnage and in a location favorable to the extraction tunnels. The flow sheet and details of the old mill will be given later under the heading of "The Experimental Mill or Mill No. 1."

The mill which it is proposed to build is shown located on the map. It's bins are about seventy feet from the portals of the extraction tunnels that have been driven to handle the ore. The flow sheet for this mill will be given later in the article under the title of "Flow sheet for Mill No. 2."

Ore Deposits:

The ore deposits supplying ore for the proposed mill lie approximately forty miles northeast of Globe, Arizona. They are in a Cambrian dolomitic limestone, and were formed by the intrusion of a diabase sill, about one hundred feet thick, which lies almost horizontal throughout the entire region. Dykes branching from this intrusion occasion sharp local irregularities of the deposit, but which, never-the-less, may be considered as generally constant throughout it's entirety.

The ore occurs in a series of blanket veins five in number, which occur one above the other through a vertical section of about one hundred and twenty-five feet. The veins all dip, at about five degrees with the horizontal, into the hill-side. In all instances, with only one exception and in a comparatively small area, the veins occur above the diabase sill. In the area where some ore is found below the sill, the veins are



GENERAL SECTION SHOWING RELATION OF FIBER STREAKS.

~ ARIZONA ASBESTOS MINES ~

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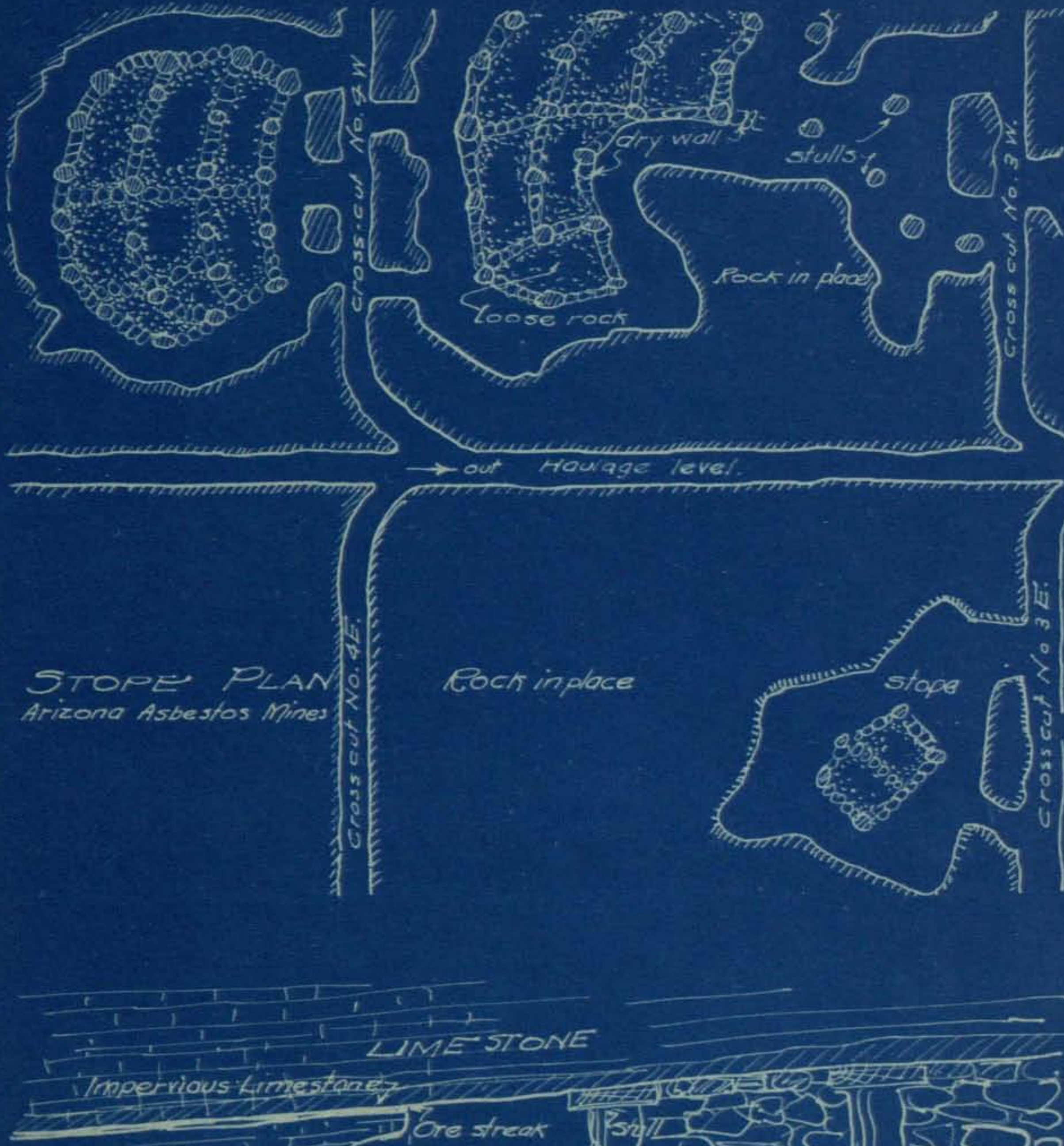
never-the-less also present above the sill. The lowest vein is about ten feet above the sill and the others range at various distances through a section of about one hundred and twenty-five feet above the lower streak. All are in a rather soft and altered limestone, carrying irregular masses of serpentine.

Methods of Minning:

Exploration of the deposit was carried on by driving tunnels into the hill side on the various veins. The veins average about three inches of ore in streaks ranging from one-eighth on an inch to one inch in length, with exceptional streaks of fiber reaching three inches in length.

In stoping the ore, drifts and crosscuts were driven into the ore areas, and stopes carried off of the crosscuts. In extracting the ore care was taken to remove as much of the fiber as crude fiber as possible as the value of this is very much greater than the concentrated fiber from the mill. To mine the ore the stopes were carried about four feet in height, carrying the ore streaks in the top of the stopes. The rock below the ore was extracted and then the ore shot down lightly. As the work progressed the stopes were supported by stulls, and drywall gobbing carried between the stulls. The limestone waste forms excellent rock for building the drywalls as it breaks in large flat pieces. About one-half of the broken waste is used in gobbing the stopes, while the balance is trammed out as waste to the waste dumps. As the stopes increased in size a general settling of the areas above the stopes took place, the distance being limited by the gobbing and stulls in the stopes. In most instances the amount was only a few inches distributed between prominent strata above the stopes. In practically all instances a slight settling between the ore in the upper level and the waste below it took place. This made the mining of the second level considerably easier and less expensive than the lower level. Consistent settling took place for all of the upper levels as they were being worked.

After the waste rock below the ore was extracted and removed, the ore was shot down. The larger pieces of waste were removed as gangue. The fiber was separated out and about one-half of it collected as crude fiber, the balance, consisting of separated fibers, pieces of short fiber and smaller stones was trammed out as mill ore.



STOPE PLAN
Arizona Asbestos Mines

SECTION THRU STOPE SHOWING ORE STREAK AND GIVING METHODS OF EXTRACTION.

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Estimated Tonnage Available:

The estimated mill ore tonnage available, and on the strength of which the design for this mill is made, is given herewith. No regular assay maps are carried, because assays of this ore are impractical and really would mean very little, as length of fiber and fineness, the two really important qualities of the ore would not be recorded by any assay methods. On all stope maps, however, the number of fiber streaks, and length and quality of fibers in each, are recorded. From these geological records the estimates of quality and quantity of fiber are made. From this source it is estimated that an average combined fiber length of three inches of fiber for each of the five veins is to be expected throughout a surface area of two million seven hundred thousand square feet, or equivalent to the surface area of three full sized mining claims. This is a conservative estimate as the deposit has been unusually regular throughout the areas of two claims and exploration on about ten other claims show very good results and a general continuity of regular deposits.

Assuming stopes carried three and one-half feet in height the percentage of fiber to be expected, considering three inches of ore, would be about seven and one-tenth per cent. of fiber by volume, or about five and eight-tenths per cent. by actual weight, as the specific gravity of the fiber is less than that of the limestone gangue. Assuming that one-half of this would be removed as crude fiber, it would leave two and nine-tenths per cent. available as mill ore fiber. It is estimated that of this amount about eighty per cent. is actually removed as mill ore, the balance being lost in operations. This would leave two and three-tenths per cent. fiber available as mill ore. Or for every cubic foot of stope carried three and seven-tenths pounds fiber for the mill are secured.

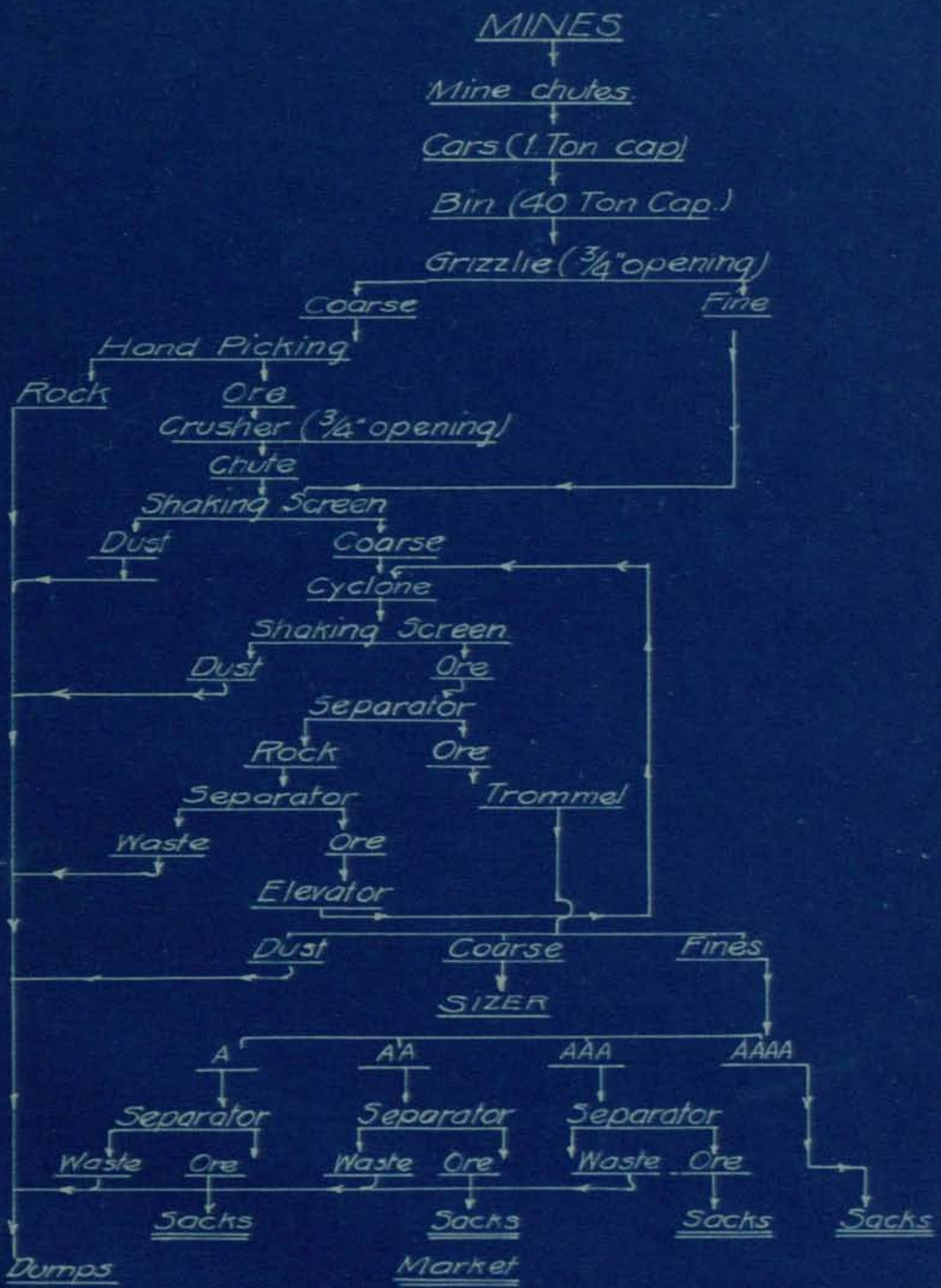
The assay of the heads for the mill show an average of ten per cent. fiber. This would mean that for every cubic foot of stope carried thirty pounds of the broken material including three and seven-tenths pounds of fiber are trammed out as mill ore. For a square foot of stope area, three and one-half feet high, approximately one hundred pounds are removed as mill ore. On this basis it requires twenty square feet of surface area to produce one ton of mill ore. With a surface area of two million seven hundred thousand square feet and five producing levels the tonnage of mill ore to be extracted would be six hundred seventy-five thousand tons, or on ten per cant. fiber assay, sixty-seven thousand five hundred tons fiber. This would allow operation for six thousand seven hundred fifty days on one hundred ton mill capacity, or something less than twenty years operation. Allowing only fifty per cent. of this estimated tonnage as mill ore, on account of unforeseen difficulties of mining, a mill run of ten years is assured on a one hundred ton daily capacity! The design for the proposed mill submitted here is for one hundred ton daily capacity, and probably would be in use throughout a period of ten years.

Mill No. 1. Experimental Mill:

The flow sheet on the following page, under the title of "Flow sheet for Mill No. 1", is the flow sheet for the experimental mill or the mill now being operated. It's capacity is estimated at forty tons per twenty-four hour run. It is the gravity type and hill-side style. A forty ton wooden ore bin is located at the head of the mill. By means of a hand operated gate ore is drawn from the bin and allowed to pass over a grizzlie with three-fourths inch openings. The coarse waste is picked out as it passes over the flat grizzlie and the balance consisting largely of lumps of ore is fed to a Blake style crusher, set with three-fourths inch discharge opening.

ASBESTOS MILL No.1

FLOW SHEET



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Shaking Screen:

From the crusher the ore passes on to a shaking screen. The fines from the grizzlie also pass to this shaking screen, which is covered with a wire woven screen having three-sixteenth inch openings. The shaking screen is about three feet wide by ten feet long and is actuated by an eccentric shaft making approximately one thousand revolutions per minute, each revolution giving an impact to the screen. The dust from the screen passes off through chutes as waste, while the oversize is passed on to a disintegrating machine called a cyclone.

Cyclone:

The cyclone consists of a vertical revolving wheel fitted with radiating hammers, which revolves in a housing carrying six to eight circular anvils. The wheel is about twenty-four inches in diameter and revolves at about one thousand five hundred revolutions per minute. As the ore enters the revolving wheel the hammers or vanes throw it against the anvils, disintegrating the fiber from the gangue. The drawing on page 19 illustrates the principle of the machine. The discharge from the cyclone passes on to a second shaking screen which separates the dust from the ore and coarser rock, the dust going to the waste chute and the oversize passing on to a separator.

Separators:

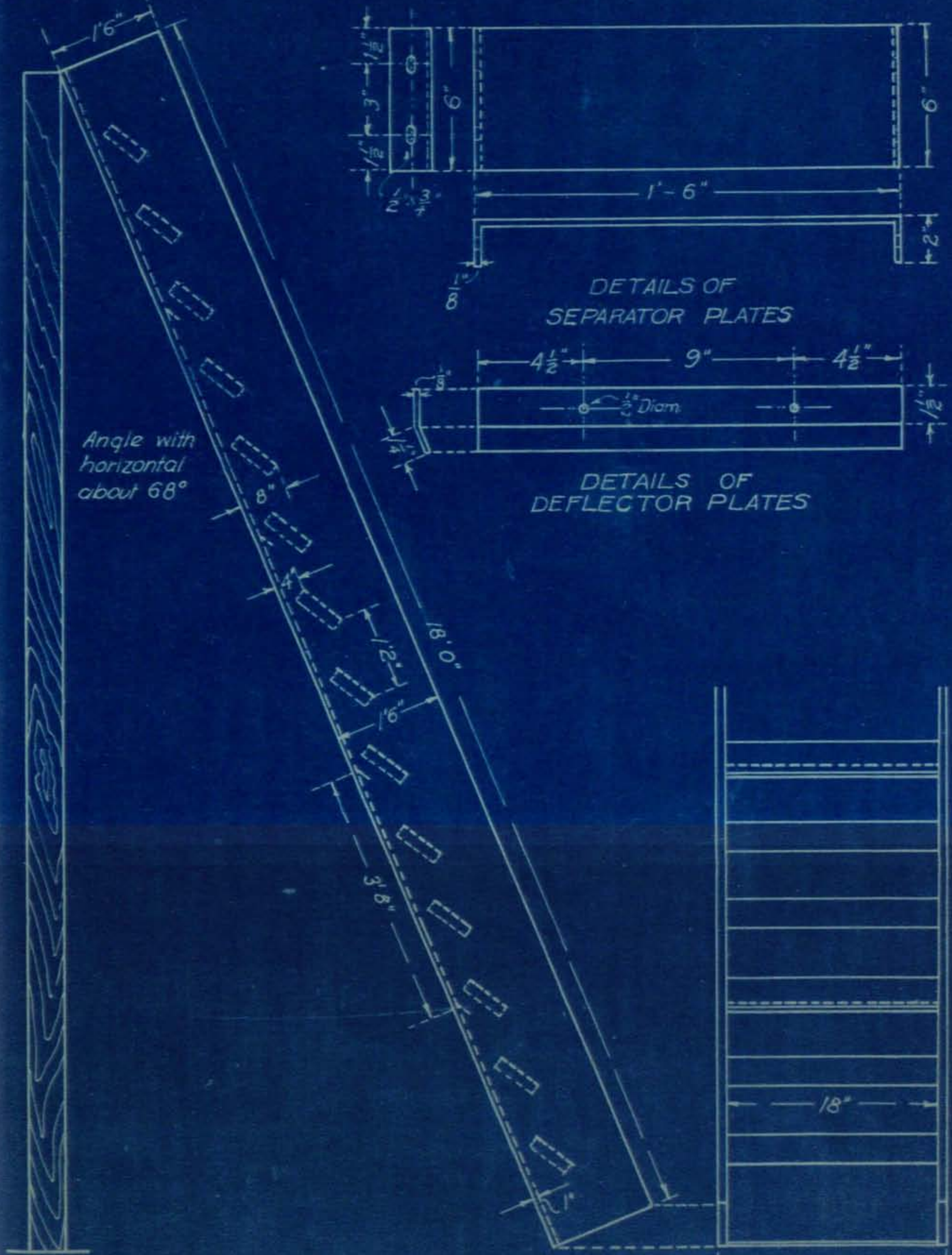
Illustrations on page 21 show details of the separators in use. They consist essentially of rectangular troughs about sixteen inches high, eighteen inches wide and eighteen feet in length. Separating plates are spaced as shown in the drawing. Ore entering at the top passes over the separating plates, the rock remaining on top while the fiber falls between the plates and slides along the bottom of the chute. Deflecting plates arranged as shown deflect any rocks, which may fall to the bottom, back onto the plates. The principle underlying this design is that the rock is compact and rebounds on impact, while the fiber is not elastic and does not rebound.

The waste from the separator passes to a second similar machine where a further separation of rock and fiber is made. The ore from here passes to a bucket elevator and reenters the cycle at the cyclone. The rock passes off as waste through a waste chute.

Trommels:

The ore from the first separator passes on to a thirty inch diameter by eight feet trommel where

SEPARATORS



STATIONARY TYPE
(used with Mill No.1)

the dust is screened out. A separation of some of the shorter fiber is also made here, the fiber passing through a three-sixteenth inch screen and being classed as mill fiber AAAA. The coarser fiber together with some rocks passes onto a sizer.

Sizer:

The sizer consists essentially of a shaking screen, as described before, with four decks, each deck being covered with a suitable screen. The upper screen is a double crimpped wire screen with five-sixteenth inch opening. The second deck has one-fourth inch opening, the third one-eight inch, and the fourth is a metal pan. The decks discharge into chutes about four feet long which have a deflector on the lower end making the final separation of ore and rock. The chutes are illustrated on page 23.

Defects of Experimental Mill:

In redesigning a mill for this deposit, the chief points of consideration, aside from suitable location and capacity, were to correct some of the defects of the experimental mill. The chief faults presented in the experimental mill were, first: irregular flow of ore through machines owing to the lack of a fine ore storage bin between crusher and concentrating machines. Irregular flow of the ore through the machines gave irregular results in concentration due to uneven working conditions for the machines. Second: uneven results owing to the unajustability of the separators, which were set alike for varying kinds and grades of ore. In the design of no other mill, irregardless of the ore treated, would it be expected to get efficient classification if the classifiers were nonadjustable. To expect such results with asbestos ore is equally impossible. Third: high costs of concentration due to irregular runs on account of shutdowns- chiefly the result of poor machine design in designing the apparatus. Fourth: general poor results owing to the impractical design of the mill, making close observation of machines impossible because of the inaccessability of many of the mahhines, and making costs high because operation required a large mill crew.

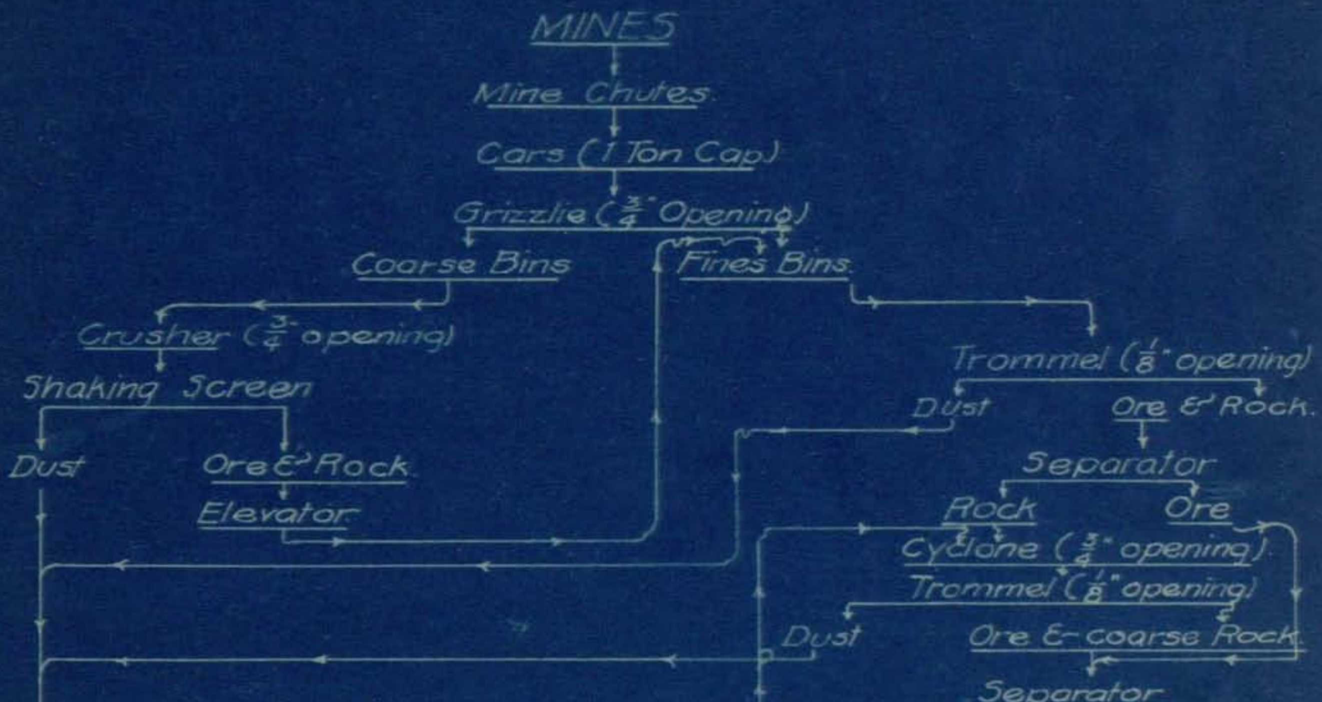
In the submitted design the above enumerated defects have been carefully considered and are largely taken care of.

Mill No. 2. Propesed Mill.

A flow sheet of mill No. 2 is given on the following page.

ASBESTOS MILL No.2.

FLOW SHEET.



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Aside from capacity the principal changes of Mill No. 2 from Mill No. 1, the experimental mill, are the separation of the coarse crushing plant from the main mill, by installation of a fine ore bin between the crusher and the concentrators proper, the redesign of the separators so that they are adjustable and can be set for various grades of ore, the elimination of troublesome and expensive shaking screens by the more economical trommels, and a rearrangement of the machinery so that the design is better balanced and the machines are more accessible.

The ore is trammed to the bins in one-ton cars, and dumpped over a grizzlie set with three-fourth inch openings. The fines pass into the fine ore bin while the coarse goes to a coarse ore bin, the two bins being of equal size and seventy-five ton capacity are separated by a partition forming a side of each of them. The coarse ore is drawn from the coarse ore bin by a hand operated chute gate and passes to a Blake type crusher, set with three-fourth inch discharge opening. From here the ore passes to an elevator which elevates the ore to the fine ore bin.

Ore is drawn from the fine ore bin to a

thirty inch diameter by ten feet trommel, covered with a double crimpped wire screen having (4) mesh and No. 3 wire of W & M gauge. The fines pass to a waste chute and are withdrawn.. From here the ore goes to a separator.

The separator is of the adjustable type as shown in the details on page 6 of the plans. A preliminary separation of rock and ore is made here, the rock passing to the disintegrating machine or cyclone. The function of the cyclone is to break the fiber from the rock. It is shown in detail on page 5 of the plans. The ore passes from the cyclone to a second trommel of the same size and specifications as No. 1. The dust is removed here and the ore passes to a second separator. The ore from the first separator also enters this second separator.

The rock from separator No. 2 is taken by an elevator and passes to a conveyor which discharges the ore to the cyclone, where it reenters the cycle.

The ore from separator No. 2 is also hoisted by an elevator and is conveyed by a conveyor which discharges it to a trommel. The trommel makes three products, dust, fine ore passing three-sixteenth inch opening, and coarse ore. The fine ore passes through chutes to the sacking room. The coarse ore passes to the sizer.

The sizer consists essentially of a shaking screen with three sets of screens and a metal pan. It corresponds in general dimensions and screen sizes to those used in the experimental mill. A description was given previously. The design of the shaking mechanism however, is new and can be found on plate No. 5 of the general plans.

Separators making a final separation of rock and fiber are placed at the discharge from the sizer. They are similar in construction to the separators previously mentioned, but are not adjustable.

Rock from these separators, as well as the other waste from waste chutes is removed from the mill by a twelve inch belt conveyor. The ore from the separators is sacked and stacked for shipment to market.

General Specifications.

Footings:

All footings for columns, machinery, foundations, and retaining walls shall be of first class materials, and shall consist of one part portland cement, two parts of sharp clean sand, and five parts of clean gravel passing one and one-half inch ring. No mill tailings are to be used. Concrete floors shall be six inches and surfaced three-fourth inch with one part sand and one part cement.

Framing Timber:

All lumber used shall be No. 1 yellow pine, and shall be surfaced as follows: Posts and girders shall be surfaced four sides; studding and joists one side and one edge; planking for siding two sides; planking for ore bins one side, all according to dimensions on plan.

Roof:

All roofs for mill and bin shall be covered with No. 20 corrugated galvanized metal.

Windows, etc.

All windows shall be stock sizes as specified on plans and shall be one and one-eight sash throughout. Windows shall be pivoted and not hung. All doors shall be built up from one inch yellow pine planking.

Stairs, etc:

All lumber used in the construction of stairs, railings, machines, machinery frames, machinery supports, and other than previously specified shall be of yellow pine surfaced four sides, and dimensions specified on plans.

Machinery:

All machinery shall be set according to plans, foundation bolts set by template as specified , and shall be of material as designed.

All line shafting shall be one and three-fourth inch diameter cold rulled steel and shall be aligned and placed according to plans.

Pulleys shall be cast iron and fastened to shaft by keyway, sizes as specified on plans.

Pillow blocks, shaft hangers, and bearings in general shall be standard equipment, Dodge or equivalent, and shall in all instances where speed is three hundred revolutions per minute or less be lubricated by hard grease with pressure cups. Where speed is above three hundred revolutions per minute bearings shall be ring oiled. In all cases bearings shall be of approved design suitable for use in a dusty atmosphere.

Belting shall be rubber ply and shall be of size and ply specified for each belt, with the exception that belt connecting motor to idler shaft shall be metal.

Conveyor belts shall be of rubber surface.

Paint:

All exposed surfaces shall be given prime and one good coat of lead and oil. Metal roofs shall be galvanized.

Labor:

All labor used in the construction of the mill shall be efficient, and work shall be subject to the examination and direction of the chief engineer of the company. All levels, alignments and engineering work required in the construction of the mill shall be furnished by engineers from the company.

Line Shafts:

All line shafts and countershafts used throughout the mill are one and three-fourth inch diameter cold rolled steel. Some of these could, according to horse power transmitted and span between bearings, have been somewhat smaller, but to make a general uniformity of bearings and bore of pulleys the above size was selected. All line shafts travel at a speed of three hundred revolutions per minute. Countershafts vary according to purpose and are stepped up or down by suitable pulleys.

Belts:

All belts used in transmitting power to line shafts are four ply six inch rubber belts.

Elevator No. 1.

Two horse power, speed three hundred forty-five feet per minute. Drive pulley twenty-four inch diameter by six inch face, on shaft with six inch pinion. Gear twenty-four inch diameter on shaft with twenty-four inch diameter by twelve inch face head pulley. Power belt four inch four ply rubber. Elevator belt four ply twelve inch rubber. Buckets six inch by four inch by four inch, twelve inches on center. Boot pulley eighteen inches diameter by twelve inches.

Elevators No. 2 and 3:

Two horse power. Speed one hundred seventy feet per minute. Drive pulley twenty-four inch diameter by four inch face on shaft with six inch pinion. Gear twenty-four inch diameter on shaft with twelve inch sprocket. Power belt four inches four ply rubber. Elevator belt netal link. Buckets six inch by four inch by four inch twelve inches on center. Boot sprocket twelve inches diameter.

Conveyors:

One horse power. Spped two hundred thirty-five feet per minute. Drive pulley thirty-six inch diameter by four inch face. Head pulley twelve inch diameter by twelve inch face. Power belt four ply four inch rubber. Conveyor belt four ply twelve inch. Idlers two feet on center.

Trommels:

One horse power. Speed twenty revolutions per minute. Diameter thirty inch. Length ten feet. Drive pulley thirty inch by four inch. Belt two inch four ply rubber. Screen opening four mesh No. 3 (W & M gauge) double crimpped wire cloth.

Cyclone :

Ten Horse Power. Speed two thousand to two thousand twn hundred fifty revolutions per minute;. Four ply six inch rubber belt. Diameter of fly wheel four feet.

Crusher:

Eight horse power. Speed three hundred revolutions per minute. Power belt four ply four inch rubber. Capacity eighty-four tons to one-half inch per twenty-four hours.

Sizing Screen:

Two Horse Power. Speed nine hundred revolutions per minute. Power belt two inch four ply rubber. Screens No. 1 four mesh No. 3 W & M gauge double crimpped galvanized iron. No. 2 three mesh No. 3 W & M gauge double crimpped galvanized iron. No. 3 two mesh No. 3 W & M gauge double crimpped galvanized iron wire. Width three feet. Length ten feet. Diameter dirve pulley twelve inches by four inch face.

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