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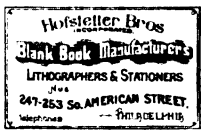
GYP SUM REDUCTION

AND CALCINING PLANT

BY

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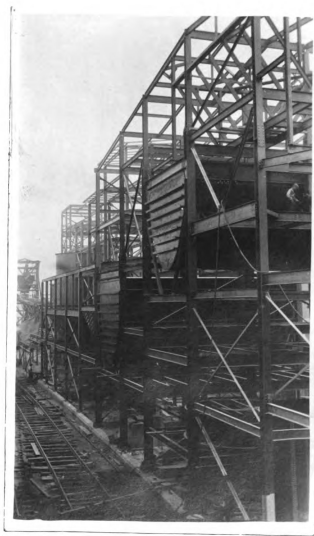
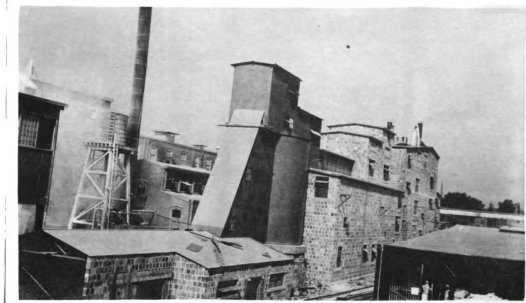
WILLIAM HENRY HARTMAN



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GYPSUM REDUCTION AND CALCINING PLANT.

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During the last five years the Gypsum Industries have advanced in remarkable strides. The increasing demand for Fireproof building construction materials has opened a large field to Gypsum Industries.

The demand for larger capacities and high grade materials has placed the problem in the hands of modern Engineering.

To show the nature and processes involved in the Engineering problems, the writer will describe and explain the Reduction and Calcining Plant designed and erected by him for one of the leading Manufacturers of Gypsum Products in the United States.

The reason for taking only the Reduction and Calcining Plant is that this portion of the whole Plant produces Calcined Plaster, or Plaster of Paris, in its finished state; and Plaster of Paris is the basis of all Gypsum Products.

PROCESS OF MANUFACTURE.

Plaster of Paris is manufactured from Gypsum Rock, which is Hydrous Sulphate of Lime ($\text{Ca SO}_4 \cdot 2\text{H}_2\text{O}$), a soft Rock, generally found with few impurities and in crystalline structure.

The average pure Rock Analysis is as follows:

Silica (Si O_2)	0.50 %
Alumina ($\text{Al}_2 \text{O}_3$)	Trace
Iron Oxide (Fe O_3)	Trace
Lime Carbonate (Ca CO_3)	1.00 %
Magnesium Carbonate (Mg CO_3)	Trace
Lime Sulphate (Ca SO_4)	78.50 %
Water ($\text{H}_2 \text{O}$)	20.00 %

Gypsum Rock is generally found in horizontal layer formation or pitched veins, probably the result of horizontal formation having been undermined by water channels and the Rock pitched down. The Rock is generally so near ~~the~~ surface that it can be quarried or mined in shallow mines.

Gypsum Rock, being soft, is easily broken, and even with low-pressure Explosives used in blasting nearly all the Rock is reduced to man size and under; it is then reduced, by Crushers, to 1" Ring and under.

As Gypsum Rock carries a great deal of free water, which hinders the process of fine reduction, it is

advisable to drive off some of the free water in some sort of Dryer.

The Rock is then reduced to a fine uniform powder ranging from 85% to 95% through a standard 100 mesh screen.

The finely pulverized Rock is now ready to be Calcined.

Calcination of ground Gypsum Rock is the process of driving off part of the water of crystallization, which is about 20 per cent by weight. This is done in a Calcining Kettle by applying heat to the material and agitating it at the same time, thereby keeping the material uniform and assisting in freeing the water vapor from the material.

As the heat is constantly applied, the temperature rises to 250° Fahrenheit, causing the material to roll and boil furiously; at the same time, large volumes of water vapor escape from the surface. When the severe rolling and boiling begins to decrease, the temperature again rises until from 320° to 325° Fahrenheit is reached; then the material seems to clear and shows practically no signs of boiling, the surface level of the material having dropped a noticeable amount. This stage is called the "First Settle", and is used by some manufacturers as a finished Plaster of Paris product.

If the process is carried beyond this stage, the material will again roll and boil almost as severely as at first until 385° Fahrenheit is reached; then the

material takes on the second settle, which is more pronounced than the first. This material settles in a lifeless mass and offers severe resistance to agitation. This stage is known as the "Second Settle" product of Calcined Plaster and is the highest point carried by commercial manufacturers of Plaster of Paris.

Plaster of Paris made at the "First Settle" shows a half hydrate ($\text{Ca SO}_4 \frac{1}{2} \text{H}_2 \text{O}$), or contains Lime Sulphate (Ca SO_4) 93.8% and Water ($\text{H}_2 \text{O}$) 6.2%.

Plaster of Paris made at the "Second Settle" shows about 2% less Water ($\text{H}_2 \text{O}$) than the "First Settle" product.

A clean setting-up Test made of "First Settle" product and 80% of Water by weight shows an initial set of 16 to 20 minutes; the same Test of "Second Settle" product shows an initial set of 24 to 30 minutes.

The "First Settle" product works creamier under the trowel and the "Second Settle" product produces the greater tensile strength.

Each material has its particular advantages for the different classes of uses for Plaster of Paris.

Pulverized Rock, or Land Plaster, is often sold, with no further preparation, as a finished product.

DESIGN OF GYPSUM REDUCTION AND CALCINING PLANT

The determining features of the Plant were as follows:

Capacity of 1000 tons of Plaster of Paris in 24 hours, or double shift.

Individual and independent departments.

Plant to be twin grouping of units so that one-half of the plant could be run as a complete Plant.

High grade product at minimum labor, attention, and costs.

An attempt was made to re-design the old existing Plant to suit the new requirements but was abandoned on account of the large capacity desired, the old Plant building being too small to accommodate the new equipment in any acceptable system, and also because of the fact that the old Plant would be thrown out of commission while the new equipment was being installed.

The accepted location was a narrow strip of land running parallel with the old Plant and between it and another building. This available site was just wide enough to permit a sufficiently wide Plant with a Railroad Siding on each side, and conveniently located that the old Plant could be used to the greatest advantage as a Warehouse and Shipping Room.

A 12" x 12" Testing Ram was placed on the site of the heaviest Mill loading at a depth of five (5) feet,

and loaded with four (4) tons of Pig Iron. This Ram settled $3/8"$ during the first day but showed no further settlement during the next five weeks.

The Ram rested on a 5-foot layer of hard stiff Clay containing some sand. Under this layer is a water bearing strata of coarse Gravel and sand. As the bulk of the foundations rested upon the stiff clay strata and the remainder went through to the water bearing gravel, the following soil bearing pressures were decided upon as safe values:

Bearing on Clay strata - $2\frac{1}{2}$ tons per sq. ft.

Bearing on Sand and Gravel strata - 1 ton per sq. ft.

As the Plant was desired to be absolutely fireproof and it was essential to have a structure rigid enough to dampen out the vibration caused by the moving machinery, the following materials were selected:

Concrete foundations.

Structural Steel for the frame

Terra Cotta Hollow Tile Curtain Walls.

Slag Concrete floors.

Plaster composition roof.

The inclined Elevator housing and the structure above the cylindrical Rock Bin were covered with copper bearing steel Corrugated Siding and Roof. This was done to permit of light steel structure.

The Windows are of ribbed wire glass set in steel frames. The glass are secured in the frames with small metal glazing angles.

The Window Lintels and Sills are of reinforced

concrete.

The doors use the Tin-clad fireproof construction set in Brick Jambs and reinforced concrete Lintels.

The principle of the design was that of selection and location of the machinery; and then designing of the structure to suit the equipment.

The design was made very complete, showing all members, gusset plates, etc. and all machinery and other equipment accurately located. In fact, the Company fabricating and erecting the Steel used the Drawings with construction numbers placed on them for their work.

All elevating and conveying machinery was designed complete; in the erection of same all that was necessary was the assembling of the parts in their proper places.

The live and dead Roof loading was placed at 40 pounds per square foot. This seems high considering the light weight of Plaster Composition Roof, but the possibility of dust collecting on the roof of a Plant of this character and the low pitch given the roof make the above loading advisable.

The roof itself is Plaster Composition, made of Plaster of Paris and Wood Shavings cast in a slab 3" thick, set $2\frac{1}{2}$ " between the roof beams and $1\frac{1}{2}$ " above. Cast in this slab are tension wires running from over top the beams to within $1\frac{1}{2}$ " of the bottom of the slab at center of the span. These tension wires are composed of two

(2) #11 Galvanized Steel twisted wires, spaced 2" apart for 6-foot spans. At the center of the span the wires are held near the bottom of the slab by placing a 5/8" round bar iron over them and across the span; this also gives it lateral strength and rigidity. The tension wires are continuous over the beams and are secured to the legs of the last roof beams by specially made hooks.

The floors in a Plant of this character often receive severe loading, resulting from the moving of heavy machinery and the discharge of large quantities of materials on to the floors in case of breakdown or plugged machinery. In anticipation of such loading, all floors were designed to support a load of 200# per square foot floor area and are constructed of 3/8" square twisted reinforcing bars imbedded in 5" thick cinder concrete - 1:2:4 mixture.

The reinforcing bars are placed upon the floor beams, spaced 8" apart for spans up to 6 feet long, and 6" apart for spans from 6 to 8 feet long. In each case cross ties are placed 2 feet apart, consisting of a 3/8" rod securely tied to each reinforcing rod.

The bottom of the floor slab is placed 3/4" lower than the tops of the floor beams. Coping angles are used at all edges and openings.

Mostly all the machines used in reducing and drying the Rock produce severe vibrations and shocks. It has been the object of the writer, as you will note by the sections, to transfer these vibrations to the founda-

tions and there absorb them by massive monolithic concrete bases. Vibrations set up by lesser sources are taken care of by the structural steel bracing.

These vibrations not only weaken the structure, but have a detrimental effect on the elevated Storage Bins, packing the finer materials in between the larger particles, and as a result the material will not flow readily from the Bin; in the case of Pulverized Rock, or Land Plaster, it will become so hard as to necessitate the use of a more severe tool than a shovel to dislocate the material.

The Crushed Rock Bin was made of 1/4" steel plate, cylindrical in shape, and placed on end over a conical concrete base which takes the whole load. This Bin stores Crushed Rock coming from the Crushing Plant and has a capacity of 400 tons.

This type of Bin was selected for the purpose because all the filling is done from one point and the discharge is from two openings in the concrete base, very close together. A cylindrical Bin of this character is a low cost container for conditions at hand. It also has the added advantage in that practically all of its contents are available without any manual assistance. This Bin also serves as the superstructure for the Conveyor Head framing and housing above the Bin.

The concrete base is reinforced and was cast a monolithic structure. As the bearing soil showed a large amount of soft wet clay, a concrete pad was placed under the base of the Bin, 2 ft. thick, and reinforced with old

light railroad rails. The bearing loading was taken as $1\frac{1}{2}$ tons per square foot.

The Dry Rock Bins, of which there are two groups divided into three compartments each, have a capacity of 100 tons per compartment or a total capacity of 600 tons; they are also of $1/4$ " steel plate.

The suspension type of Bin was selected because of the large amount of available material contained by them, the clear, unobstructed head room underneath them, and the economical design for an elevated bin.

These Bins are not a true catenary curve, the side sheets running straight as they near the side girder; in this manner the side sheets act as a deep plate girder and assist in carrying the suspended load. It would be rather hard to determine just how much this girder action is; however, in these cases the writer assumed it to be 15% of the total load. A small plate girder carries the remaining load.

The Bin ends and division walls were reinforced by 7" I- Beams running horizontally and riveted to the $1/4$ " Steel division plates. This construction carried all the stresses to the $1/4$ " Steel side sheets of the Bin. A small plate girder was placed between the columns to take the compression due to the bin load at the bin ends and division plates.

The Land Plaster Bins, of which there are two groups, are each divided into two Bins, making four (4) 100 ton capacity separate bins. These Bins are similar to the Dry Rock Bins in design and construction.

Both the Dry Rock and the Land Plaster Bins have 1/8" steel tops placed on 6" I beams, to prevent dusting and eliminate danger of falling into the Bins.

The following weights were used in computing and designing the Bins:

Damp Crushed Rock--	85	lbs.	per	Cu.	ft.
Dry Crushed Rock--	90	"	"	"	"
Land Plaster--	80	"	"	"	"
Plaster of Paris--	70	"	"	"	"

BUILDING WALLS

The walls of the building carry no loads or stresses excepting those due to the weight of the wall itself.

Owing to the fact that the outside walls are simply curtain walls, a light weight substantial material was desired. Six cell, 8", unglazed, Hollow Terra Cotta Building Tile was used.

The Tile was laid so that the cell partition stood in a vertical position. This was advisable as the walls ran from 30 feet to 55 feet high.

As the structural steel columns were of different sizes and many columns reduced in sections at their upper end, it was necessary to place the walls at different distances from the column faces, this distance varying from 1 to 2½". The working face of the wall was kept at equal distance from the column centers.

The method of securing the wall to the Steel was very important, the pressures to be taken care of being that of wind from the outside and inside.

The vibration of the building was not taken into consideration as the structural steel was designed to absorb all vibration or transfer it to the building foundations.

The wind pressure from the outside was taken as 25 lbs. per square foot exposed area. This value was

considered sufficient as the exposure was broken by adjacent buildings.

The inside pressures on the walls, which may develop through open doors and windows, was taken as 15 lbs. per square foot wall surface.

After making some crude tests, the following method was selected to fasten the walls to the structural steel columns, which were 16 to 18 feet apart, no other places of support being taken into consideration; however, additional fastenings were put in where conditions were favorable to do so.

The wall ties were made in two groups, viz: - Tension Ties were designed to take pressures developed from the inside and Compression Ties to take pressures developed from the outside. All ties were made of 7/16" round steel and were imbedded in the mortar joint between the Tile.

The Tension Ties were made of two kinds, to suit either side of an I section column. When the flat side of the column was against the wall, two ties were used at a joint in the tile and made in the following manner:

A piece of round steel was bent over itself at the center and this double section bent into a hook with a 2" leg, which was hooked over the leg of the column and the two ends bent so that they lay in the center of the Tile wall, forming a 4" long leg on each end pointing in opposite directions.

When the legs of the columns faced the wall, two ties were used and made in the following manner:

A hook was forged in the end of a Steel rod so that it hooked over the leg on opposite side of the column; on the other end of the rod was welded a bar 8" long, which in turn was imbedded in the mortar joint.

The two kinds of ties described suited all the requirements for tension ties.

The Compression Ties were made from one general design and in the following manner:

The bar steel was bent in the form of the letter "U" excepting that the ends were bent at right angles and in opposite direction to form a 4" leg. In position the bottom portion of the "U" bears against the column and the two 4" legs are imbedded in the wall joint. When the flat side of the column is against the wall, one tie is sufficient per joint, but if the legs are facing the wall, two ties are required - one against each leg.

A slab of tile was placed between the wall and the columns and resting on the Tension Ties, thereby making them also an effective Compression Tie as well.

Every two (2) feet, for the first 30 feet in height, there was a tie joint, alternating Tension and Compression, attaching the wall to the columns. From 30 feet up the spacing was reduced to one (1) foot.

Where floors existed, they were extended out to meet the wall, which also made a good Compression Tie.

ELECTRIC POWER AND LIGHTING.

Electric energy is furnished to the Plant at 13,200 volts and is transformed to 440 volts, 3-phase, 60 cycles in a Transformer House independent of the Plant buildings.

The Switchboard Room is a part of the Transformer House and the Switchboard has a panel for each Power feeder. On these panels are placed the necessary instruments and an automatic Oil Circuit Breaker. On the face of each panel are placed current Transformer Testing Clips and also potential terminals; these are for testing the power of each circuit with very little trouble.

Each Department in the Plant is supplied with an independent feeder circuit. These circuits are run overhead and at the outside of the buildings, on steel brackets, to their centers of distribution; thence to the individual motors.

Each Motor is supplied with a steel frame, upon which are mounted the Starting Compensators, together with an enclosed fused Knife-blade line Switch and running Fuses enclosed in separate steel cases. This arrangement permitted the Power to be thrown off at will from the Starting devices, thereby allowing adjustments and repairs to be made with safety.

In case of examining, entering or repairing Power-driven Machines, where life would be in danger,

should the Power be thrown on it is essential that the Motor line Switch be opened and the steel case, enclosing the Switch, closed and locked, if necessary, thereby eliminating the possibility of accident on that score. The line Switches are high mounted that the steel case may be closed with Switch in full open position.

All Motor Starting Compensators have no-voltage release coils, which trip the Starting Compensators to off position upon failure of the voltage. Push buttons are placed in circuit with the no-voltage release coils, in convenient locations, that the Motor can be released from different parts of the Department, if desired. It is always necessary to use the Starting Compensator to start the Motor. This is desirable in order that an inspection of the starting and running condition of the Motor can be easily made.

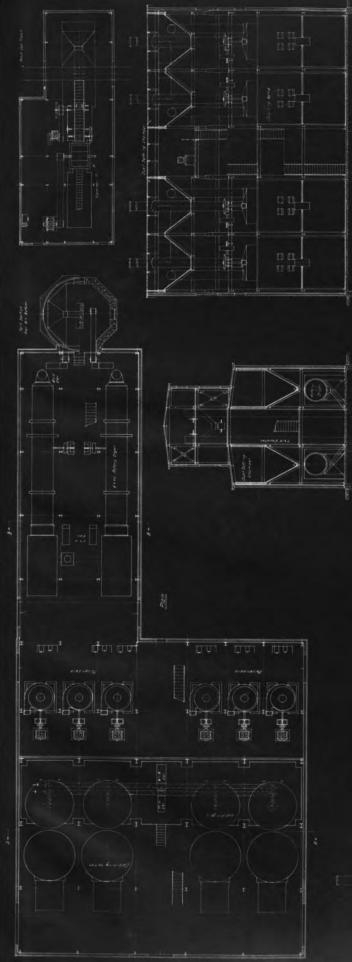
GUARDING

All Stairways and Floor openings are railed with Standard $1\frac{1}{4}$ " Pipe Railings, 42" high, and with 2" x 6" toe boards.

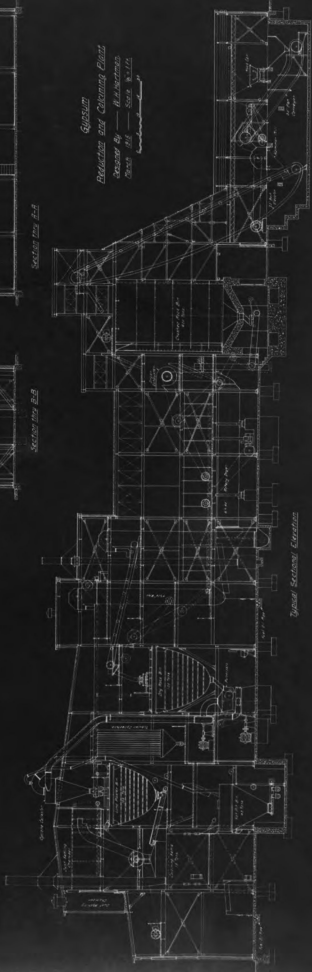
All Belts, Pulleys, Shafting, etc. under seven (7) feet from the floor are carefully guarded with Steel guards made of #12 gauge sheet Steel and $1\frac{1}{4}$ " angles. The sheet Steel was perforated only in locations where it was desirable and this method of perforation proved to be more economical and stronger than using the all-perforated plates.

All necessary permanent steel Ladders and grating runways were installed for safety in the oiling and inspection of machinery.

As Grease is used throughout for the lubrication of Power transmission shafting, the dangerous or inaccessible points of lubrication were piped away to safe locations, thereby simplifying the Guarding materially.

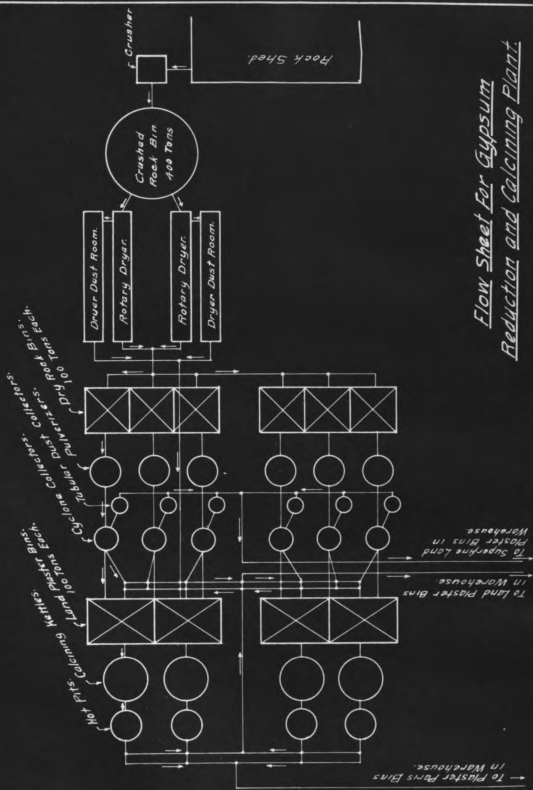


Gypsum
 Production and Coking Plant
 Designed by — H. J. Hartman
 March 1914 — Scale 1/8" = 1'-0"



Typical Section of Elevator

Flow Sheet For Gypsum
Reduction and Calcining Plant.



DESCRIPTION OF UNITS IN PLANT.

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ROCK CRUSHING DEPARTMENT.

The capacity of the Reduction and Calcining Plant is 1000 Tons of Calcined Plaster per day of two (2) 10-hour shifts. Gypsum Rock, in process of manufacture to Calcined Plaster, suffers a reduction of about 20 per cent by weight; therefore, 1250 tons of Gypsum Rock will be required to produce the 1000 tons of Calcined Plaster.

The crude Gypsum Rock in the bulk storage at the Plant is of 6" ring size and under, and it was desired to reduce it to 1" ring size in one operation.

It was also desired to have the Crushing Plant large enough to supply the necessary amount of crushed rock in a single shift of 10 hours. This required a capacity of 125 tons per hour continuous service.

A large hammer pulverizing mill was selected to make the reduction, with a capacity of 150 tons per hour when the material is supplied to the Mill at a uniform rate. As this mill required a feeder, the following arrangement was made:

The Rock comes from the bulk storage in 3-ton side-dump Cars and is discharged in a hoppers bin placed over a 30" high side Pan Conveyor with 12" Pans and

running at the rate of 50 feet per minute. This Pan Conveyor acting as its own feeder draws the material from the hopper and discharges it into the hammer mill. The hammer mill reduces the rock to 1" size and under, discharging the material into a 20" inclined continuous bucket belt Elevator running at 150 feet per minute, 67½ feet centers, and inclined at an angle with the horizontal of 63 degrees. The inclined belt Elevator discharges directly into the 400 ton circular Rock Bin, which in turn feeds the Dryers.

A 15 H.P. back-gearred Motor runs the Pan Conveyor and also a car dump hoist.

A 125 H.P. External Resistance type Motor runs the hammer mill at a speed of 700 R.P.M. The belt transmitting the Power is a 20" double leather belt running at a speed of 4375 feet per minute.

A 20 H.P. back-gearred Motor drives the inclined belt Elevator.

These Motors and those used in the Shed for loading bulk rock are connected to one feeder circuit coming from the Transformer House and terminating in this Department. All the Motors have push button stops, centralized at a convenient location for the operator.

The chutes to and from the hammer mill have pressure operated hinged gates in them to avoid dusting due to wind produced by the revolving hammers. These pressure opened hinged gates are so designed that the gate, which is hinged at the upper end in the chute, is normally closed due to the angle and weight of the gate

itself. A low head of material coming between the chute bottom and the gate will force the gate open and allow the material to flow, but retains a sufficient head of material to counteract the closing properties of the gate. The material thus retained makes an effective seal, especially on the finer materials.

This Crushing Department is designed to operate with one attendant and it will also be his duty to assist in discharging the rock cars.

DRYING DEPARTMENT

In the process of drying, the Rock is taken from the Rock Storage Bin, passed through the Dryer, which removes the free water, and is discharged into the Dry Rock Bins for the Pulverizers.

The capacity of the Drying department was based upon two (2) 10-hour Shifts, as one attendant can operate the department to full capacity and smaller units and bin capacities could be used.

Two drying units, each capable of drying 35 tons of Rock per hour, furnish ample capacity and are in keeping with the idea of a twin Mill. These Dryers were designed complete by the writer to meet the requirements and are as follows:

The Dryers are direct heat rotary type, 40 feet long with an inside diameter of 6 feet and supported on two rolled steel tires 8" wide.

The Dryer is driven by a three-set train of

Gears to a large girth gear , with 8" face, placed around the Dryer shell. The pinion driving this girth gear is offset two (2) feet from the perpendicular center line of Dryer and on the rising or lifting side.

The supporting steel tires run over sets of two stationary trunion rollers. These rollers run in water to keep their surfaces clean. End thrust rollers are placed against one of the tires to prevent end movement of Dryer.

The interior of the Dryer has a series of pitching and lifting flights so arranged that the Dryer, when set perfectly horizontal, will feed the material through rapidly and will not hold over 5 tons of rock at one time, when operating at a capacity of 35 tons per hour per unit. These lifting flights are so shaped that they will carry the material to the top of the Dryer and discharge it through the hot gases about ten times in going the length of the Dryer.

The furnace for supplying hot gases to the Dryer is located at the discharge end of the Dryer. This furnace has a large chamber, back of the bridge wall, for the purpose of settling the ash and foreign matter coming from the fuel, as it is desired to have the rock as clean as possible and the Dryer is to aid in freeing the rock of foreign matter by reason of the heat and induced gas velocities.

The sloping furnace arch top, rising from the furnace front towards the dryer throat connection, was designed to insure perfect combustion before the gases

passed into the Dryer proper. Stationary Grates are used with 30 square feet Grate area. A clean grade of furnace coke is used as a fuel. An auxiliary stack connects with the furnace through the floor and just back of the bridge wall, which is used in starting fires and to carry away the gases arising from a heavy fire should it be necessary to stop the Dryer.

The rock to be dried enters the rotary Dryer at the end opposite the furnace and travels against the flow of hot gases, discharging at the furnace end.

A 30" diameter Dryer neck connection connects the feed end of the Dryer to a 70" Exhaust Fan, which in turn discharges into a dust-settling chamber. This Dryer neck also contains the feed chute to the Dryer. The Exhaust Fan produces the necessary draught for the furnace and carries away the water vapor driven off from the rock. As the finer particles of the rock are carried by the air, it is advisable to keep the air velocity not to exceed 400 lineal feet per minute; hence a large exhauster was selected and runs at slow speed.

The Dryer neck makes a very sharp angle after leaving the Dryer and rises nearly vertical to the exhauster, which is located above it. This was done to avoid low angled runs, as air at that low velocity will deposit material on the flatter runs; consequently, the velocity of the air will be increased at those points.

The Exhaust Fan discharges, through a short connection with a sloping bottom, to the dryer dust-settling chamber.

The dust-settling chamber was located idrectly over the Dryer to save as much floor space as possible and also to keep the walls of the chamber warm. This dust-settling chamber should be kept warm enough to keep the water vapor from condensing, as it is highly desirable to reclaim the dust in a dry state. The dust chamber has a cross-section of 150 square feet and is 54 feet long, with the gas entrance at one end and the discharge at the other end, in the roof. There are no obstructions or baffles of any kind in the chamber. The settling capacity of the chamber is based on the gentle flow of expanded air pressure. The hoppers bottom with steep sides and a 9" screw conveyor in the bottom, running its length, carries the dry dust away as fast as it settles.

Each Dryer unit has its own furnace, exhauster and dust-settling chamber.

The Complete drying equipment is as follows:

The rock is delivered to the Dryers from the circular rock bin by a reciprocating feeder, placed under the bin base, operating at 80 strokes per minute with a stroke from 3" to 6" long, to suit the feed required. This feeder delivers to an 18" Belt Conveyor running 150 feet per minute and discharges to a 10" x 6" bucket elevator; thence to the Dryer. Each Dryer has an independent feed system as above.

After the rock is dried it is discharged from each Dryer into a separate 14" x 7" bucket Elevator - one for each Dryer - elevated 35 feet, and both discharged on an 18" Belt Conveyor running at 300 feet per

minute, 36 feet centers and with a 24" magnetic head Pulley. This Belt Conveyor discharges over the dry rock bins.

A 24" Belt Shuttle Conveyor is used to distribute the rock over the dry rock bins. There are six (6) dry rock bins, made in ~~two~~ groups of three bins. Each bin has a capacity of 100 tons or a total capacity of 600 tons.

The rotary magnetic head Pulley is for removing the stray iron that may become mixed with the rock.

The settlings from the dryer dust chambers are conveyed by 9" screw conveyors to a 14" x 7" bucket elevator and elevated 43 feet to a 12" screw conveyor, which discharges into the conveying system over the Lard Plaster, or can be spouted directly into one of the dry rock bins. The dust settlings from each Dryer are about three (3) per cent of the material delivered to the Dryers.

The object in keeping the dryer dust room settlings and the dry rock from the dryer discharge separate is as follows:

The trade demands two grades of Plaster of Paris, which can be called First and Second Grades.

First grade Plaster of Paris must be absolutely pure clean and uniformly white in color.

Second grade Plaster of Paris may contain a small percentage of foreign matter, which may discolor the product slightly but not effect the strength and setting properties.

To meet the demand of the First grade product, advantage was taken of the separation made in the process of drying.

The rock, in the process of drying, is tumbled about in the rotary Dryer until the entire surfaces of the Gypsum have been cleansed of foreign matter by the abrasive action of the mass of rock. The foreign matter, together with other lighter particles, becomes very dry from being in contact with the hot gases and is carried by the air currents through the Exhaust Fan and deposited into the dust-settling chamber. The material discharged by the Dryer is therefore clean rock of sufficient size and weight not to be effected by the air velocity within the Dryer.

This method produces a maximum amount of material for First grade products and all that is necessary is to keep the two materials separate in the operations to follow.

The bulk of the foreign matter to be contended with is in the form of a clayed substance on the surface of the rock and is very satisfactorily removed by the above method.

The dryer dust settlings, ordinarily, are of about 85 per cent through 100 mesh product and can be used as a Second grade material with no further reduction, and as such can be conveyed directly to the Land Plaster bins.

Each Dryer is a unit in itself and can be run independently or together, as desired. The Dryer feed ends are run by one (1) 25 H.P. Motor and feeds two (2)

Dryers. Each Dryer is driven by a 35 H.P. Motor. The Dryer discharge ends are run by one (1) 25 H.P. Motor and take the material from two Dryers, delivering it to the different bins.

The Dryer department is in charge of one operator.

The circular rock bin feeding the Dryers is provided with a safety ladder and man well on one side, and also has safety belt strap rings made of 1" pipe placed on inside perimeter of bin at intervals of 5 feet apart, starting from bottom up. These safety precautions were made so that should it be necessary for a man to enter the bin to dislocate the material or do other work, a safety belt should be worn and attached to the rings, thereby preventing sliding into a crater and the possibility of being buried under a slide.

PULVERIZING DEPARTMENT

The fineness and uniformity of the product obtained by pulverizing the dry rock is an essential feature of a superior grade product.

Gypsum rock is more or less of the selenoid crystal formation, and as such reduces very easily to a coarse product, but to reduce it further that 92 per cent will pass 100 mesh standard screen represents a great deal of work and is the problem to be met.

In the writer's experiences the smooth pressure rolling process has proven very successful as a Gypsum

pulverizing medium, when the contact areas are so placed that the material cannot lay or collect on them. With this process it is essential that the rock shall be dry.

To produce the desired fineness air separation seems the most capable, as there is very little to get out of order and it is practically impossible to get a coarser product than the air velocity is designed to carry. The power cost of air separation is very high in comparison with a vibrating or mechanical screen.

The pulverizing machines selected embodied both the roll process and the air separation system in one complete unit. The capacity of each unit is from seven to eight tons per hour when reducing 1½" ring material to 92 per cent through 100 mesh standard screen.

The pulverizing rolls have a 75 H.P. Motor direct connected through a flexible coupling, and the air separation system has a 40 H.P. Motor direct connected to a 42" fan, through a flexible coupling.

To secure the desired capacity, this department was taken on the double shift basis, with six (6) pulverizing units to furnish the capacity required.

Each pulverizing unit has a separate rock bin with a capacity of 100 tons dry rock. The rock is fed to the mill through a telescoping chute; the feed is controlled by a roll feeder on the mill itself. The air separation system takes the pulverized product from the mill and delivers it to the Land Plaster bin.

The air separation system is a closed air circulating system produced by a large Exhaust Fan, and with

the roll mill in the air circuit. The separating chamber of the system is made a part of the mill itself. The air passes up through the pulverizing region of the mill and carries with it such particles as are reduced enough to float in the air velocity produced in the separation chamber. The separation chamber is above the mill proper and forms the top housing of the same. From the separator, the air, with the reduced material, passes through the exhauster to the top of the building and discharges into a 7-foot Cyclone type Collector located over the Land Plaster bins. The bulk of the material carried by the air is discharged in passing through this Collector and is delivered, through a material seal pressure operated hinged gate to two (2) 12" distributing screw conveyors over the Land Plaster bin. The air, after passing through the Collector, returns to the pulverizing mill to be used over again.

As it is practically impossible to keep all parts of the system air-tight, the excess air getting into the system is allowed to escape through an 8" vent pipe placed at the highest point in the return air circuit and piped to a tubular dust collector, where the material carried by the air is retained and the air allowed to escape. A separate elevating and conveying system is installed to deliver this material to a special bin in the warehouse, as the product is extremely fine and as such is marketable as a special product. The capacity, however, is less one-fourth ($1/4$) of one per cent of the output of the pulverizing units.

The tubular Collectors discharge into a 9" screw conveyor running underneath them and carries the material to a 10" x 6" bucket elevator, elevating 20 feet and discharging into a 9" screw conveyor running to the Warehouse storage bin.

The air system not only separates the product but elevates the material as well and discharges it into each of two separate screw conveyors, by the aid of a bifurcated spout, or directly into the bin below, as desired.

Owing to the fact that two classes of materials are to be made and that pulverized rock, or Land Plaster, is often disposed of with no further preparation, a system of 12" screw conveyors was placed over the Land Plaster bins whereby two screw conveyors placed side by side and travelling in opposite directions, with connections to receive material from each pulverizer discharge and to discharge into any of the Land Plaster bins; also into a 12" screw conveyor running to the Land Plaster bin in the Warehouse. This arrangement makes it possible to handle and separate the material, as desired.

The Land Plaster bins are placed in two groups of two bins each. Three pulverizerx collectors are arranged over each group of bins. The capacity of each bin is 100 tons, or a total Land Plaster capacity of 400 tons.

The pulverizing department is to be operated by two men - one to each three units.

CALCINING DEPARTMENT

In the process of calcination, or dehydration of pulverized rock, or Land Plaster, the larger part of combined water is driven off.

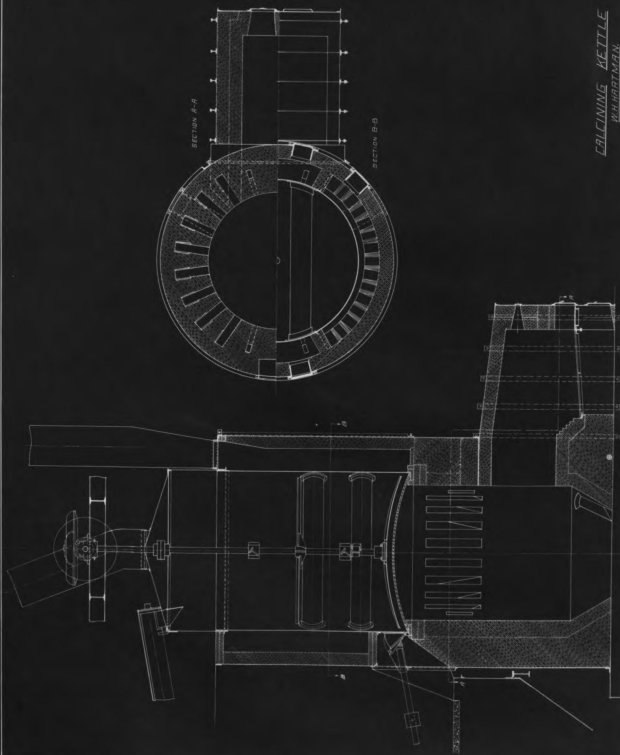
To produce a superior grade of Plaster of Paris it is essential that the dehydrating process be carried to the same degree at the completion of the operation and that the product be absolutely uniform throughout.

The writer has studied the action of materials and fuel gases on other designs, and by having carefully watched for the first signs of weaknesses and their developments, gathered a great deal of information. In the design of this new Calcining Kettle, the writer attempted to eliminate all former troubles and weaknesses, and also aimed to get greater capacities and output, higher fuel economies, and small maintenance costs.

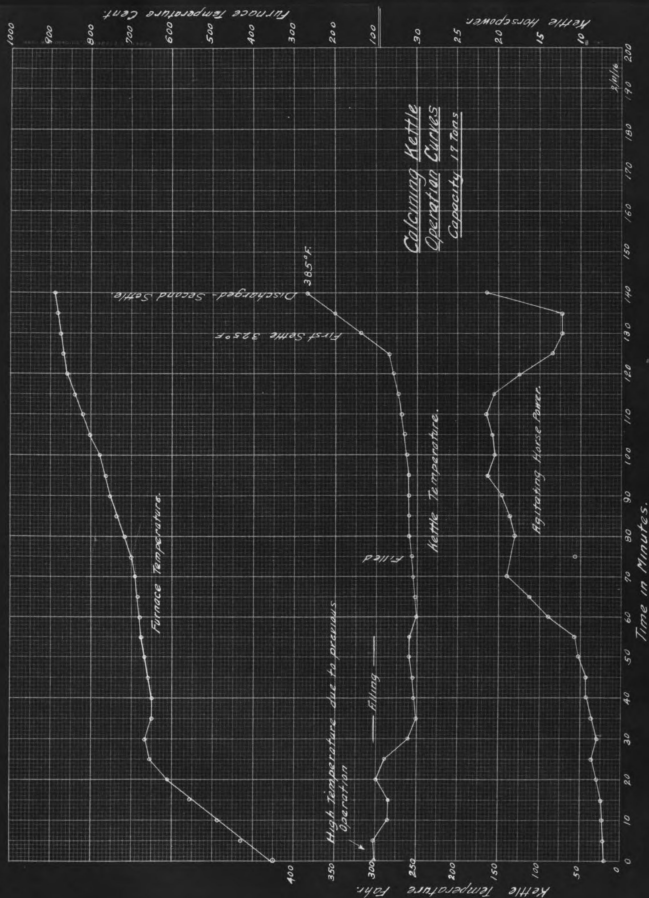
The principle of the Calcining Kettle is the batch process. The general dimensions are as follows:

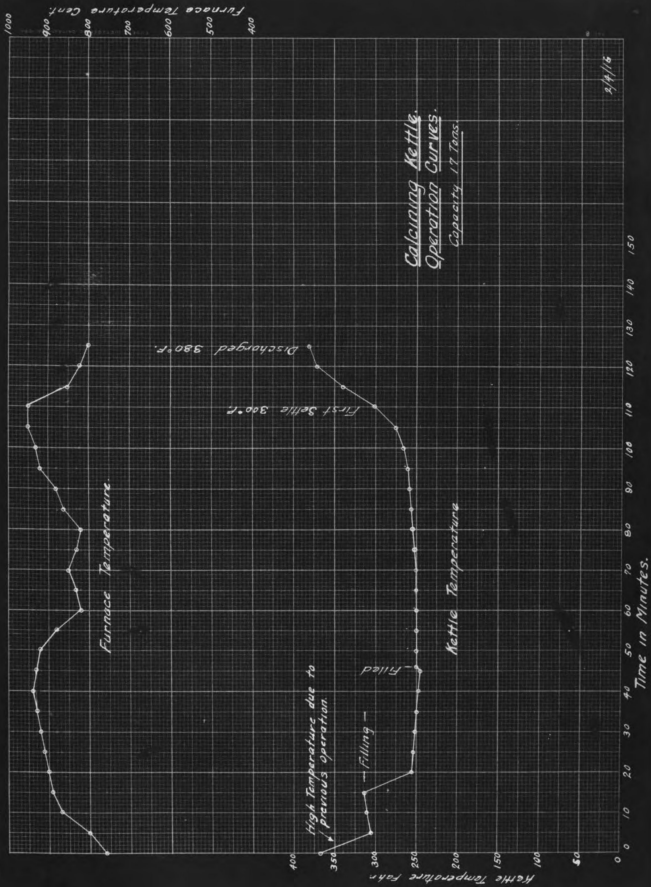
The Kettle proper is 10 feet in diameter and 15 feet high, with four (4) 15" diameter flues running horizontally through the shell, and a four-arm agitator shaft running in its center from above. The bottom of the Kettle is spherical in shape, with a rise of 12" in its center, and is located 10 feet above the Grates. The furnace is of the extended front pattern and has 26 square feet of grate area. Bituminous Coal is used as fuel.

COLLING KETTLE
W. H. HARTMAN



Colorming Kettle Operation Curves Capacity 17 Tons





The Kettle proper is located over a ported construction fire brick base, that the heat may strike the bottom and pass around the Kettle, through the flues, and thence to the Stack. The entire unit is encased in a 3/16" Steel jacket 14 ft. 3 in. in diameter and 24 ft. 6 in. high, with the necessary inspection and cleanout doors secured to it.

Each Calcining Kettle has a 100 Ton Land Plaster bin from which to draw its material. This material is delivered to the Kettle from the bin by a special designed power operated screw conveyor feeder consisting of two 9" screw conveyors in a 10" W.I. pipe, delivering to one 14" screw conveyor running on an incline and delivering the material to the Kettle through an opening in the top. The Kettle vertical shaft carries a bottom sweep arm and three agitator arms placed three feet apart from bottom up. The bottom sweep arm is curved to suit the curvature of the kettle bottom, with a space of 4" between them, and has attached to it 3/4" anchor chains, arranged in loops so that the dragging chains sweep the complete bottom at all times. This sweep prevents any material becoming attached to the Kettle bottom, for should this condition exist the bottom would readily be destroyed by over heating and burning.

The vertical shaft is driven at 25 R.P.M. by a 25 H.P. back-gearred Motor and a heavy set of bevel gearing.

When the Calcining Kettle is started in operation, the material is delivered into the Kettle with the

agitators running and the heat is so applied that the Kettle proper shall not be less than 212° Fahr.

The water vapor formed by the calcining of the material is carried to the kettle dust-settling chamber ^{dia.} through a 30" steam stack rising from the kettle top to the dust chamber. When the calcining process is finished the material is discharged, by gravity, through a 12" x 14" opening hinged counterweighted gate located at the bottom of the Kettle, and passes into the Hot Pit, or receiver bin.

Each kettle has its own receiver, or Hot Pit, having a capacity of 30 Tons of freshly calcined Plaster. Each Hot Pit has a 12" vent pipe leading to the roof for the purpose of allowing the air to escape as the Kettle is discharged into it. The Hot Pit is enclosed with a concrete top, and has a Man-hole with raised sides in its center, so that no foreign matter can enter the Pit.

The capacity of each Calcining Kettle was placed at 15 Tons per batch of Calcined Plaster, and with an average of 250 tons per unit in 20 hours, or two shifts. Four Calcining units were necessary to give the desired capacity of 1000 tons of Calcined Plaster.

One large dust-settling chamber of 260 square feet in average cross-section and 25 feet long accommodates two Calcining Kettles. It is located above the Kettles and has two hoppers with 9" screw conveyors in them, to carry the settlings back to the Land Plaster bin for use again.

Where the walls of the dust-settling chamber

came in contact with the building walls, an extra insulating wall of Gypsum Blocks was used, as it is highly desirable to keep the temperature of the dust-settling chamber high enough to prevent any condensation of water vapor. The dust-settlings cannot be returned to the Land Plaster bin unless they are dry.

The Kettle smoke stack passes through the dust chamber but is protected by a steel shell forming a 4" air space around same in the dust chamber; this also aids in maintaining a high temperature.

A Washing Room is provided at the exit from the dust chambers where the water vapor passes through a fine water spray and any dust present is washed down and carried away with the waste water, while the gasses pass out of the ventilators in the roof of this Washing chamber.

Plaster of Paris is the product discharged from the Calcining Kettles into the Hot Pit. This product, due to its nature, requires careful handling and great precautions must be taken that it does not come in contact with dampnes or any un-calcined material. This material is discharged into the Hot Pit at a temperature of from 300 to 350 degrees Fahr. and ~~XXXXX~~ possesses the fluidity of water, but if allowed to remain quiet for a short time until some of the entrained air escapes, the material may refuse to flow at all, without agitation.

The Hot Pit was designed with a steep pitched conical bottom terminating in a specially designed 9" screw conveyor feeder. This feeder discharges the

material into one of two 12" screw conveyors placed under the feeder. The 9" screw conveyor feeder has a 4" to 9" varying pitch screw placed in a 10" W.I. pipe and is driven by power.

The Calcined Plaster is discharged from the Kettle by gravity into the Hot Pit, as it is desirable to get the material out in a short time. The average discharging time is less than one minute. To get the gravity discharge it is necessary to have the Hot Pit as low as the discharge gate, which, in making a Hot Pit large enough to hold two batches from the Kettles, brings the bottom of the container well below the ground floor line of the Kettle, and in a region subjected to water and ground moisture. To overcome the objection to water and dampness in connection with the Hot Pits, Elevators and Conveyors carrying this material, the following provisions were made:

The Hot Pit bins are supported clear from the foundations and are not in contact with them. The Elevator boots are made water-tight up to 12" above the floor line and the screw conveyors are set clear of the floor by over 12", so that not until the water is 12" high over the Hot Pit basement floor will any water enter the system; the dampness, however, is objectionable and under ordinary conditions should not exist to any extent.

In case of an accident or failure of power while a Calcining Kettle is in operation and it becomes necessary to discharge its contents before the operation

is completed, this material would have to be returned to the Land Plaster bin and re-calcined. As the raw or uncalcined material is very detrimental to the finished product, an entirely separate system of conveying and elevating is supplied to take this material back to the Land Plaster bin.

The material is drawn from the Hot Pit by the power feeder and discharged into the first 12" screw conveyor, which carries the material to a 14" x 7" bucket Elevator and is elevated to a point above the two (2) 12" distributing screw conveyors over the Land Plaster bins; it can be discharged into either of these conveyors or into the 12" screw conveyor leading to the Land Plaster bin in the Warehouse, by the aid of a special three-way spout. By discharging the material from the elevator to one of the two (2) Land Plaster distributing conveyors, the material can be placed in any one of the bins desired.

The Calcined Plaster is taken from the Hot Pit by the special feeder and discharged into the second 12" screw conveyor running to the 18" x 8" bucket Elevator, elevated 60 feet and discharged into a 10" screw conveyor, which in turn discharges into two 12" screw conveyors running at right angles through a high bridge to the Calcined Plaster storage bins in the Warehouse. These conveyors are run at 32 R.P.M. and at that speed the conveyor flights agitate and tend to lift the material somewhat as it is being conveyed. As these conveyors have screened tops this agitation and exposure to the air

produces a cooling effect sufficient to permit the Calcined Plaster to be stored in large bins with safety.

The capacity of the Hot Pit feeder is 35 tons per hour at 100 R.P.M. and the Elevating and Conveying systems from the Hot Pits are designed to handle the material from four (4) Calcining units at one time.

The Hot Pit feeders and conveyors are driven by two (2) $7\frac{1}{2}$ H.P. back-geared Motors, one for each two Kettles.

The Kettle Feeders are driven by one (1) 10 H.P. Motor.

The Hot Pit Elevators and Conveyors over the Land Plaster bins are driven by one (1) 35 H.P. Motor.

The screw conveyor system from the Hot Pit Elevators to Calcined Plaster bin in the Warehouse is driven by a 15 H.P. back-geared Motor.

The Hot Pit Feeders require one operator. The four (4) Calcining Kettles require one Calciner, one Fireman and one coal-passer.

The entire Plant, with the exception of the Crushing Department, is built on the twin mill plan, dividing each section into one (1) Dryer, three (3) Pulverizers, and two (2) Calcining Kettles.

In designing the Plant great care was taken to have all parts rugged and ample to do the work under such conditions as generally exist in Plants of this

character. Specially designed machines or parts were used wherever advisable.

All parts of the system were designed with an object to reduce inspection and attention to a minimum, and also to permit of a cheaper class of labor.

This Plant, at the present writing, has been in operation for four months and has well proven the claims made for it by the writer; in some cases very remarkable results were attained. All of these, in their effect, have produced a superior first grade product.

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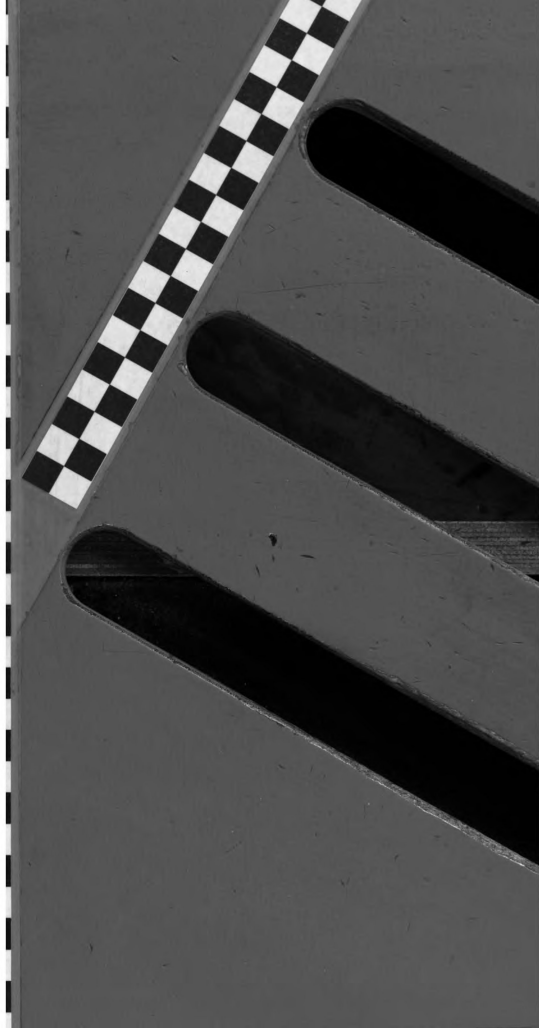
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