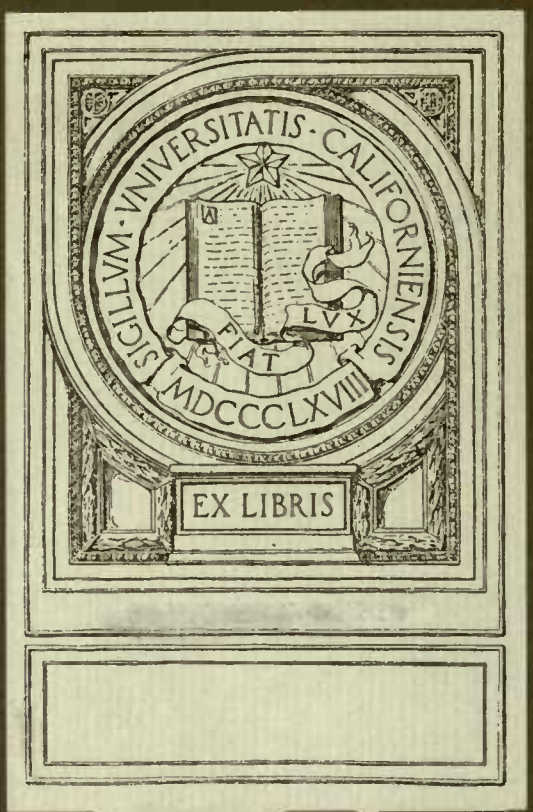
THE MODERN FERTILIZER PLANT

STURTEVANT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STURTEVANT

It symbolizes Growth.
The branches cover much of this old Earth. The roots transmit, from great factories, streams of Sturtevant genius to limbs bearing that which can nowhere else be produced. It is truly a Live Oak.

STURTEVANT MILL COMPANY

HARRISON SQ. BOSTON, MASS.

Shadowed by this Royal Oak
King James I
bestowed British Letters
Patent for improvements
in treating Iron, on
Simon Sturtevant.

If the life-chain of either the King or Simon, straining into the misty ages of creation, had lacked one link this meeting could not have taken place; but the fortunes of Simon now reach to the Sturtevant Mill Company and they have left here and there Inventors to receive distinction and reward.

STURTEVANT MILL COMPANY

Mr. Charles H. Macdowell, President of the Armour Fertilizer Works, in his Presidential address before the National Fertilizer Association at White Sulphur Springs, West Virginia, June 22nd, 1921, stated:

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"There are other hidden losses in manufacturing, such as low yields in sulphuric acid, high insolubles in acid phosphates from uneven grinding and poor mixing, from excess iron and alumina, or improper handling of acid phosphate after it has been made. A chemical control of plant manufacture and manipulation is essential in avoiding these losses. Excessive shrinkages in high cost materials can easily occur if a superintendent is in a hurry to get out a large tonnage. Bad weighing of bags can lose the industry hundreds of thousands of dollars a year."

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Mr. Fred S. Lodge, Assistant Director of Manufacturing, Armour Fertilizer Works, stated:

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"A large sum of money is lost annually by the fertilizer manufacturer through insoluble phosphoric acid. The average insoluble phosphoric acid found by the state chemist of one of our middle west states in 16 per cent. acid phosphate was 1.2 per cent. This represents 169 samples collected from some 56 manufacturers shipping 48,000 tons of 16 per cent. acid phosphate into the state. It is entirely practical to manufacture acid phosphate in good mechanical condition with 0.5 per cent. insoluble phosphoric acid or even less. On the average every one of the 48,000 tons of acid phosphate carried a loss of 0.7 of a unit of phosphoric acid or 33,600 units equivalent to over 1000 tons of 72 per cent. rock worth say $12 a ton delivered or $12,000. The only extra expense to convert this 1000 tons of rock into available acid phosphate would be the cost of extra sulphuric acid necessary to acidulate and it is reasonable to assume in the majority of cases sufficient acid was used to correctly acidulate if proper chemical control had been exercised. Furthermore these 48,000 tons carried also an average overrun of 0.8 per cent. available phosphoric acid."

CHEMICAL CONTROL

"Good chemical control will ship acid phosphate with not over 0.25 per cent. overrun. This excess overrun of 0.55 per cent. available

phosphoric acid on the 48,000 tons is equivalent to 26,400 units or 1650 tons of 16 per cent. acid phosphate. At a factory cost of say $12 per ton this amounts to $19,800. In this one state (not a particularly large user of fertilizer by the way) in one brand alone $31,800 was lost to the fertilizer manufacturer. This loss is over and above that necessary to insure guarantees, and is due solely to inefficiency and lack of factory chemical control. Like conditions prevail in all states."

"Consider the number of fertilizer consuming states. Think of the number of brands sold in each. Similar losses can be shown for the other elements of plant food. In one of our largest fertilizer consuming states the average overrun in commercial valuation of the 16 largest shippers was found by the state chemist to be $1.39 per ton. Over a million tons were shipped into this state. The two states mentioned above are particularly noted for the accuracy of their control work and these results are accepted as authentic." * * * * * * * * * * *

LABOR

"The third item of cost is the one of labor. Efficiency has become almost a slogan in American factory practice, yet it is just in its infancy in the fertilizer industry. Too many fertilizer superintendents are rule of thumb operators, loathe to try labor saving devices, content to use men where machines could be utilized to better advantage. Thirty-five men was a standard gang for a mixing unit, often fifty were employed. Ten pickers and ten shovelers were often used on an acid phosphate pile to keep one mixing machine in operation."

"Three men with five pounds of dynamite and a loading machine or one or two men with a power shovel can now do the same work with more ease. Furthermore, the hopper on the loader or the dipper on the shovel permits the cart man to obtain a full load at once without waiting for the shovelers to load him. The electric dump truck with one operator takes the place of three one-man carts. More efficient screens and tailings mills eliminate the necessity for men constantly whipping the screens."

"Better mechanical condition of goods also helps and prevents blocking of elevators, bridging in hoppers, etc., all of which require labor as well as loss of tonnage. Automatic Scales and Bag Sewing machines speed up output and eliminate men. Conveyors and Electric Platform trucks simplify and expedite removal of bags to cars and replace men."

POWER COST

"Naturally the substitution of machinery for men would be supposed to increase our fourth item of cost, power. However, the improvement in machinery may be used to offset this largely. The use of dust proof roller and ball bearing equipment has greatly reduced the friction load on modern fertilizer machinery so that the power costs on a modern crane type plant are little in excess of those in older type plants. The power necessary to operate an electric truck in ordinary service should not be more than fifty to seventy-five cents a day." * * * * * *

HIDDEN LOSSES

"The seventh item of cost, Hidden Losses, has been touched on in each of the others. Few executives have a true conception of the magnitude of the summation of these items. Lack of proper chemical control is the most common and probably the greatest of all hidden losses. The work should start with the purchase of the proper raw materials, follow their receipt into the factory to assure the billed weights and analyses are actually received, supervise their storage for accessible location and proper segregation, economically formulate the brands to be shipped, check the mixing weights, oversee the mixing operation and check the bag weights when filled."

CONCLUSION

"The shipping department of a factory essentially strives for tonnage. Unless they are under strict supervision for chemical control accuracy is very likely to be sacrificed for speed. Proper chemical control in the acidulating department assures acid phosphate of good mechanical condition and satisfactory analysis, so no direct analytical loss is suffered, nor is there untold hidden loss due to rehandling sticky goods, digging out blocked elevators, etc., and eventually satisfying just complaints of rotten bags and undrillable goods."

"If factory accounting is based on units instead of pounds, the question of moisture shrinkage will be eliminated by chemical control, for materials will be analyzed just before use and figured on actual analysis and not on an analysis on which they were purchased months before. In fact, chemical control properly carried out assures goods of satisfactory condition and of the guaranteed analysis reaching the consumer. State analyses consequently will not demand underrun settlements and the sales department will have a satisfied customer to approach for repeat orders." * * * * * * * * * * * * * * * * * * *

Acid Phosphate made by the Sturtevant Process being bagged and shipped without milling or screening
Note absence of lumps (see page 26)

INTRODUCTORY

For thirty-nine years the Sturtevant Mill Company has built Fertilizer Machinery, therefore it is fair to assume its experience has value.

Until twelve years ago its efforts were principally confined to the United States, but since that time it has been in close touch with European practice through its Associates, the Sturtevant Engineering Company of London and Paris, who have specialized in complete fertilizer equipment with the result that Sturtevant Machinery is as well known abroad as it is in the "States."

In most respects the American Manufacturer is far ahead of his foreign cousins, but conditions are not the same, and the processes are dissimilar except as applied to the manufacture of Acid Phosphate (Super) in which respect Great Britain and Europe have progressed much farther than America.

The development in this process abroad will be a revelation to the uninitiated, and as The Sturtevant Mill Company, through its Associates, has designed and supplied the machinery largely used in Great Britain and Europe, for the manufacture of Acid Phosphate during the past seven years, facts can be stated and proven, by many successful installations.

The Sturtevant Mills Co.'s reason for delay in introducing these methods into the United States was to avoid costly experiments to American friends, and to thoroughly convince itself that foreign systems were not only suitable, but superior, to American methods.

The Manager of its Engineering Department, who is well versed in American and Foreign Fertilizer manufacture, has made extensive trips throughout England, Scotland, Spain, Belgium and Holland, inspecting not only the various Sturtevant installations, but those of other designs, resulting in the purchase of the American Patents of the Beskow System, which is second only to the Sturtevant-English Process. The Sturtevant Mill Company is now in a position to use the best features of each of these proven methods for the benefit of American users.

No fertilizer manufacturer can fail to be interested in such radical improvements in the making of Acid Phosphate, which, combined with other Sturtevant Devices, are the last word in Fertilizer Plants.

This book, therefore, is devoted to Sturtevant Fertilizer Machinery and Equipment, the result of brains, initiative, and world-wide experience, which, coupled with Sturtevant Engineering and Service, places this Company in a position to give the Fertilizer Manufacturer the best at reasonable cost.

First, your attention is called to a complete Fertilizer Installation, (shown on large folder at back of book) of all steel, Crane Type construction; then the individual Units and Machines, which are incorporated in this plant.

As a great variety of Units and Equipment is used to suit various conditions, only a few will be illustrated, but a sufficient number to give an idea of the scope of Sturtevant practice.

The Sturtevant Mill Company not only build Fertilizer Machinery, but are experts in Plant design, and supply Engineering Service entirely separate from its manufacturing business. They design complete Plants, or any part thereof.

DESCRIPTION

(Open folder at back of book when reading this description)

The Phosphate Rock is received in Box Cars, from which it is removed with a Power Shovel (1) directly into a Swing Sledge Mill (2) which crushes the rock to one inch size and smaller. If Florida Rock is used no crushing is needed and the Mill is not operated, the rock simply by-passing to the Elevator (3) which delivers it to the Silo (4). The Silo may be of any size, the one shown holding 1200 tons. A tunnel is built under the Silo, the roof of which carries the weight of the rock in storage. This rock is drawn off through the sides of the tunnel in several places by Gates (5) and deposited on a Belt Conveyor (6) which takes it to the Elevator (7) that fills the Bin (8) (holding approximately 40 tons), over the Ring-Roll Mill (9).

Rock from this Bin is fed by gravity, controlled by a Gate, to the Ring-Roll Mill (9), where it is pulverized and discharged into Elevator (10) leading to the Air Separator (11). The Separator removes the fines and returns the oversize through a Chute (13) to the Mill for regrinding. The fines drop into a Screw Conveyor (12) and are carried to a dust Storage Bin (14) holding 70 tons.

A Dust Collecting System with Filter (15), Exhaust Fan (16), Piping (17) removes the fine dust and creates a suction, where needed, to keep the plant clean, the dust from the Filter being discharged into the dust bin.

A Screw Conveyor (18) runs under this Dust Bin taking the dust to small Elevator (19) which discharges into Screw Conveyor (20) which keeps the Scale Hoppers (21) full of dust. Small hoppers are used over the automatic scales (22) so that no bridging or clogging can occur to prevent the even flow necessary to accurate automatic weighing. To maintain a constant "head" above the scales these hoppers are constantly kept full, the surplus dust being carried over and returned to the dust bin by another Screw Conveyor (23) and Chute.

A one-half day's supply of tempered acid is kept in a tank (24) above the automatic Acid Scales (25) so the Mixer operator's whole attention is confined to weighing, mixing and operating the Dens.

Now the operator simply moves two levers, one for acid and one for dust, the weights are secured automatically and both charges are passed into the Mixer (26). The Mixer is then started, the mix completed and the charge dumped into the Den (27). The Mixer is then ready for the next batch.

When the Den is filled the material therein is allowed to set for about fifteen minutes before the sides (28) are loosened, the door (28A) raised, and the cutting and aerating mechanism (29) started. This machinery is Automatic and discharges the finely flaked shavings of aerated acid phosphate onto the Pan Conveyors (30) which parallel the Den sides, and deposit the finished Phosphate, without mulling, into a Pit (31) ready for the Crane.

When two Dens are used the operator is free to go to the second Den after the last charge is dumped from the Mixer into the first Den, because a helper is the only man necessary to cut out, or ex-den, each machine. The helper is not needed for the weighing, mixing or Den filling operations. Therefore three men, the operator and two helpers, are all the labor required to run two machines.

Fumes, generated by the chemical re-action in Den, pass through the duct (32) into a dry fume chamber (33) where much of the solids are deposited, the remainder passing through the special wood constructed Exhauster Fan (34) which blows these gases into a series of water sprayed compartments in Chamber (35), the cleaned and scrubbed air passing out of flue (36), the water discharging through pipe (37).

The finished, sliced and aerated Phosphate is picked up by the Grab Bucket (38), operated by the Crane (39), and deposited in storage piles.

Acid Phosphate, when bag shipments are desired, is placed by the Crane in Hopper (40), Filler in Hopper (41) and Scales (42) beneath these Hoppers control the weights of the materials.

The Shipping Unit (43) is used for Milling, Screening and Sacking this Acid Phosphate. It can also be used for Shipping conditioned complete goods.

Unit (44) on the opposite side of the building is used for bulk shipments and is similar in operation to (43).

Hoppers (45) are for the various ingredients used in making either base or complete goods. Each Hopper is filled by the Crane with the materials desired. Unit (46) is a Basing Unit, or a Mixing and Shipping Unit for Complete Goods. When used for basing, the materials are returned to the main bay by Belt Conveyor (47) for the Crane to pile. When used for Shipping, the sacking arrangements shown, suffice.

Unit (48) is a Shipping Machine, in all respects similar to (43) and is used for sacking and shipping Complete Goods.

Crane (49) is employed to assist in filling the various Hoppers and to carry away and pile the base goods when made.

Space reserved for Foreman's office (50).

Phosphate Rock, being used in large quantities, is handled mechanically to reduce labor costs, and its storage concentrated to economize space.

UNLOADING---POWER SHOVEL

Any grade of Phosphate Rock, with the exception of the very large pieces of Tennessee Blue, is economically unloaded from Box Cars by means of a Power Shovel. By this method, one man can unload a car in less than one hour. If hopper bottom cars are used a slight change in the unloading arrangements can be effected to serve equally well.

When rock is received in boats, grab buckets and electric overhead cars are employed to advantage.

When the rock is removed from the Car or Boat it must be stored, (also crushed, if lump rock is used). Rock storage is arranged, therefore, to allow for economy in crushing, if this is required, placing in storage, also for mechanically removing from storage and delivering to the Grinding Unit.

CRUSHING

A Sturtevant Swing Sledge Mill, hoppered to receive the rock directly from the Power Shovel, is used for crushing lump rock. This Mill is of the Open Door, accessible type, heavily lined, and carrying coarse grate bars which form the bottom and act as a rough sizing Screen, (to 1″).

Operated at one half the usual speed, this machine is peculiarly well adapted to this preliminary work owing to its reliability, low head room, large capacity, free discharge, difficulty in clogging, even product, quick and easy accessibility, low power and small upkeep.

The Mill discharges into an Elevator of equal capacity to that of the Power Shovel and Mill.

The unloading arrangements embody provision for by-passing the Mill, when rock requiring no crushing, such as Florida Pebble, is used.

SILO STORAGE

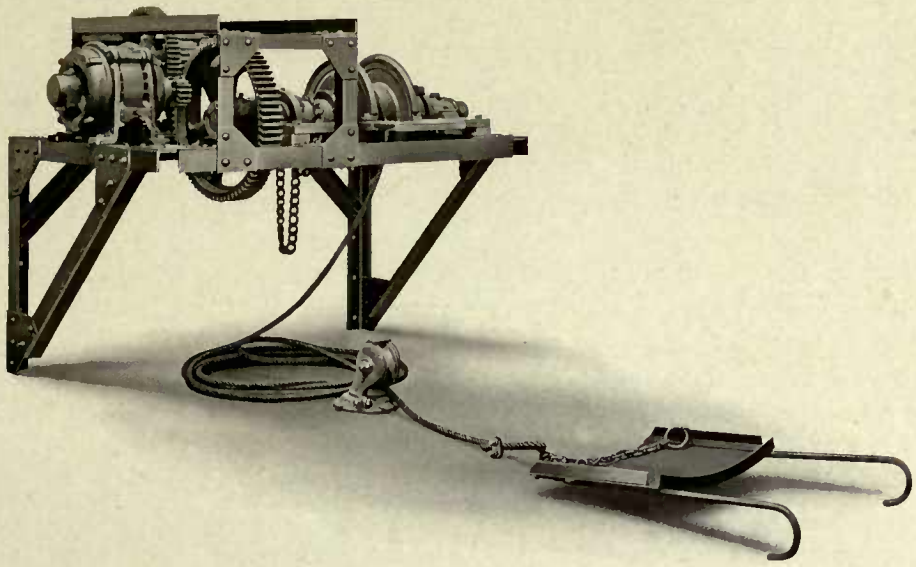
Several methods may be employed for storing the rock.

When possible, the Silo type is preferred, because less ground area is occupied than when storing the same quantity on the ground floor of a building. Further, a Belt Conveyor placed in a tunnel under the Silo, easily reclaims the major portion of stored rock and requires little labor.

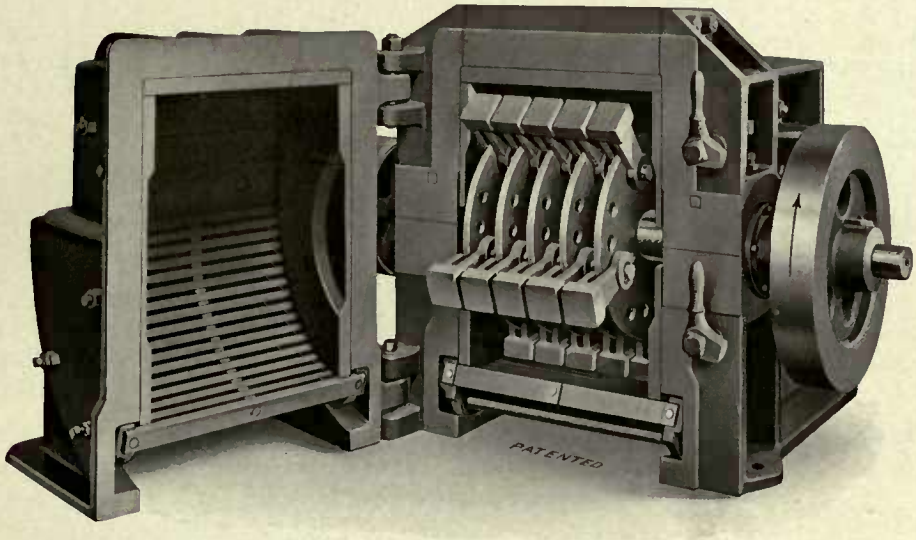
Rock piled on the ground, by means of an overhead Conveyor or Car, which inexpensively places it in storage, cannot be readily or cheaply reclaimed. If a Conveyor of any kind is placed under such a pile, the ground area is so great that only a small percentage is automatically reclaimed, and the balance requires hand labor for trimming.

Storing rock in piles around the building is both expensive to place and to reclaim, as much labor is necessary for both operations.

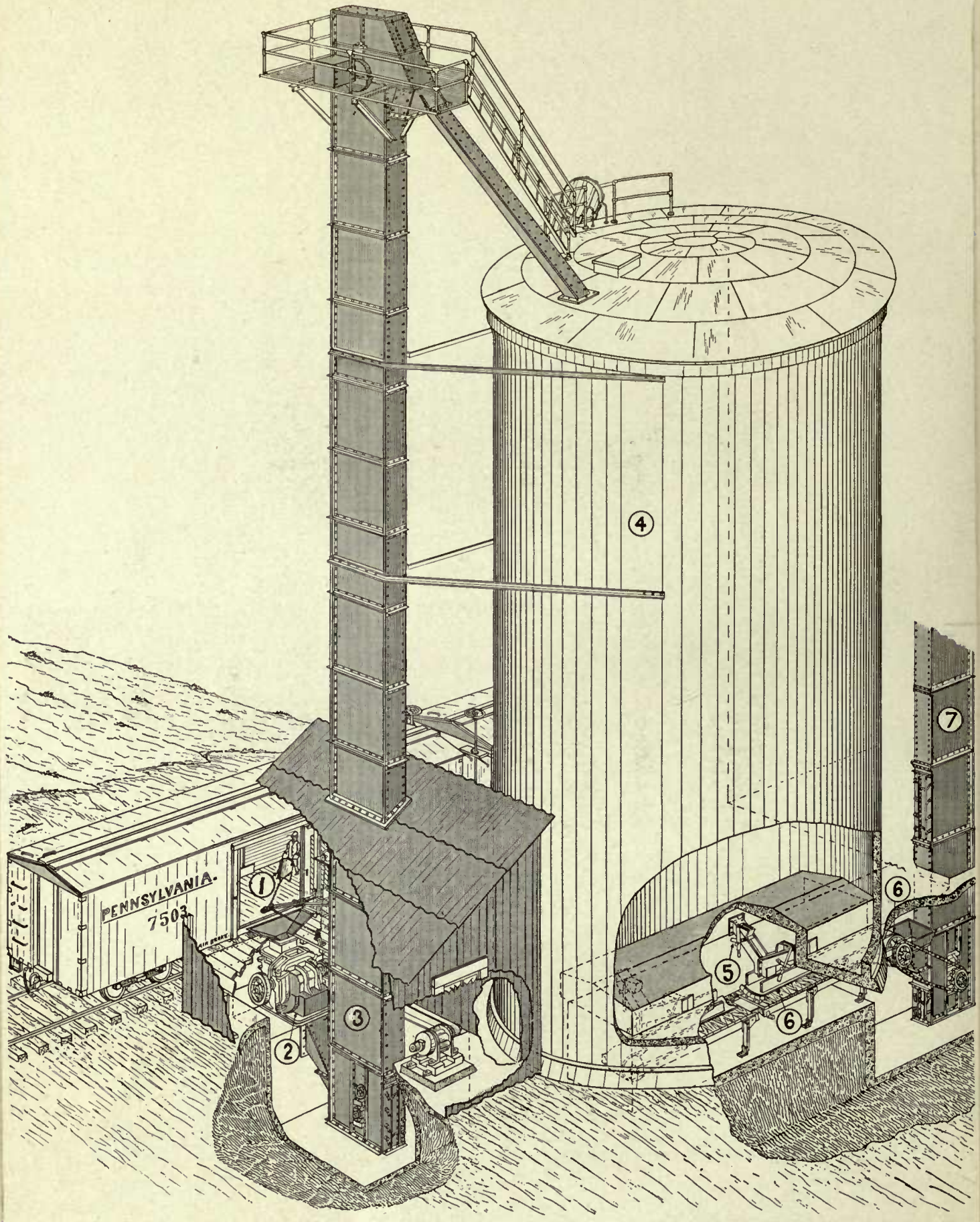
The Silo is the cheapest form of bin for its capacity, and can be duplicated when increased storage is needed.



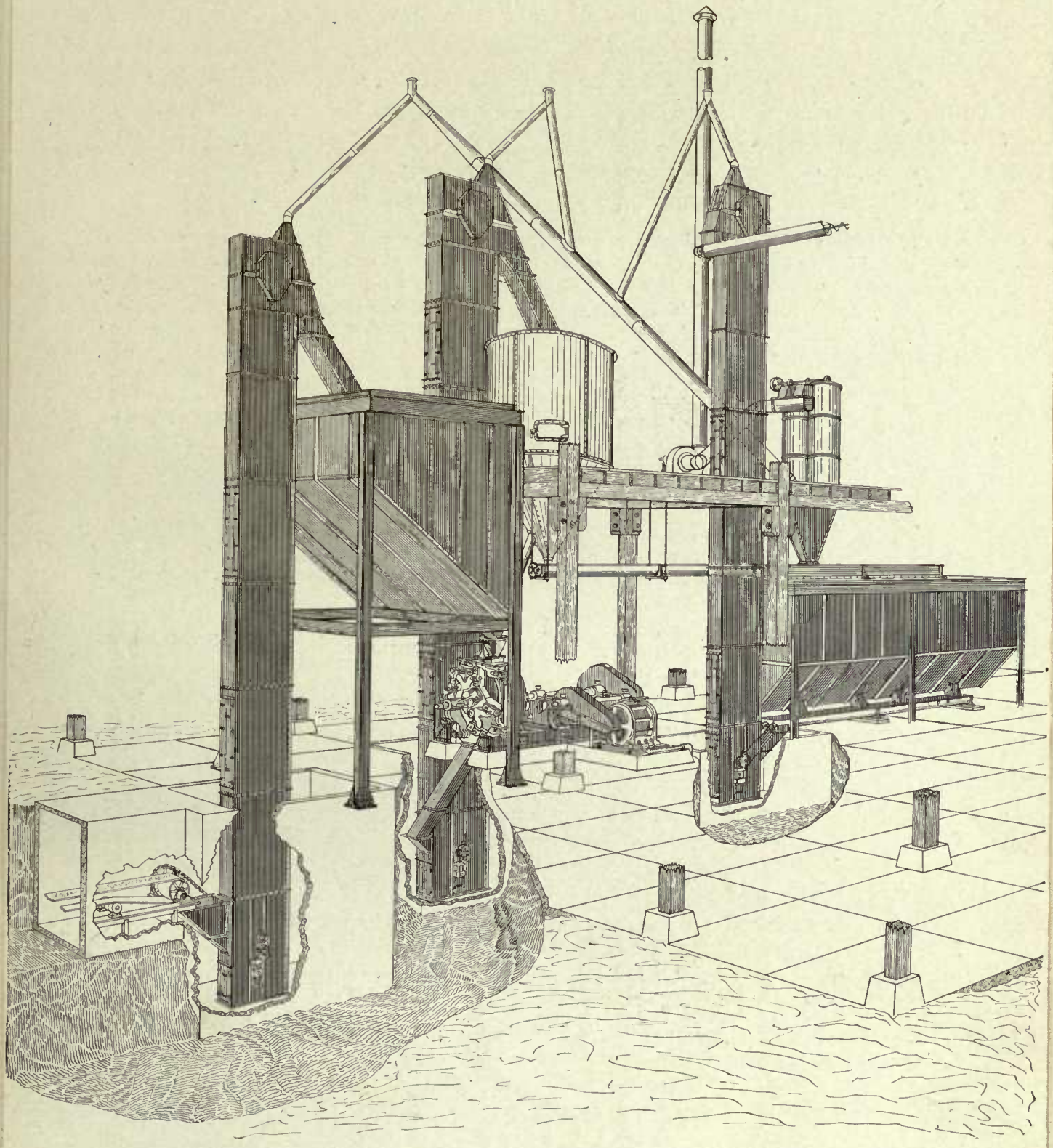
Sturtevant Power Shovel
For Unloading Rock from Cars



Sturtevant Swing Sledge Mill
For the Preliminary Crushing and Sizing of Lump Rock



Sturtevant Rock Unloading, Crushing, Sizing and Storage Unit



Sturtevant Ring-Roll Mill and Air Separator Rock Grinding Unit with Dust Collecting System

The grinding of Phosphate Rock is an important item in the manufacture of Fertilizer, therefore has led to the development of many types of grinding mills, more or less successfully used, for this purpose.

As the rock must be screened or separated after grinding, to produce the required fine, uniform dust, this feature is equally important to that of grinding.

The necessarily insufficient screen area of internal screen mills does not permit of the free discharge of finished dust as fast as made. In consequence much effort is wasted and action cushioned by the grinding members working upon material already of the proper fineness, but which cannot escape. Therefore small capacity, large Horse Power per ton of rock ground, excessive upkeep and clogging, due to damp rock blinding the meshes of the fine screens, have resulted in the practical elimination of such machines.

To overcome these objections other mills were developed, using large independent screens, entirely separate from the grinding mill. This system consists of a Pulverizer, a Circulating Elevator and a Screen. The rock passes through the Mill, up the Elevator and over the Screen, where the fines are removed, and the oversize is returned to the mill for further reduction.

The maintenance of Screens, however, proved expensive, as frequent renewals of the screen cloth were necessary to prevent leakage. The moisture element was also objectionable, as the best of fine screens coat over and require constant brushing to maintain capacities.

Grinding Mills have not been materially changed, but Air Separators have been developed to overcome screen troubles.

The Sturtevant Ring-Roll Mill—Air Separator Grinding Unit stands pre-eminent for producing uniformly fine Phosphate Rock at minimum expense.

OPEN DOOR RING-ROLL MILL

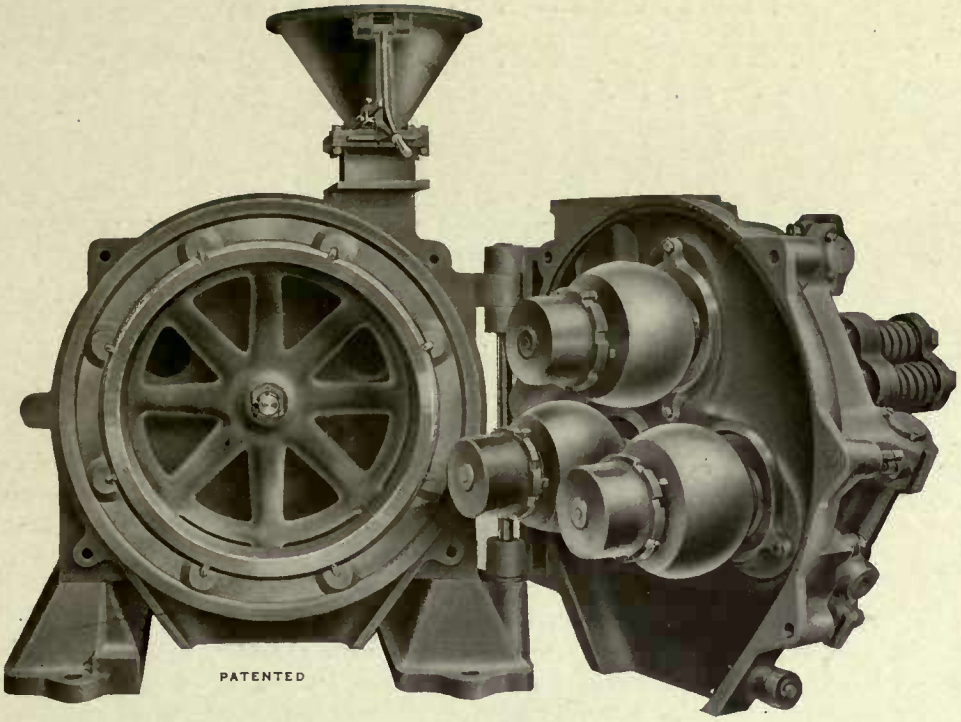
The Sturtevant Ring-Roll Mill is extensively used wherever Phosphate Rock is ground. It is a machine of the vertical ring and roll type, slow speed, durable, of rugged construction, and cannot be equalled for dependability, accessibility, large capacity, small power and low upkeep.

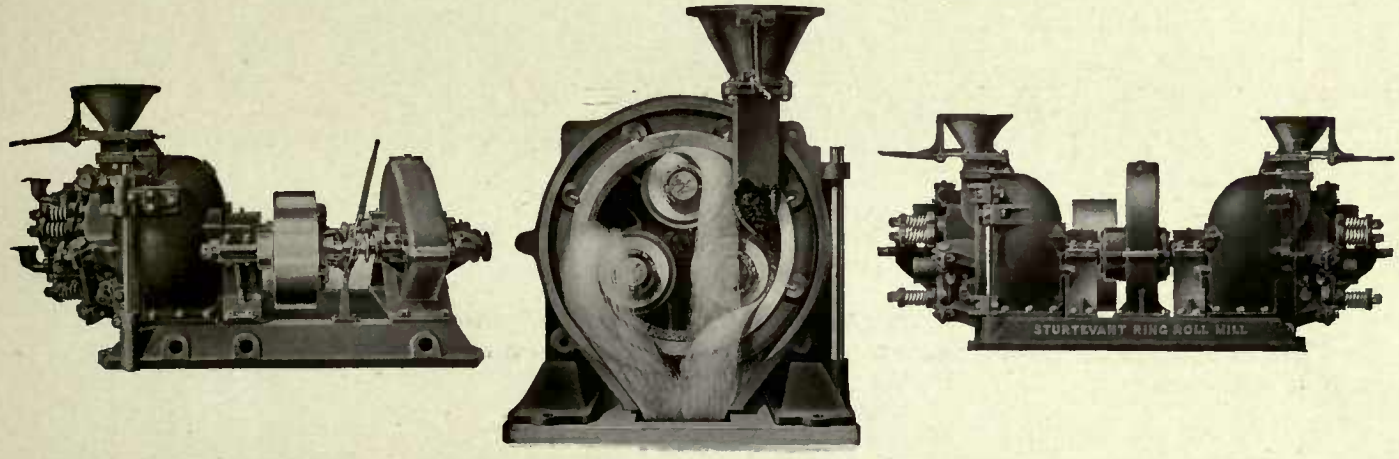
It grinds by enormous pressures exerted by powerful spring-pressed rolls against a layer of rock fed to the inner surface of a revolving ring and held thereon by the centrifugal force generated by the ring's rotations. The material crushes and grinds upon itself and, as there is no slip or rub to either ring or rolls, durability is assured.

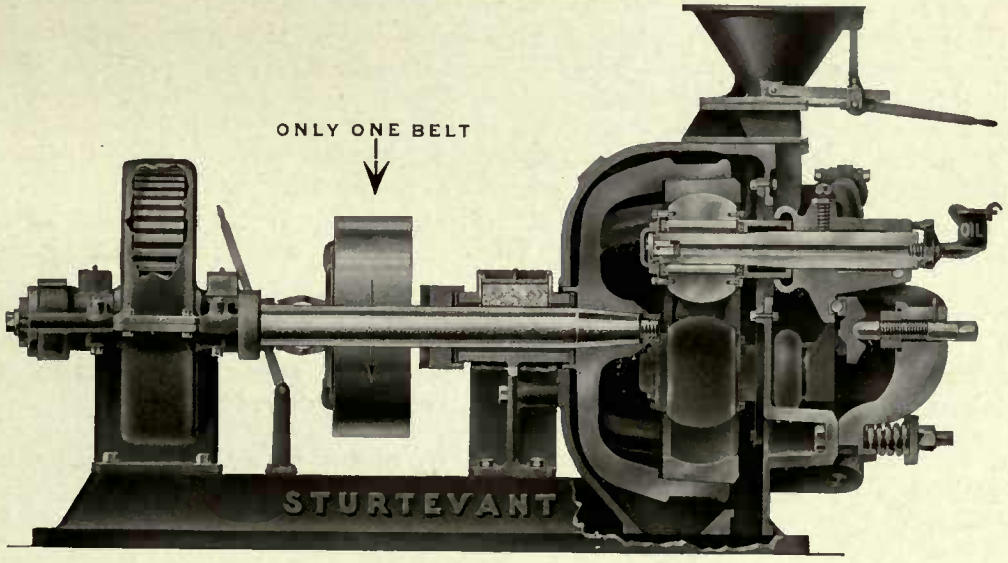
Ring-Roll Mills run smoothly, quietly and almost without vibration. They are built on the "Open Door" principle for accessibility. Opening this door, the work of a few minutes, exposes the whole interior for inspection or replacement of ring or rolls, its only wearing parts of importance, which last several years.

The drive is by single belt or, if preferred, by motor, direct connected to the mill, with a silent chain running in oil.

For Specifications see page 79







Open Door Ring-Roll Mill for Pulverizing Phosphate Rock
Patented

OPEN DOOR ELEVATORS

The product discharged from the mill falls into an All Steel Sturtevant Elevator of the chain and bucket type, designed for this installation.

These Elevators are built with steel casings, well re-enforced, and with large clean-outs, or inspection doors, conveniently located for quick accessibility, and being self contained permit prompt, easy and cheap installation. Steel encased Elevators, carefully made, prevent the escape of dust, are fire-proof, more durable and much more satisfactory than those of wooden construction.

Built with split head casings, self-cleaning boots, geared heads, self-aligning ball and socket bearings, they are fool proof and power savers. Automatic spring tension take-ups act as a relief to prevent chain breakage, and automatically keep the chain taut.

For specifications see page 58

STURTEVANT AIR SEPARATOR

From the Elevator the ground rock is discharged into a Sturtevant Air Separator.

This machine has been developed to produce a fine, uniform grade of Phosphate Rock Dust and to eliminate the usual difficulties inherent to Screens.

The principle of air separation is the passing of a current of air through a thin, falling stream of material, at the required velocity to obtain the degree of fineness wanted and to then separate the dust from the air.

In the Sturtevant Air Separator centrifugal force is also employed to retard the coarser material, causing re-action against the air velocity and thereby insuring cleaner separation.

The material is fed onto a revolving plate which centrifugally distributes it in a thin stream, through which a strong air current is passed, removing all of the fine material and thus a partial separation is accomplished.

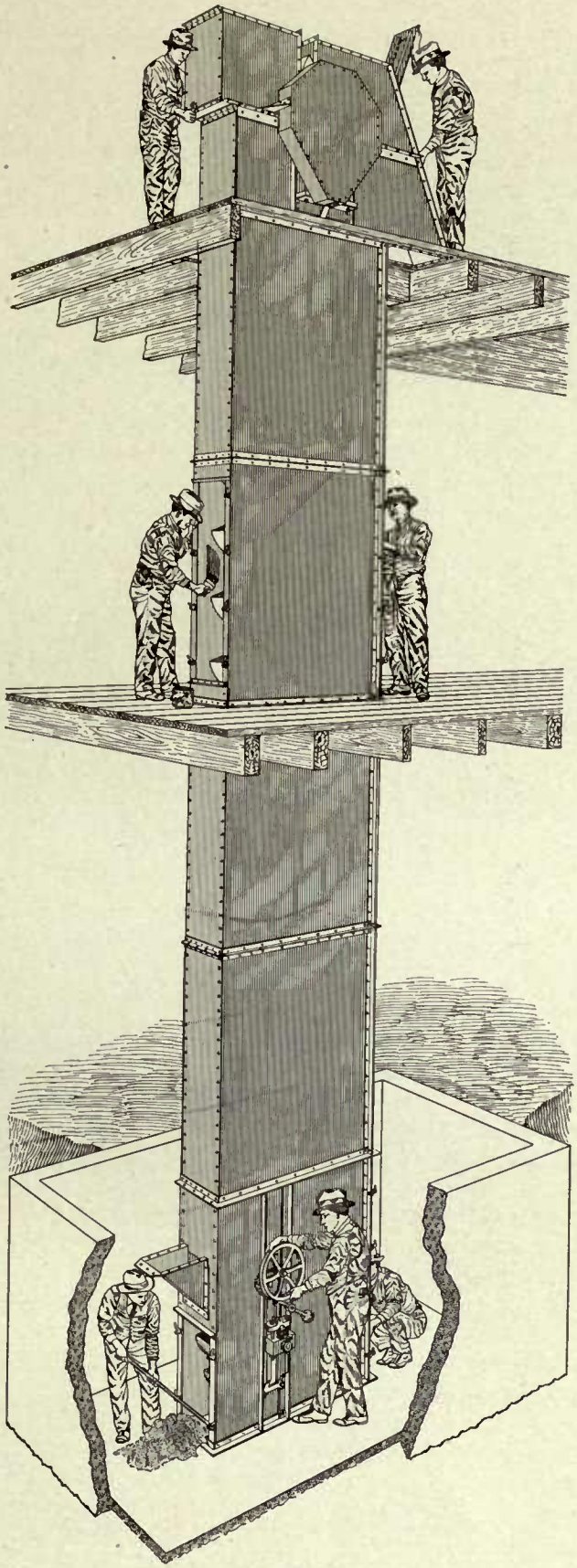
This product is whirled spirally upward by the Fan suction: the coarser particles, being more strongly acted upon by centrifugal force, are held within an inverted conical chamber, thus being prevented from following the fines, or dust, which pass upward and out with the air, through a large slow-speed fan, which carries them into a second Cylindrical compartment. The dust is herein again rapidly whirled by the Fan blast and the increased centrifugal force thus created is sufficient to cause the fine particles to cling to the exterior walls of this chamber, gradually working spirally downward by gravity.

A series of adjustable, tangentially arranged vanes surround the inner cylinder in the path of the return air current, and accelerate the already strong centrifugal effect, allowing the air to enter, but repelling the dust particles, which settle into a cone-shaped discharge hopper.

The same air is used indefinitely, the volume remains constant, and the desired fineness of product is obtained by regulating the Fan speed and adjusting the openings between the vanes.

From 6 to 10 Horse Power is all that is required to operate any size Separator.

For specifications see page 79



Sturtevant Open Door Elevator

Patented—Patents Pending

The separated dust, now of required fineness, and deposited or settled in the discharge cone is carried away to storage. The coarse, or rejected, particles are returned to the Ring-Roll Mill for regrinding. The air current is of low velocity, consequently little power is used and the upkeep is small. The use of an Air current for separating tends to dry the material, therefore, rock of higher moisture content can be ground with less trouble than when screens are used.

The No. 1 Ring-Roll Mill and Air Separator Unit requires from 35 to 40 H.P.

CAPACITY

Tennessee Rock	Florida Pebble
60 mesh 4-5 tons per hour	3-4 tons per hour
80 mesh 3-4 tons per hour	2½-3 tons per hour

The No. 2 Ring-Roll Mill and Air Separator Unit requires from 60 to 70 H.P.

CAPACITY

Tennessee Rock	Florida Pebble
60 mesh 8-10 tons per hour	6-8 tons per hour
80 mesh 6-8 tons per hour	5-6 tons per hour

The No. 2 Duplex Ring-Roll Mill and Air Separator Unit requires from 120-130 H. P.

CAPACITY

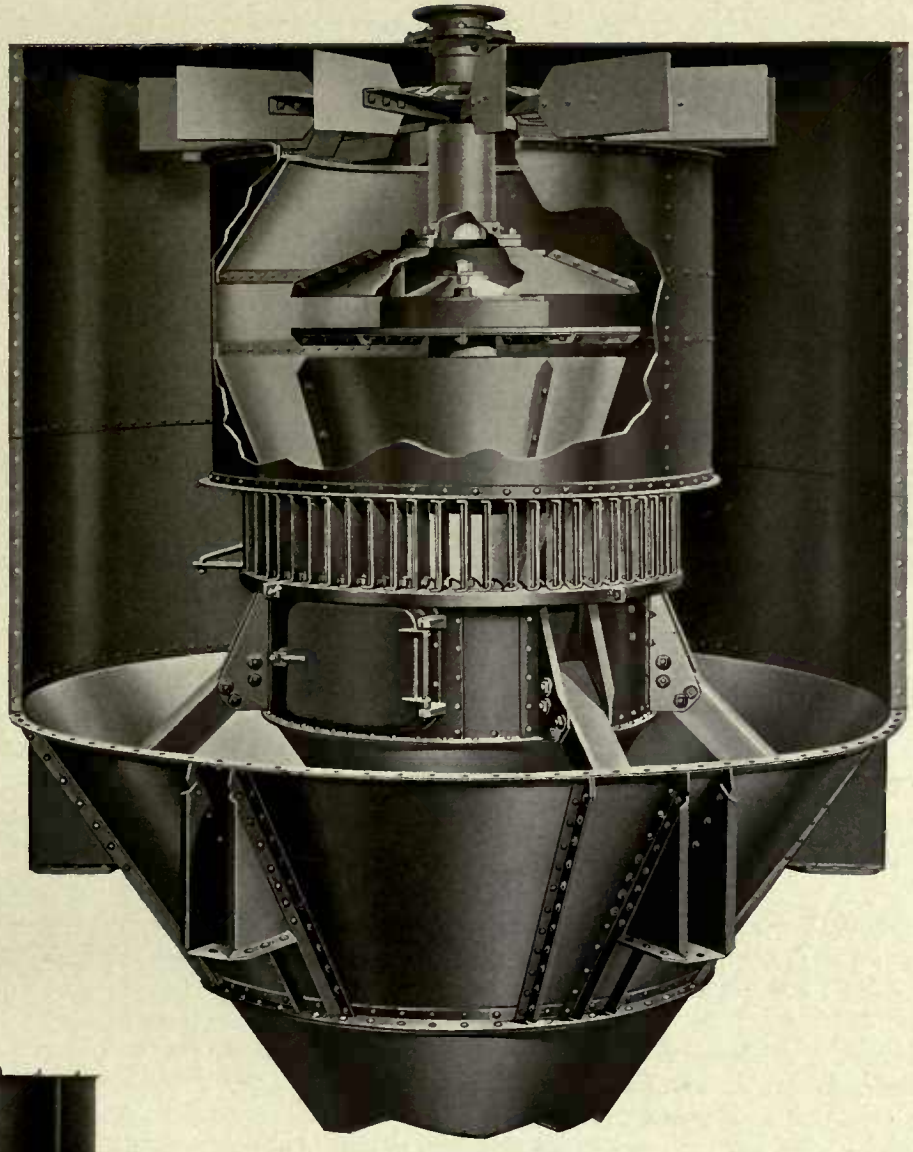
Tennessee Rock	Florida Pebble
60 mesh 16-20 tons per hour	12-16 tons per hour
80 mesh 12-16 tons per hour	10-12 tons per hour

The capacities will vary according to the grade of rock ground, its size and moisture content and are therefore averages only.

Phosphate Rock should be ground to a sufficient fineness to allow the acid to quickly penetrate to the center of the particles and to eliminate the small black specks sometimes found, as they delay re-action.

A fineness of 90 per cent through an 80 mesh screen as produced by an Air Separator, gives a uniform grade, free from black specks, and requires a minimum amount of acid. Finer grinding is sometimes advocated as a means of saving acid, but this is done at greatly added expense of power, maintenance and capacity. Sturtevant methods of mixing ground dust, of the above fineness, with acid, produce as much saving in acid and make a better conditioned phosphate than when finer grinding and less efficient methods are employed and do it at a lower cost per ton.

Here is where the first real saving occurs in the Sturtevant Process of acidulating. It costs approximately twice as much to grind to 90% 100 mesh as it does 90% 80 mesh, as the output of the mill is only one-half when grinding to this fineness, and the power, and wear and tear is the same. With the Sturtevant Acidulating System there is no advantage in using dust finer than 90-92% 80 mesh.



Sturtevant Air Separator

Patented—Patents Pending

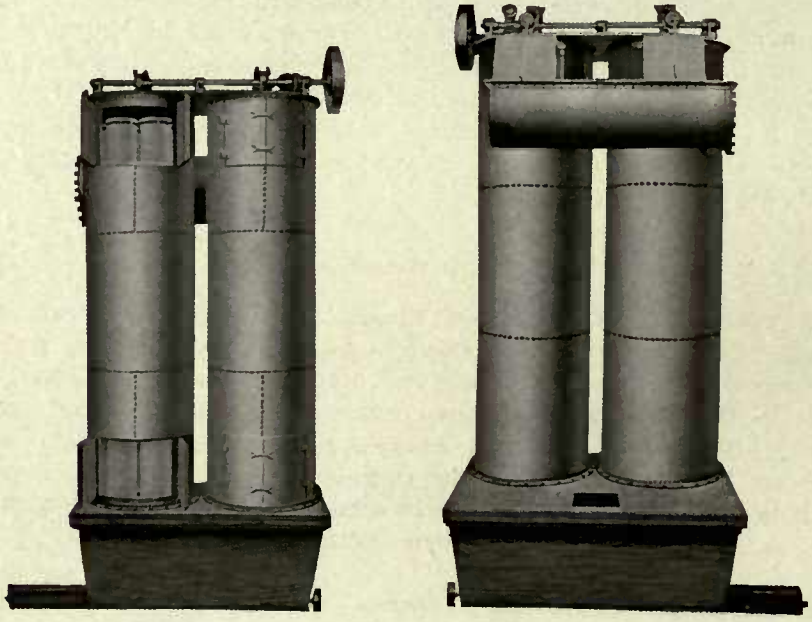
The Phosphate dust should now be conveyed to a storage bin, preferably placed on the ground. The bin should be of sufficient capacity to contain one day's supply of dust so that in case of a shut-down in the grinding department the acidulating unit can continue working.

The handling of the dust to the Acidulating Unit is described elsewhere in this book.

DUST COLLECTING SYSTEM

Preventing the escape of dust in a Grinding Plant has obvious advantages: Saving of dust, which has a money value, cleanliness, better working conditions, elimination of bearing troubles and wear, and reduction of moisture in rock being ground, due to the drying effect of air suction.

The Sturtevant Dust Collecting System is simple and comparatively inexpensive. By tapping and piping the heads of three Elevators, connecting these pipes with a Filter, and using an Exhaust Fan, a sufficient suction is created throughout the system to collect the fine dust, which would otherwise escape, and place it in the ground rock bin.



Sturtevant Dust Filter

Patented

The steel plate Fan, especially designed for this service, discharges horizontally, at either right or left, or vertically, at either top or bottom, as desired; the pulley can also be arranged for either right or left hand drive to suit conditions.

The dust passes into an Automatic Bag Filter wherein the air is cleansed, the dust being deposited on the bags, the air passing through the cloth texture of these bags and out by way of a duct through a Fan which exhausts it into the atmosphere. Nothing passes through the Fan but clean air.

At frequent and alternating intervals each section of bag filters is closed, the air current reversed, and the bags shaken to remove the adhering dust, which falls into the hopper below. These actions are accomplished simultaneously and automatically, by a single, simple mechanism and require no labor. The accumulated dust is deposited by gravity in the rock dust bin.

Only three Horse Power is required to operate this Unit.

SULPHURIC ACID

The acid used, if obtained from the plant's own chambers, should be sent to the Acidulating Unit Supply Tank of correct Bé. and temperature.

If obtained from Tank Cars it should be drawn off into a Storage Tank to prevent delay in unloading. An open tempering tank, holding a sufficient amount for at least ½ day's requirements, should be provided, into which the acid is placed, and the corrections made to bring it to the proper strength and temperature.

A Bé. reading of 53° at a temperature of 60° Fahrenheit is the proper Standard. Good results have been obtained with an actual temperature of 85° Fahrenheit Acid, also with hot acid, up to 150° Fahrenheit. Using a higher temperature Acid with Florida Rock assists in throwing off the Fluorine Gas, which is very desirable, especially in plants using Fluo-Recovery Systems. Cold Acid does not prevent the proper rise in temperature in the Den, and the elimination of water and steam is as successfully accomplished as when hot acid is used, due to efficient mixing and aerating of the Phosphate as it leaves the Den.

ACID PHOSPHATE

Acid Phosphate manufacture is a subject that appeals to all in the Fertilizer business because this material is most used, causes the most trouble, and is the source of the greatest expense. The Fertilizer Manufacturer therefore is interested in any improvement in the production of Acid Phosphate that will lower its cost and better its mechanical condition. The use of sulphuric acid is responsible for its comparatively high first cost, and is the cause of excessive maintenance and depreciation of plant and equipment. It is an important factor in the design of a new plant, and must be properly considered in relation to the balance of the factory.

Before describing the Sturtevant process of Acid Phosphate manufacture it may prove interesting, as well as instructive, to many, to give a brief history of this important department of the Fertilizer Industry.

In the earlier methods of making Acid Phosphate, simply a Mixer of some form was used, with the necessary boxes or scales for weighing or measuring the dust and acid. The material from the Mixer was usually discharged into a hand-propelled car, which was pushed into the storage building, at an elevation, and the phosphate dropped onto an open pile within a building, where it remained until re-action was sufficiently complete to allow it to be used. It was then shoveled or picked out, passed through a Shipping Machine, bagged and sent away. It was soon discovered that objectionable fumes were liberated, which passed through the building, and the surrounding neighborhood, causing deterioration to plant and equipment, and was a source of serious complaints from neighbors. It was later discovered that chemical re-action was hastened by the greater amount of heat generated, if the material was placed in enclosed piles and left for a time before going to storage.

This led to the introduction of the Den, or Box, which was either of wood or concrete construction, with a Mixer placed on top, and a Fan attached to draw off the gases, formed by chemical re-action. This Den, or Box, was located on the ground, and was emptied by means of picks and shovels, through a door in one side. The usual method was to install a pair of these boxes, alternately filling one while emptying the other. Attempts were also made to remove and condense, by water sprays, the obnoxious fumes formed by the chemical re-action.

For a great many years the only change in this method was in the manner of excavating. In some instances the Dens were elevated, and by means of a slot across the bottom, covered with loose boards, the men were enabled to discharge the contents through this slot into an Elevator placed between the two Dens. In order to avoid elevating the Dens, another method consisted of Conveyors placed underneath the slots which carried the acid phosphate to a common point where it could be elevated.

The inability to get men to stay in these Dens long enough to empty them, especially in hot weather, caused the development of Mechanical Excavators in the form of electrically operated shovels, or scoop buckets, to reduce the number of men, but the use of the slot and Conveyor, continued.

Of necessity these Dens were very heavily constructed, owing to the swelling and pushing effect of the acid phosphate while in the Den, and were not only costly to build, but expensive to maintain.

Only of late have there been any extensive changes or improvements in these methods of manufacturing acid phosphate.

The comparatively recent use of the Electric Overhead Traveling Crane for handling the material in and out of the main storage building, was responsible for the employment of the same Crane for emptying the Dens. This resulted in constructing an open top Den, either of round or square form, with a movable cover, and traveling Mixer. By this change the Mixer could be moved out of the way, the Crane with its bucket passing over the Den could remove the cover, pick up the material from the Den and deposit it in the storage building. This process, however, requires a very heavy, expensive steel building and therefore is not adaptable to the majority of plants as now constructed.

Photograph of Acid Phosphate Removed from Sturtevant Den after Fifteen Minutes set
(Three times actual size)

In Europe, hand-operated Dens are seldom used, having been displaced by various types of Mechanical Excavators of which two, the Beskow and Sturtevant, have proved greatly superior to the others as evidenced by the fact that during the past few years these systems have been installed to the practical exclusion of other processes.

All other systems cut within a closed chamber and do no aerating, which is vital to success, but must depend upon an auxiliary rasping chamber to granulate and aerate the phosphate, which means two handlings, at much added initial and maintenance expense, and unnecessary complication.

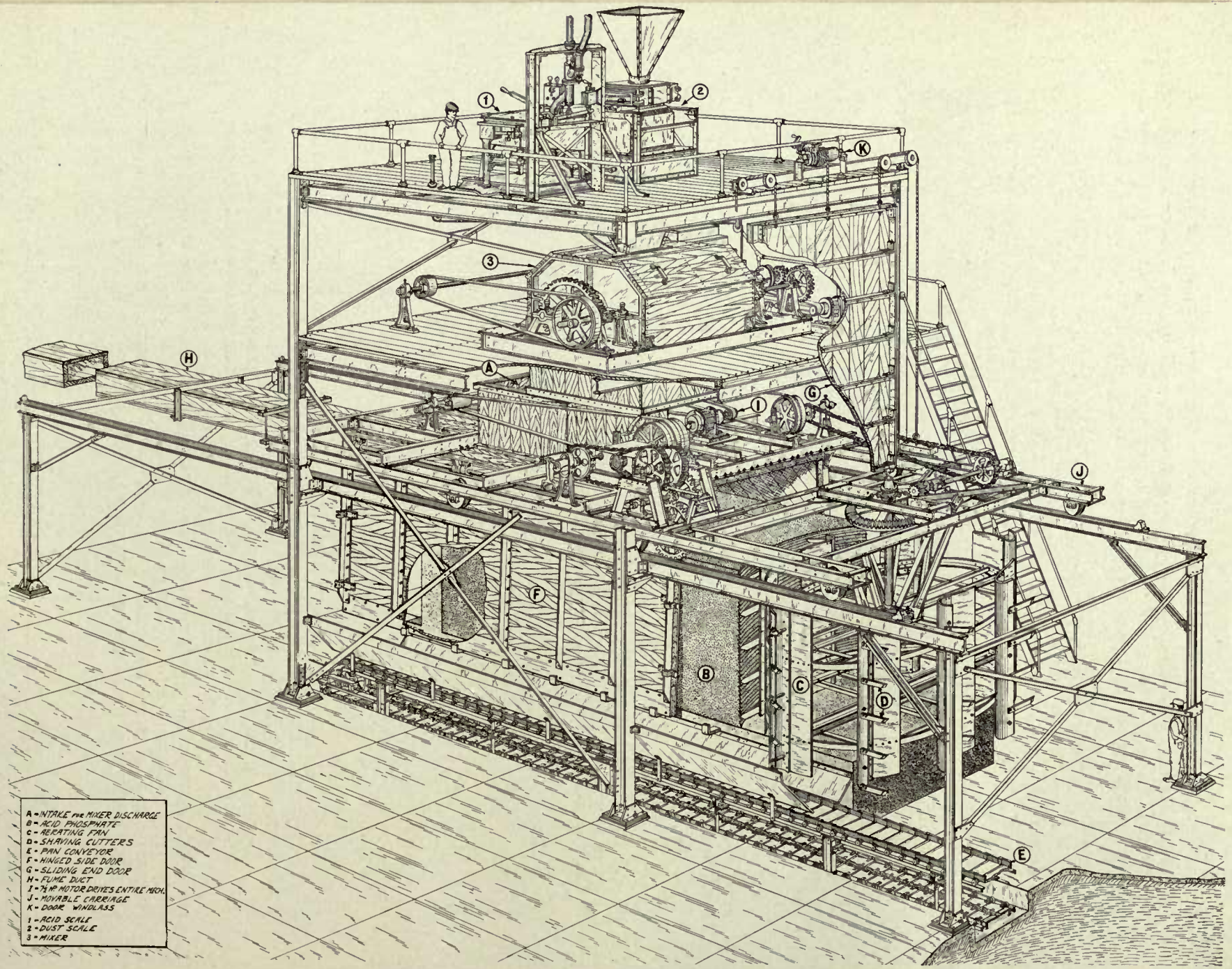
No system can be really satisfactory unless it cuts in the open with a strong air draught for carrying off the steam, and eliminates scraping, rubbing or mulling of the acid phosphate, so that the finished product will be in a dry, and good mechanical (granular) condition.

The American Patents for the Beskow, Ekedahl and Sturtevant Systems are controlled by the Sturtevant Mill Company, who are free, therefore, to combine the best features of each in the American Sturtevant System.

As stated in the Introduction, the Sturtevant Mill Company for thirty-nine years has been vitally interested in the manufacture of all forms of Fertilizer and Fertilizer plant equipment. (Its President, Mr. Thomas L. Sturtevant, with the late Mr. W. H. Bowker, founded the Bowker Fertilizer Company, and for many years was actively engaged in the Fertilizer business.) It has developed the Ring-Roll Mill Unit for the grinding of Phosphate Rock, various machinery and units for mixing, grinding and shipping, also Labor Saving Devices for handling and treating ingredients used in the fertilizer plant. The Acidulating department, however, has not until recently been supplied by it, for the reason that this important feature, for the past seven years, was being developed in England and Europe by its Associates the Sturtevant Engineering Company of London and Paris.

The history of Acid Phosphate in Europe has travelled along nearly the same lines as in America, except that, for some years, hand-operated Dens of the type employed in this country have been replaced by Mechanical Excavators of various forms, as previously described. European conditions and methods are such that large buildings are not used, or required; in fact new buildings are put up with much less frequency than in America. It was therefore obligatory to develop means whereby, with great economy of space, large quantities of Acid Phosphate could be produced cheaply. Though the pre-war cost of common labor was much less than in America, nevertheless Europeans watched the pennies much more closely than did Americans, and the saving of labor meant and still means much to them. The Sturtevant Engineering Company having used various types of American, British and other European apparatus, were in position to design, build and install an acidulating system, which has proven superior to any of the other forms now or heretofore employed, and it is so recognized among Fertilizer Manufacturers abroad.

When the Sturtevant Mill Company became convinced that the Sturtevant-English Process was thoroughly perfected, and no longer an experiment, it again investigated European conditions to finally ascertain if these devices were ready to be introduced to the American Manufacturer.

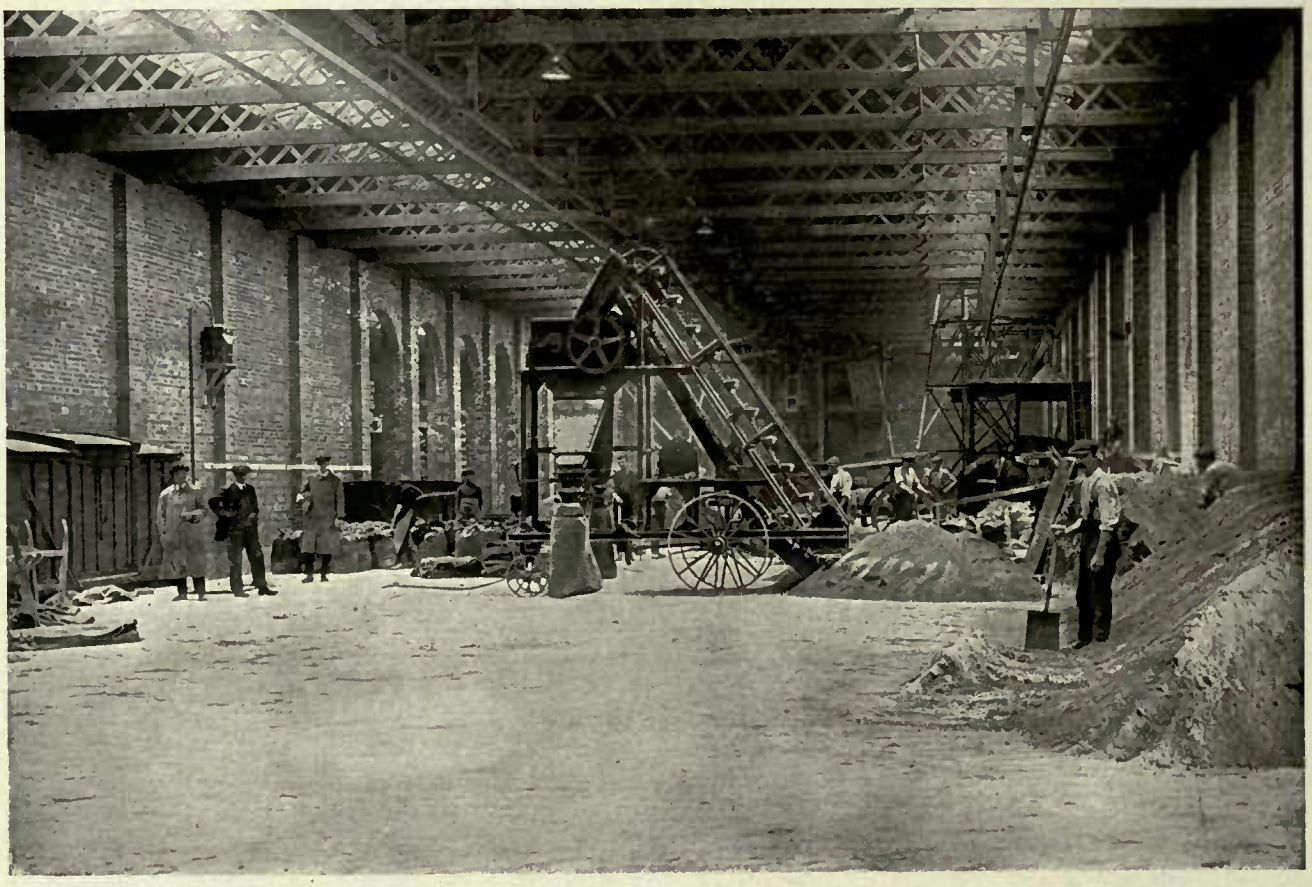


Sturtevant Acidulating Unit

Patented—Patents Pending

With this in view it requested the Chief Engineer of the Sturtevant Engineering Company to visit America. While here he was courteously shown many American plants and methods. The Sturtevant Mill Company then sent an Engineer to Europe, who thoroughly investigated the processes used in England, Scotland and other European Countries where acid phosphate is extensively made, studying methods, types of apparatus, and conditions. The conclusions reached were that foreign Acid Phosphate was better, cheaper and superior in mechanical condition to that made in America, and showed ample reasons why it should be better, and that there was no reason why Americans could not make the equivalent, or even higher grade, Acid Phosphate than that made in Europe, by employing similar methods.

The Sturtevant Mill Company is therefore now prepared to furnish the Sturtevant Acidulating Unit, designed to suit American Plants, and manufactured exclusively by this Company, which will produce acid phosphate, at a cost and of a quality previously unknown in this Country, that is in a dry, granular condition, with a minimum of insoluble. It can do this without the use of men for ex-dening, or carrying the acid phosphate to storage building. A Mixer operator and helper are the only men required to weigh, mix, excavate and carry to storage the output of the acidulating unit.



Acid Phosphate being bagged and shipped direct from the storage pile without screening or milling

To illustrate the unusually dry, granular and fine condition of the Acid Phosphate made by the Sturtevant process it may be said that abroad this material is bagged directly from the storage pile and shipped without screening or pulverizing, as shown in picture opposite.

Every Fertilizer Manufacturer appreciates what this means all along the line. Mixing Units and Bagging Machines will turn out more tonnage owing to the absence of lumps, thus eliminating shut-downs and greatly reducing the shipping and handling costs per ton.

Through efficient methods of quick, accurate and automatic mixing and weighing, acid is saved without the necessity of finer grinding than 90 per cent through 80 mesh. Thus grinding costs are minimum. Excessively fine grinding is not necessary to produce superior quality acid phosphate when using the Sturtevant System. Some manufacturers are inclined to feel that very fine rock is essential, even at a high grinding and maintenance cost per ton. The resultant saving in acid and the possible quickening of the re-action in the pile are given as the principal reasons. Inaccurate weighing of acid and rock, inefficient mixing and ventilation are the real reasons for fine grinding, which to some extent compensate for the above deficiencies. It is, however, more of an excuse than a reason. The Sturtevant System, with moderately fine rock, makes the same saving of acid and produces a far superior grade of acid phosphate, in much better mechanical condition, with lower insoluble, and at greatly reduced cost per unit.

The formula is carried out rapidly and accurately by the use of Automatic Machinery, which leaves nothing to the guess or judgment of operators. The maintenance, power, labor and depreciation expenses are reasonable. The floor space occupied will compare favorably with any present method. It does not necessarily require a new building, as old buildings for making Acid Phosphate by any method can be readily adapted to this improved acidulating unit without extensive changes. Whether or not buildings are of the gravity type, whether Dens are located on the ground or elevated, whether of the silo or the square pocket type emptied by a Crane, the Sturtevant Unit can be placed therein, and acid phosphate can be manufactured cheaper, and of much better quality than by present systems.

The cost of the entire Sturtevant Unit installed is no more than of the average hand-operated Dens of equal capacity; the latter, however, cannot be compared favorably as to results.

The length of time required for conditioning is materially lessened, thus the large expensive buildings covering many square feet of floor space are unknown in Europe. A material saving in acid is effected, because the acid is more correctly utilized to produce the finished results. Built on the unit principle, and using a quick batch method, which is a very near approach to the Continuous, a plant can be economically operated at half the usual producing rate, should business conditions make this desirable. The labor element is reduced to a minimum, as only two or three men are required for two Dens operating together, for mixing, weighing and taking care of the apparatus and placing the Acid Phosphate in storage building.

The usual size Unit is one making 25-30 tons of Acid Phosphate per charge. Extra Units can be used for greater tonnage.

The chemical control of 30 ton batches is far superior to that of large batches, as a check is made every 30 tons instead of every 100, 150, or 200 tons; thus any imperfect formula or mixing is discovered and remedied before great loss results.

The following schedules show what is required and accomplished by these Units:

ONE 25-30 TON UNIT

Three charges: Time—9 hours 45 minutes—Result: 75 to 90 tons of Acid Phosphate.
Approximately 40 to 45 tons each of dust and acid required for 8 hours.
One Mixer man 8 hours work.
One Helper 8 hours work.

7 A. M.- 8.15 A. M. — Mixing.
8.15 A. M.- 8.45 A. M. — Setting.
8.45 A. M.- 9.45 A. M. — Cutting Out. 8.30 Helper starts.
9.45 A. M.-10.15 A. M. — Returning Den and preparing for next charge.
10.15 A. M.-11.30 A. M. — Mixing.
11.30 A. M.- 12 NOON — Setting. Mixer man at lunch.
12 NOON- 1 P. M. — Cut Out. 12.15 P. M. to 12.45 P. M. Helper lunches.
1 P. M.- 1.30 P. M. — Returning Den and preparing for next charge.
1.30 P. M.- 2.45 P. M. — Mixing.
2.45 P. M.- 3.15 P. M. — Setting.
3.15 P. M.- 4.15 P. M. — Cutting Out. 3.30 Mixer man through.
4.15 P. M.- 4.45 P. M. — Returning Den and preparing for next charge. (5P. M. Helper through.)

Maximum production with one machine in 24 hours: 7 charges—Result: 175 to 210 tons of Acid Phosphate.

TWO 25-30 TON UNITS

Six charges: Time — 11 hours. Result: 150 to 180 tons of Acid Phosphate.
Approximately 75-90 tons each Dust and Acid for 11 hours.
One Mixer Man.
Two Helpers.

UNIT "A"

7 A. M. — Mixing.
8.15 A. M.- 8.45 A. M. — Setting.
8.45 A. M.- 9.45 A. M. — Cutting Out.
9.45 A. M.-10.15 A. M. — Returning Den and preparing for next charge.
10.15 A. M.-11.30 A. M. — Mixing.
11.30 A. M.- 12 NOON — Setting.
12 NOON- 1 P. M. — Cutting Out.
1 P. M.- 1.30 P. M. — Returning Den and preparing for next charge.
1.30 P. M.- 2.45 P. M. — Mixing.
2.45 P. M.- 3.15 P. M. — Setting.
3.15 P. M.- 4.15 P. M. — Cutting Out.
4.15 P. M.- 4.45 .P M. — Returning Den and preparing for next charge.

UNIT "B"

8.15 A. M.- 9.30 A. M. — Mixing.
9.30 A. M.- 10 A. M. — Setting.
10 A. M.- 11 A. M. — Cutting Out.
11 A. M.-11.30 A. M. — Returning Den and preparing for next charge.
11.30 A. M.-12.45 P. M. — Mixing.
12.45 P. M.- 1.15 P. M. — Setting.
1.15 P. M.- 2.15 P. M. — Cutting Out.
2.15 P. M.- 2.45 P. M. — Returning Den and preparing for next charge.
2.45 P. M.- 4 P. M. — Mixing.
4 P. M.- 4.30 P. M. — Setting.
4.30 P. M.- 5.30 P. M. — Cutting Out.
5.30 P. M.- 6 P. M. — Returning Den and preparing for next charge.

Mixer man at lunch 12.45 P. M.-1.30 P. M. — finishes work at 4 P. M. (8½ hours).
One Helper lunches 11.30 A. M.-12.15 P. M. — works 8.30 to 6 P. M. (9 hours).
One Helper lunches 12.15 A. M.- 1 P. M. — works 8.30 to 6 P. M. (9 hours).
Maximum production with two machines in 24 hours: 14 charges — Result: 350 to 420 tons of Acid Phosphate.

ANALYSIS

Analysis of Acid Phosphate made by the Sturtevant System from a report of a Fertilizer Manufacturer at Brest, France.

Rock used — Constantine (No. Africa) 64.9% B.P.L.
Acid used — 53° Bé. at 59° F.
Amount Rock 660 lbs.
Amount Acid 561 lbs. (85% of Rock)
1221 lbs. to the mix.

From Den after ½ hour set.

Soluble	14.59%
Insoluble	1.79%
Free total acid	6.59%
Moisture	15.04%

Sample of above 48 hours later.

Soluble	15.59%
Insoluble	.79%
Free total acid	3.59%
Moisture	12.00%

PLANT REQUIREMENTS

To accomplish these truly remarkable results it is first necessary to have a rock grinding plant of sufficient capacity to furnish the dust needed to acidulate the tonnage of acid phosphate desired. The dust should be ground to a fineness of approximately 90 per cent through an 80 mesh screen.

A Sturtevant Ring-Roll—Air Separator Grinding Unit will be found to be the most efficient that can be employed for this work, due to its reliability, large capacity, low power and maintenance cost per ton.

A large storage hopper for dust should be provided, usually carrying at least one day's supply of ground rock; also, a storage and tempering tank containing at least ½ day's run of acid. In order that the acid be reduced to the proper strength and temperature, facilities should be provided for water to dilute, steam to heat and air to agitate so no separation of acid and water can take place. This is much preferable to tempering the acid at the time it is being mixed. The mixer operator should not do such important work, thus dividing his attention, slowing production and causing inaccuracies. It should be tempered correctly by a more experienced foreman or chemist.

Chemistry is a science of exactness and nothing should be left to the guess or judgment of the inexperienced.

The manufacture of Acid Phosphate requires careful analysis of the rock and accurate weighing of the dust and acid so that full control of the re-action is assured. Haphazard and slack methods of weighing are always costly, for if there is no accurate control over the ingredients used and only averages employed, the result is invariably a loss of unit values. By the Sturtevant method, dust and acid are weighed accurately by automatic scales. Each will weigh in a minimum amount of time, approximately 30 seconds per charge. They prepare the two charges entirely independently of the operator. He simply starts the machine, which weighs the charges for him without further attention on his part. Thus the human element is practically eliminated, the charges are always the same in weight, and accuracy is assured. Ample means are provided for changing the formula as the quality of rock varies.

DUST AND ACID SCALES

The operating principle of both Dust and Acid Scales are similar. Both are simple in design and operation.

The inlet valve of the weigh hopper is opened by simply pushing an electric button, or pulling a lever, which at the same time closes an electric circuit that holds the valve open. When the weight is obtained the Scale beam rises and opens this electric circuit, which automatically closes the inlet valve.

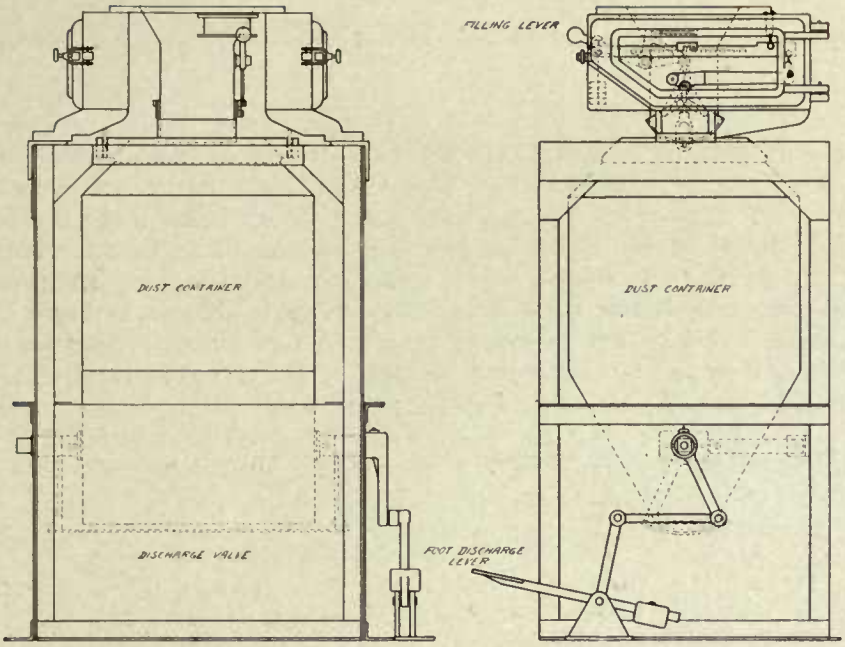
An electric light shows when acid and dust are flowing, and automatically goes out when weight is reached.

The outlet valve may be operated by either a foot pedal or a hand lever, causing the material to discharge into the Mixer.

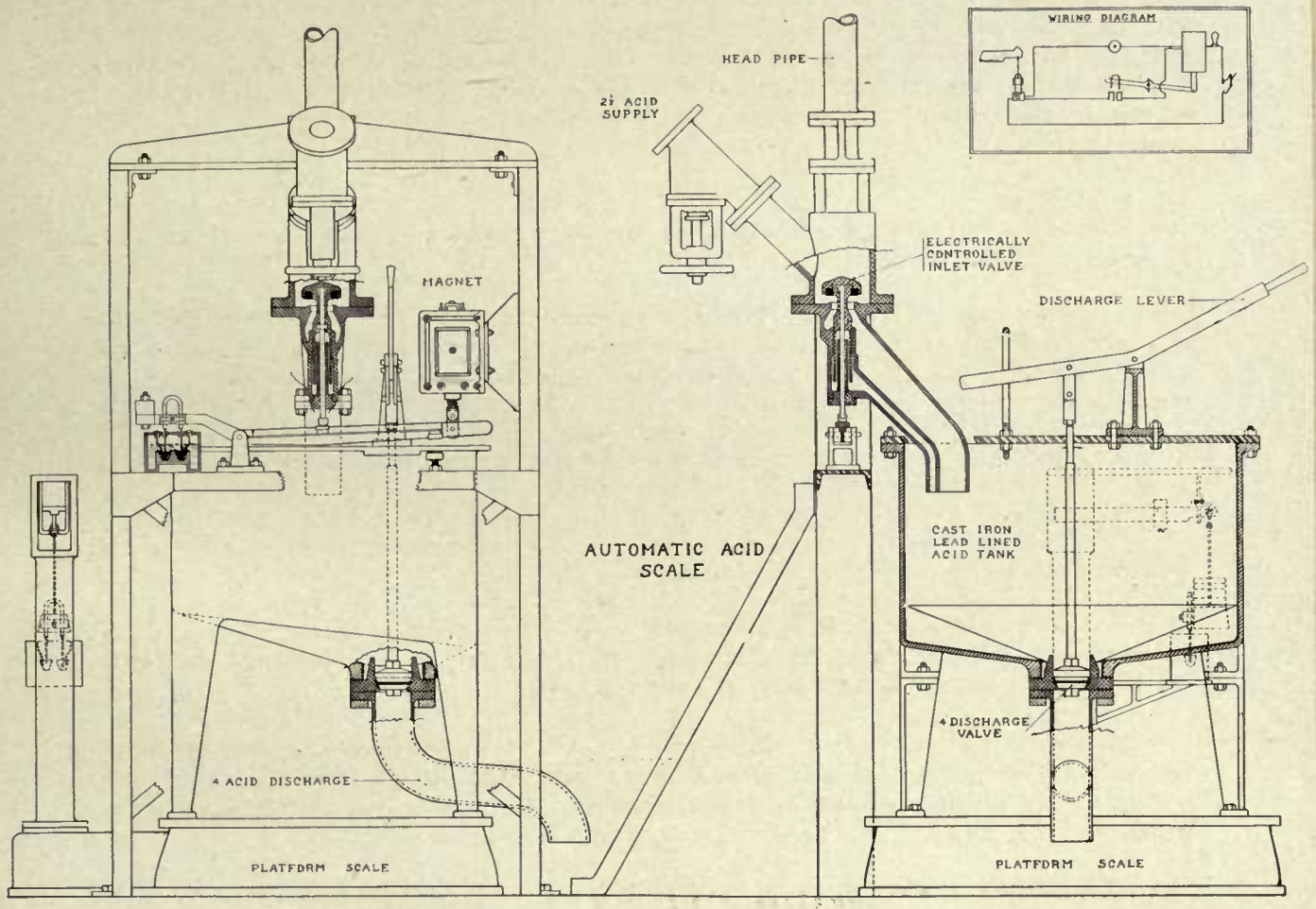
The weighing operation is automatic and is independent of the operator. The discharge valves are manually controlled and are carefully constructed to prevent leaks and to resist acid corrosion in the acid scales.

It is necessary for correct automatic weights to have conditions and installation favorable. With the dust scale a small steep sided dust hopper, kept full at all times, maintains a constant head and causes a regular, even flow of dust to the scale without danger of bridging or packing so that accuracy is assured.

Acid being free flowing, it is a simple matter to get proper automatic weights.



AUTOMATIC DUST SCALE



Sturtevant Automatic Dust and Acid Scales

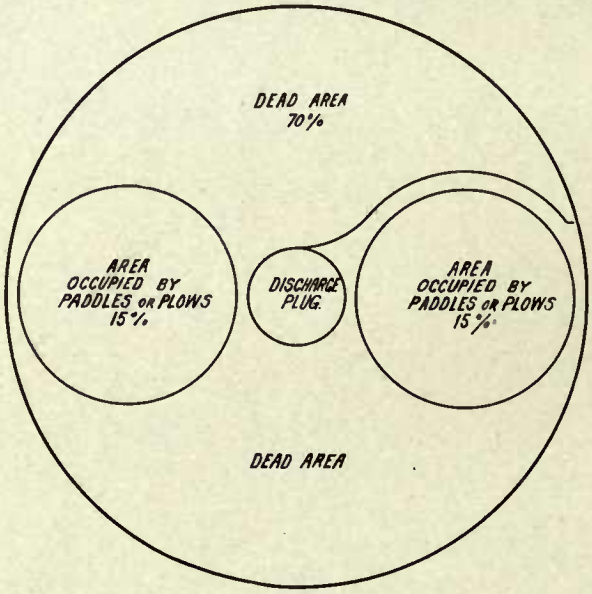
Patented—Patents Pending

ACID MIXER

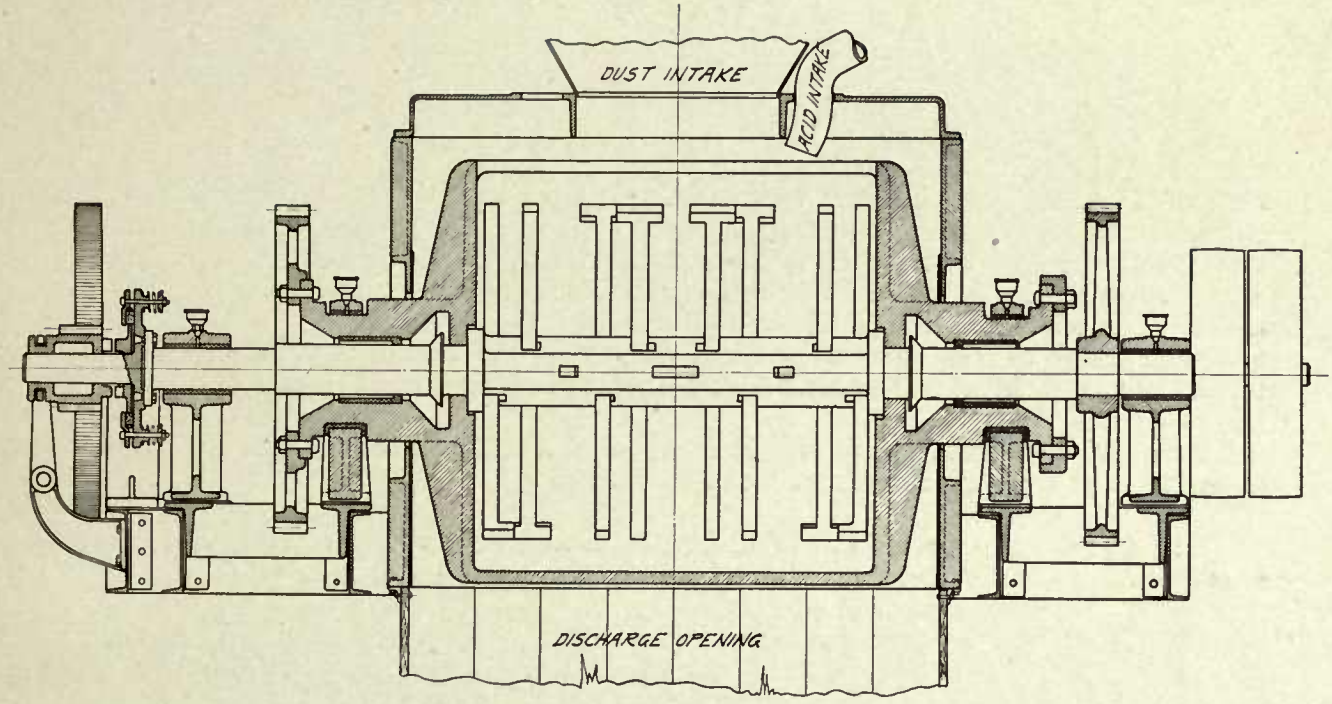
From the Scales the charges of dust and acid are deposited into the Sturtevant Acid Mixer. This machine consists of a cast iron rotatable cylinder or drum, 4 feet long and 4 feet in diameter, having a slot the entire length of its top (16" x 48") This slot is the only opening in the Mixer, and when at the top serves as an entrance for the dust and acid and also forms the discharge opening when the cylinder is revolved and the slot has reached the bottom position. A central shaft, with stirrers, or paddles, attached thereto, extends through the drum and runs continuously, at a speed of 35 r. p. m., while the Mixer is operating, and not only thoroughly agitates and mixes the mass of dust and acid, but also assists in completely discharging the Mixer when the drum is revolved and the slot is at the bottom. In mixing, the operator starts the two Scales, which automatically prepare their charges, and which he simply discharges into the Mixer. This operation only requires the movement of two levers. Pulling another lever causes the drum to rotate one revolution in one-half a minute, and dump its contents into the Den. When the drum reaches its original position, as shown to operator by an indicator, it is ready for another charge; in fact, while the operator is discharging the Mixer, the dust and acid Scales are automatically preparing the next batches.

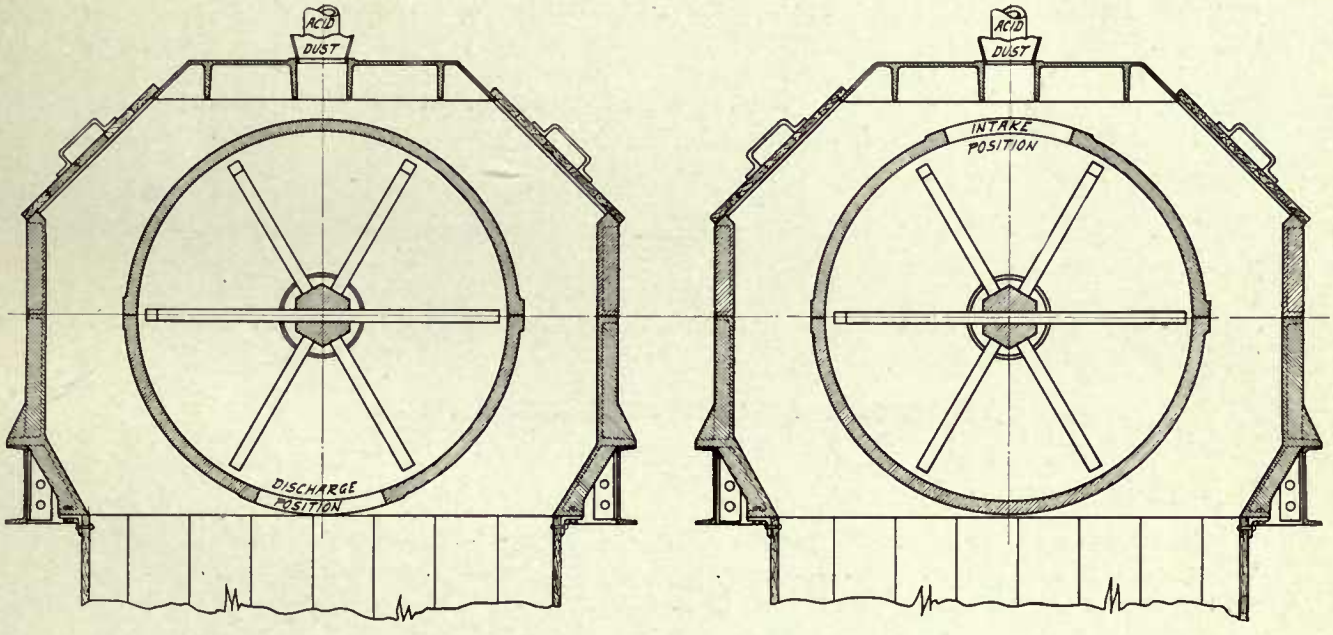
It is a principle of the Sturtevant method to use small charges, which are easy to thoroughly agitate and intimately mix for efficient and quick re-action, and which is accomplished only in this type of Mixer. Even under these circumstances, using approximately 1300 pound batches, 36 charges per hour are maintained. The Mixer is enclosed in a box connected by hopper to the Den, from which the Fan exhausts the gasses and fumes, and in consequence of this downward suction of air from the Mixer, no obnoxious fumes penetrate the plant, or annoy the Mixer operator. This form of Mixer is far superior to the Pan for obvious reasons.

In the Pan Mixer the only efficient and violent mixing actions are in the small areas occupied by the plows (see illustration), which form about 30% of the total Pan area, thus 70% is not mixing at all, or at least not efficiently. Centrifugal force



Drawing Showing Inefficiency of Pan Type of Mixer





Sturtevant Acid Mixer
Patented—Patents Pending

generated by the revolving pan tends to throw the material to the sides of the Pan. The plug and its seat very frequently wear out of true, causing leaks and allowing acid to run out of Mixer into Den before being mixed with the dust. Under these conditions dust alone is dicharged into the Den, in an endeavor to take up this Acid. To prevent this leak, dust is sometimes placed in the Mixer before the Acid, which is a difficult method of mixing, as this action causes the formation of dust balls, which are difficult for the acid to penetrate; thus only partial mixing is accomplished.

As all of the material has to discharge through a central hole, scrapers that require excessive power and maintenance are necessary.

The manual labor required for lifting the heavy plug and scrapers many times hourly is a tedious job for the operator in addition to his other duties.

The Sturtevant mixer has no discharge plug to gum up or leak acid. The dust and acid are more thoroughly mixed, due to the shape of the Container and the use of paddles which violently agitate the entire mass. There are no dead spots and as the acid and dust tend to drop to the bottom, while the paddles lift and at the same time thoroughly stir them back and forth, quicker and more intimate mixing is accomplished. When the drum is revolved the slot is at the bottom; thus the material falls out by gravity. If any hesitates it is instantly assisted by the revolving scrapers or paddles. A "set" rarely occurs, but should this happen the top covering is easily removed for cleaning. This Mixer requires only 5 Horse Power, or one-third that of others. Its moving parts are few, and being made of cast iron is acid resisting and durable.

The Acid should go to Mixer first, then the dust, as better mixing is accomplished by this method; furthermore the mixing paddles are washed by the acid every batch, are thus kept cleaner.

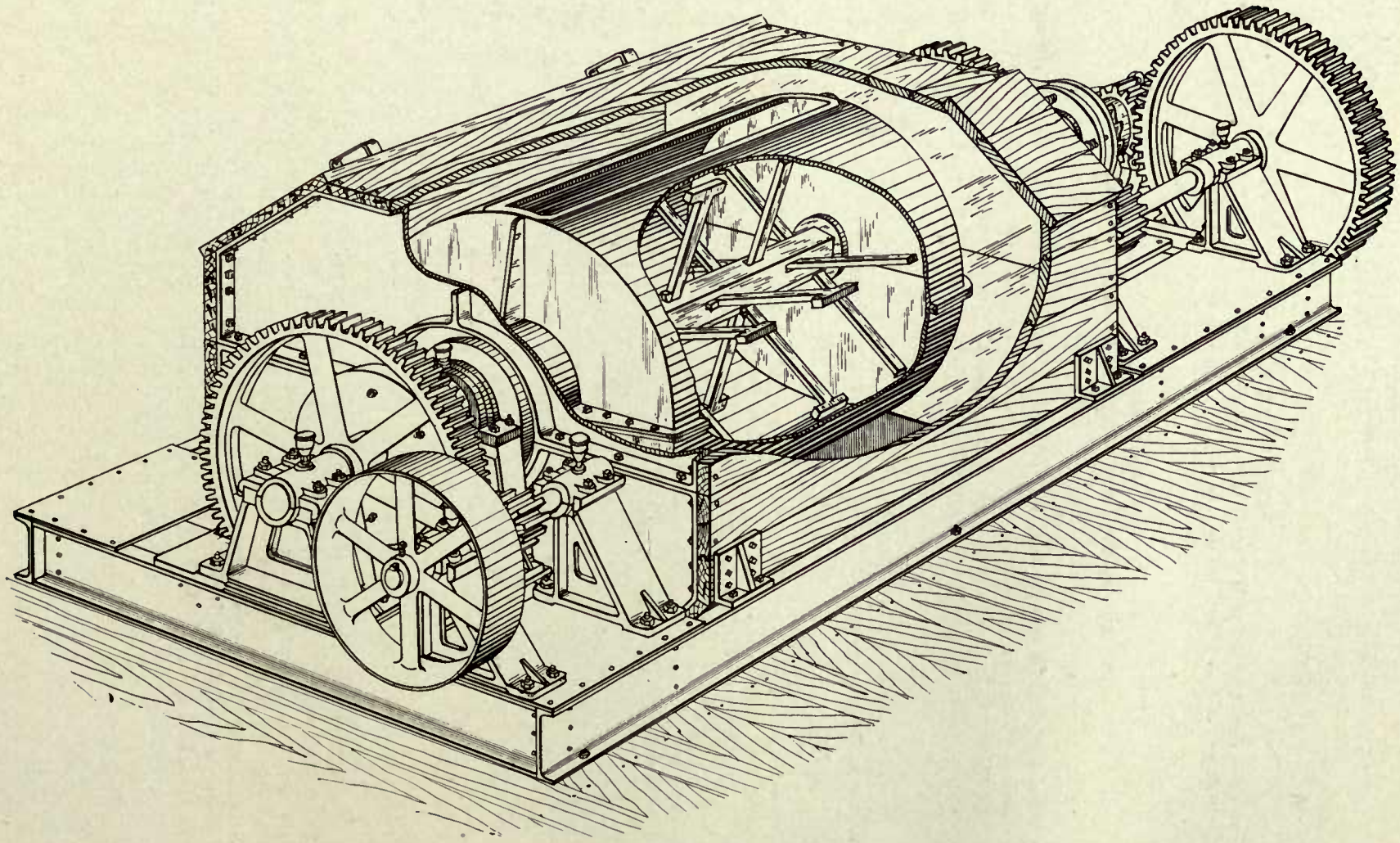
The quicker the mix, if the ingredients are thoroughly intermingled, and the quicker the discharge, the more efficient is this machine, for it takes advantage of the gases formed, causing a quick "set" in the den which allows the nicely honeycombed acid phosphate to be cut out almost immediately after the last charge enters the den.

REPORT FROM DOUGHTY SON & RICHARDSON, LTD.
Lincoln, England

Regarding Sturtevant Mixer:

"Probably the best on the market. Well designed and very substantially made. We worked it for 10 months in an extensive way. We had no trouble with it, and we cannot see any wear and tear on its working parts."

Signed: F. Wuyts.



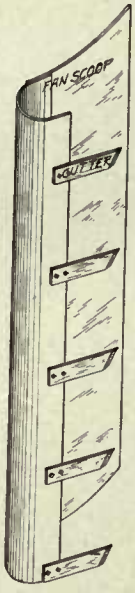
Sturtevant Acid Mixer
Patented—Patents Pending

AUTOMATIC MECHANICAL DEN AND EXCAVATOR

The Mixer is placed on a floor directly above the Automatic Mechanical Den and Excavator. In shape the Den resembles the familiar type of Box Den. The floor and rear end wall are made of concrete. The sides and top are supported on a metal, movable wheel carriage or chassis, mounted on overhead tracks. The sides are hinged at the top and locked at the bottom against the concrete block which forms the base or floor. The front end is a sliding door which is raised when Den is ready to empty. The carriage is operated by a motor and moves in either direction at various pre-determined speeds, like the bed of a metal planer. A large vertical cutter is mounted on this carriage opposite the end door, and is composed of eight large scoops, or fans, on the blades of which cutting knives are fastened. This Cutter is revolved by the same motor at an approximate speed of 11½ r. p. m.

It resembles the paddle wheel of a river steamboat, only it is set vertically. It is 15′ 9″ in diameter, while the block of acid phosphate being cut is only 8′ wide; therefore the cutter overhangs the block on each side (See illustration, page 39) and the shavings are deposited easily on the conveyor below, paralleling the side of Den.

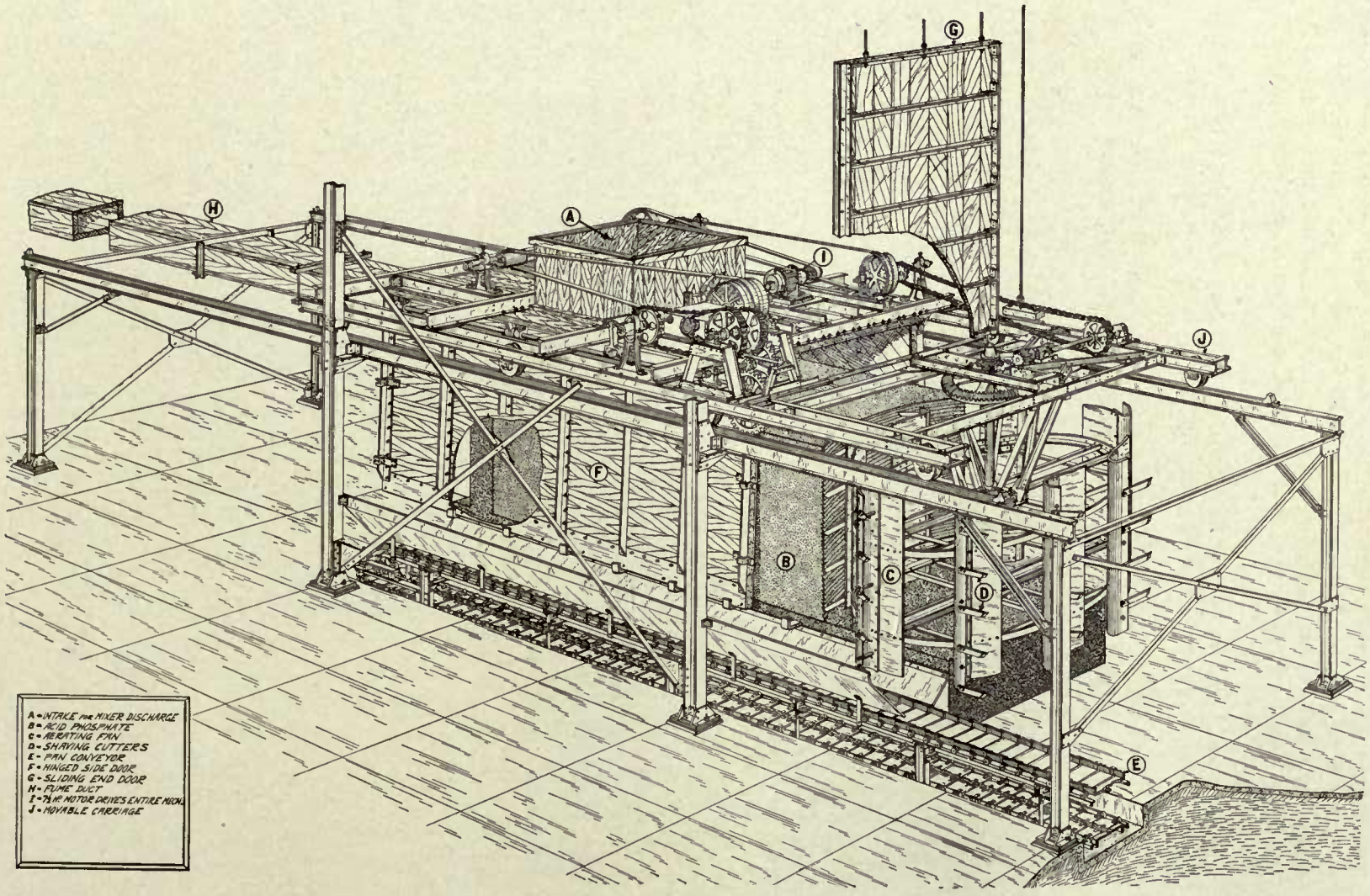
When filling the Den the side and end doors are rigidly fastened together, and the charge is placed in the Den as fast as it is mixed. In the mixing of 30 tons, one hour and fifteen minutes is required. At the expiration of this period about fifteen minutes is allowed for the phosphate to set before removing the locks, holding the side doors to the concrete base. The counter balanced sliding door is then raised, and a large block of acid phosphate is found resting upon the concrete floor. The carriage motor is now started, which advances the carriage, with the Cutters, towards the block of acid phosphate, at a speed of about four inches per minute. The Cutters are then started, which revolve and horizontally cut off small thin Shavings of Acid Phosphate from the mass, as the cutter advances, the air draught, created by the Fan's rotation, blows these thin particles onto a Pan Conveyor traveling parallel to the side of Den. These knives, 3½″ wide x ½″ thick x 12″ long, slice off thin pieces (11/32 of an inch thick) of the Acid Phosphate, but only one set of knives cut at the same time, at the same place, and, being staggered, the same set of knives makes a complete revolution before cutting again in the same place, and as there are eight fans and eight sets of cutting knives it will be seen that eight blasts of air are blown against the *exposed cut* before another slice is removed from the same place.



These knives are self-sharpening, last about one year and can be replaced by any blacksmith.

Cutters also are placed upon the bottom of the fans to shave off any of the Acid Phosphate that might otherwise remain on the concrete base.

While this Cutter only turns at 11½ R.P.M. and is a slow speed device, yet it is fifteen feet nine inches in diameter and the curved Fan blades are two feet wide, (therefore the peripheral Fans are moving at a speed of 560 ft. per minute) thus a strong draught results which is thrown against the block of Acid Phosphate as the knives cut.



Sturtevant Mechanical Automatic Den and Excavator

Patented—Patents Pending

This air blast carries off the steam, liberated by the cutting action, which rises in clouds, but is only water and has no acidity. A large ventilating tower on the roof carries this steam to the outer air.

This Cutter is the only type that slices in the open air, and employs an air blast, which aerates as it cuts and therein lies the secret of aeration. It is not enough to simply cut the phosphate, the steam must also be liberated to produce a higher soluble, by eliminating a large proportion of the water. Care is taken, however, that the product is not cooled too much, as it is necessary to retain a sufficient amount of heat to carry on and complete the re-action in the pile, and thus further eliminate moisture, and reduce the free acid and insoluble.

Results clearly indicate that the Acid Phosphate is not cooled too much, as the reaction is continued in the pile (See analysis, page 29).

As the flakes of Phosphate fall they are carried around by the air current, and sufficient moisture is driven off to prevent their being plastic or sticky as they drop directly on the Pan Conveyor like damp corn flakes, and immediately break up, owing to their thinness and porosity, and then resemble damp sand rather than sticky clay. No scraping nor mulling occurs as they are carried to an elevator for filling overhead cars, or into a pit for Crane handling. If the Den is at an elevation, the Pan Conveyor can discharge directly into overhead cars for carrying it into the storage building. This operation of ex-dening, or excavating, simply requires the starting of the machinery, which is usually done by the Mixer operator when he has finished mixing. He generally has one helper to properly care for the equipment and to see that the Acid Phosphate is traversed and properly cut out; the machine is then reversed and quickly brought back to its original position (in five minutes), the doors are again rapidly secured, and it is ready for another charge. A 30 ton batch can be prepared, that is, weighed, mixed, allowed to set, excavated, and the machine brought back to position in approximately 3¼ hours' time.

This entire Excavating Unit requires only seven Horse Power to operate.

The Den sides and end door are made of heavy steel frames to which are bolted 2" pitch-pine planks, tongued and grooved and treated with preservative.

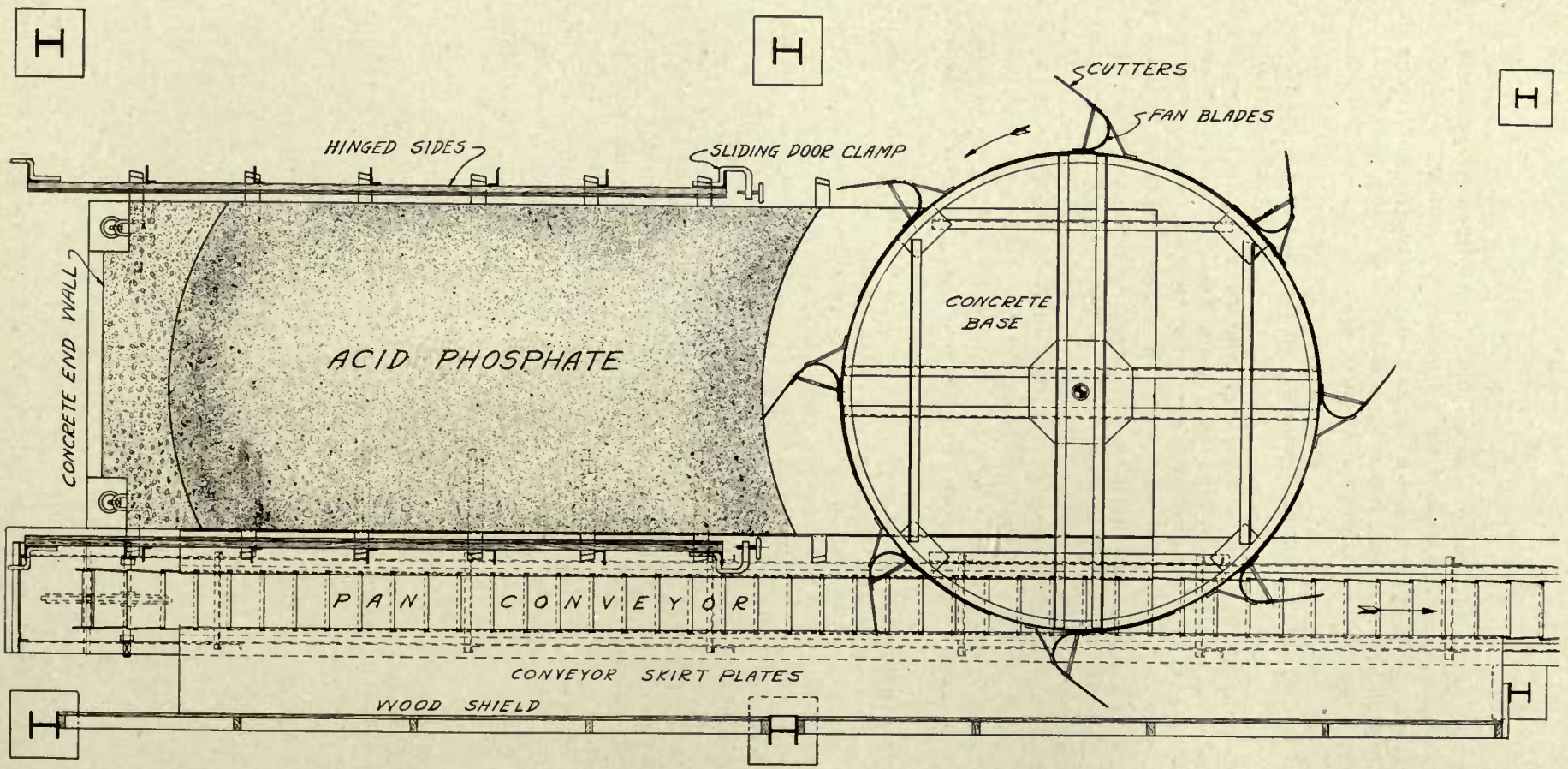
A skin lining 1" thick, also tongued and grooved and similarly treated, is blind-nailed diagonally to the 2" planks. Tar paper between the two assists in preventing leaks. This is a very durable construction, especially as the thin film of acid phosphate adhering to the sides acts as a further preservative and is never scraped off.

Leather-scrap, shoddy, wool-waste, hair and other low grade Ammoniates can be acidulated in this Den, and cut out. These require a longer time to set, due to the increased moisture which they contain. They will set, however, but must be cut out more slowly than Acid Phosphate, and provision is made for driving the carriage at slower speed for this purpose.

An inspection door in the roof of the Den is provided, so that the charge may be inspected to ascertain if a "set" has taken place.

If, through wide variation in the grade of rock used, or incorrect formula, an acid phosphate is produced which does not set up readily, the Den can be emptied by hand. Any charge that is set sufficiently to prevent flow can be excavated by the Cutter.

Approximately one inch of Acid Phosphate remains on the concrete floor of the Den after excavation is completed. This is left to seal the cracks between the floor and doors, making the Den tight.

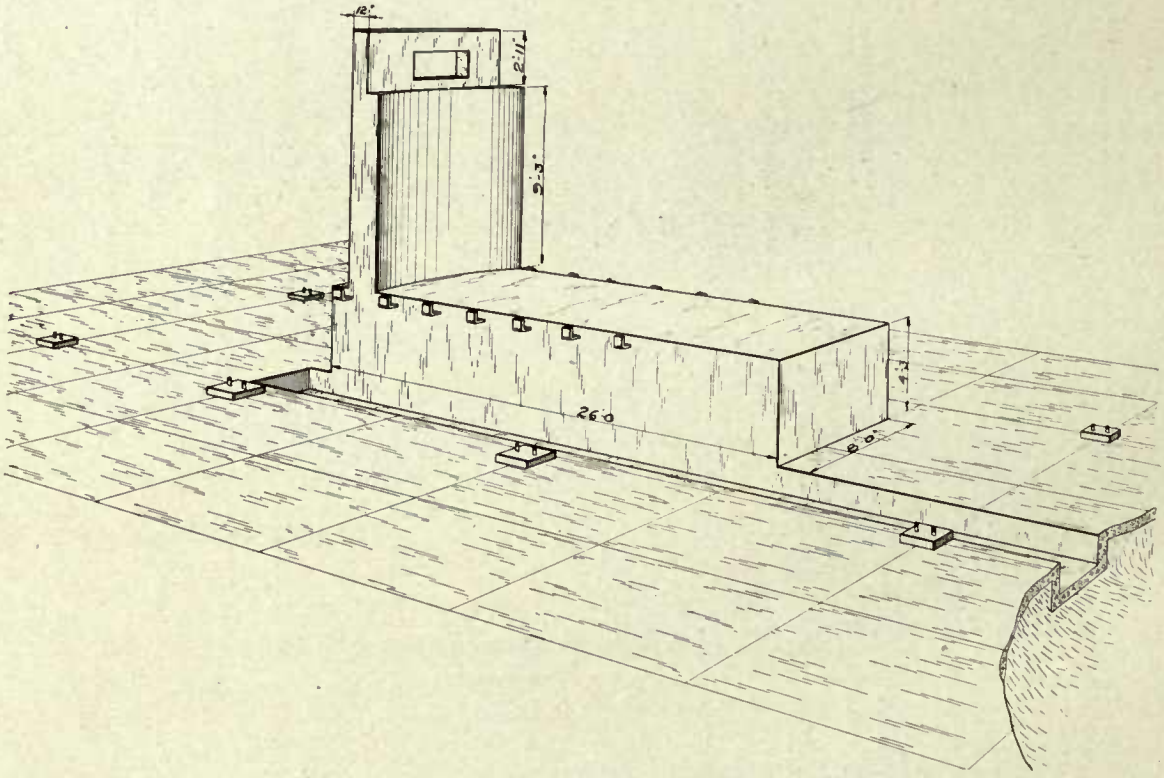


Sturtevant Mechanical Automatic Den and Excavator—Plan View

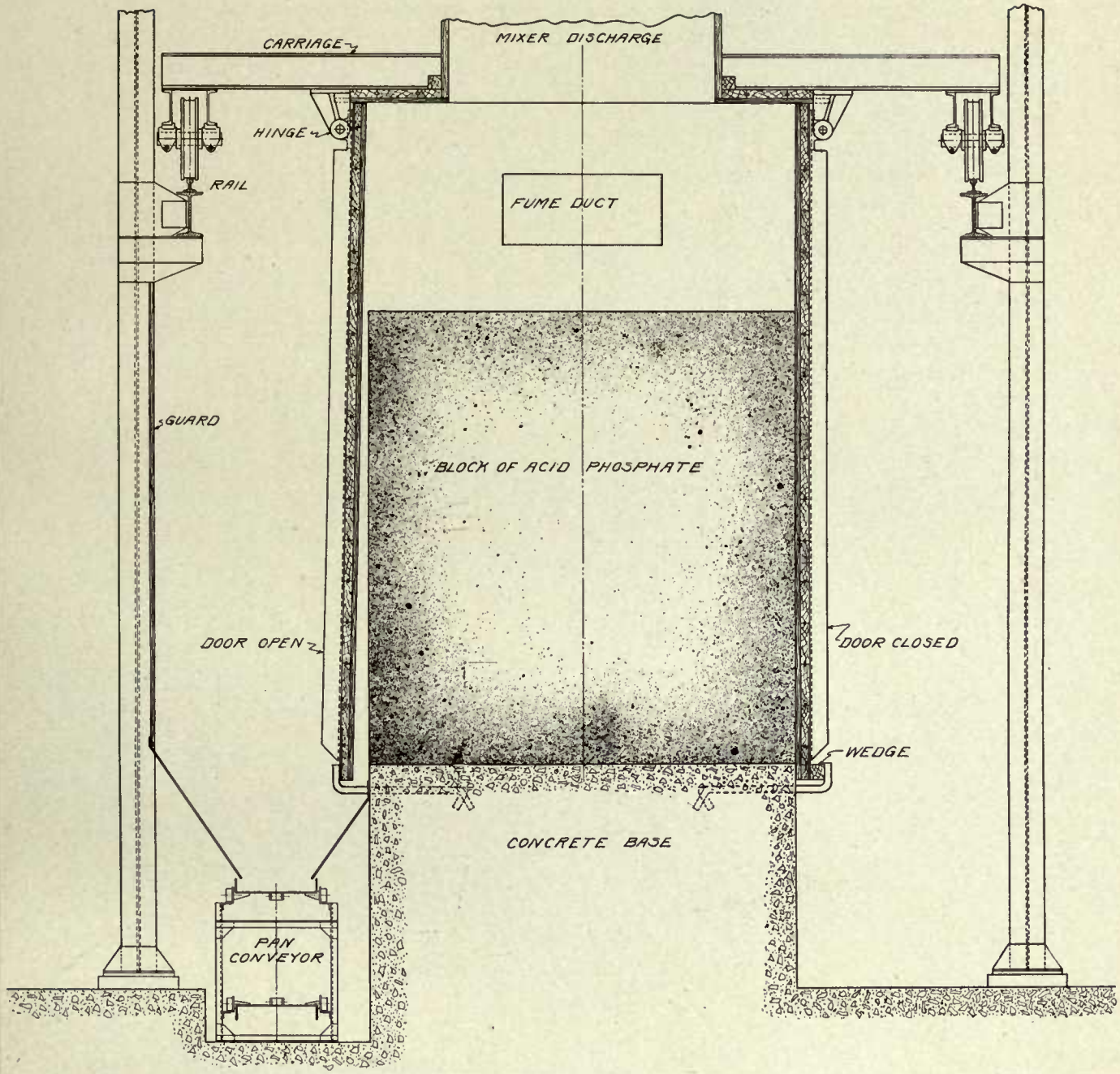
Patented—Patents Pending

APPROXIMATE DIMENSIONS, WEIGHTS, SPEED, ETC., OF AUTOMATIC DEN AND ELEVATOR UNIT

Ground Area 18′ wide by 53′-6″ long
Area of Mixer Floor 18′ x 19′
Height of Mixer Floor 22′-5″
Area of Scale Floor 18′ x 19′
Height of Scale Floor 30′-5″
Total overall height to top of Scales 37′-7″
Size of Cutting and Aerating Fan 15′-6″ diameter by 9′ high
Speed 11½ R.P.M.
Peripheral speed 560 ft. per minute
Cutting speed, average, 4″ per minute, adjustable for speeds, 3″, 4″ or 5″ per minute.
Time of cutting out at speed of 4″ per minute, one hour
Weight of Den and Excavator, approximately 24,000 lbs.
Motor for operating Den and Excavator 7½ H.P.
Weight of Mixer alone 15,000 lbs.
Speed of Beaters 35 R.P.M.
Speed of Drum 2 R.P.M.
Motor to operate Mixer 7½ R.P.M.



Concrete Base, End Wall, Conveyor Pit and Footings



Sturtevant Mechanical Den and Excavator—Front View

Patented—Patents Pending

To assist in reducing the free acid content of the Phosphate, also to increase availability, three per cent of dry rock dust is often discharged through the Mixer into the Den just before the "cutting out" operation. This rock is spread over the block of acid phosphate and the cutters thoroughly work it into the mass while cutting, thus making it available and increasing solubility.

FUME CONDENSING CHAMBERS

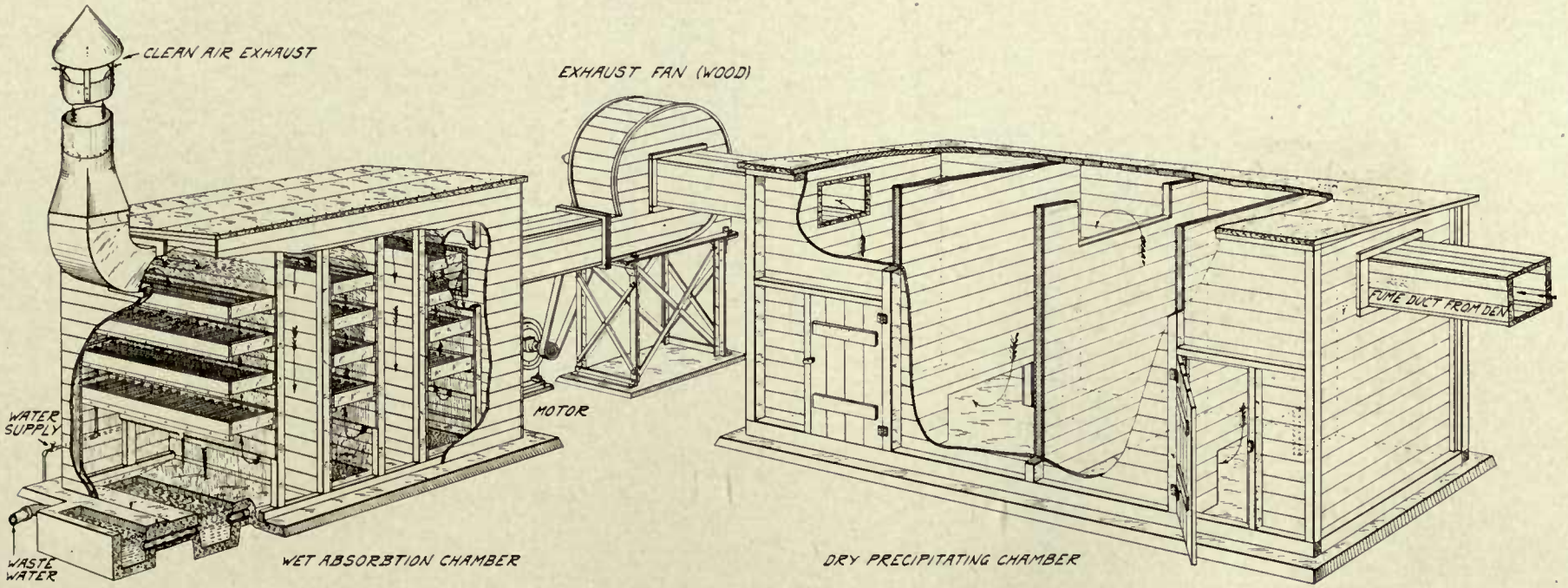
The fumes emanating from the Mixer and from the Dens are successfully treated by dry and wet condensing chambers with the aid of a slow speed, especially constructed wooden Fan (to withstand the corrosive action of acid) of large dimensions, (48″) which runs at 400 R.P.M. and requires 3 to 4 Horse Power, thus the objectionable odors in the surrounding atmosphere and the pollution of water in rivers and streams is avoided.

It will be seen that acid fumes are not allowed to come in contact with the operators, nor with the metal work, which, therefore, is not exposed to the deteriorating effect of the acid.

The dry and wet method consists of a large dry chamber with baffle walls placed between the fan and den. This chamber, owing to its size, reduces the velocity of the gases and causes the solid matter, held in suspension, to separate and fall to the floor, thus relieving the Fan of this burden. The Fan blows the partially cleaned gas from this chamber into another chamber, filled with partitions and water sprays. The gas follows an up and down course through these sprayed compartments, precipitating the remaining solids, or powder (hydrofluosilicic acid), and allows only pure air to escape. As the dry chamber has separated most of the hydrofluosilicic acid, the acidity of the condensing water discharged is much less than if no dry chamber had been used.

This hydrofluosilicic acid can be converted into silico-fluoride of sodium, the selling price of which often covers the cost of condensation.

Special Wood Constructed Fume Fan



Sturtevant Fume Condensing Chambers

BASIC PRINCIPLES AND RESULTS

The basic principles involved in the manufacture of Acid Phosphate, and on which the Sturtevant Acidulating Unit and methods have been worked out are as follows: Fast and accurate automatic weighing of dust and acid in small batches of the correct temperature and strength; quick and intimate mixing and discharging; efficient ventilation of the Den and Mixer; cutting and aerating the phosphate as it is removed from the Den; avoiding any mulling action in so doing; delivering the acid phosphate into storage with as little handling as possible. In carrying out these principles it was found that the Sturtevant Acidulating Unit was the only one embodying all of these factors, and as the finished acid phosphate speaks for itself it is evident that all are required.

From figures obtained abroad, the cost of weighing, charging, excavating and conveying to storage, including labor, oil, maintenance, etc., is from 6 to 8 cents per ton of acid phosphate.

This Acidulating Unit was submitted to more than 60 Fertilizer Manufacturers, Chemists, Engineers and Mechanical experts at the Convention of the National Fertilizer Association held at White Sulphur Springs, W. Va., during the week of June 19th, 1921, and not a single constructive criticism was made.

Fourteen other American experts had passed upon it, prior to that meeting, with the same results.

From information obtained abroad, it is understood that of the last 20 plants erected, 18 were equipped with the Sturtevant-English Process and two with the Beskow System, to the exclusion of all others; both of these patents are controlled by Sturtevant Mill Co. Of the 18 Sturtevant plants, Sturtevant Engineers have visited 12 and have actually seen the proof of these astonishing results.

No other processes were seen in plants built in the last few years.

FROM H. G. McCREATH & SONS, BERWICK-ON-TWEED, ENGLAND

"I am in receipt of your letter of the 14th inst., and note contents.

"I am glad to say the Mechanical Den is doing remarkably well. It has worked without a hitch since the start and everything is very satisfactory. In fact, it has done everything we have asked it to do. The superphosphates are in first-class condition, and the solubility is rather better than we were getting from our old plant.

"I shall be pleased to show the plant to any one you may wish to send through any time, if you will let me know so that we may have it working.

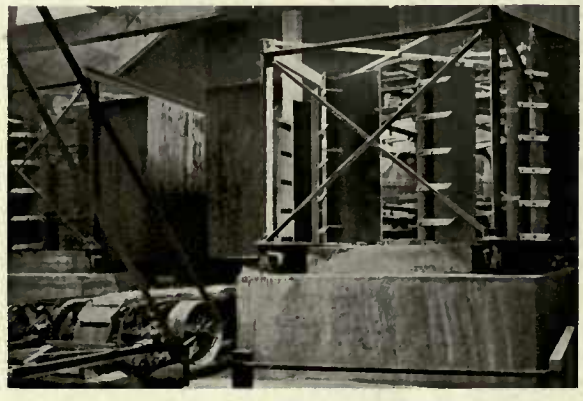
"The fact is, we can put through more than 100 tons per day, so we don't need to have it working continuously."

A partial list of users of Sturtevant Automatic Den and Excavator:

The Aberdeen Lime Co., Ltd.,
Blaikie's Quay,
Aberdeen, Scotland.

Johnson & Darlings, Ltd.,
Berwick-on-Tweed, England.

Edward Webb & Sons, Stour-bridge, Ltd.,
Saltney, England.
Nr. Chester (two plants)



Thomas Vickers & Sons, Ltd.,
Widnes Phosphate Works,
Widnes,
Lancashire, England (two plants)

Doughty, Son & Richardson, Ltd.,
Lincoln, England (two plants)

Spooner & Bailey, Ltd.,
Eling,
Nr. Southampton, England.

Ste. Ane. de Produits Chimiques de l'Ouest,
Ste. Marc,
Pres Brest, France.

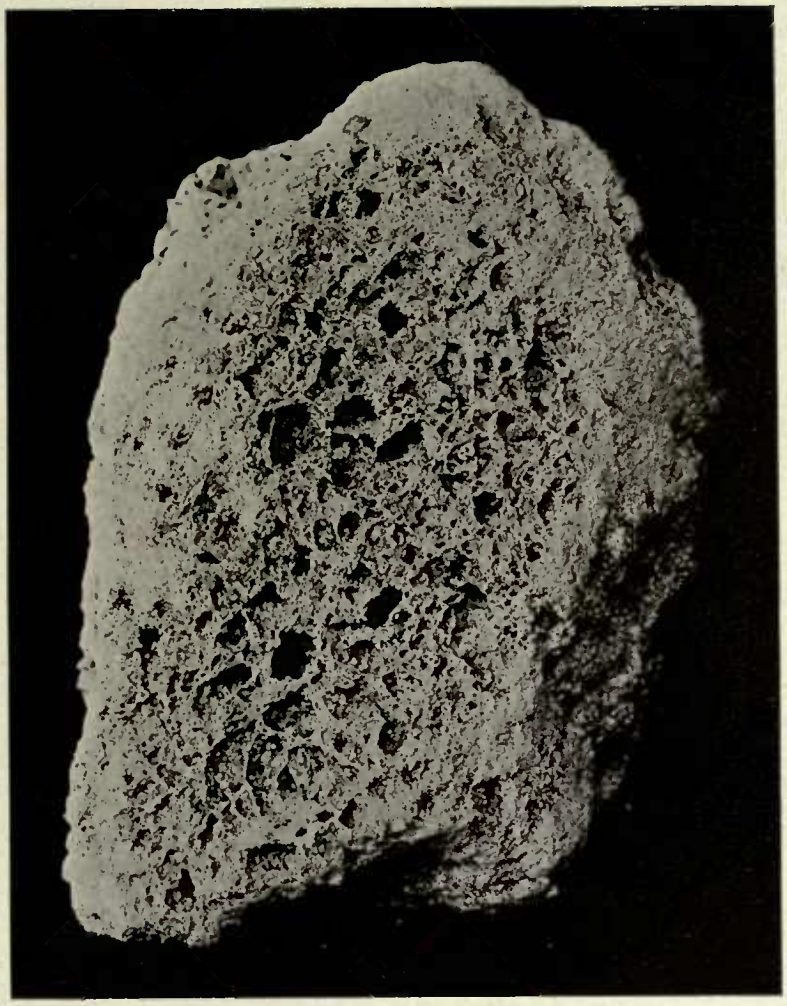
Kynoch, Limited,
South Africa.

H. G. McCreath & Sons,
Berwick-on-Tweed,
England.

Charles Norrington & Co., Ltd.,
Chemical Works,
Cattedown,
Plymouth, England.

Briton-Ferry Chemical Co., Ltd.
Briton-Ferry (two plants), England.

National Smelting Co., Ltd.,
Avonmouth (two plants),
England.



Acid Phosphate, Actual Size, 15 Minutes after Last Mix was Dumped into Den
Note its porosity and "set"

Acid Phosphate, Actual Size, as Cut Out of Den 15 Minutes after the Last Mix was Dumped into Den
Note its granular form and absence of lumps---95 per cent passed a 6-mesh screen

The Acid Phosphate is now manufactured, cut out, aerated and is in a fine, dry, mechanical condition for storage.

In designing a storage building for the various materials used in the manufacture of Complete Fertilizer it is highly important that handling costs into, within and out of the building be as low as possible.

Many plants cover a large area but are not designed for the high piling of materials to increase capacity.

The "A" frame building, used for many years, gives a large storage area free from posts which, by the use of overhead cars, can be practically and economically filled with almost no waste space.

There is, however, no practical means of emptying same except by diggers with push carts or electric trucks, neither of which are economical and therefore this type of building is now used mostly for the smaller plants.

The use of steel construction in place of wood, for fire protection, and to allow the use of Cranes, is responsible for the adaption of the Crane Type building. Further, a Crane is a very efficient means of filling and emptying the building, as all of the ground area can be reached by the Crane Bucket and large hourly tonnages can be handled very cheaply by one man.

The height of the storage pile can also be increased by this equipment, and thus more tonnage per square foot of ground area is obtained.

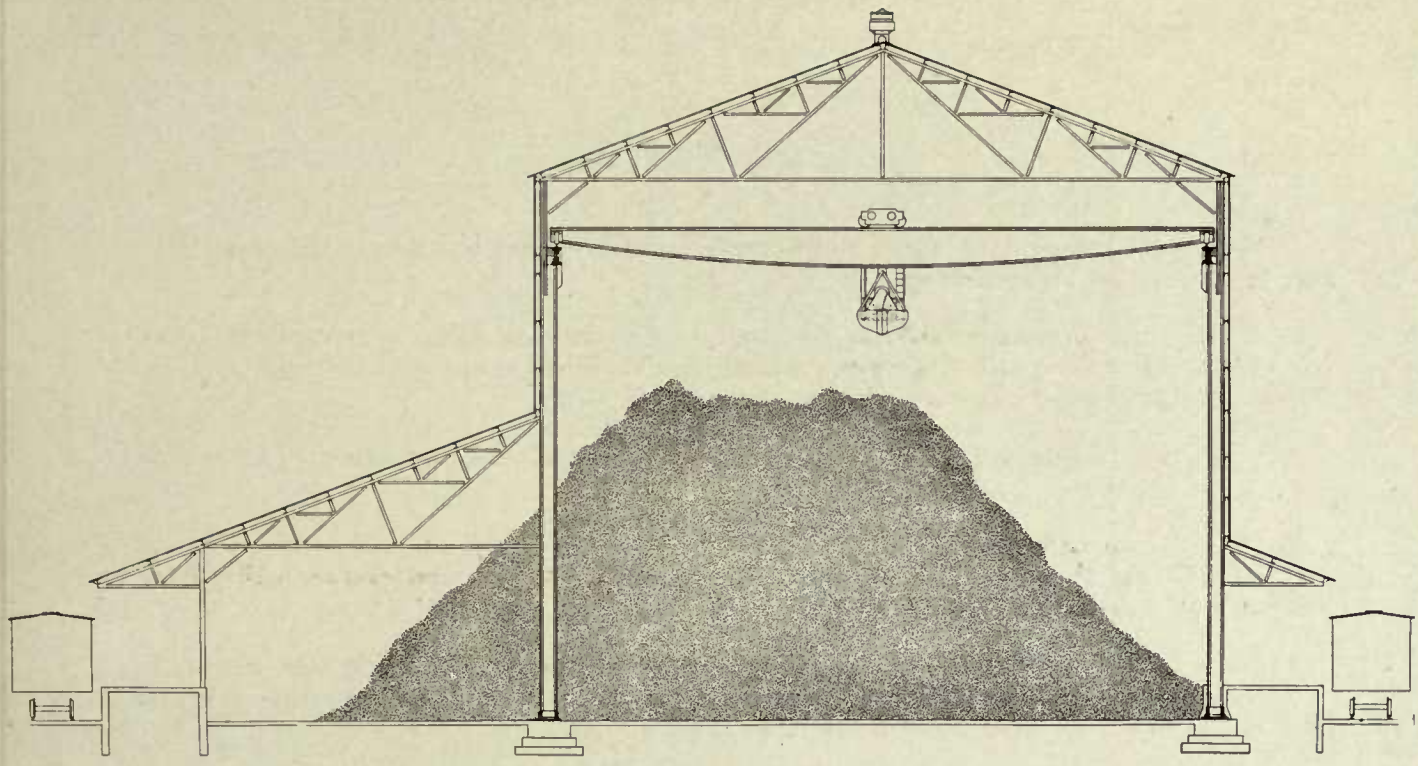
As Cranes are expensive and require strong steel buildings, their use is limited to plants of sufficient capacity to carry the burden of the initial investment and therefore are not universally used.

For smaller plants, either a combination building of the "A" Type with a square posted wing or a straight square-posted building having 16′ to 20′ bays can be used. In either case overhead push or electric cars, at a uniform level, should be used. (See pages 82, 83, 84.)

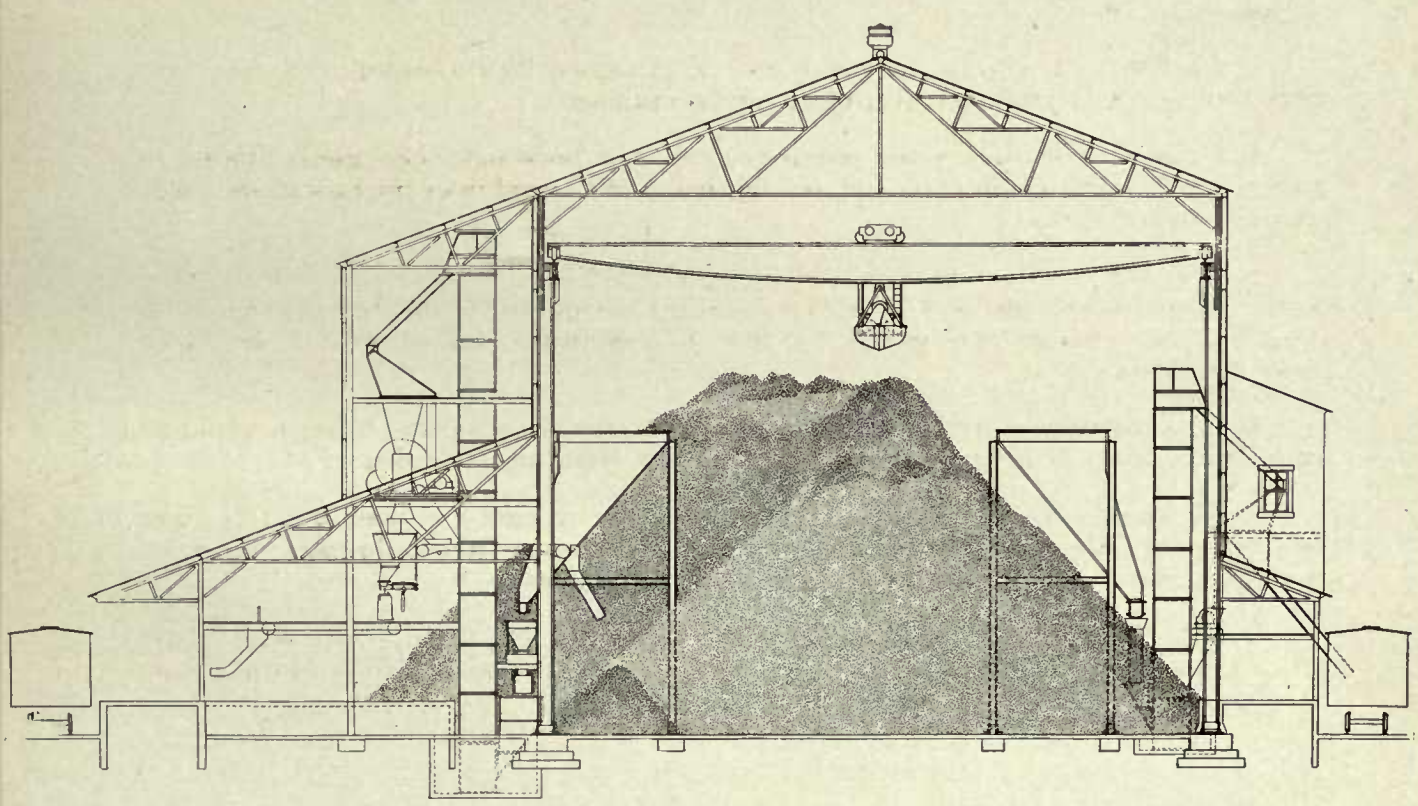
As the plant illustrated (see folder at back of book) is of sufficient size to economically use Cranes, a typical Crane Type Storage Building is shown.

An 80′ span is used for the two Cranes. A wing or leanto, on one side, forty feet wide provides room for the shipping and mixing machines, materials in bags, bag room and office, and storage of bagged goods ready for shipment.

Double tracks on this side give good car facilities. On the opposite side a bulk shipping machine is utilized for shipments of this nature, and a wide platform allows for the unloading of cars without spotting same.



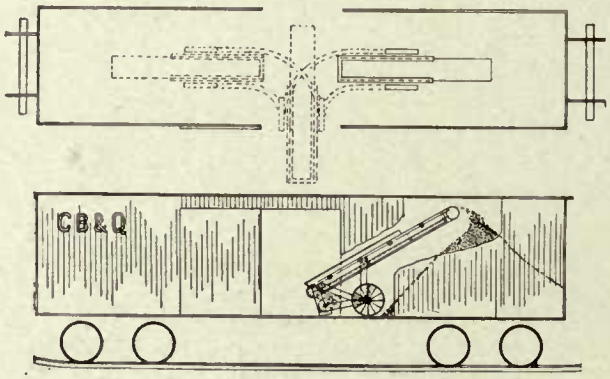
Section of Building Showing Storage Pile



Section of Building Showing Storage Piles, Basing and Shipping Unit and Bulk Shipping Unit

PORTABLE CONVEYORS

Through doors in the side of the building, short portable Belt Conveyors can be used to advantage to carry incoming materials within reach of the Crane. This is the receiving side of the structure and rock is also unloaded from cars on the same track.



Portable Car Loader

The Sturtevant method of manufacturing Acid Phosphate delivers the product by Pan Conveyors from the Dens (both being on the ground) into a pit, from which it is picked up by the Crane and piled in the Storage Building.

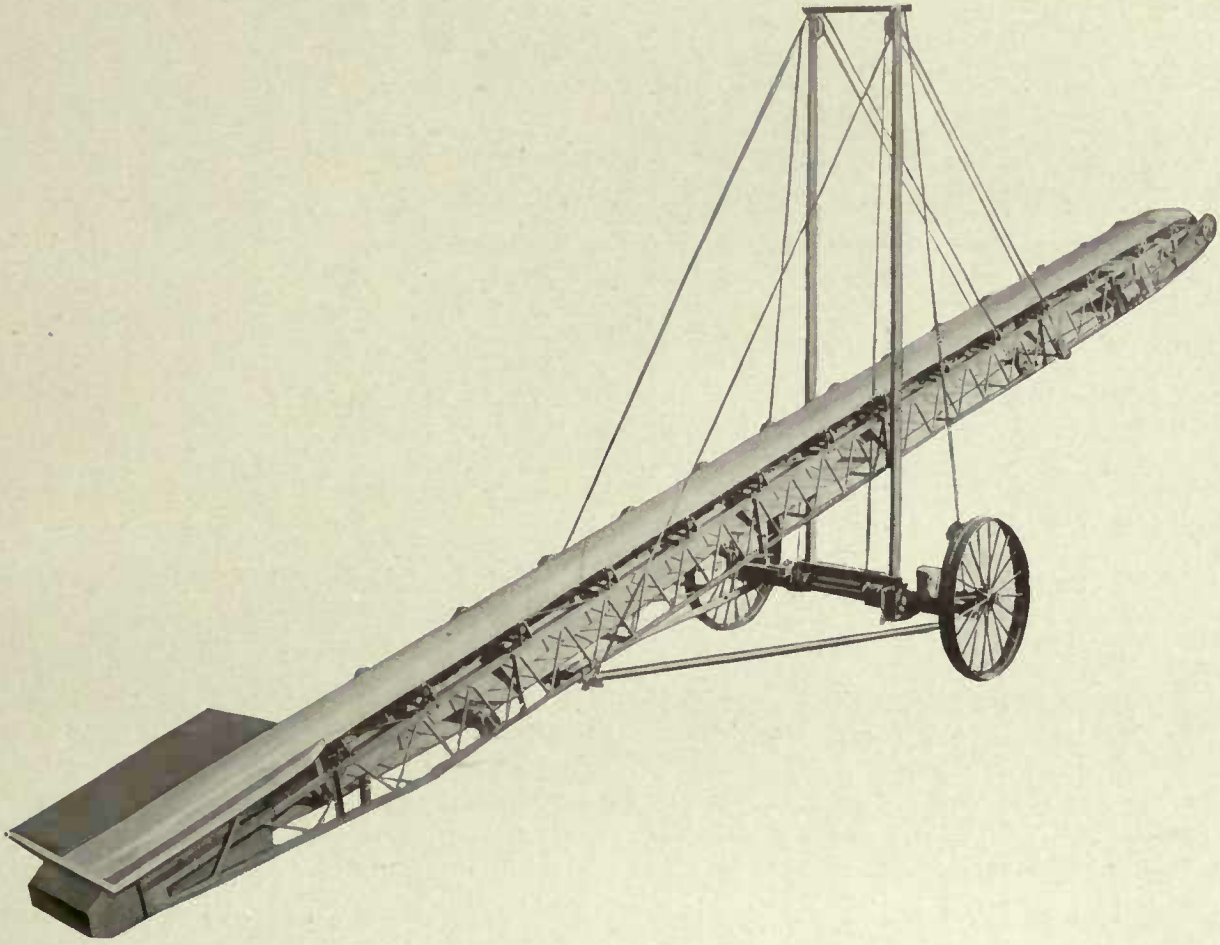
Acid Phosphate is stored in the section of the building nearest the acidulating department. It can then be shipped out in bags through the Bagging Unit or through the Bulk Shipping Unit.

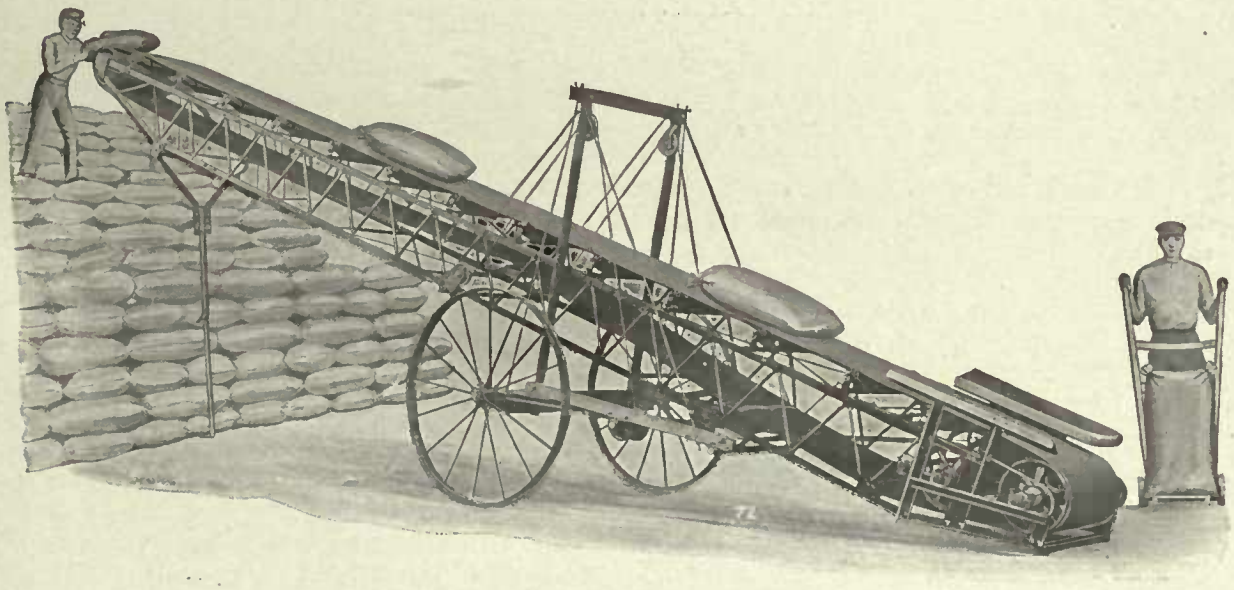
Each Unit is equipped with receiving hoppers for both Acid Phosphate and Filler, also with weigh hoppers beneath, for proportioning.

BASING, MIXING AND SHIPPING UNIT---HOPPER SYSTEM

The center Unit is a formulating or Base Mixing Unit.

The ingredients to be used are placed in their respective Hoppers by the Cranes. Eight Hoppers are shown, each of which may contain a separate material such as acid-phosphate, filler, tankage, etc., or if an extra large amount of any one ingredient is used, then more than one hopper may be utilized for this particular material. Arranged as shown, these Hoppers do not interfere with the maximum storage capacity of the Crane Bay. They occupy what is open or waste air space along the pile, as the natural slope of the pile reaches only to the supporting columns. If these bins were placed across the Crane Bay, in a position at right angle to those shown, a large Storage space would be wasted. Not only the ground area but the pile would have to be divided in two parts, each sloping to the top and both ways from the bins. As every square foot of storage space covered by the Crane is very valuable, this design permits the use of more area, therefore maximum storage in the Crane Bay. Considering only the Crane Bay, hoppers placed across the building absolutely eliminate approximately 100,000 cu. ft. of storage space under the Crane, where it is the most valuable, which, figuring at 50 lbs. per cubic foot, equals a storage loss of 2500 tons of material, all of which is saved by the Sturtevant method, without interfering in any way with the Crane operations.





Portable Conveyors for Piling Material or Bagged Goods

BASING, MIXING AND SHIPPING UNIT---HOPPER SYSTEM

Underneath each bin a Scale is placed, with a small Hopper. The correct weight of each ingredient is drawn off as determined by formula. A gate in the bottom of this Scale Hopper is then opened and the contents discharged onto a Belt Conveyor directly below. One man can handle several Scales and, as the weights remain the same until the formula is changed, accuracy is assured.

This bin or hopper system permits the assembling of materials very quickly and saves much labor. The supply overhead is maintained by the Cranes therefore if the batching machine is of the correct size, for the tonnage desired, there is no delay in producing the daily output. Using one ton batches the hourly capacity of approximately thirty tons is averaged.

The method of collecting the various materials, weighing and placing them on a Conveyor Belt for delivering to the Basing Unit having been described, the next operation is that of Basing.

The Conveyor Belt discharges its batch into an Assembly Hopper, holding one ton, at the boot of the Unit Elevator. Here all the materials are collected so that they may be admitted together into the Elevator. A man stationed at this assembly hopper, when signalled that the Mixer is free, opens the shutters or gates, allowing the materials to enter the Elevator, and when hopper is empty closes same and signals the weighing man to send along another charge.

The basing machine or Unit is a standard Sturtevant Single Elevator Mixing Unit. The materials delivered into the Elevator are lifted sufficiently high to discharge onto a "BB" Screen. The fines are collected in the Mixer Hopper beneath the Screen, and the oversize passes to the Pulverizer for further reduction.

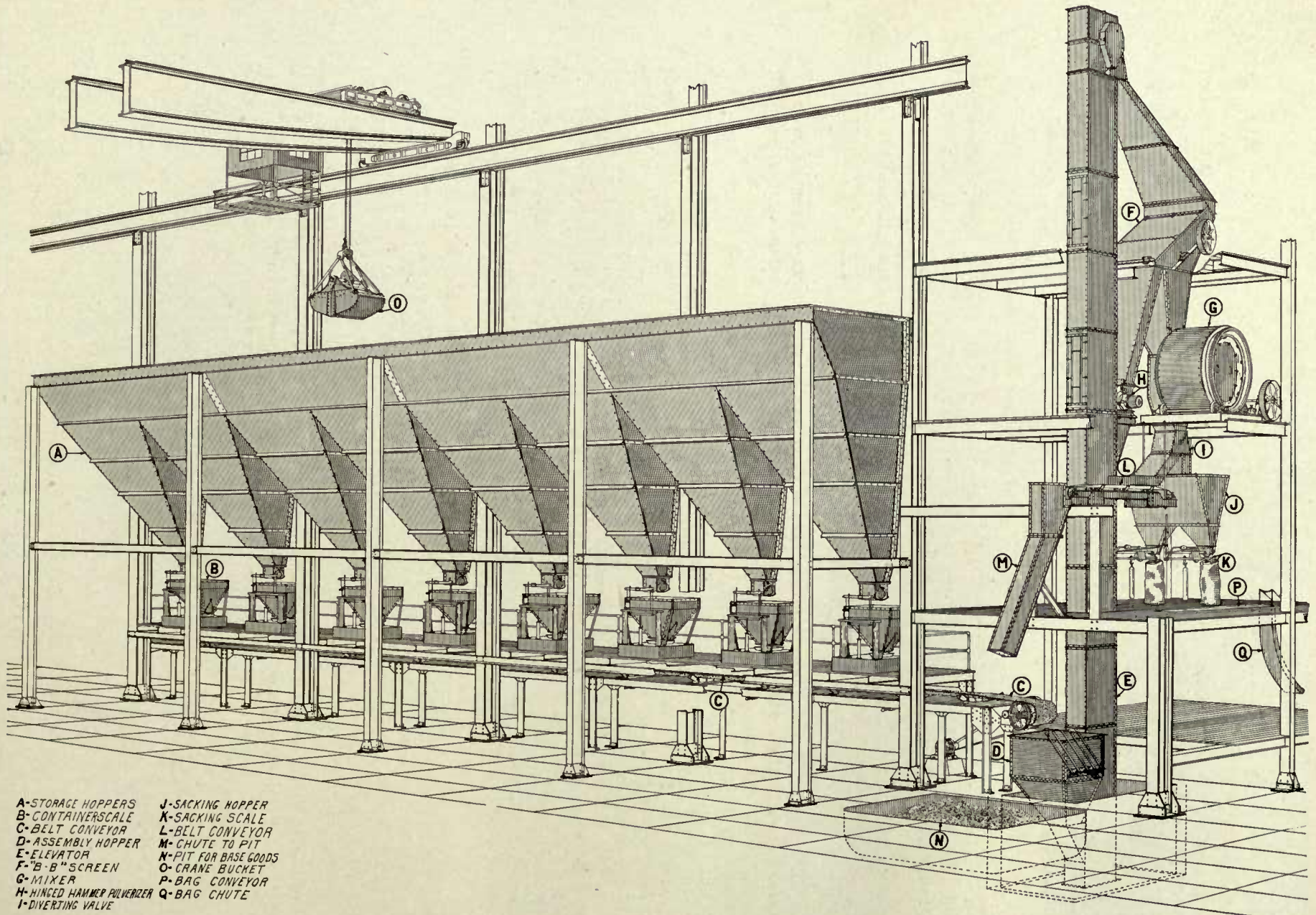
The now finely ground oversize from the pulverizer is discharged into the same Elevator, passes through the same Screen, and rejoins the batch from which it was previously extracted, before any of the material enters the Mixer.

The original one ton batch now properly ground and sized is in the Mixer Hopper underneath the Screen. A discharge gate in the bottom of this Hopper is opened and the material enters the Mixer. The mixing operation is completed in one half minute.

This Unit may be used for either Basing or Shipping:

Basing. In case it is employed as a Basing Unit the mixed goods are discharged from the Mixer through a spout, onto a Belt Conveyor, which delivers it to a Pit, from which it can be removed by the Crane Bucket and stored wherever desired.

Shipping. When used as a Shipping Unit the mixed goods are discharged into a Double Weighing and Sacking Hopper, equipped with Scales and Bag Holders so that quick and accurate weights may be secured. The filled and weighed sacks are dropped onto a Slat Conveyor which carries them forward out of the way of the operators. The



Sturtevant Basing, Mixing and Shipping Unit---Hopper System

Patented

sewers ride on this Conveyor with the Sacks, sewing as they move. When finished they walk back, threading their needles on the way, and repeat the operation.

The object of placing the Conveyor and weighing arrangements at an elevation from the track platform, is to permit the Conveyor to discharge the filled, weighed and sewed bags down a chute either to electric or hand trucks on which they are easily piled.

This method eliminates the usual truckers employed to take the bags from the Scales to the sewers, and relieves the congestion at the Scales, as it is necessary, for efficient work, to allow plenty of free working space around these machines.

The above Unit when handling thirty one-ton batches per hour requires the following men:

Three weighers at storage hoppers
One assembly hopper man
One Mixer man
Two weighers and sackers
Four sewers
One helper or handy man.

The number of truckers removing bags from Conveyor Chute depends on the distance to the car being loaded. Usually two truckers with one man to assist in piling the bags on the trucks are sufficient.

This Unit can also be used between Seasons for grinding and sizing tankage, cotton seed meal, etc., which can sometimes be advantageously purchased raw or unground if pulverizing equipment is available.

This ground and sized material is discharged by the Belt into the Crane Bay for piling.

SHIPPING UNITS

In addition to the Basing Unit, which can be used for bagging and shipping, two other Units are provided. These are placed adjacent to the materials they will handle, such as Acid Phosphate and Complete Goods.

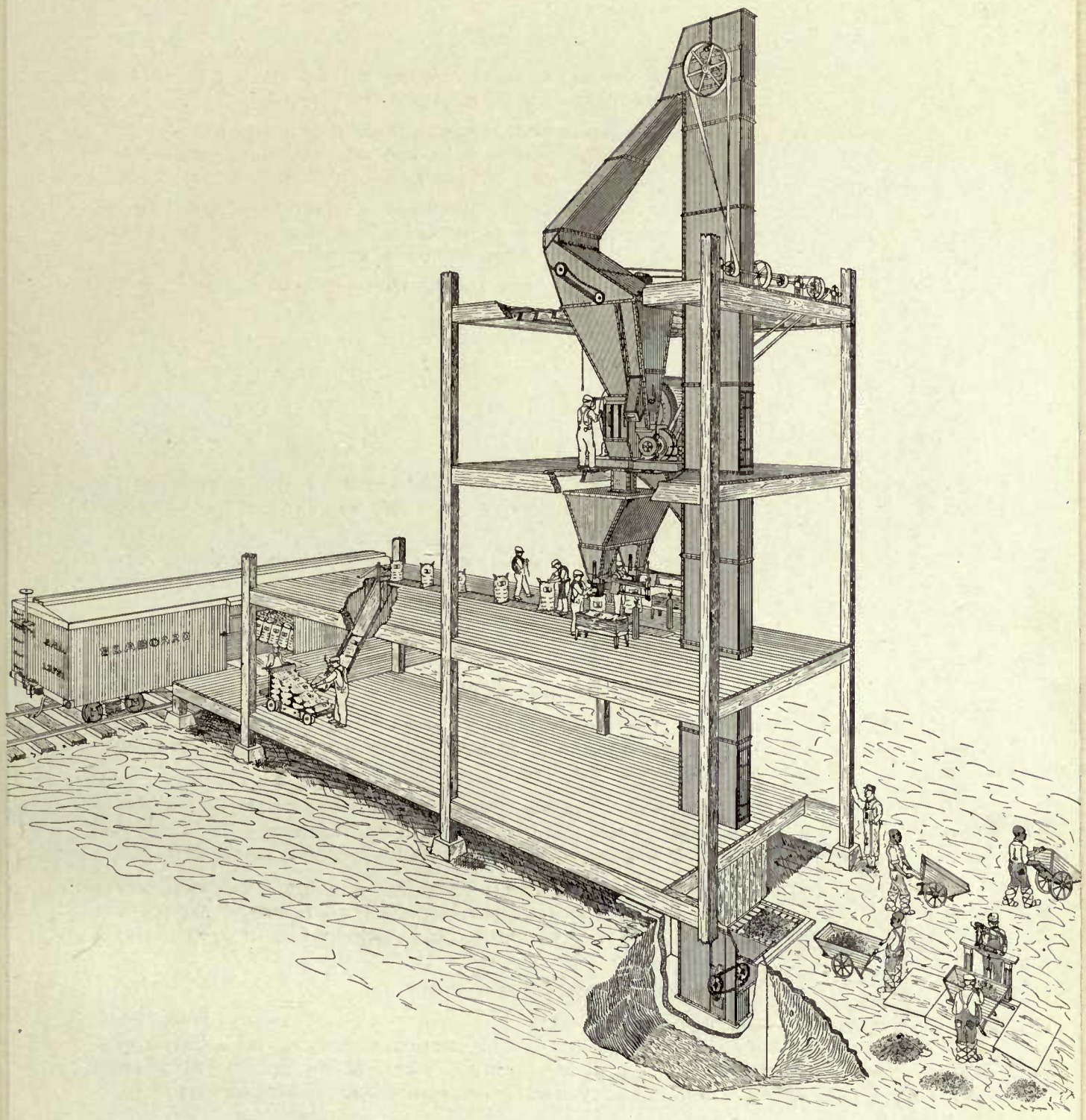
They are provided with Scale equipped Hoppers in event of reformulation being required. An Elevator, "BB" Screen, Pulverizer, Sacking Hoppers with Scales and Sewing Conveyor make a complete labor saving and highly efficient Shipping Unit.

The bulk Shipping Unit for Acid Phosphate, or other materials, differs from the above Unit, only in that the sacking arrangements are eliminated, and by the use of a spout and Portable Belt Car Loader large tonnages can be shipped quickly and cheaply.

EQUIPMENT USED IN UNITS

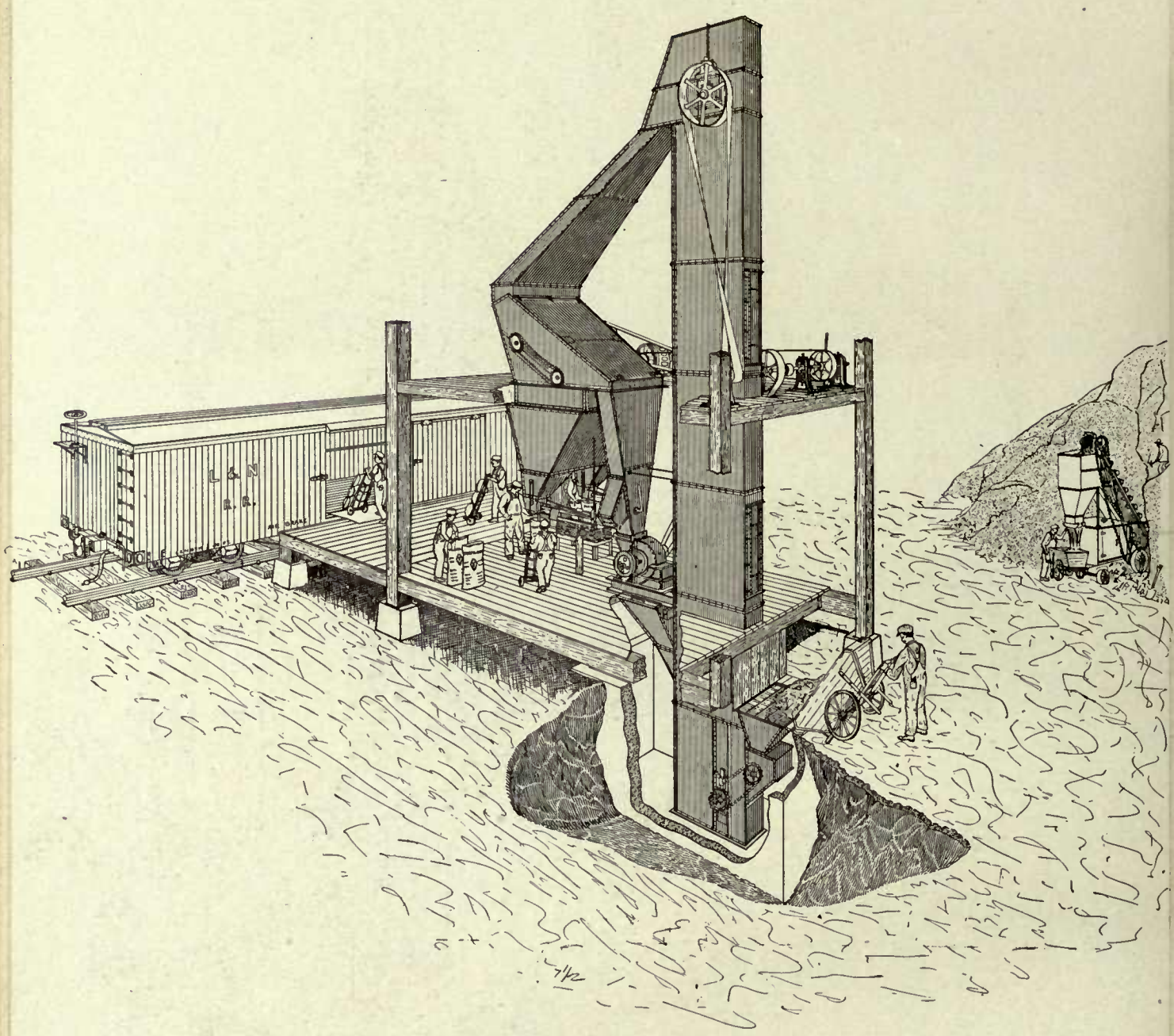
The equipment used in the various Mixing, Basing, Grinding and Shipping Units is of special design and construction, built for this particular service, and will be appreciated by every Superintendent, as all are painfully aware of the cost resulting from breakage, clogging, insufficient capacity, and the deplorable lack of accessibility of most fertilizer machinery.

Simple, durable, rugged, reliable equipment of instant and complete "Open Door" accessibility is an asset to any plant, for if trouble comes, as it does in the best of factories, the cost of making repairs and clean-outs is minimized by Sturtevant Equipment, and a few minutes only are necessary to locate and remedy the trouble, at low cost.

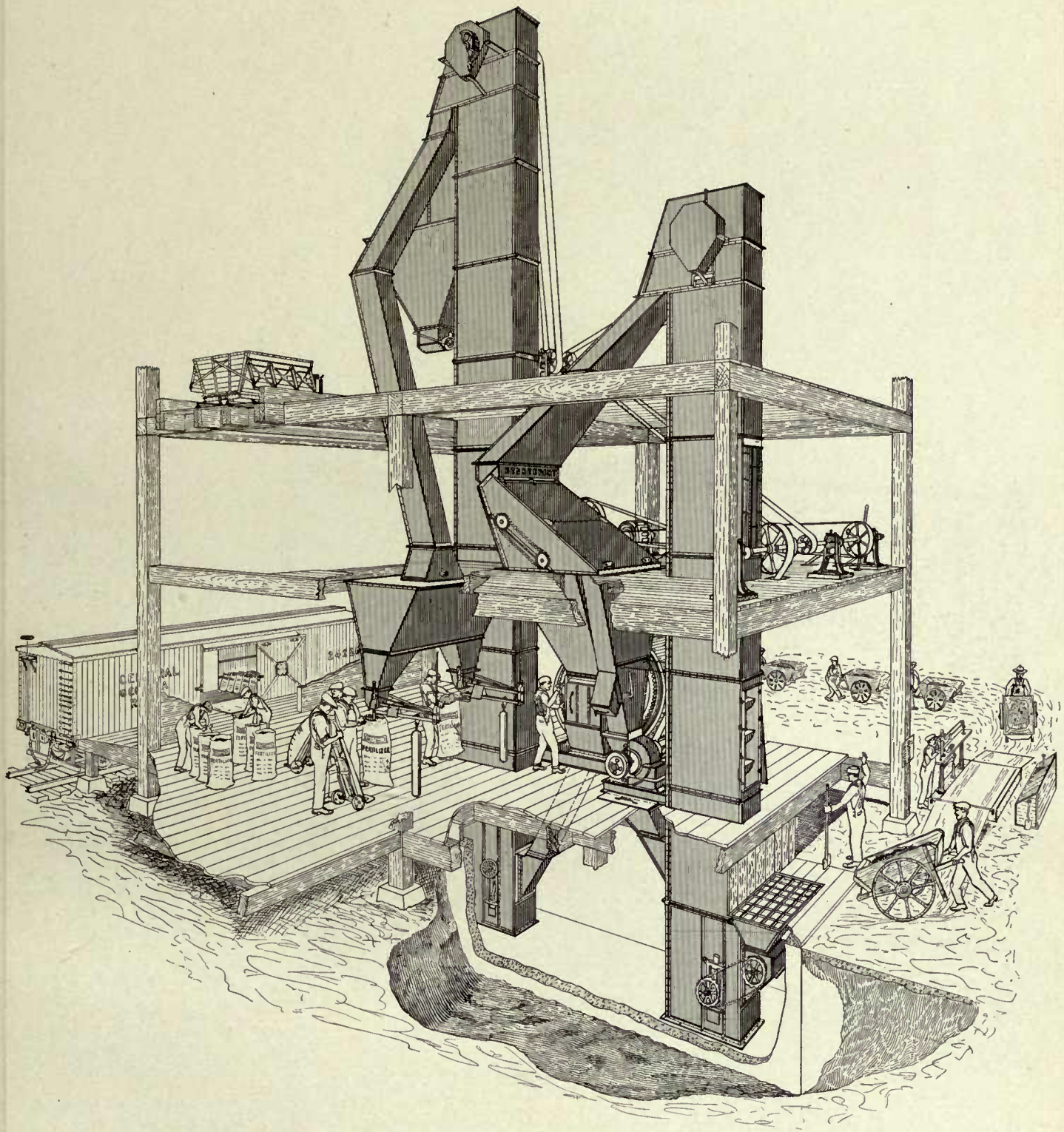


Sturtevant Single Elevator
Mixing and Shipping Unit with Sewing Conveyor and Chute

Patented

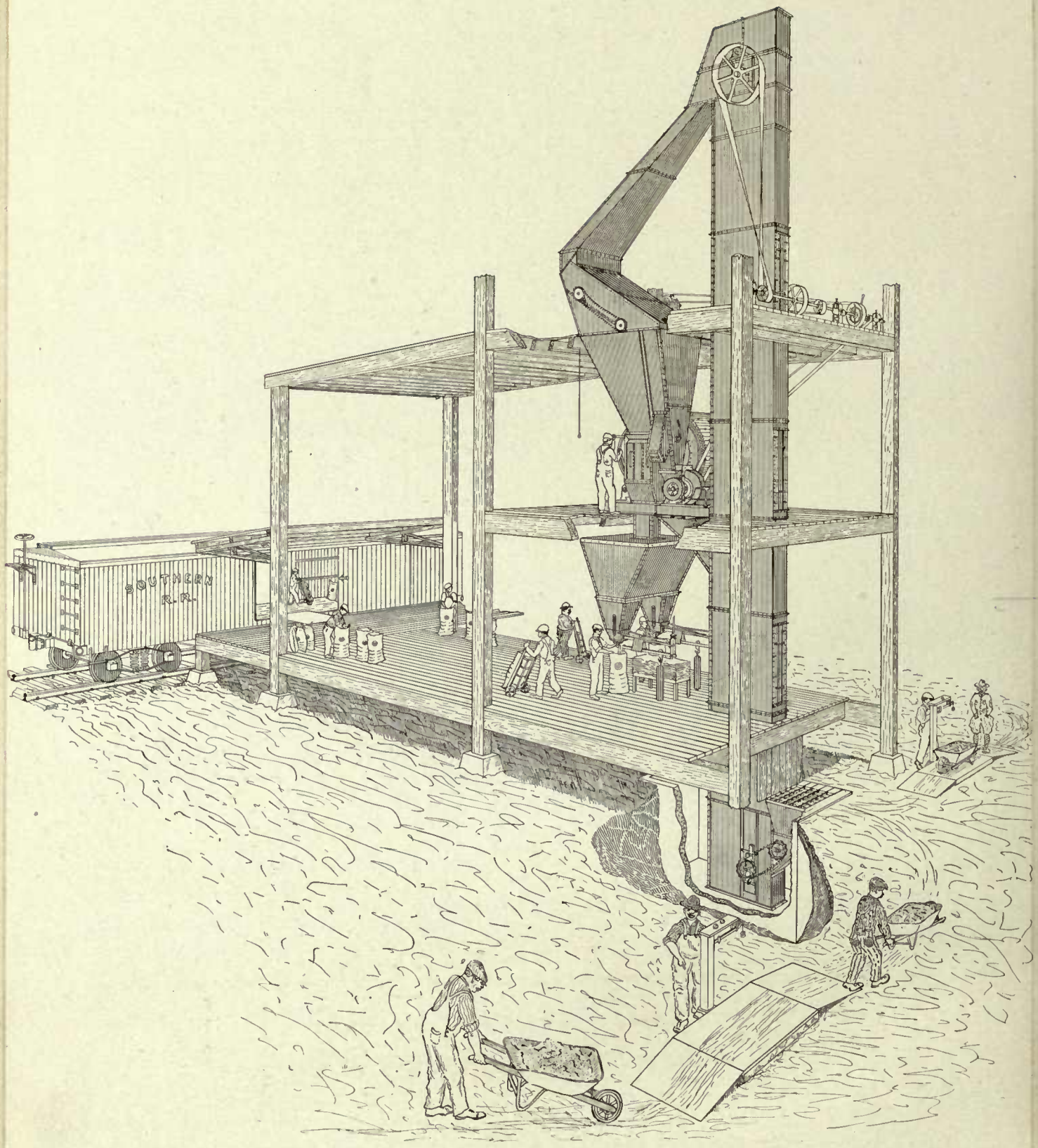


Sturtevant Shipping Unit



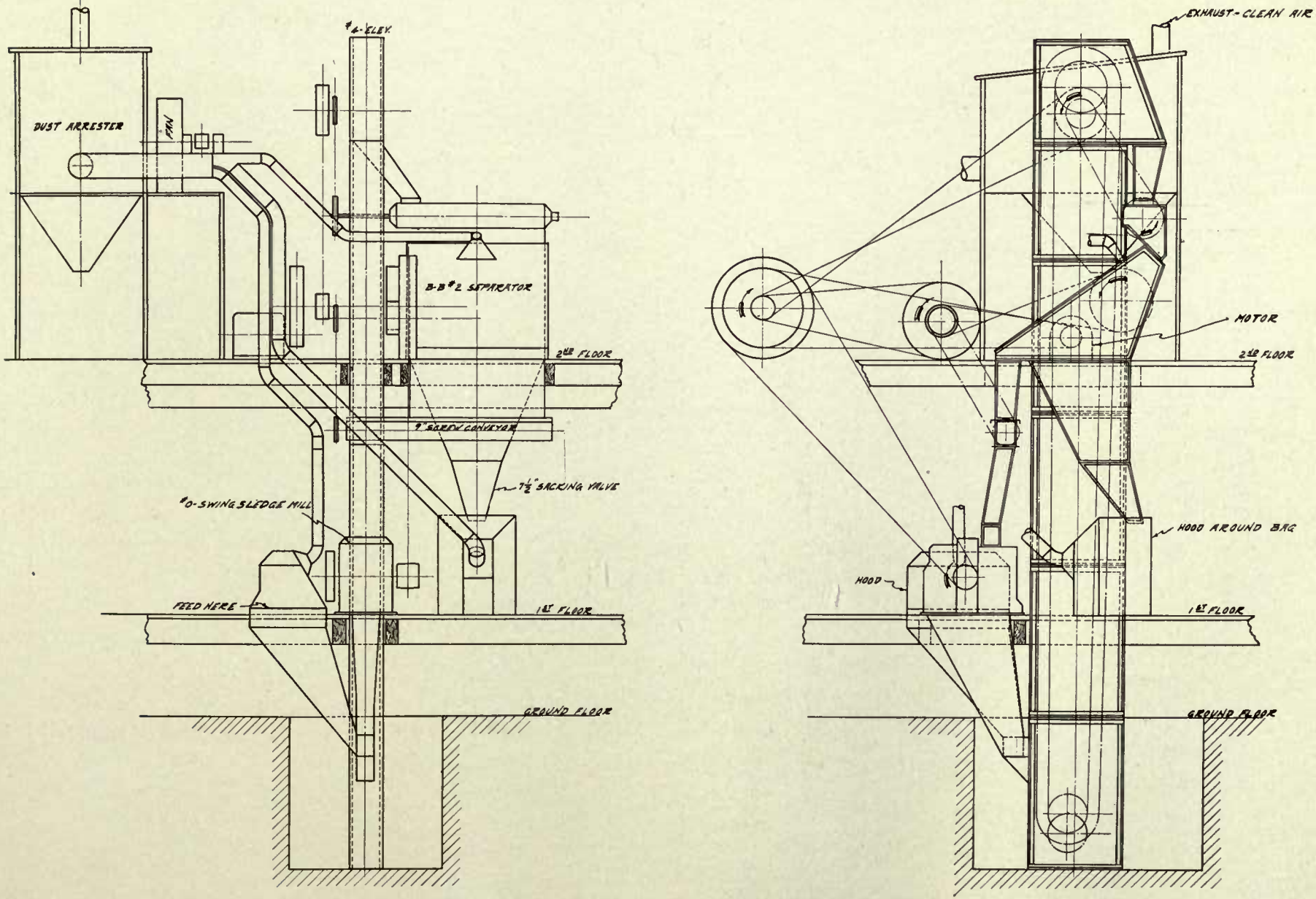
Sturtevant Combination Basing, Mixing, Shipping and Unloading Unit

Patented



Sturtevant Single Elevator Mixing and Shipping Unit

Patented



Sturtevant Bone or Tankage Grinding Unit with Dust Collecting System

These are simple machines, largely used, but when of poor design and construction are a source of much trouble and expense. The Sturtevant Elevator, however, need cause no worry.

These Elevators are made for service — every part is designed for continuous operation and to give no trouble. But if, by abuse, clogging or breakage occurs, their accessibility will prove a time and labor saver, for it makes replacements and clean outs quick and easy. Being all steel, of "Open Door" construction one man in one minute can open any door, without the use of tools and immediately get at all important parts. Self-contained, complete, ready to set up when received; big accessible discharge with fixed spill board; split head, heavy gears and pinions, ample shafts, with self-aligning ball and socket bearings, together with automatic spring relief take-ups for quick, accurate and fool-proof adjustment, make the Sturtevant "Open Door" one-man, one minute Elevators unequalled. All parts are made to jig and replacements fit.

Chain or Belt: Centrifugal, Continuous or Perfect Discharge Types, with steel or wood casings.

Sturtevant Open Door Elevators

DIMENSIONS

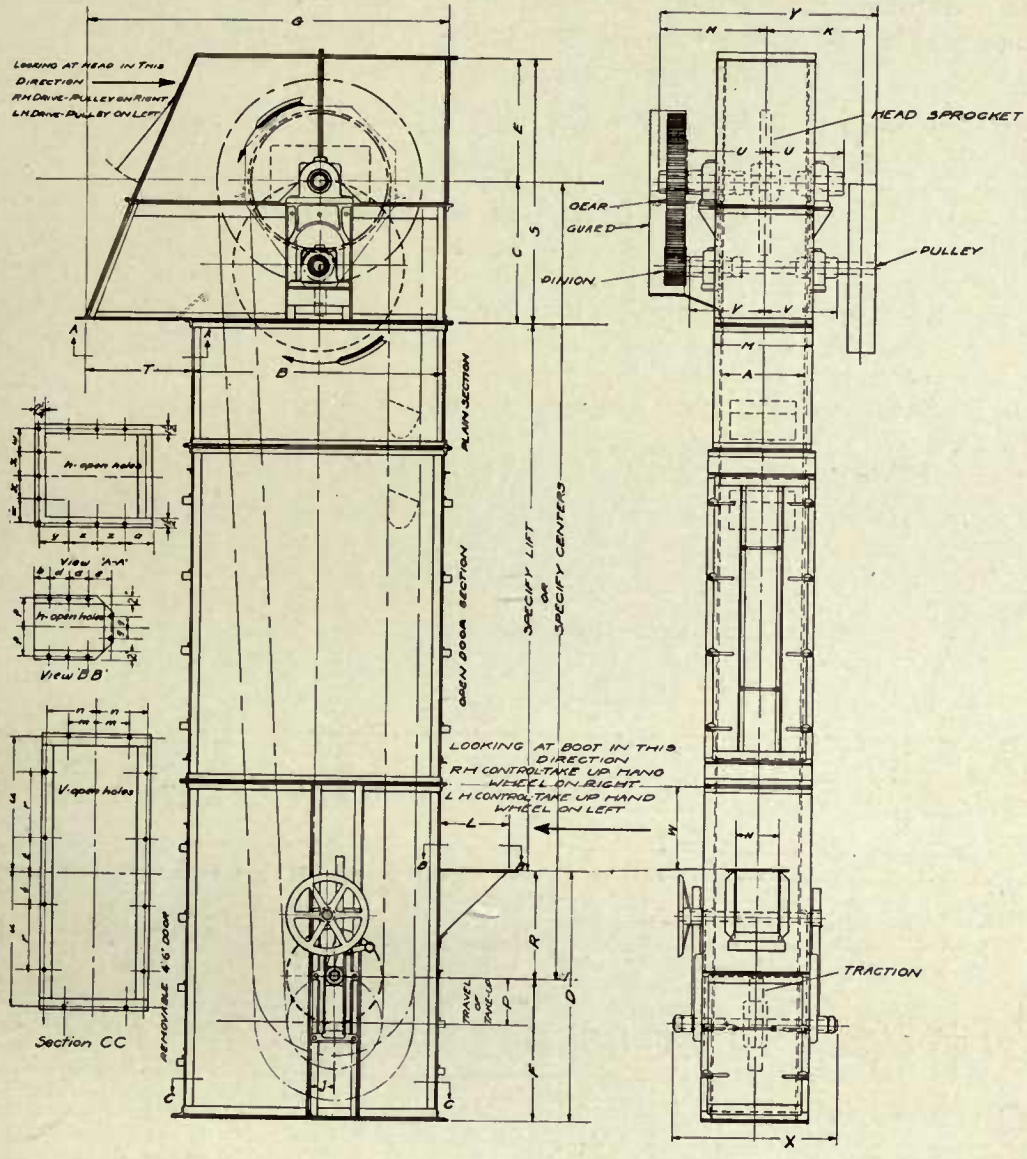
NO.	SIZE	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S	T	U	V	W	X	Y	W+C
2-3	12 x 42	12"	42"	2'-1"	3'-8"	1'-9"	2'-2"	5'-0"	1'-6¼	3¼"	1'-6"	12"	15"	5"	8"	1'-6"	3'-10"	1'-6"	14"	11½"	2'-4¼"	2'-4"	3'-3½"	4'-5¼"
4	15 x 44	15"	44"	2'-3"	4'-0"	1'-10"	2'-5"	5'-3"	1'-9"	3⅛"	1'-8"	12"	18"	8"	8"	1'-9"	4'-1"	1'-7"	15¾"	13¼"	2'-0¼"	2'-8"	3'-8¼"	4'-3¼"
5-6	18 x 54	18"	54"	2'-6"	4'-6"	2'-3"	2'-7"	6'-5"	1'-11½"	5"	1'-11½"	15"	21"	10"	10"	1'-11"	4'-9"	1'-11"	17¼"	15 11/16"	1'-6¼"	2'-11¼"	4'-3"	4'-0¼"
7	23 x 54	23"	54"	2'-9"	4'-6"	2'-3"	2'-7"	6'-8"	2'-4¼"	5"	2'-2½"	15"	27"	15"	10"	1'-11"	6'-0"	2'-2"	21"	18¼"	1'-6¾"	3'-4"	4'-10¾"	4'-3¼"

OPENINGS

NO.	a	b	d	e	f	g	h	m	n	r	t	u	v	w	x	y	z
2-3	4½"	2 5/8"	3½"	3½"	3 5/8"	0	7/16"	4¼"	7½"	15"	0	1'-10½"	⅞"	1⅞"	5"	5"	5"
4	5½"	2 11/16"	3½"	3½"	5 5/16"	1½"	7/16"	5"	9"	15"	0	1'-11⅝"	⅞"	4 3/16"	4 3/16"	5"	5"
5-6	6"	3 1/16"	4"	5¼"	6 5/16"	2½"	7/16"	7½"	10½"	14"	7"	2'-4 5/8"	⅞"	4 15/16"	4 15/16"	6 5/8"	6"
7	5 7/8"	3 1/16"	4"	5¼"	7 13/16	2 13/16	7/16"	9"	13"	14"	7"	2'-4 5/8"	⅞"	6 3/8"	6¼"	7 5/8"	7"

ELV. NO.	SHAFTS			GEAR				PINION					RATIO	HEAD SPROCKET				TAIL SPROCKET OR TRACTION			
	HEAD	DRIVE	BOOT	P.D.	FACE	PITCH	TYPE	MAT'L.	P.D.	FACE	PITCH	TYPE	MAT'L		P.D.	NO.	TEETH	TYPE	P.D.	NO.	TEETH	TYPE
2	2 7/16"	1 15/16"	1 15/16"	23.22"	2½"	1"	CAST	C.I.	5.73"	3"	1"	CAST	C.I.	4 to 1	24¼"	188	29	SPLIT	18½"	188	22	SPLIT
3	2 7/16"	1 15/16"	1 15/16"	23.22"	2½"	1"	"	"	5.73"	3"	1"	"	"	"	24¼"	188	29	"	18½"	188	22	"
4	2 15/16"	1 15/16"	1 15/16"	23.22"	3½"	1"	"	"	5.73"	4"	1"	"	"	"	24¼"	102	19	"	18"	102	14	"
5	2 15/16"	2 7/16"	2 7/16"	29.12"	4"	1½"	"	"	7.21"	4½"	1½"	"	"	"	30¼"	111	20	"	21¼"	111	14	"
6	2 15/16"	2 7/16"	2 7/16"	29.12"	4"	1½"	"	"	7.21"	4½"	1½"	"	"	"	30¼"	111	20	"	21¼"	111	14	"
7	3 7/16"	2 7/16"	2 7/16"	34."	5"	1¾"	"	"	8.4"	5½"	1¾"	"	"	"	29½"	132	15	"	19¾"	132	10	"
8	3 7/16"	2 7/16"	2 7/16"	34."	5"	1¾"	"	"	8.4"	5½"	1¾"	"	"	"	30¼"	102	24	"	20½"	102	16	"

ELV. NO.	BUCKETS	SPACING	CHAIN	DRIVE PULLEY UNDER 30' CTRS.	DRIVE PULLEY 30'-60' CTRS.	DRIVE SHAFT R.P.M.	CHAIN SPEED FT. per MIN	CAPACITY IN TONS PER HOUR AT LISTED SPEED			HP to 30' CTRS. 90 LB. MAT	HP to 60' CTRS. 90 LB. MAT.	WEIGHT 24' CTR'S.	WEIGHT PER FOOT
								40 LB. MAT.	50 LB. MAT.	90 LB. MAT.				
2	6×4"	16"	#188 K.2. - 6th	24"×4"	24×6	150	232	4½	5½	10	.7	1.4	2700	60
3	8×5"	16"	" "	24"×4"	24×6	150	232	8½	10½	19	1.0	2.0	2800	65
4	10×6"	16"	102 K.2. 4th.	24×6"	24×6	150	232	16½	20½	37	1.8	3.6	3600	75
5	12×7"	19"	111 K.2. "	36×6"	36×8	142	274	26½	33	60	3.2	6.4	4900	98
6	14×7"	19"	" "	36×6"	36×8	142	274	31	38	70	3.6	7.2	4950	100
7	18×8"	18"	132 K.2. 3d	36×6"	36×8	142	274	56	70	125	6.2	12.4	5850	130
8	18×8"	20"	2 strand 102 K.2. 6th	36×6"	36×8	142	274	50	63	110	6.2	12.4	5900	135



Sturtevant Open Door Elevators

Patented—Patents Pending

Fertilizer Screens need the "kick of a Broncho" to successfully handle poorly conditioned fertilizer ingredients. If the Screen fails to function, the whole Unit becomes inefficient and a tax on production and accuracy.

The Screen surface in "BB" Separators is 5′ wide by 8′ long, of 2, 2½, 3 or 4 mesh cloth, set at a 35 degree angle in a tightly sealed steel box of "Open Door" quick accessibility.

Its clothing needs no frame. It is oblong, the corners cut square, and is flatly laid on an inclined, open-rodded table-top, through which any screenable substance will drop. The clothing is secured between two opposite Sturtevant Pincher grips that never let go, nor tear; and the clothing is released quickly for removal.

This table-top saddle, which carries the screen cloth and its load, and shakes both, is formed of parallel, inclined, longitudinal rods, between which any substance passing the fine clothing, freely flows.

Upon this table-top saddle the screen clothing is laid, without tensioning.

The table, and its clothing, and its load of material, is vibrated by the cams below the Broncho Saddle; every moving part is composed of springy steel, hot riveted to this pony's elastic ribs.

The channels that shelter the cams are of bent elastic steel, of ample size, and are actuated by the hard, sturdy, simple cams. These cams produce sharp and violent jars and slams, in numerous directions, that clean the meshes. The name "Broncho" indicates that few things can stick to this Arizona "Bucker."

The table-top with its clothing receives its load to be screened, shakes its load, slaps and slams the wire clothing, which is untouched by other parts. Therefore this screen's meshes last, because this table-top does all the work.

Observe that screen meshes on the Broncho can never sag, because they are slammed flat on the table-top against closely spaced supporting wires, and can go no farther down. The Screen's clothing is here, always supported, and is stronger than any unsupported screen clothing can be.

There are no screen frames to bother with. The clothing is simply cut to proper length and rolled for quick transport.

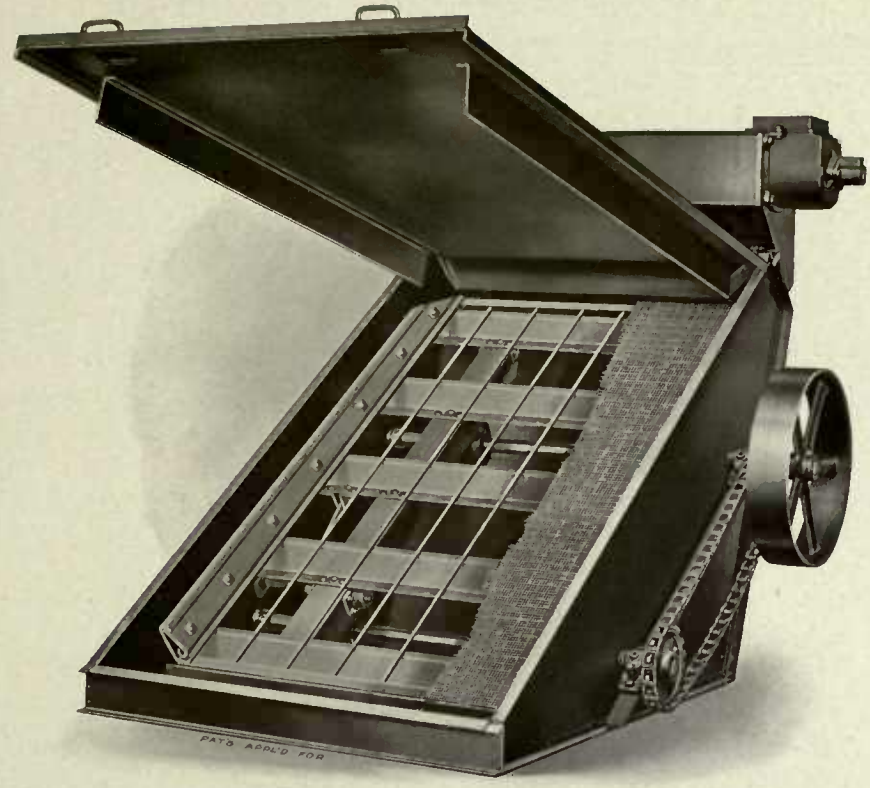
All repairs are small, and wire clothing is made less expensive than in any other screen, because no frames are fitted or attached. Frames in this screen have no usefulness whatever.

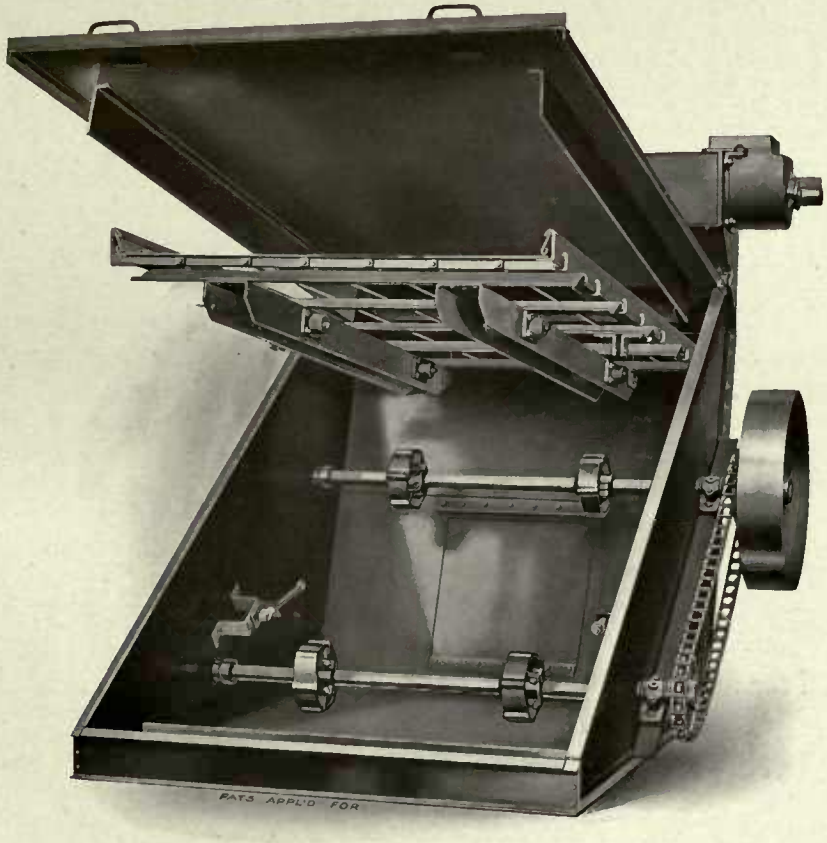
Every part is made of Steel, as elastic as a bow and as strong as a beam, its cams protected, its heavy wire clothing supported, in fact it has proven a revelation to fertilizer manufacturers for durability, efficiency and capacity.

SPECIFICATIONS

No. of Mach.	Style of Feeder	Approx. Depth with Cover Closed	Approx. Depth with Cover Raised	Approx. Width	Approx. Height	Driving Pulley	Driving Pulley Speed	Screen Surface	Approx. Weight (lbs.)	Approx. Weight Crated for Export (lbs.)
0	Conveyor	7′–00″	8′–8″	5′–9″	6′–4″	18″–4″*	110 r.p.m.	18 sq. ft.	1200	1600
	Chute	9′–6″	9′–6″	4′–9″	12′–6″	24″x4″	35 "	18 "	1500	2000
	Spout Feed Box	6′–11″	8′–00″	4′–9″	5′–2″	24″x4″	35 "	18 "	1000	1200
1	Conveyor	6′–11″	8′–8″	7′–7″	6′–4″	18″x4″†	110 "	30 "	2000	2500
	Chute	9′–6″	9′–6″	6′–10″	12′–6″	30″x6″	35 "	30 "	2200	2800
	Spout Feed Box	6′–11″	8′–00″	6′–10″	5′–2″	30″x6″	35 "	30 "	1600	1900
2	Conveyor	8′–5″	10′–6″	7′–7″	7′–3″	18″x4″†	110 "	40 "	2400	2900
	Chute	11′–00″	11′–0″	6′–10″	14′–7″	30″x6″	35 "	40 "	2500	3100
	Spout Feed Box	8′–5″	9′–8″	6′–10″	6′–2″	30″x6″	35 "	40 "	2000	2300

*Also requires 24″x4″ Pulley on Cam Shaft at 35 r.p.m.
†Also requires 30″x6″ Pulley on Cam Shaft at 35 r.p.m.





Sturtevant Open Door "Bucking Broncho" (BB) Screen

Patents Pending

This Mixer differs from all others in several important features: —

It has only one opening for receiving and discharging its batch; therefore only one opening to seal against the escape of dust instead of two, as in other Mixers.

A large, man sized "Open Door" in the other end allows quick and easy accessibility for cleaning, inspection or replacement of parts.

The material being mixed has no fixed line of travel (in one end and out of the other) allowing the fine, light ingredients to remain on top and unmixed. The narrow, large diameter drum, with its paddles and deflectors, forces quick and intimate mixing, and allows no separation of the ingredients.

The steel drum is supported on roller wheels, fixed to the steel channel bed. A gear on each end driven by pinions revolves it in perfect alignment.

The intake and discharge spouts or scoops are attached to the same slide. When filling the Mixer a lever places the intake spout into the receiving position; reversing this lever brings the exit scoop in place for completely discharging the machine.

One half minute is sufficient time for mixing.

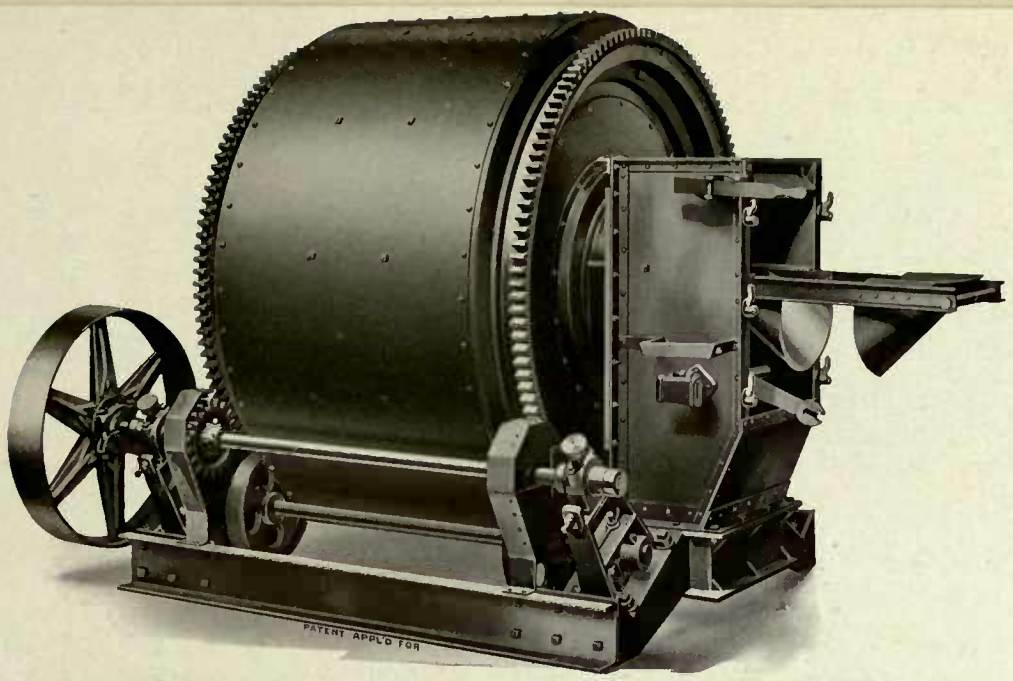
This is the only Mixer which can be cleaned easily, thus preventing material from caking within the drum while the machine is idle, and this, if allowed to remain in the machine, will be discharged with the first batch when starting again, and if this entire batch is not thrown away or remilled these hard cakes will get into the bags, break the farmers' drills, and often cause the loss of a good customer.

Every Mixer should be thoroughly cleaned at noon and at night, thus eliminating this source of trouble.

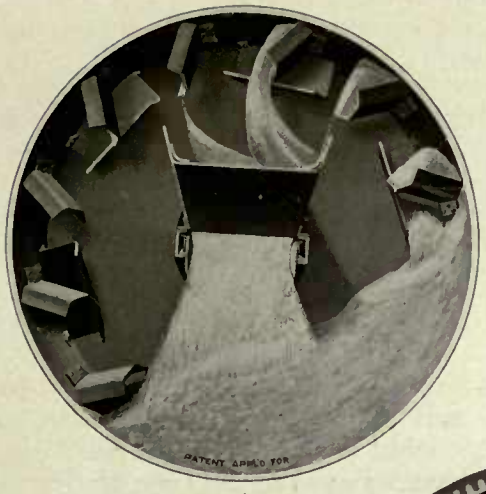
Ten minutes is ample to clean out the Sturtevant Mixer.

SPECIFICATIONS

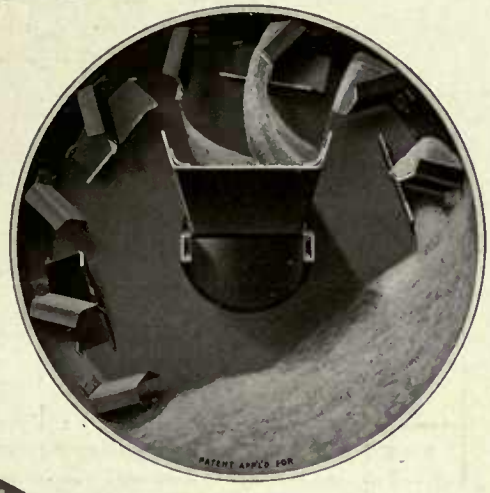
Size Batch	Drum Mixing Capacity	Drum Capacity	Height with Hopper	Length with Hopper	Height without Hopper	Length without Hopper	Width	Pulley	Speed	Power	Capacity Tons per Hr.	Weight with Hopper	Weight without Hopper	Code Word
¼ ton	13 cu. ft.	25 cu. ft.	8′ 0″	7′ 6″	5′ 0″	5′ 4¾″	5′ 0¾″	24 x 4	120	3 to 5	4 to 5	2900	2660	Quarton
½ ton	27 cu. ft.	54 cu. ft.	12′ 0″	10′ 5″	5′ 8″	6′ 6″	6′ 9″	30 x 6	100	4 to 7	10 to 12	4100	3500	Halfton
1 ton	60 cu. ft.	116 cu. ft.	12′ 0″	12′ 0″	7′ 1″	8′ 10″	7′ 11″	36 x 8	75	5 to 10	20 to 30	6265	5700	Tonmix
2 ton	125 cu. ft.	246 cu. ft.	——	——	9′ 3″	10′ 3″	10′ 7″	36 x 8	100	10 to 12	50 to 60	——	11500	Twoton



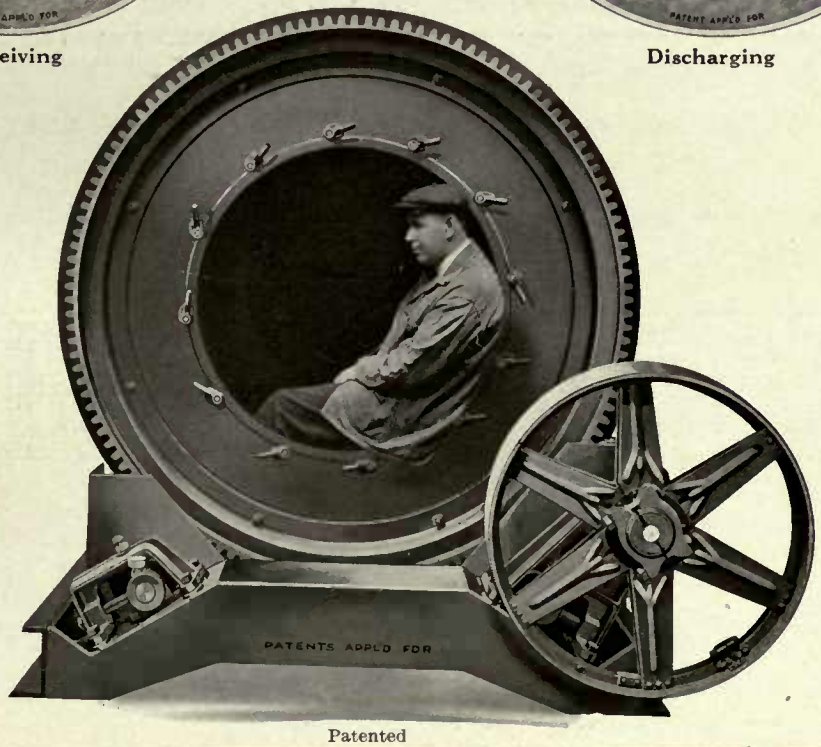
Sturtevant Open Door Mixer



Receiving



Discharging



Patented

OPEN DOOR HINGED HAMMER PULVERIZER

Pulverizing Dry Fertilizer materials is not difficult, but when damp or green goods are encountered or when tramp iron enters the machine every one expects trouble.

To minimize these irritating and expensive delays and for ease in replacing wearing parts, the Sturtevant Pulverizer was invented.

Its "Open Door" does not prevent trouble, but such complete accessibility allows instant cleaning and the removal of uncrushable substances, also quick and easy replacement of parts.

Its flexibly mounted hammers are hard to break because they give back in relief when iron is encountered, thus preventing serious breaks or expensive repairs.

Its big receiving and discharge openings do not invite clogging, in fact it is a difficult material indeed that causes trouble with this Pulverizer.

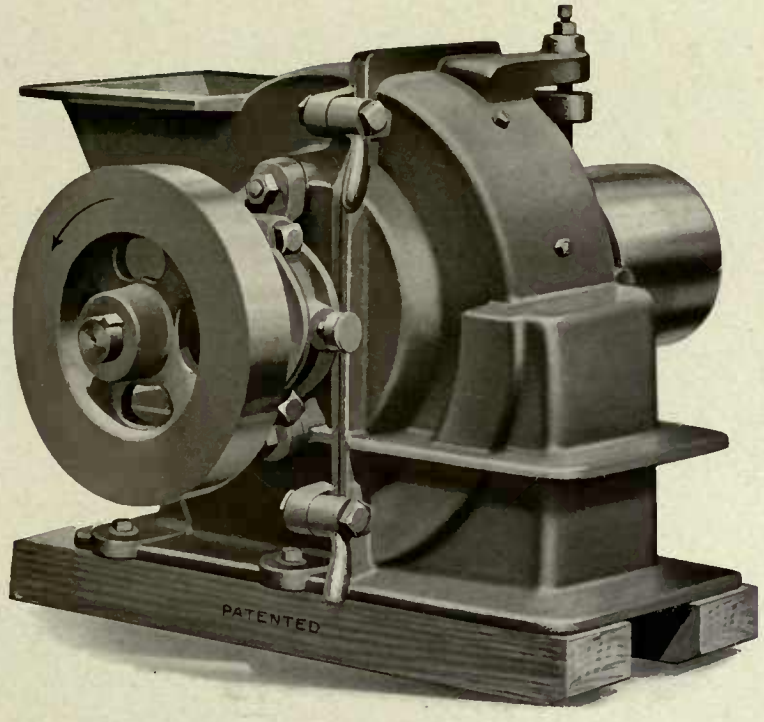
Five Horse Power is usually sufficient to operate it on the easy running, self aligning Hyatt Roller Bearings, yet the terrific blows of the hammers shatter and reduce to atoms any grindable substance.

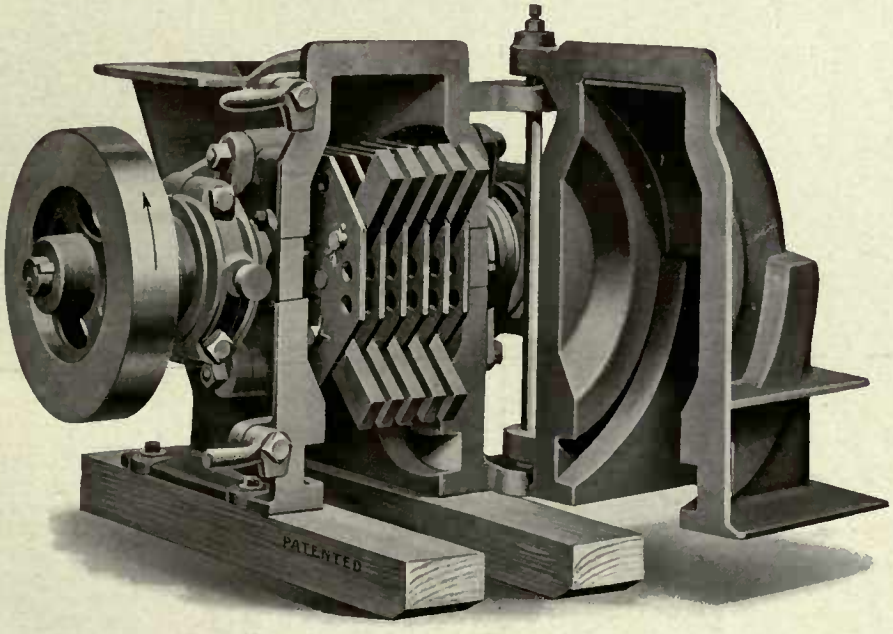
When unground tankage or similar materials are being pulverized, sizing grates are placed around the bottom of the casing, but when used as a tailings grinder only, no grates are necessary or desirable.

SPECIFICATIONS

No. of Mill	Length Over All Door Closed	Length Over All Door Open	Width Over All	Height Over All	Inside		Feed Opening *	Driving Pulley	Pulley Speed	Approx. H. P.	Approx. Weight Net	Approx. Weight Gross	Code Word
					Dia.	Width							
0	3′, 7″	4′, 4″	4′, 2″	2′, 6″	24″	9″	12½″ x 12″	12″ x 8″	1000 to 1200	5 to 15	1700	2000	Ohinge
1	3′, 7″	4′, 8″	4′, 10″	2′, 6″	24″	18″	12½″ x 18″	12″ x 8″	1000 to 1200	10 to 20	2300	2600	Wihinge

* Does not mean size material machine will take





Sturtevant Open Door Hinged Hammer Pulverizer

Patented

Automatic Scales when used on Acid Phosphate and Complete Fertilizer, in some cases, work efficiently, but in most plants are a constant source of trouble, owing to the difficulty in securing an even flow of material into the Scale, upon which its accuracy absolutely depends; therefore the manually operated and simple Scales are shown and recommended.

Automatic Scales are particularly well adapted to weighing Rock Dust, if small, steep sided bins are used, with a constant head of dust, thus preventing bridging and clogging and insuring an even, constant flow of dust into the Scale. Acid may also be accurately weighed automatically.

The Sacking Scales used on Sturtevant Units combine a Bag Holder and Valve, which, being self contained, are bolted directly to the hopper.

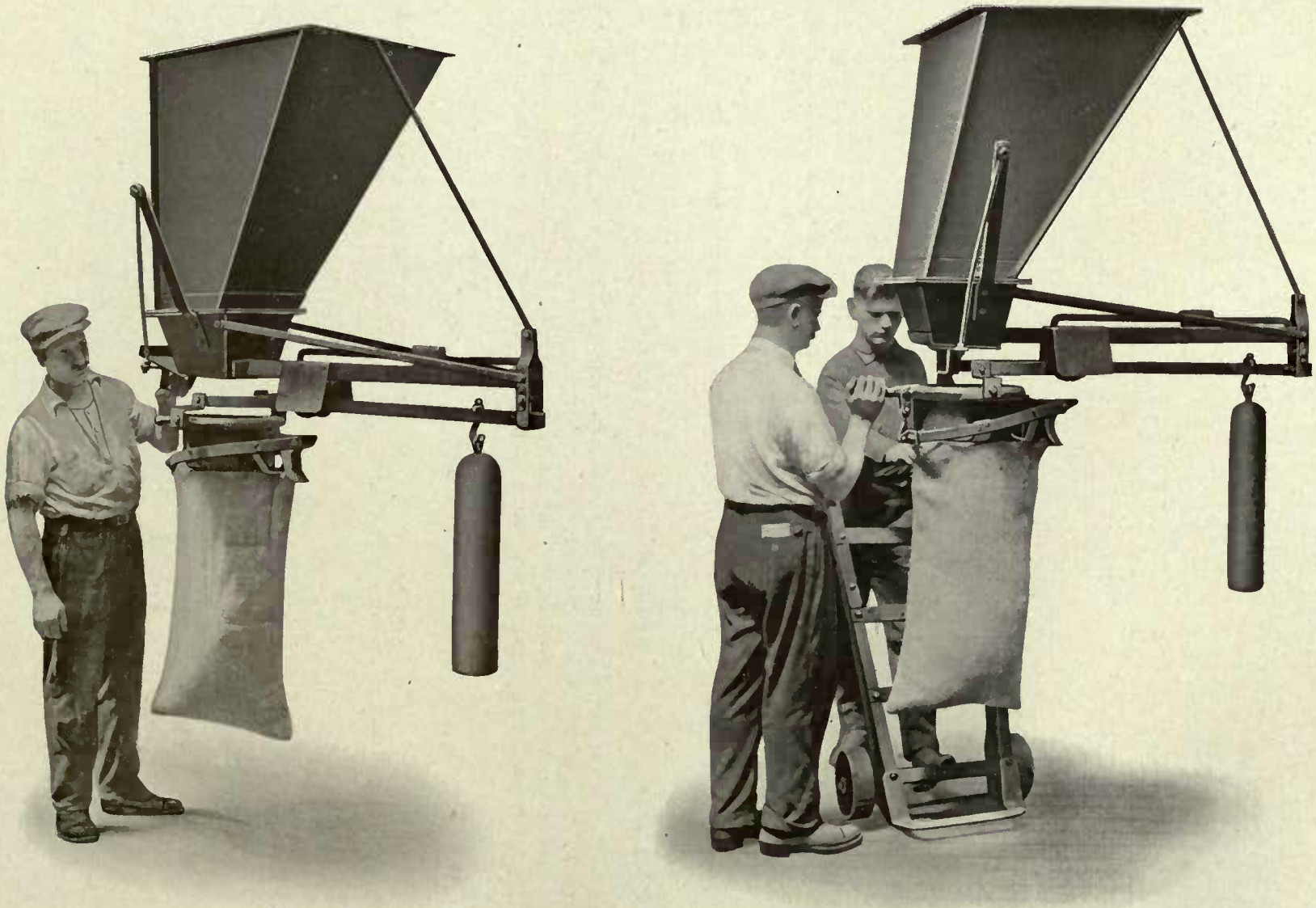
With no legs or floor supports the space around the bag is free from obstructions which hinder the truckers.

The Scale is made on the steelyard principle, the Bag Holder on one end of the single lever and a counterweight on the other end. The bag holder chutes the discharged material from the Hopper Valve directly into the bags. The bag-holding mechanism has a powerful grip to prevent slip, yet will not tear the bags, and releases quickly.

The valve is a single undercut gate, easily operated by a lever, which has proven the most efficient type for fertilizer.

The Scale will weigh accurately when different sizes of bags are used, by adjusting the counterweight.

The shape of the Bag Holder permits an open space in front of the operator, at the top of the bag, through which he can trim the filled bag, if necessary. Five to six bags per minute can be accurately weighed.



Sturtevant Fertilizer Sacking Scales

Under the heading of Phosphate Rock Grinding we have advocated the use of Air Separators instead of Screens, but we are in a position to supply the best of either at the customer's option, and herein illustrate the Open Door Super Screen of Unit construction, which has a range of output from ¼" to 100 mesh.

Screens are generally recommended for products coarser than 60 mesh, and are very efficient up to that point; finer than 60 mesh we frankly prefer Air Separators for most materials.

Sturtevant Super-Screens are built on the Newaygo principle, and are largely used throughout the world as standard equipment.

The Screen wire is stretched taut on small Unit frames, set at an angle of between 35° and 45°, therefore a comparatively coarse mesh delivers a fine product and greatly increases the life of Screen Clothing.

The frames (not the wire) are tapped by hundreds of hammer blows, which transmit the vibration to the screen wire, thus keeping the meshes open and producing maximum capacity.

The feed is either by Screw Conveyor and adjustable feed board, or by baffled chute. The discharge is arranged for Screw or Belt Conveyor, gravity, or a combination of both. Small, accessible Units are bolted together to make a Screen of any practical size, yet all parts are comparatively small and easily handled.

The Open Door construction gives instant accessibility, and it is the work of a few minutes only to replace screen frames, brush clothing or to inspect. No Screen compares with it for effectiveness, simplicity, durability or convenience.

One, two or three accurately sized products may be screened at the same time by one separator.

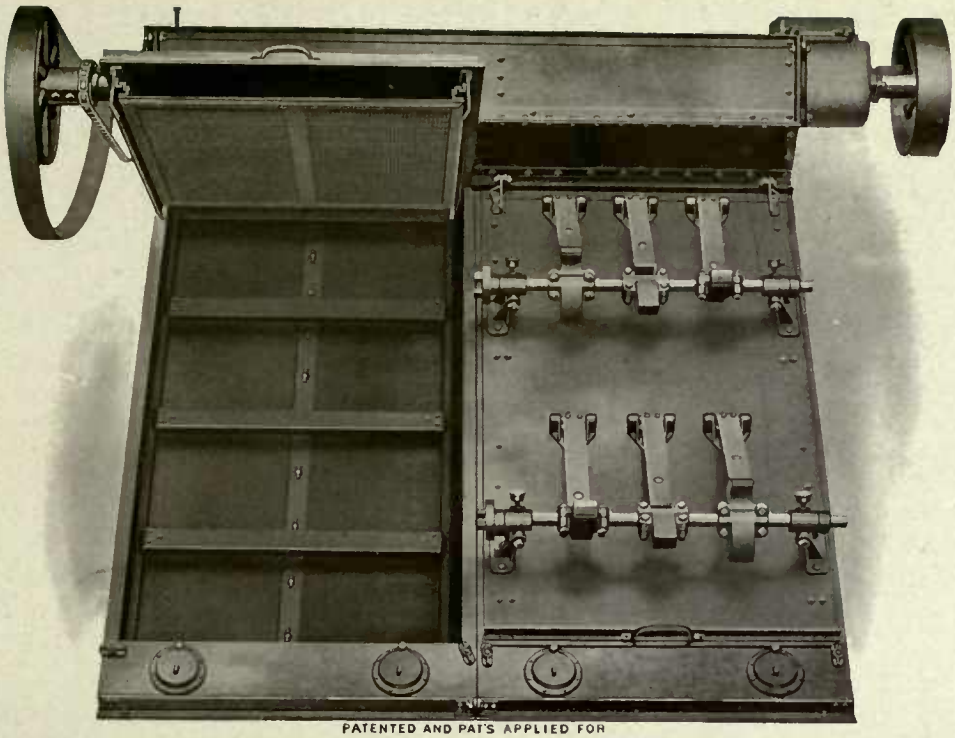
Approximate Capacities, Etc., to Various Finenesses

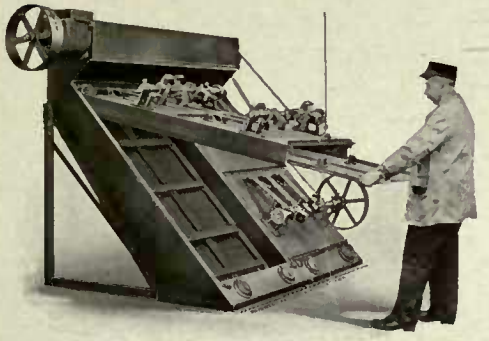
*To ascertain the capacity of any number, or combination of units, multiply the capacity of a one-unit screen by the number of units in battery.

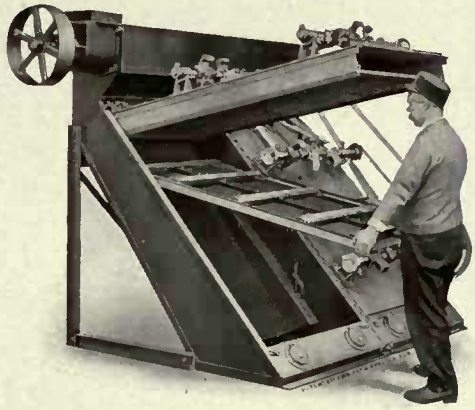
Cloth Mesh	Diameter of Wire	Opening	Approximate Mesh of Product	Capacity Approx. lbs. per hour 1 Unit* Separator	Cloth Mesh	Diameter of Wire	Opening	Approximate Mesh of Product	Capacity Approx. lbs. per hour 1 Unit*
2	.120	.380	4	14000	22	.017	.0285	45	6000
3	.092	.241	6	13000	24	.015	.0267	50	5500
4	.080	.170	8	12000	26	.015	.0235	55	5000
5	.072	.128	10	11250	30	.0135	.0198	60	4000
6	.047	.120	12	10500	35	.013	.0156	70	3500
7	.054	.089	14	9500	40	.011	.0140	80	2500
8	.047	.078	16	9000	50	.009	.0110	90	1400
10	.035	.065	20	8750	60	.008	.0087	100	1000
12	.032	.051	24	8500	70	.007	.0073	120	800
14	.028	.043	28	8000	80	.00575	.0068	140	700
16	.023	.0395	30	7500	90	.00525	.0059	160	675
18	.020	.0356	35	7000	100	.0045	.0055	180	550
20	.018	.032	40	6500					

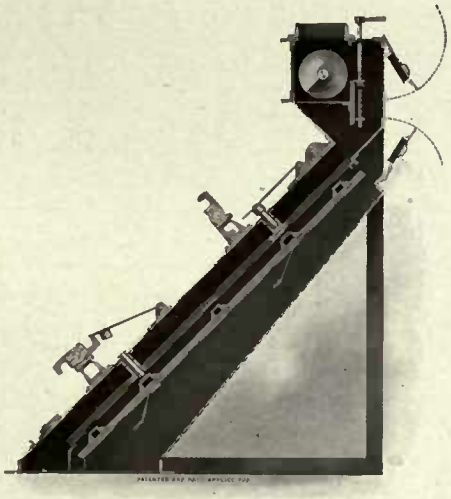
SPECIFICATIONS STYLE M. "SUPER-SCREEN"

No. of Units	Approx. Depth Over All	Approx. Width Over All	Approx. Height Over All	Driv'g Pulley	Driv'g Pulley Speed	Screening Surface sq. ft.	Approx. Weight lbs. Net	Approx. Weight lbs. Gross for Export	Code Word with one Screening Surface No Scalper	Code Word with one Screening Surface and Scalper	Code Word with two Screening Surfaces No Scalper	Code Word with two Screening Surfaces and Scalper
1	70"	5' 10"	80"	18 x 4	110	18	1000	1400	Superone	Twoperone	Twovribone	Threperone
2	70"	9' 2"	80"	18 x 4	110	36	1850	2600	Supertwo	Twopertwo	Twovribtwo	Threpertwo
3	70"	12' 7"	80"	18 x 4	110	54	2700	3050	Superthree	Twoperthre	Twovribthe	Threperthe
4	70"	17' 0"	80"	24 x 4	110	72	3775	4500	Superfour	Twoperfor	Twovribfor	Threperfor
5	70"	20' 2"	80"	24 x 4	110	90	4625	5525	Superfive	Twoperfive	Twovribfiv	Threperfiv
6	70"	23' 9"	80"	30 x 4	110	108	5475	6125	Supersix	Twopersix	Twovribsix	Threpersix









Sturtevant-Newaygo Super-Screens

Patented

With the exception of Florida Pebble Rock most other Phosphates require preliminary crushing to reduce the material to from one inch to one-half inch for the pulverizer.

We have shown the Swing Sledge Mill for this purpose, at the beginning of this book, on account of its low head room and almost unlimited capacity, but, if preferred, the Rotary Crusher may be used with equal efficiency, in fact a great many are in use both in this country and abroad.

The Rotary Crusher is a slow speed, durable machine of Open Door, one man, one minute accessibility. It will reduce large pieces of phosphate rock to any size between 1″ and ¼″, requires small power, has large capacity, is easily repaired, difficult to clog and makes an excellent preliminary machine.

It is really a massive Coffee Mill, crushing by gradual reduction between the heavy chilled iron nuts (revolving on a large vertical square shaft, at slow speed), and the durable liners which are bolted onto the inside casing. Raising or lowering the shaft regulates the size of product.

Its open door construction gives immediate access to the machine's interior, for replacements, inspection and the removal of tramp iron which often enters and stops the crusher.

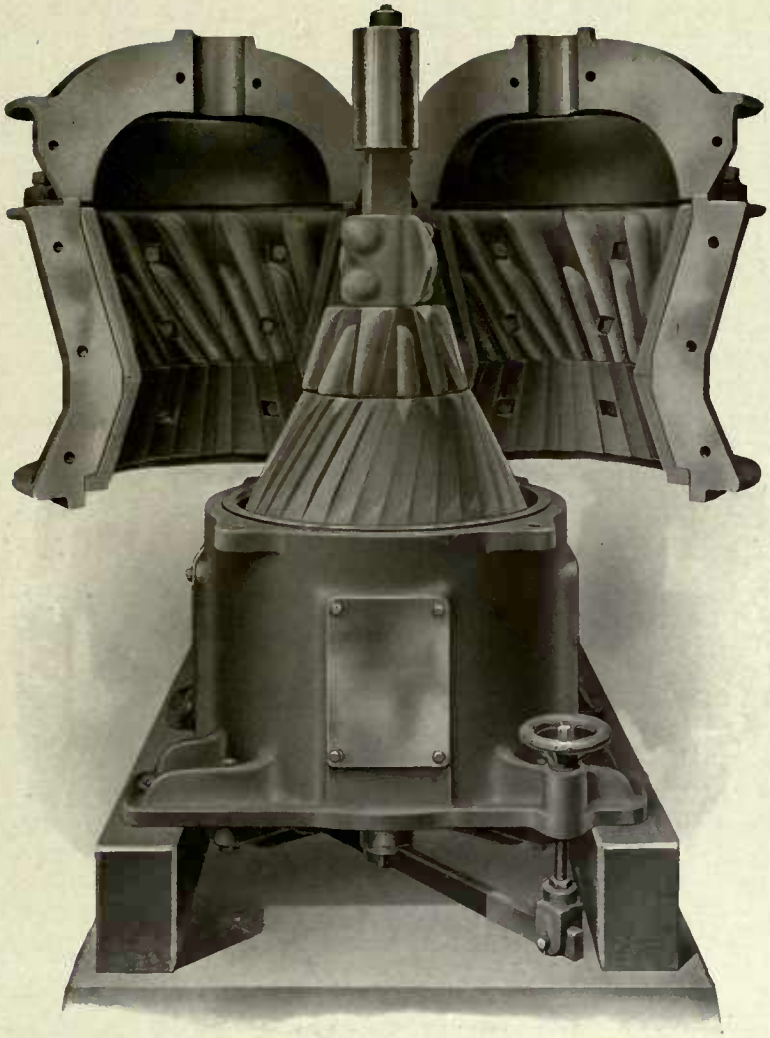
SPECIFICATIONS

Code Word	No.	†Hopper Opening	Approx. Cap. Tons per Hour ¼″ Setting	Approx. Horse Power	Speed Rev.	Pulley Diam. Face	Length	Width	Height	Approx. Weight Net lbs.	Approx. Weight Gross lbs.
Bial	00	6″ x 18″	1 to 1½	1 to 2	300	12 x 4	3′ 9″	2′ 5″	3′ 5″	900	1050
Bion	0	9″ x 18″	1 to 2	3 to 4	250	18 x 6	4′ 7″	2′ 4″	3′ 7″	1300	1600
Biacchi..	1	6″ x 19″	2 to 4	6 to 10	300	24 x 8	6′ 4″	3′ 6″	5′	4000	4700
Biante ..	1½	10″ x 28″	5 to 7	15	200	30 x 10	7′ 3″	3′ 6″	6′	6000	7000
Bistro...	2	19″ x 30″	8 to 10	15 to 20	250	30 x 12	8′ 8″	3′ 10″	7′ 1″	9000	10500

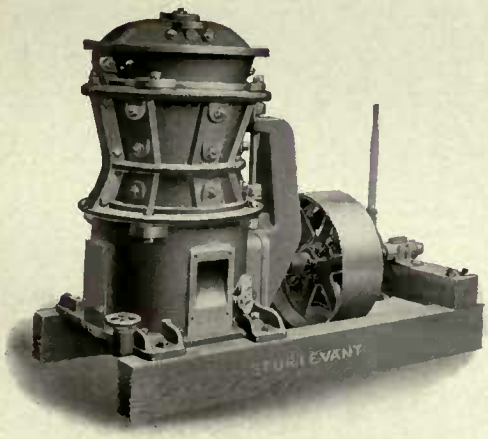
Subject to change without notice.

*Smallest dimension given means largest CUBES the crusher will take.
†These approximate dimensions do not mean the size rock the machine can grip.

The capacities are based on ¼″ setting and will necessarily vary according to the material being crushed, its friability, specific gravity, moisture content and size of feed.



Patented



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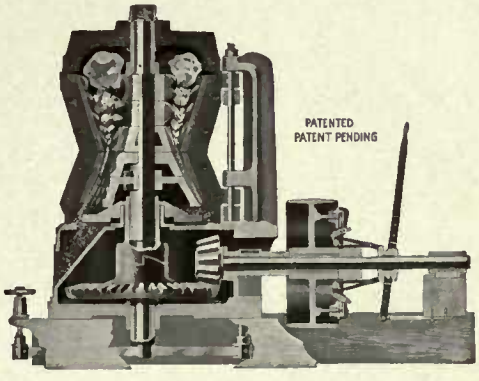


Sturtevant Open Door Rotary Crusher

This machine has been briefly illustrated and described, in the first part of the book, as a preliminary Crusher for Phosphate Rock; also a similar though lighter machine has been shown as a Tailings Mill, and known as the Hinged Hammer Pulverizer. In both cases the machines have easy work to perform, one doing coarse preliminary crushing, the other simply regrinding material which has already been pulverized, but which has become caked or lumpy, and has failed to pass the screen.

The Swing Sledge Mill, however, is strictly a heavy duty machine, carefully designed and massively constructed to operate at high speed and grind hard, tough, fibrous substances to a sufficient fineness to pass through a drill.

Bones, Tankage, Fish Scrap, Meat Cake, Cottonseed Cake, Shells, Limestone, etc., are some of the materials successfully pulverized in this machine.

As much tramp iron is encountered in most of these materials, the machine must have quick accessibility for removing same, as it cannot be ground and soon causes disaster if left in the system. The Open Door leaves little to be desired, for one man, in one minute, can open the door of the largest Mill, exposing its entire interior for the easy removal of tramp materials, for cleaning out, replacements, adjustments and inspection.

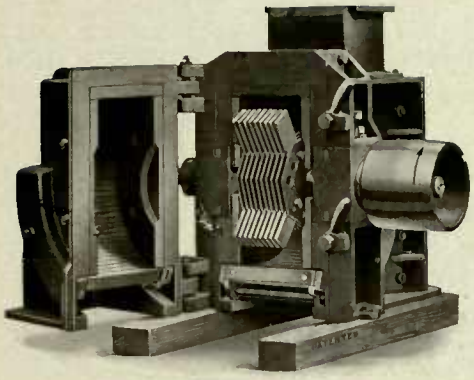
Many types of hammers are used for different work; they are flexibly mounted to give back in relief when uncrushable substances are encountered, thus eliminating much danger of breakage.

The mill runs easily on Hyatt Roller Bearings; the grate spacings at the bottom regulate the size of its product, but in some instances it is desirable to remove some of these bars to allow free discharge, and use an outside Screen for sizing, returning the oversize for further pulverizing.

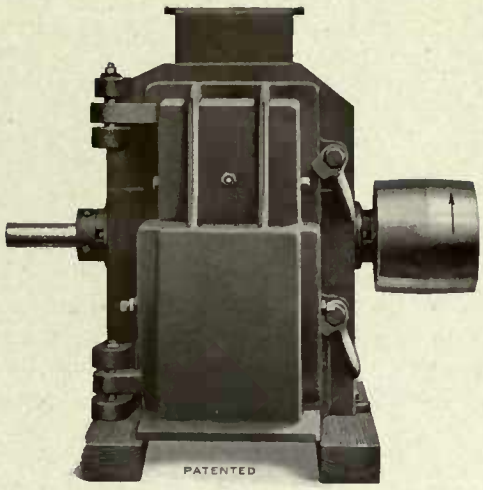
An illustration is shown on page 57 of a typical Bone Grinding Unit, incorporating this Swing Sledge Mill, Open Door Elevator, "BB" Screen and Dust Collecting System.

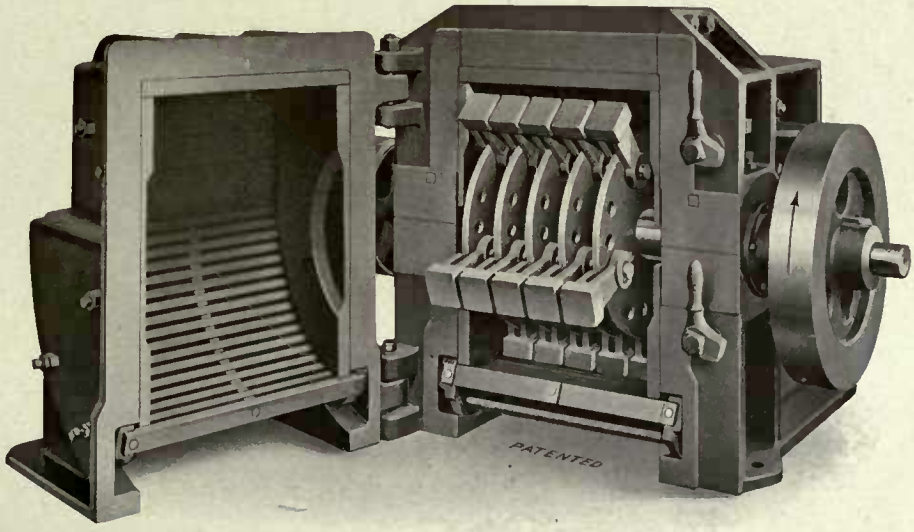
RENDERING PLANTS

Swing Sledge Mills can be very effectively employed in Rendering Plants. When equipped with hatchet hammers (that is, hammers sharpened on the edges like a hatchet) the mills can be used on butchers' refuse, green bone, meat, etc., to shred same into small pieces before cooking. Shredding before cooking increases recovery, also allows the bones to be made into meat cake. When equipped with plain bar hammers they can be used for grinding meat cake into meal, or for pulverizing tankage. An Elevator and Screen are used in connection with the Mill for sizing the meal, or tankage.



No. 0 With Tool-Steel Bar Hammers





Sturtevant Swing Sledge Mill
For the Preliminary Crushing and Sizing of Lump Rock

SPECIFICATIONS—WITHOUT FEEDER

No. Mill	Length Over All Door Closed	Length Over All Door Open	Width Over All Door Closed	Width Over All Door Open	Height Over All	Inside		Feed Opening *	Driving Pulley	Pulley Speed	Approx. H. P.	Approx. Capacity Per Hour 10 Mesh	Approx. Weight Net	Approx. Weight Gross	Code Word
						Dia.	Width								
00	1′–11″	2′– 3½″	2′–6″	2′– 6″	1′–6″	12″	5″	6″ x 4¾″	6″ x 6½″	{ 2000 3000	6	250 lbs.	425	500	Oosledge
0	4′–0½″	4′–11½″	4′–1″	4′–3½″	3′–6″	24″	10″	12¾″ x 11″	12″ x 10½″	{ 1000 1200	12	1 to 2	3350	3700	Oswing
1	5′–1″	6′– 7½″	5′–5¼″	6′– 0⅝″	3′–8½″	30″	20″	17″ x 20½″	15″ x 12½″	{ 1200 1500	40	3 to 7	6300	7000	Oneswing
2	6′–0¼″	8′– 3″	7′–0″	8′–11⅜″	4′–5″	36″	30″	14¾″ x 2′ 6½″	20″ x 16½″	{ 1000 1200	80	8 to 15	12000	14000	Twoswing

*Does not mean size material machine will take

HAND FURNACES

For crushing Pyrites for either hand-charged or mechanical furnaces, the machines illustrated on the following page are especially adapted.

The Jaw Crusher is adjustable for 1½" or finer crushing, and delivers a product remarkably free from fines and dust.

It will take large, hard rocks of any size that the jaw opening permits, and will reduce them economically and rapidly to the required fineness for hand furnaces, or act as a preliminary crusher to be followed by Rolls, when a finer product is desired for mechanical furnaces.

These Crushers are made in several sizes to suit conditions, are of strong, rigid construction, the side castings are of steel, the jaw plates of Manganese Steel, the cam and roll of high carbon forgings, in fact they are strictly high grade in every respect and give excellent satisfaction.

Many of the largest mines in Spain are equipped with these machines and a large number are used in this country and abroad.

MECHANICAL FURNACES

Mechanical Furnaces require finer rock than do Hand Furnaces, it being necessary to reduce the Pyrites to approximately ⅜".

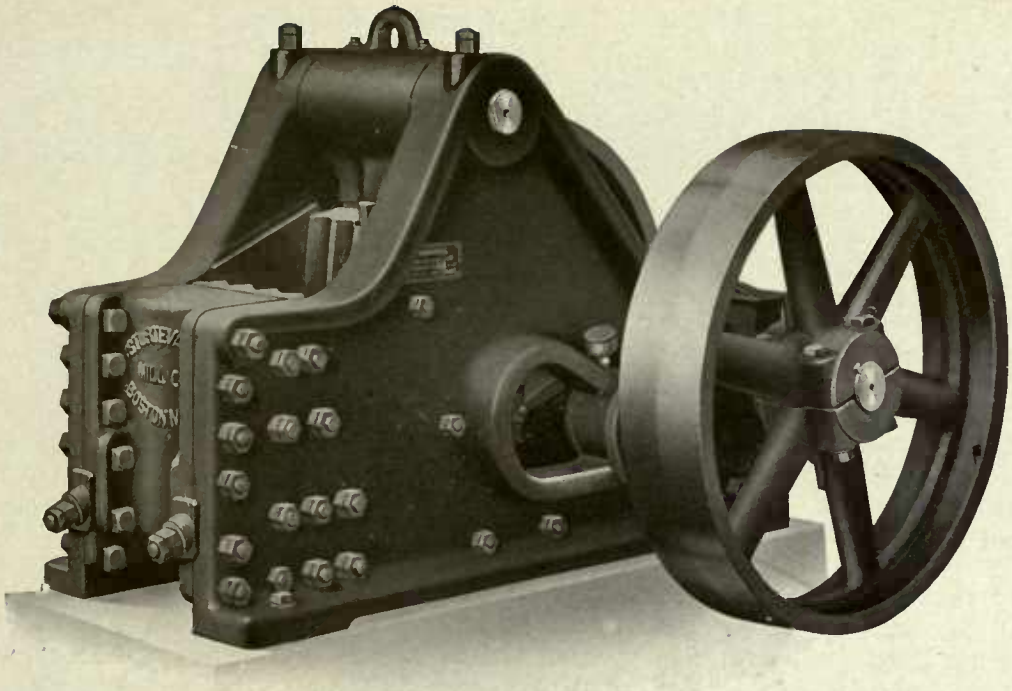
Therefore the Crusher, previously described, is used for the preliminary work, reducing the large rock to approximately 1¼" size, which is then of the proper fineness to feed to the Balanced Crushing Rolls, which complete the reduction to ⅜", finer or coarser as may be desired.

This makes a truly rugged plant of unusual reliability, rarely injured, even if tramp iron or other uncrushable substances enter the machines through error, and lasts many years.

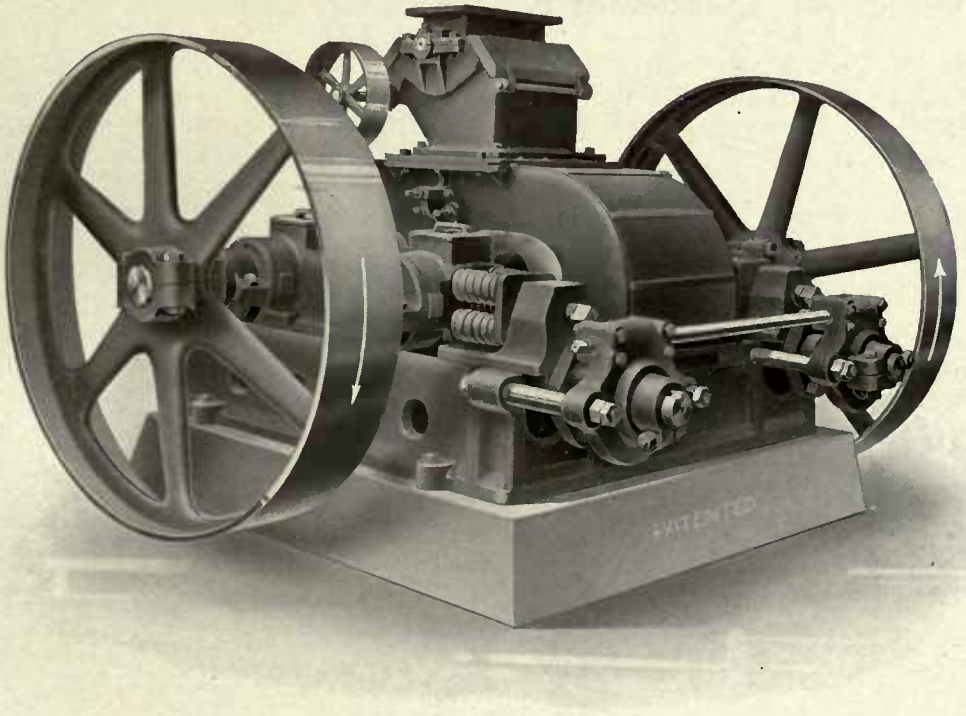
Strong springs are placed back of both shafts against car-box bearings giving the required amount of crushing pressure, and at the same time act as a spring safety valve to prevent breakage, should uncrushable material get between the roll tires. It is seen in these rolls, having equal spring pressure back of each bearing, that when one gives back in relief, all four are similarly affected, so that a perfect balance results, and the crushing shocks are only ¼ as great as in other mechanisms having springs back of two bearings only.

These machines are noted for their ability to withstand hard usage under trying conditions, and operate smoothly at small cost.

For Specifications see page 79



Sturtevant Jaw Crusher
Patented



Sturtevant Balanced Crushing Rolls
Patented

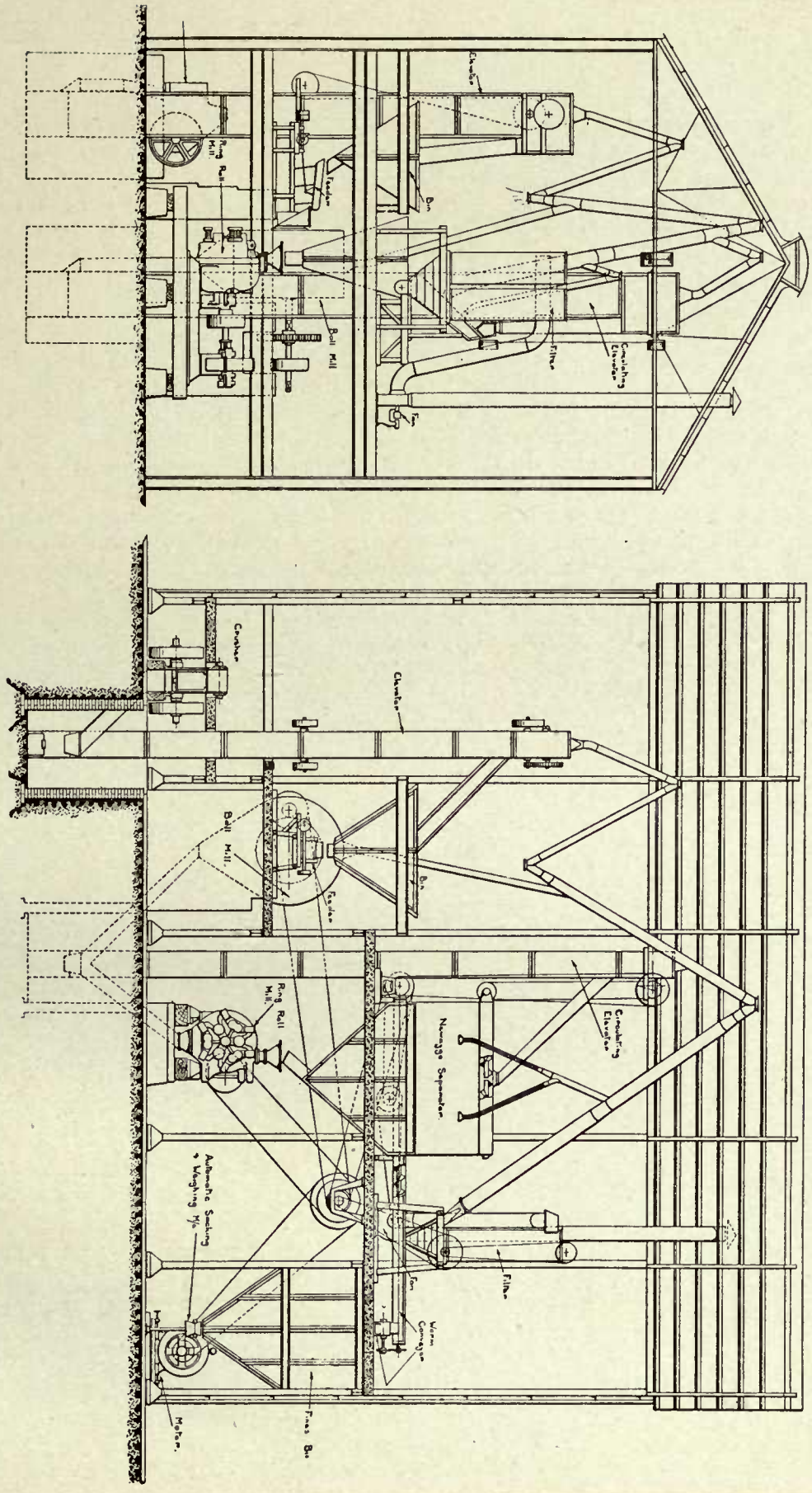
BASIC SLAG GRINDING PLANT

Comparatively few Basic Slag Grinding Plants are operated in this Country, although in Europe they are quite common in the Fertilizer industry.

We are prepared to design and equip such plants, and as this Slag contains much iron, particularly disastrous to ordinary machinery, it is essential to have a plant of proper design and construction, incorporating equipment that has proved economical and practical for such severe service.

A Slag grinding plant is herein illustrated and it will be noticed that the preliminary breaking is accomplished in a Jaw Crusher (reducing to 3 to 4 inch). This material is then elevated to a bin over a Ball Mill, fitted with a coarse screen (¼"), which is too fine for tramp iron to pass through and this is therefore retained in the Ball Mill until its accumulation requires removal. The ¼" slag passes to an Elevator, which discharges on a Newaygo Screen, where the fines are removed, and the oversize goes into a Ring-Roll Mill for further reduction. This Mill discharges into the same Elevator, carrying the material in a closed circuit, back to the same screen. This process continues until all the Slag is reduced to the proper fineness, and the finished product is removed by conveyor to the Bagging Hopper for sacking and shipment.

A dust Collecting System with filter is incorporated for cleanliness, and to prevent the abrasive dust from getting into the bearings of the machines.



Sturtevant Basic Slag Grinding Plant

While this material is not exactly a Fertilizer, but a soil sweetner, it is closely allied to the Fertilizer business, and a few words regarding the machinery employed for producing it may prove of interest.

There are two types of plants largely used for the purpose:

1st: The plant of large capacity and cheap production, using a Jaw Crusher, Ring-Roll Mill and Super Screens. Such a plant is very similar to that used for pulverizing Phosphate Rock, illustrated in the first part of this Book, but Screens are substituted in place of Air Separators, as the product, as a rule, need not be as fine.

Such a plant is the best and cheapest for large tonnages.

2nd: For small or medium size plants, where the investment is limited, a Jaw Crusher and Swing Sledge Mill, without other auxiliaries, give excellent results. Elevators, Bins, and Conveyors greatly add to plant efficiency, and are employed to advantage, should the capital available be sufficiently large to allow of such refinements.

Either of these plants may be of any capacity desired.

This is a subject that deserves especial attention, and should be treated at length to do it justice.

The Sturtevant Mill Company is in position to give details and quote figures for complete equipment, for any tonnage of ground limestone.

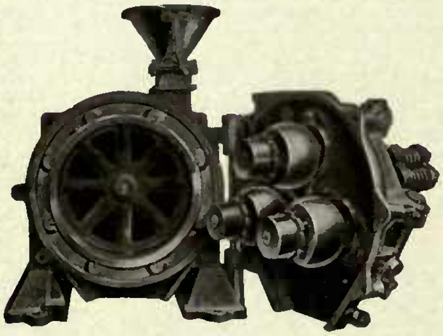
OUTPUTS OF SINGLE UNITS

Ring-Roll Mill Plant

No. 0 Ring Roll Mill to 20 mesh	2 to 3 tons per hour
No. 1 " " " " 20 "	3 " 5 " " "
No. 2 " " " " 20 "	7 " 10 " " "
No. 2 (Duplex)" " " 20 "	14 " 20 " " "

Swing-Sledge Mill Plant

No. 00 Swing Sledge Mill to 10 mesh	½ to 1 ton per hour
No. 0 " " " " 10 "	1 " 2 " " "
No. 1 " " " " 10 "	3 " 7 " " "
No. 2 " " " " 10 "	8 " 15 " " "

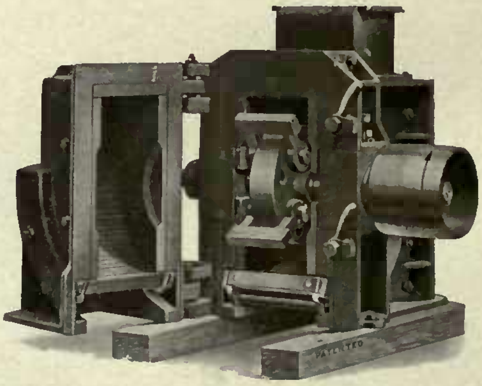


Patented

Sturtevant

Ring-Roll Mill

Swing-Sledge Mill



SPECIFICATIONS AND APPROXIMATE CAPACITIES, HORSE POWER AND WEIGHTS

Air Separators

Dia.	Approx. Capacity 95%, 100M	Approx. Horse Power	Pulley	Pulley Speed	Approx. Height Over All	Approx. Width Over All	Approx. Weight
4′	1 to 2 tons Per Hour	2 to 4	12″x4″	250–350	7′–7″	5′–0″	1500 lbs.
10′	6 to 8 tons Per Hour	5 to 8	24″x6″	350–400	14′–8½″	11′–6″	6100 lbs.
12′	8 to 12 tons Per Hour	8 to 10	24″x6″	400–500	16′–2½″	13′–6″	9000 lbs.

Ring-Roll Mills

Size	Code Word	Ring inch Dia. & Face	Rolls inch Dia. & Face	Pulley inch Dia. & Face	Pulley Speed Rev. per M.	Ring Speed Rev. per M.	Horse Power Approx.	Dimensions Over All Approximate Width	Length	Height	Approx. Net Weight lbs.	Approx. Gross Weight lbs.	Approx. Capacity tons per hour
No. 0	Ringbe	24 x 7	14 x 7	36 x 10	125	125	8 to 15	ft. in. 4 0 *6 4	ft. in. 10 1½ *11 3	ft. in. 4 6	7,000	8,000	Write for capacities, stating material and fineness desired. These requirements vary so that it is impossible to give them here. See next page.
No. 1	Ringo	33 x 7	14 x 7	30 x 8	320	80	18 to 25	5 3½ *8 10½	11 0 *12 7	5 11	13,000	14,000	
No. 2	Ringal	44 x 12	18 x 10	36 x 12	300	63	40 to 45	6 11 *10 6	13 5 *15 6	7 4	27,000	29,000	
No. 1 Duplex	Ringdu	33 x 7	14 x 7	30 x 12	375	80	35 to 50	6 0 †13 0	12 10 *15 8	6 2	21,000	24,000	
No. 2 Duplex	Ring-dex	44 x 12	18 x 10	42 x 20	325	64	80 to 90	7 8 †15 3	16 4 *20 2½	7 6	45,000	50,000	

* With door open to 120°
† " doors " " "

Jaw Crushers

Jaw Opening	Capacity, Tons per Hr., Jaws Set to		Horse Power	Speed R. P. M.	Pulley, Inches	Length Over All	Width Over All	Height Over All	Weight Heaviest Piece	Net Weight	Gross Weight	Code Word
2 x 6	¼ inch 250 to 350 lbs.	¼ inch 350 to 600 lbs.	1	350	18 x 3½	2′ 9½″	1′ 10″	1′ 10″	300 lbs.	900 lbs.	1,000 lbs	Baer
4 x 8	¼ inch ½ to 1	½ inch 1 to 1½	2 to 3	250	30 x 4	3′ 10″	3′ 2½″	2′ 11″	1,200 "	2,700 "	3,000 "	Bareto
5 x 10	½ inch 1 to 1½	¾ inch 2 to 3	3 to 4	170	30 x 6½	4′ 10″	3′ 0″	3′ 4″	375 "	3,600 "	4,000 "	Beno
6 x 15	½ inch 2 to 3	¾ inch 3 to 4	8 to 10	160	36 x 8	6′ 0″	4′ 7″	3′ 9″	800 "	7,600 "	8,400 "	Botox
8 x 10	½ inch 3	2 inches 6 to 10	8 to 10	160	30 x 6	5′ 1″	3′ 3″	3′ 4″	1,370 "	3,500 "	4,000 "	Bligo
10 x 15	1 inch 8 to 10	2 inches 12 to 18	15	155	48 x 10	7′ 6″	5′ 0″	4′ 4″	1,500 "	11,000 "	12,000 "	Bligoten
6 x 20	¾ inch 5 to 7	2 inches 16 to 20	20	160	48 x 10	5′ 8″	5′ 3″	3′ 5″	2,600 "	8,750 "	9,500 "	Bligosix
12 x 26	1½ inch 12 to 15	2 inches 20 to 30	25	140	60 x 10	9′ 9″	7′ 0″	6′ 2″	2,660 "	22,500 "	25,000 "	Blartant

Balanced Rolls

Code Word	Size (Inches)	Pulley (Inches)	Approx. Horse Power	Speed R. P. M. *	Approx. Length	Approx. Width	Approx. Height With Fly Wheel	Approx. Weight Net Lbs.	Approx. Weight Gross Lbs.
Bonnie	16 x 10	48 x 4	3 to 4	200 to 270	5′-9″	5′-4″	4′-6″	6,000	7,000
Ceatry	36 x 16	72 x 10	14 to 18	60 to 85	9′-8″	9′	6′-6″	34,000	37,500
Plem	20 x 14	48 x 6	7 to 10	150 to 215	7′	6′-8″	5′	10,000	11,200
Plip	22 x 14	48 x 6	7 to 10	150 to 215	7′	6′-8″	5′	10,600	11,800
Ceadar	24 x 15	60 x 8½	8 to 12	115 to 160	7′-10″	7′-3½″	5′-6½′	13,350	14,750
Ceamot	30 x 16	66 x 10	12 to 15	80 to 100	8′-6″	8′-6″	6′-2″	20,000	21,500
Ceasel	32 x 16	66 x 10	12 to 15	80 to 100	8′-6″	8′-6″	6′-2″	20,750	22,250
Ceagot	36 x 20	72 x 12½	16 to 20	60 to 85	10′-5″	10′-2½″	6′-0″	32,400	35,000
Ceafto	38 x 20	72 x 12½	16 to 20	60 to 85	10′-5″	10′-2½″	6′-0″	33,700	36,300
Plain Balanced Rolls ***									
Plyd	36 x 16	66 x 10	14 to 18	60 to 85	8′-6″	8′	6′-5″	22,000	23,500
Ploss	38 x 16	66 x 10	14 to 18	60 to 85	8′-6″	8′	6′-5″	22,700	24,200
Laboratory Rolls **									
Billey	8 x 5	18 x 4	1	150	33″	29″	22″	650	700
Plag	12 x 12	36 x 6	3 to 4	150	4′	4′-8″	3′-2″	3,000	3,500

*The speed of Rolls varies according to size and kind of material.
**Laboratory Rolls have springs back of two bearings only.
***Plain Balanced Rolls have shim adjustments.

This book would not be complete if Laboratory Machinery was omitted, and we herein illustrate a very complete line of Equipment for Sampling purposes.

AUTOMATIC CRUSHER AND SAMPLER

This machine is a miniature Open Door Rotary Fine Crusher, yet it is capable of crushing Phosphate Rock from 2″ to 3″ in size to ¼″ at the rate of approximately one ton per hour, at the same time extracting a representative sample of 5, 10 or 15% of the whole, for analysis. Should this resulting sample be too large, say 100 to 200 lbs., then this sample may again be passed through the machine, in which case the amount from the sample spout will be only a few pounds. Three sizes of sample spouts are supplied with each machine.

This Sampler saves much labor, and gives far more accuracy than hand methods.

LABORATORY JAW CRUSHER

For crushing hard rocks to ¼ inch and finer this little machine has no equal, and will produce approximately 300 to 600 lbs., per hour. It is very similar to our regular Crushers, and will stand up under hard work and give satisfaction for years.

Hundreds are used all over the world in Mines, Colleges, Assay Laboratories, etc.

LABORATORY ROLLS

This machine is very similar to our large Rolls, and is capable of hard, continuous work. It will crush hard or soft rocks from ½″ size to ⅛″ or from ¼″ to 10 mesh, etc. A 3 to 1 reduction is about the limit of Roll work although on some materials 4 to 1 is practical.

SAMPLE GRINDER

The Sample Grinder has a wide field of usefulness. It can be used for grinding tankage, cotton seed meal, rock, etc. It is capable of grinding Phosphate Rock to 100 mesh without screening, or to any degree coarser. For Cotton Seed Meal, and other tough, fibrous materials special grinding discs are supplied.

It is built in three sizes.

LABORATORY HAMMER MILL

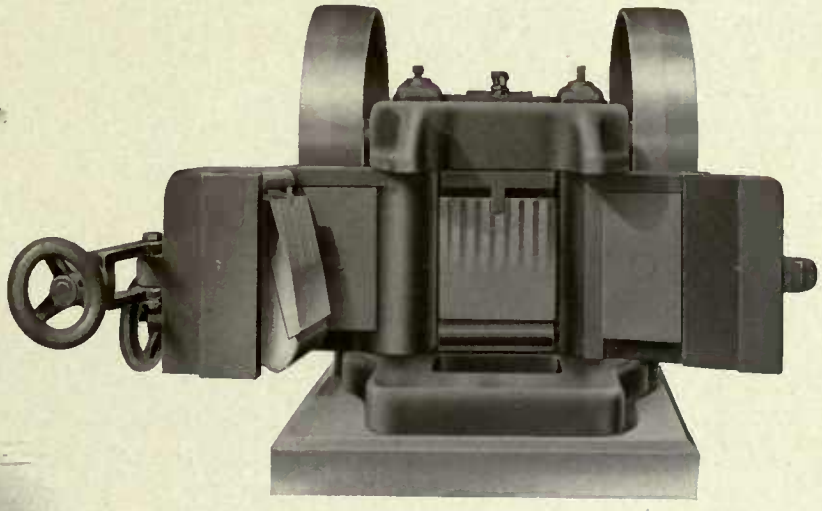
Built in a very similar manner to our Swing Sledge Mills, this little machine will do anything that the larger ones can do, but with reduced capacities.

For Bone, Tankage, Meat, Cottonseed Meal, Shells, Fish Scrap, Rock, etc., it has no equal for producing products from ¼″ to 20 mesh.

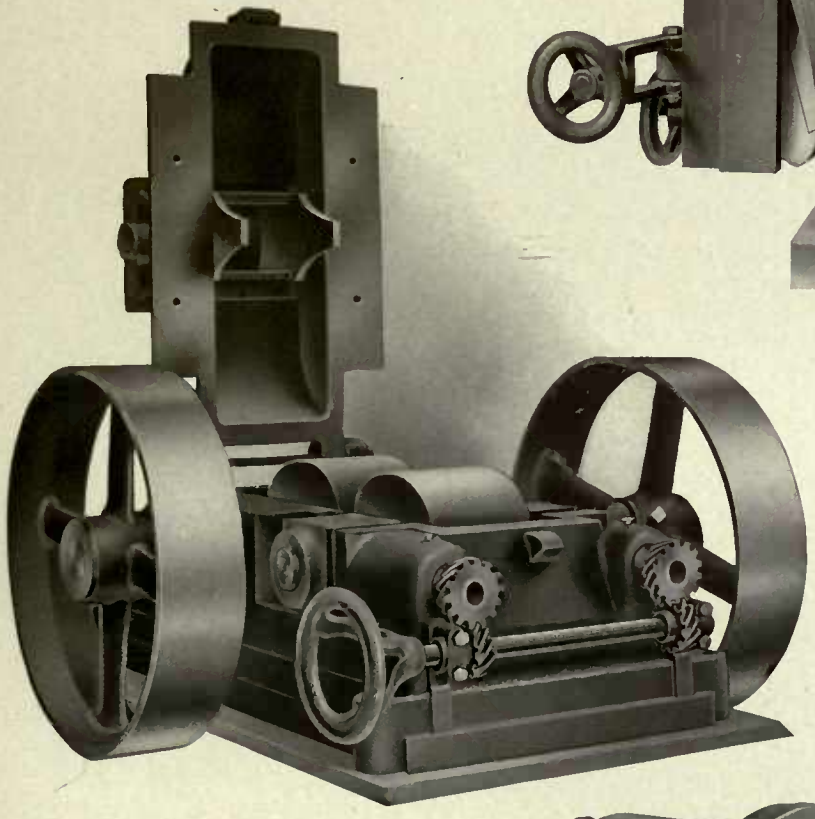
LABORATORY SCREEN

A small Screen is built for sampling work having a range of output from ¼ inch to 120 mesh.

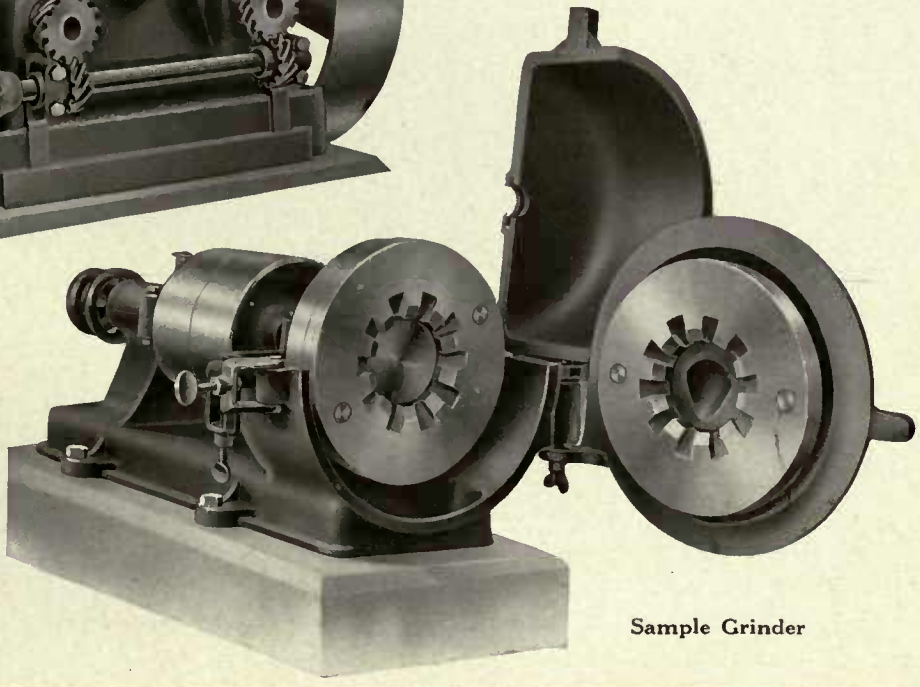
Automatic Crusher and Sampler



Jaw Crusher



Crushing Roll



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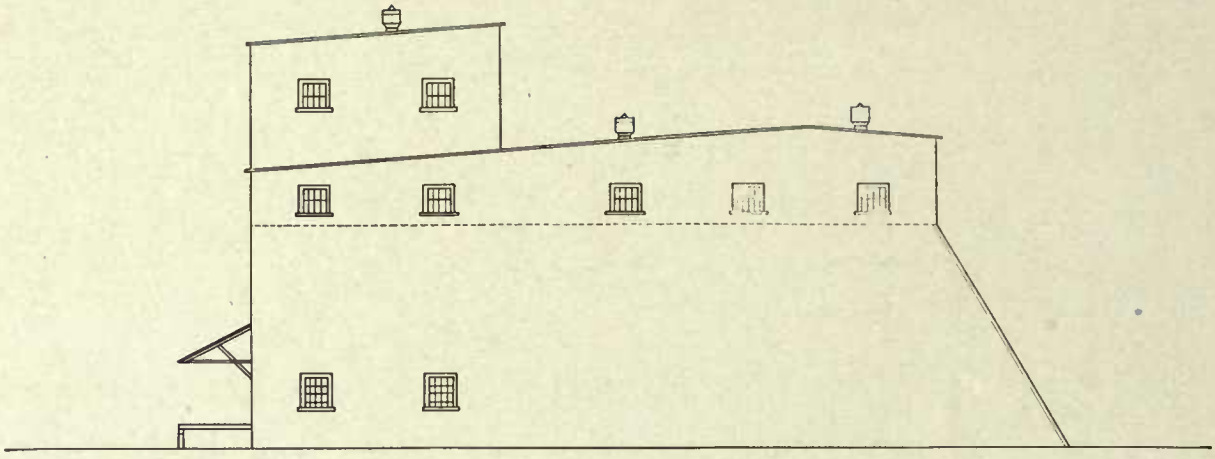
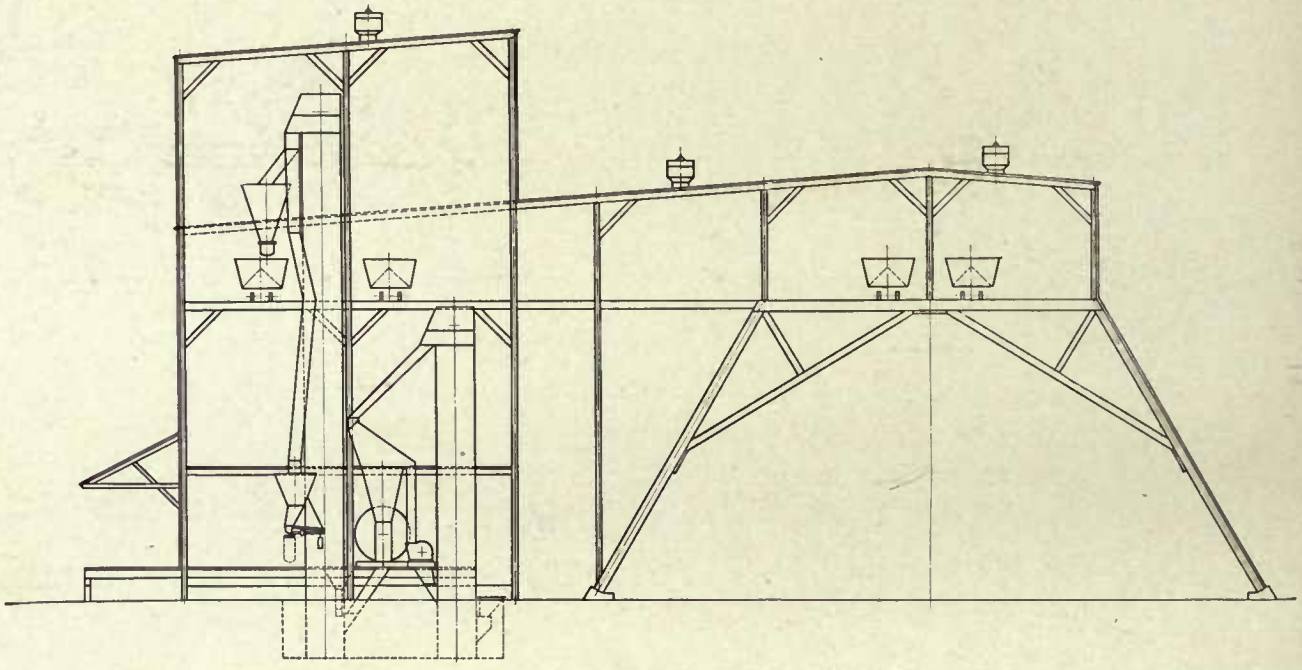
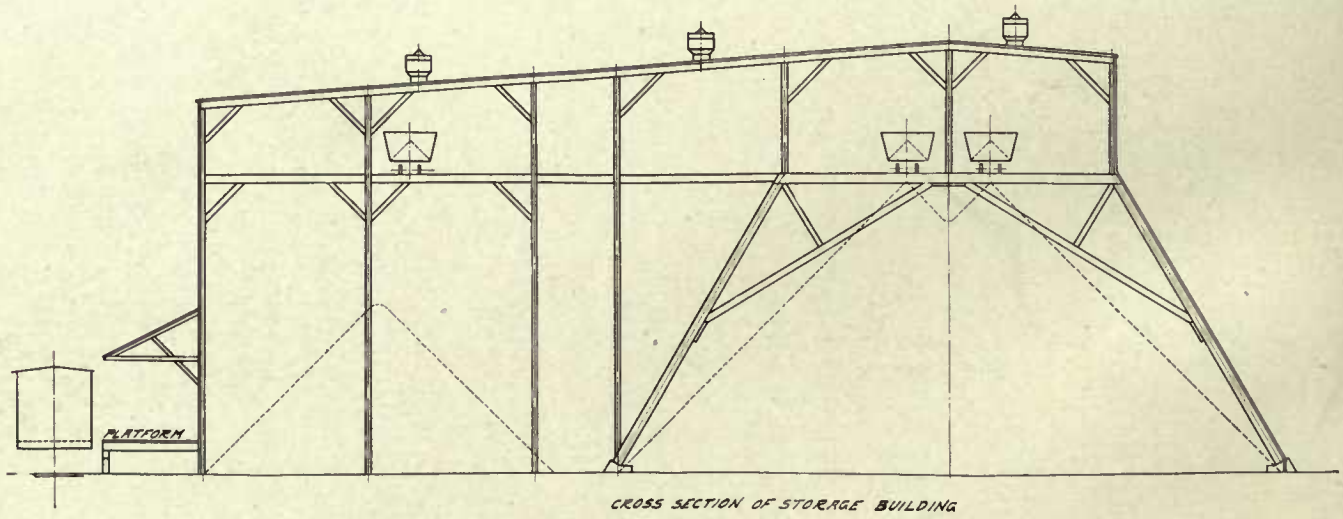
Sample Grinder



END ELEVATION

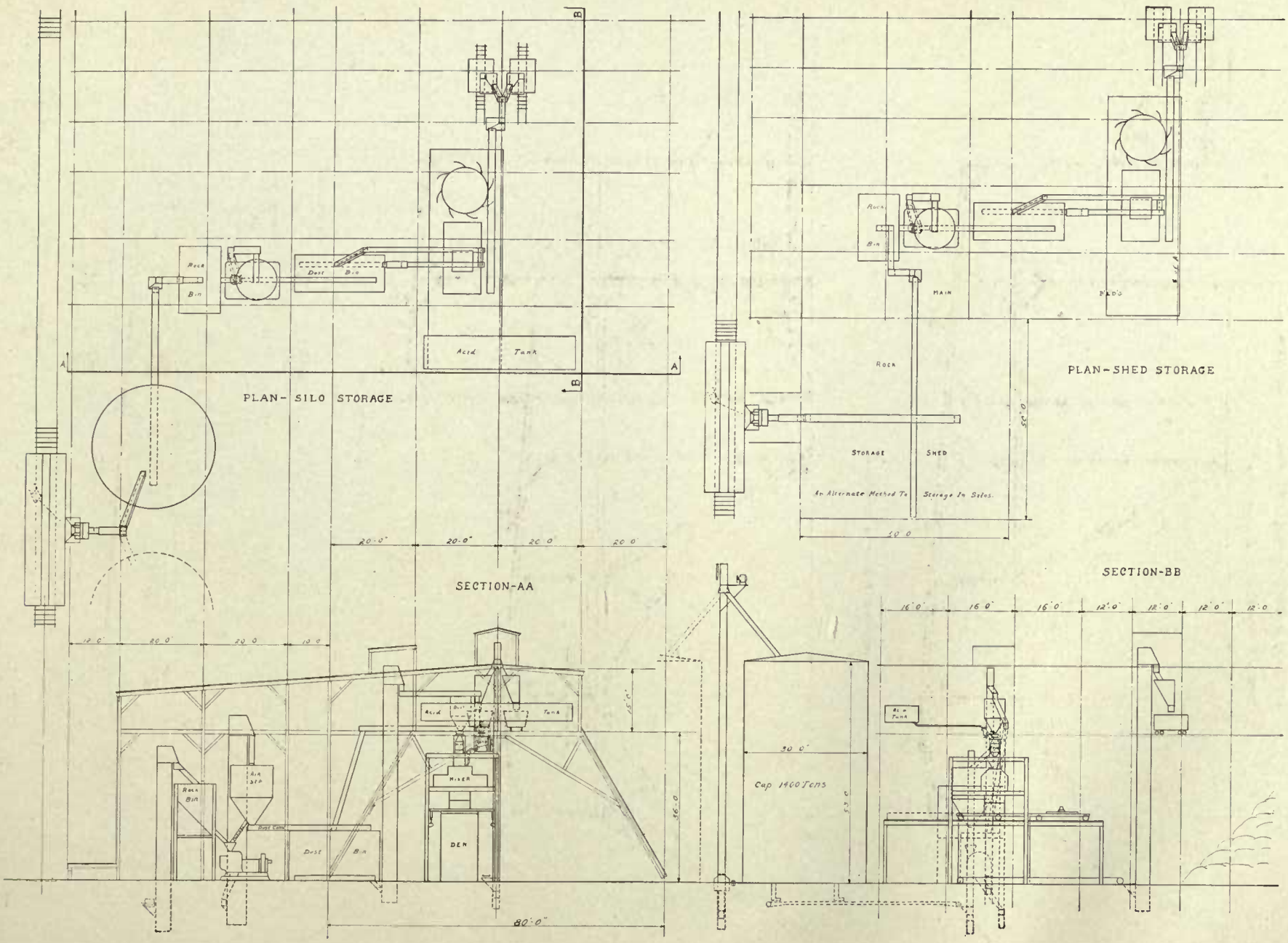


CROSS SECTION SHOWING MIXING UNIT

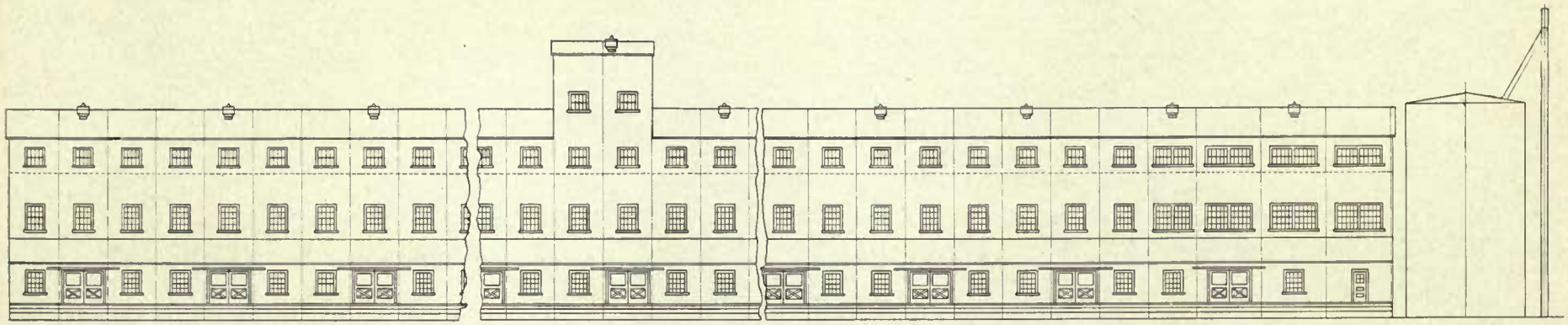


CROSS SECTION OF STORAGE BUILDING

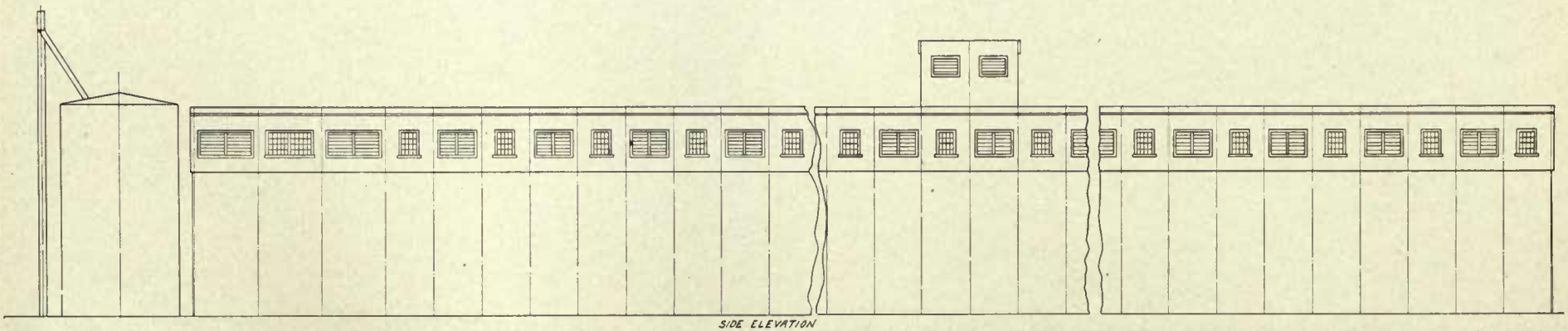
Combination A Frame and Square-posted Building



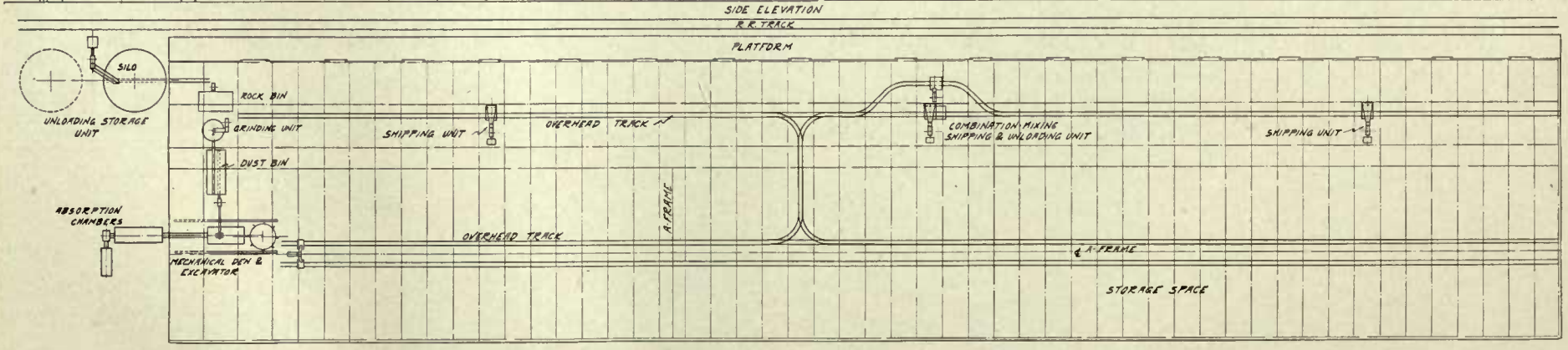
Combination A Frame and Square Posted Building



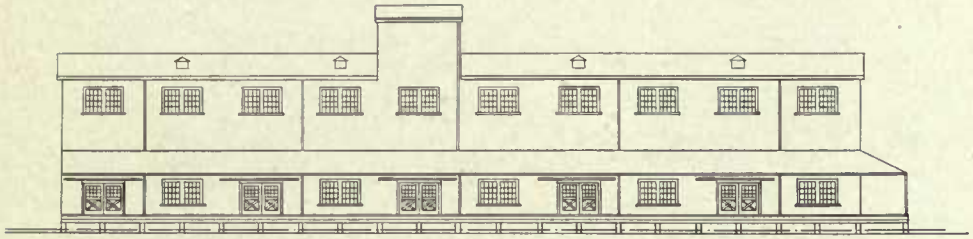
SIDE ELEVATION (TRACK SIDE)



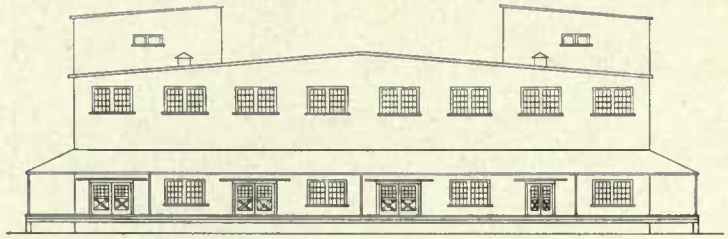
SIDE ELEVATION



Combination A Frame and Square Posted Building

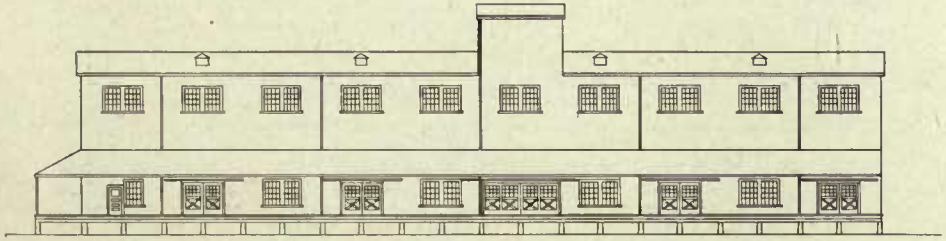


EAST ELEVATION

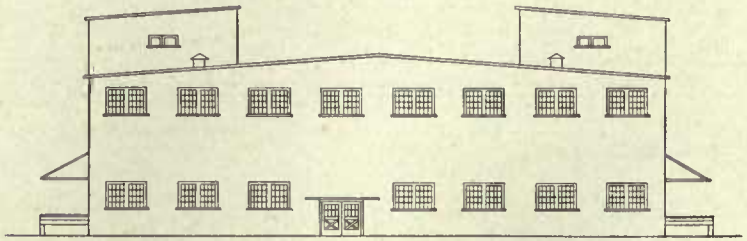


NORTH ELEVATION

STURTEVANT
DRY MIXING FERTILIZER PLANT



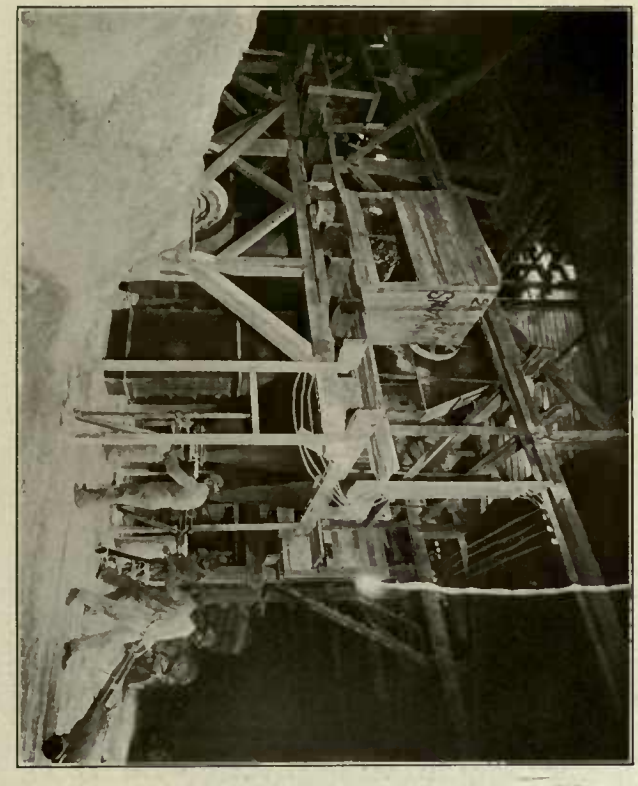
WEST ELEVATION

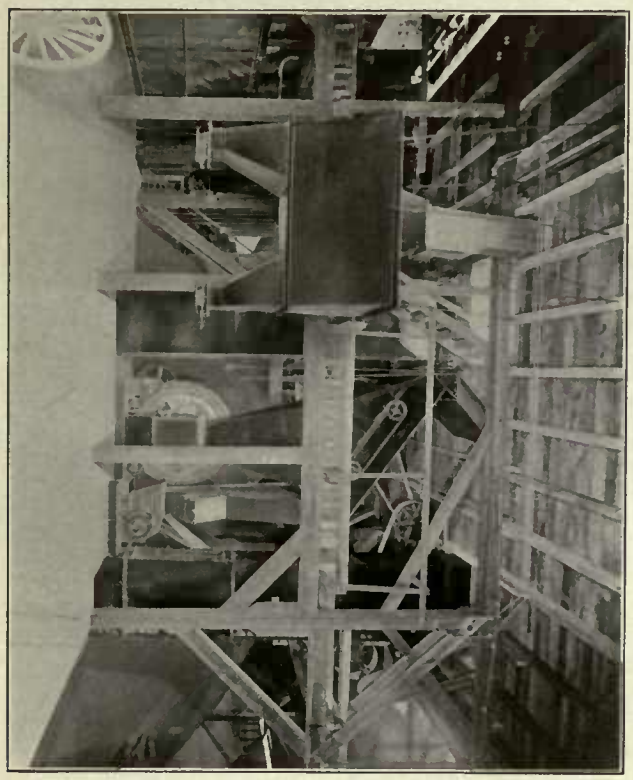


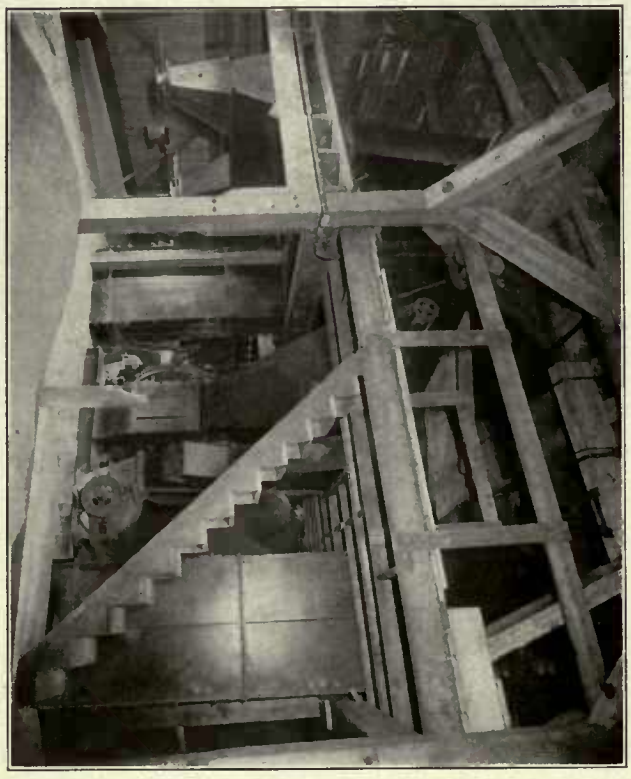
SOUTH ELEVATION

Sturtevant Dry Mixing Plant

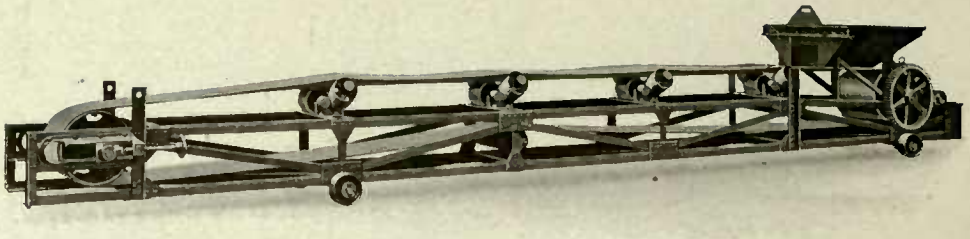

International Products Corporation
"Victory Fertilizer"
Norwood Mass.

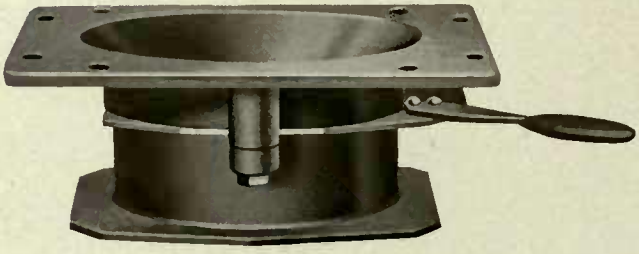


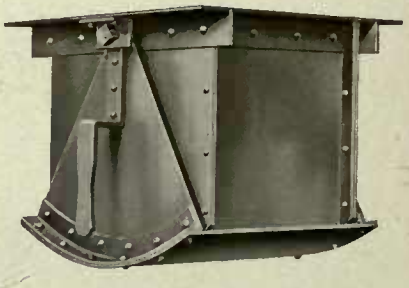


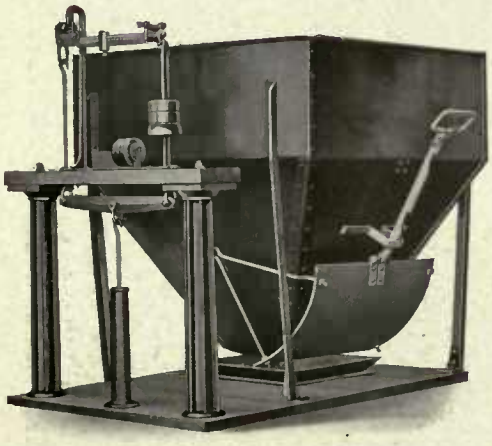


Patented
Valve Bag and Holder

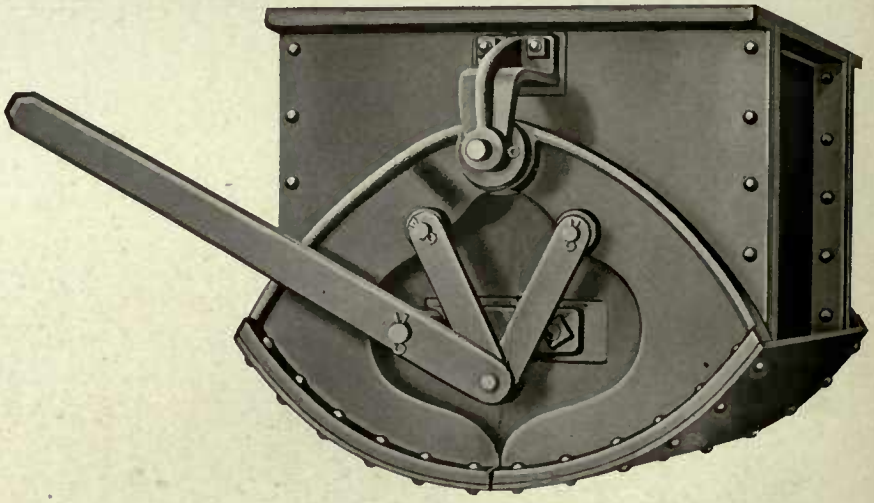






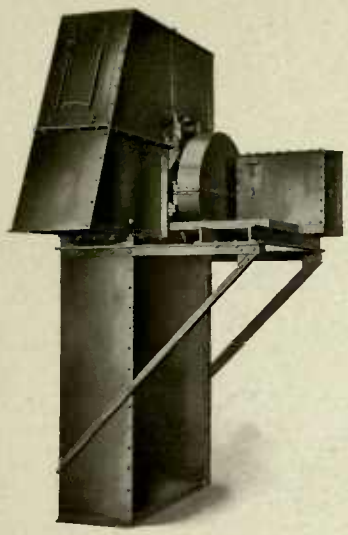


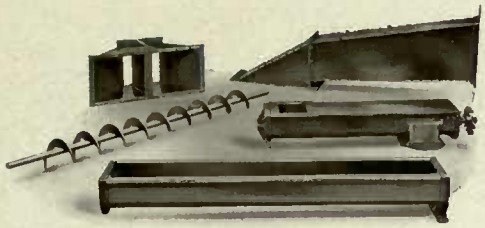
Weighing Hopper and Scale

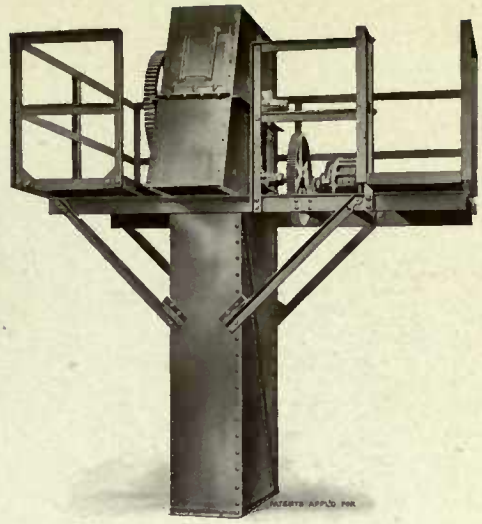


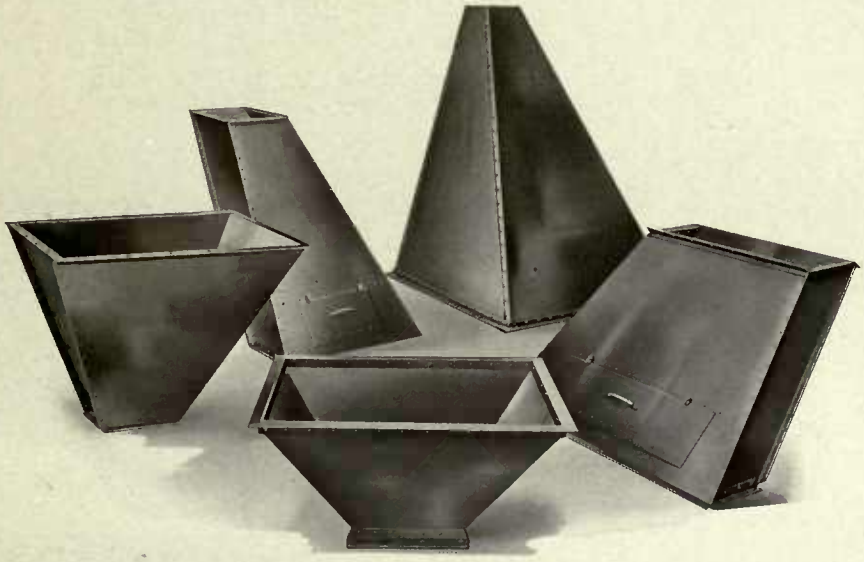
Hopper or Cut-Off Valves

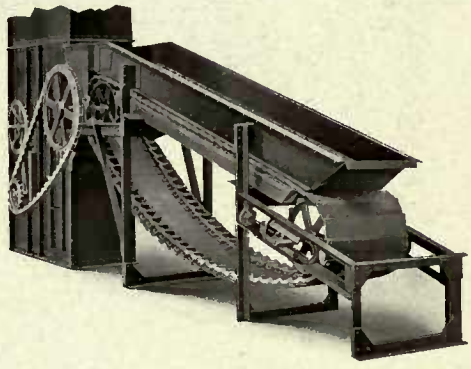
These illustrations show a few auxiliary devices of Sturtevant design and manufacture

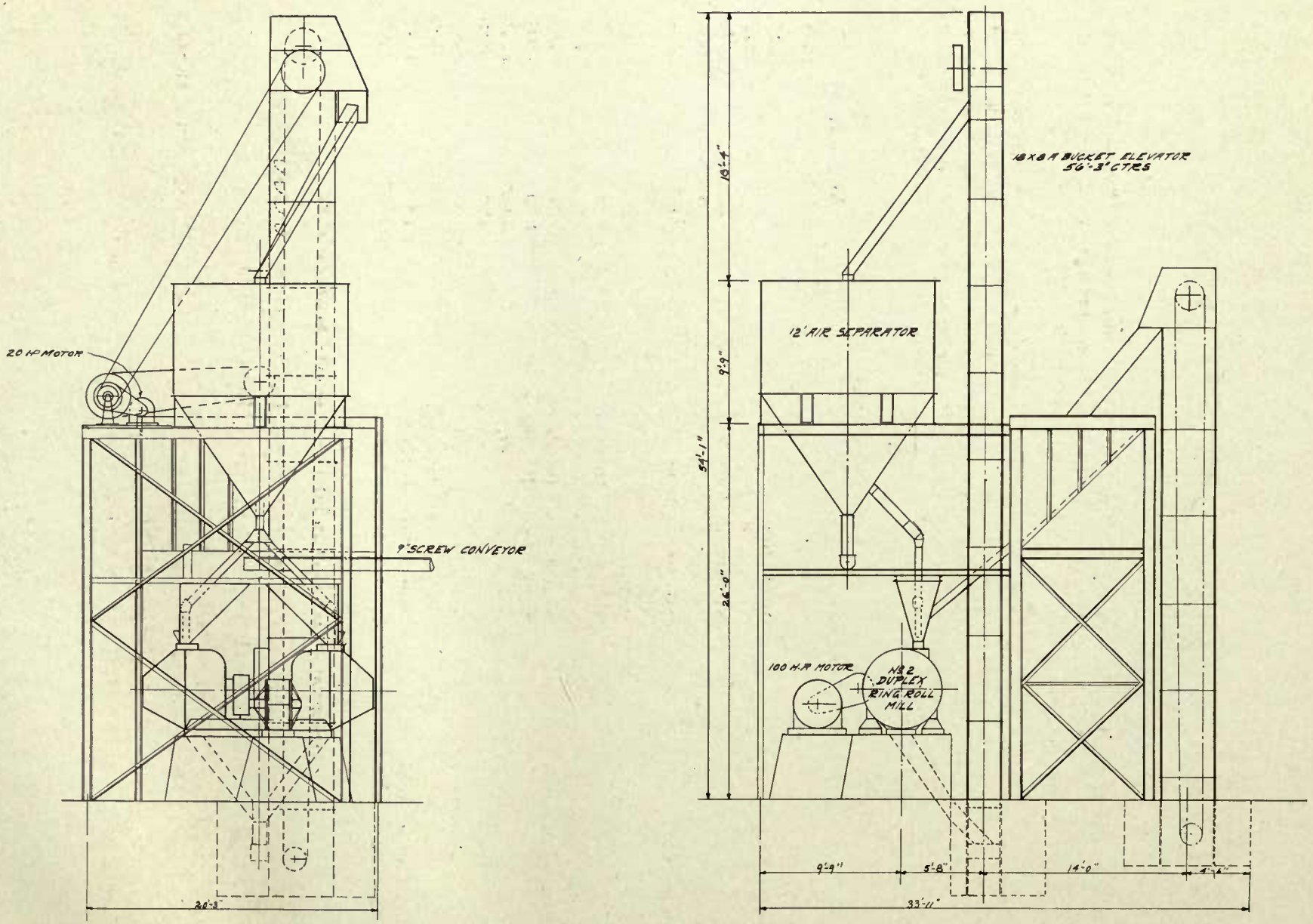












Sturtevant Duplex Ring-Roll Mill, Air Separator Unit

We are indebted to Dr. Samuel W. Wiley, President and General Manager of Wiley & Company, Inc., Baltimore, Maryland, for the following information, which it is believed will prove valuable to the Fertilizer Manufacturer.

Dr. Wiley is too well known to the Fertilizer trade in general to need introduction, but to those who have not had the pleasure of his acquaintance it may not be out of place to say that he enjoys an enviable reputation as one of the leading Fertilizer Chemists in this Country, and his friends are legion. He operates a fully-equipped Modern Laboratory in Baltimore, and has a large business among Fertilizer Manufacturers.

CONVERSION FACTORS

A	B	Multiply by A to B	Multiply by B to A
Nitrogen	Ammonia	1.2158	.8225
"	Nitrate of Soda	6.0678	.1648
"	Nitrate of Potash	7.2170	.1386
"	Protein	6.2500	.1600
Ammonia	Nitrate of Soda	4.9906	.2004
"	Nitrate of Potash	5.9358	.1685
"	Protein	5.1404	.1945
"	Sulphate of Ammonia	3.8791	.2578
Nitrate of Soda	Nitrate of Potash	1.1894	.8408
Actual Potash	Muriate of Potash	1.5830	.6317
" "	Sulphate of Potash	1.8500	.5405
" "	Nitrate of Potash	2.1467	.4658
" "	Carbonate of Potash	1.4671	.6816
Muriate of Potash	Sulphate of Potash	1.1687	.8557
" " "	Carbonate of Potash	.9268	1.0790
Phosphoric Acid	Bone Phos. of Lime	2.1850	.4577
Carbonic Acid	Carbonate of Lime	2.2748	.4396

CHEMICAL REACTIONS IN SUPERPHOSPHATE MANUFACTURE

Superphospahte—$Ca_3(PO_4)_2+2H_2SO_4+5H_2O=CaH_4(PO_4)_2H_2O+2CaSO_42H_2O$.

Reversion—$CaH_4(PO_4)_2+H_2O+Ca_3(PO_4)_2=2Ca_2H_2(PO_4)_24H_2O$.

Fluorides—$CaF_2+H_2SO_4=2HF+CaSO_4$

$4\,HF+SiO_2=2H_2O+SiF_4$ (100 lbs. CaF_2 = 125.6 lbs. H_2SO_4)

$3\,SiF_4+2H_2O=SiO_2+2H_2SiF_6$

Carbonates—$CaCO_3+H_2SO_4=CaSO_4+H_2O+CO_2$ (100 lbs. $CaCO_3$ = 125 lbs. 60° acid)

MIXING GUIDE—FLORIDA PEBBLE

The exact amounts to be used, however, can be found only by trial

1090 lbs. rock (60 mesh).
1090 lbs. 50° Bé acid or its equivalent as 52° acid.

2180 lbs. minus loss of moisture (8 - 9%) equals 2000 lbs. net.

1118 lbs. rock (80 mesh).
1062 lbs. 50° Bé acid or its equivalent as 52° acid.

2180 lbs. minus loss of moisture equals 2000 lbs. net.

MATERIALS NOT TO BE MIXED

Nitrate of soda should not be mixed with Acid Phosphate containing large excess of acid, as the free sulphuric and phosphoric acids drive off nitric acid and cause a loss.

Pyrites Cinder should not be used to reduce your acid phosphate as the free acid unites with the iron to form an insoluble phosphate of iron.

Certain ammoniates contain iron, and if mixed with acid phosphate you will lose a considerable portion of your available phosphoric acid.

Lime should not be mixed with Sulphate of Ammonia and materials containing lime should not be used in this connection without advice from an experienced fertilizer chemist.

Excessive quantities of lime should not be mixed with Superphosphate, Barnyard Manure or Bone Meal.

Sulphate of Ammonia should not be mixed with Thomas Slag and Norwegian Nitrate.

Basic Slag should not be mixed with Sulphate of Ammonia, Blood or Tankage as the lime affects these materials and releases ammonia.

Cyanamide must not be mixed directly with Sulphate of Ammonia, but if mixed according to directions given by the cyanamide manufacturer will give good results.

It is better to consult a good firm of fertilizer chemists, giving full information as to materials desired to be used, before trying experiments which may prove unsatisfactory and costly.

The subjoined tables on this and the following page have been approved and adopted as standard (June 23, 1904) by the Manufacturing Chemists' Association of the United States.

Acknowledgment is made to the Manufacturing Chemists' Association for permission to use these tables, which have been prepared by and are the property of that Association.

The Manufacturing Chemists' Association has a supply of the tables made up in card form for laboratory use, which may be procured from the Secretary of the Association, Mr. John I. Tierney, 540 Woodward Building, Washington, D. C.

The Chemical authorities in the work were W. C. Ferguson and H. P. Talbot. The freezing points assigned were calculated from Pickering's results, Journal of the London Chem. Society, vol. 57, p. 363.

Specific gravity determinations were made at 60° Fahr., compared with water at 60° Fahr. From the specific gravities, the corresponding degrees Baumé were calculated by the following formula:

$$\text{Baumé} = 145 - \frac{145}{\text{Sp. Gr.}}$$

Baumé hydrometers for use with this table must be graduated by the preceding formula, which formula should always be printed on the scale.

66° Baumé = Sp. Gr. 1.8351. One cubic foot of water at 60° Fahr. weighs 62.37 pounds avoirdupois. Atomic weights from F. W. Clark's table of 1901, standard.

O = 16. H_2SO_4 = 100 per cent.

	H_2SO_4	O.V.	60° Bé
O.V.	93.19	100.00	119.08
60°	77.67	83.35	100.00
50°	62.18	66.72	80.06

Acids stronger than 60° Bé should have their percentage compositions determined by chemical analysis.

SULPHURIC ACID TABLES

Bé°	Sp. Gr.	Tw.°	Per Cent H_2SO_4	Weight of 1 cu. ft. in lbs. Av.	Per Cent O. V.	Pounds O. V. in 1 cu. ft.
0	1.0000	0.0	0.00	62.37	0.00	0.00
1	1.0069	1.4	1.02	62.80	1.09	.68
2	1.0140	2.8	2.08	63.24	2.23	1.41
3	1.0211	4.2	3.13	63.69	3.36	2.14
4	1.0284	5.7	4.21	64.14	4.52	2.90
5	1.0357	7.1	5.28	64.60	5.67	3.66
6	1.0432	8.6	6.37	65.06	6.84	4.45
7	1.0507	10.1	7.45	65.53	7.99	5.24
8	1.0584	11.7	8.55	66.01	9.17	6.06
9	1.0662	13.2	9.66	66.50	10.37	6.89
10	1.0741	14.8	10.77	66.99	11.56	7.74
11	1.0821	16.4	11.89	67.49	12.76	8.61
12	1.0902	18.0	13.01	68.00	13.96	9.49
13	1.0985	19.7	14.13	68.51	15.16	10.39
14	1.1069	21.4	15.25	69.04	16.36	11.30
15	1.1154	23.1	16.38	69.57	17.58	12.23
16	1.1240	24.8	17.53	70.10	18.81	13.19
17	1.1328	26.6	18.71	70.65	20.08	14.18
18	1.1417	28.3	19.89	71.21	21.34	15.20
19	1.1508	30.2	21.07	71.78	22.61	16.23
20	1.1600	32.0	22.25	72.35	23.87	17.27
21	1.1694	33.9	23.43	72.94	25.14	18.34
22	1.1789	35.8	24.61	73.53	26.41	19.42
23	1.1885	37.7	25.81	74.13	27.69	20.53
24	1.1983	39.7	27.03	74.74	29.00	21.68
25	1.2083	41.7	28.28	75.36	30.34	22.87
26	1.2185	43.7	29.53	76.00	31.69	24.08
27	1.2288	45.8	30.79	76.64	33.04	25.32
28	1.2393	47.9	32.05	77.30	34.39	26.58
29	1.2500	50.0	33.33	77.96	35.76	27.88
30	1.2609	52.2	34.63	78.64	37.16	29.22
31	1.2719	54.4	35.93	79.33	38.55	30.58
32	1.2832	56.6	37.26	80.03	39.98	32.00

SULPHURIC ACID TABLES (Continued)

33	1.2946	58.9	38.58	80.74	41.40	33.42
34	1.3063	61.3	39.92	81.47	42.83	34.90
35	1.3182	63.6	41.27	82.22	44.28	36.41
36	1.3303	66.1	42.63	82.97	45.74	37.95
37	1.3426	68.5	43.99	83.74	47.20	39.53
38	1.3551	71.0	45.35	84.52	48.66	41.13
39	1.3679	73.6	46.72	85.32	50.13	42.77
40	1.3810	76.2	48.10	86.13	51.61	44.45
41	1.3942	78.8	49.47	86.96	53.08	46.16
42	1.4078	81.6	50.87	87.80	54.58	47.92
43	1.4216	84.3	52.26	88.67	56.07	49.72
44	1.4356	87.1	53.66	89.54	57.58	51.46
45	1.4500	90.0	55.07	90.44	59.09	53.44
46	1.4646	92.9	56.48	91.35	60.60	55.36
47	1.4796	95.9	57.90	92.28	62.13	57.33
48	1.4948	99.0	59.32	93.23	63.65	59.34
49	1.5104	102.1	60.75	94.20	65.18	61.40
50	1.5263	105.3	62.18	95.20	66.72	63.52
51	1.5426	108.5	63.66	96.21	68.31	65.72
52	1.5591	111.8	65.13	97.24	69.89	67.96
53	1.5761	115.2	66.63	98.30	71.50	70.28
54	1.5934	118.7	68.13	99.38	73.11	72.66
55	1.6111	122.2	69.65	100.48	74.74	75.10
56	1.6292	125.8	71.17	101.61	76.37	77.60
57	1.6477	129.5	72.75	102.77	78.07	80.23
58	1.6667	133.3	74.36	103.95	79.79	82.95
59	1.6860	137.2	75.99	105.16	81.54	85.75
60	1.7059	141.2	77.67	106.40	83.35	88.68
61	1.7262	145.2	79.43	107.66	85.23	91.76
62	1.7470	149.4	81.30	108.96	87.24	95.06
63	1.7683	153.7	83.34	110.29	89.43	98.63
64	1.7901	158.0	85.66	111.65	91.92	102.63
64¼	1.7957	159.1	86.33	112.00	92.64	103.75
64½	1.8012	160.2	87.04	112.34	93.40	104.93
64¾	1.8068	161.4	87.81	112.69	94.23	106.19
65	1.8125	162.5	88.65	113.05	95.13	107.54
65¼	1.8182	163.6	89.55	113.40	96.10	108.97
65½	1.8239	164.8	90.60	113.76	97.22	110.60
65¾	1.8297	165.9	91.80	114.12	98.51	112.42
66	1.8354	167.1	93.19	114.47	100.00	114.47

ALLOWANCE FOR TEMPERATURE

At 10°	Bé,	.029°	Bé or	.00023	Sp. Gr.	= 1°F.
" 20°	"	.036°	"	.00034	"	= 1° "
" 30°	"	.035°	"	.00039	"	= 1° "
" 40°	"	.031°	"	.00041	"	= 1° "
" 50°	"	.028°	"	.00045	"	= 1° "
" 60°	"	.026°	"	.00053	"	= 1° "
" 63°	"	.026°	"	.00057	"	= 1° "
" 66°	"	.0235°	"	.00054	"	= 1° "

YIELD OF SULPHURIC ACID

Theory is 4.92 lbs. of 50% 50° Bé acid from 1 lb. of sulphur burned.
In practice the yield of 4.7 lbs. is considered satisfactory.

CONVERSION OF CENTIGRADE AND FAHRENHEIT THERMOMETERS

To convert—

°C. to °F., multiply by 9, divide by 5, then add 32.

°F. to °C., first subtract 32, then multiply by 5, and divide by 9.

To change one result at a given moisture, to another moisture basis: Divide the per cent. of *dry matter in the original sample into the per cent. of dry matter in the sample at required moisture, and use this as a factor by which to multiply the original result.

To change to dry basis: Divide 100 by the per cent. of *dry matter in sample and use this as a factor by which to multiply.

*(Dry matter equals 100 less the per cent. of Moisture.)

CAPACITY OF PIPES AND CYLINDRICAL TANKS

Of various diameters in gallons per foot of length

	INCHES											
Feet	0	1	2	3	4	5	6	7	8	9	10	11
0	....	.0408	.1632	.3672	.6528	1.020	1.469	1.999	2.611	3.305	4.080	4.937
1	5.875	6.895	8.000	9.18	10.44	11.79	13.22	14.73	16.32	17.99	19.75	21.58
2	23.50	25.50	27.58	29.74	31.99	34.31	36.72	39.21	41.78	44.43	47.16	49.98
3	52.88	55.86	58.92	62.06	65.28	68.58	71.97	75.44	78.99	82.62	86.33	90.13
4	94.00	97.96	102.0	101.1	110.3	114.6	119.0	123.4	128.0	132.6	137.3	142.0
5	146.9	151.8	156.8	169.9	167.1	172.4	177.7	183.2	188.7	194.3	199.9	205.7
6	211.5	217.6	223.4	229.5	235.7	242.0	248.2	254.7	261.1	267.7	274.3	281.1

	INCHES					INCHES			
Feet	0	3	6	9	Feet	0	3	6	9
7	287.9	308.8	330.5	352.9	21	2591	2653	2716	2779
8	376.0	399.9	424.5	449.8	22	2844	2909	2974	3041
9	475.9	502.7	530.2	558.5	23	3108	3176	3245	3314
10	587.5	617.7	647.7	679.0	24	3384	3455	3527	3599
11	710.9	743.6	777.0	811.1	25	3672	3746	3820	3896
12	846.0	881.7	918.0	955.1	26	3972	4048	4126	4204
13	992.9	1032	1071	1111	27	4283	4363	4443	4524
14	1152	1193	1235	1278	28	4606	4689	4772	4856
15	1322	1366	1412	1457	29	4941	5027	5113	5200
16	1504	1551	1600	1648	30	5285	5376	5465	5555
17	1698	1748	1799	1851	31	5646	5738	5830	5923
18	1904	1957	2011	2066	32	6016	6111	6206	6302
19	2121	2177	2234	2292	33	6398	6496	6594	6692
20	2350	2409	2469	2530					

EQUIVALENTS

Linear

1 cm.	0.39370 inch	0.03280 foot	0.01093 yard
2.540	1.	0.08333	0.02778
30.480	12.	1.	0.33333
91.440	36.	3.	1.

Volume

1. liter	1,000 cu. cm.	0.03531 cu. ft.	61.022 cu. in.	0.2642 gal.
28.317	28,317	1.	1,728.	7.4815
0.0164	16 16.388	0.00058	1.	0.00433
3.785	3,785.	0.13367	231.	1.

1 liquid oz. 29.57 cc.
1 liquid qt. 0.9463 liter
1 dry qt. 1.101 liters

Surface

1 sq. cm.	0.0001 sq. meter	0.15500 sq. in.	0.00108 sq. ft.	0.000119
10,000.	1.	1,550.	10.7638	1.1960
6.4516	0.000645	1.	0.00694	0.00077
929.036	0.09290	144.	1.	0.11111
8,361.27	0.83613	1,296.	9.	1.

Gravimetric

1. gr.	0.001 kg.	0.03527 oz.	0.0022046 lbs.	0.0000011 tons
1,000.	1.	35.2736	2.2046	0.0011023
28.350	0.028350	1.	0.0625	0.00003125
453.60	0.45360	16.	1.	0.0005
907,180.	907.18	32,000.	2,000.	1.

One dry qt. = 1.164 liquid qt. (U.S.) = 67.2 cu. in.
One liquid qt. = .859 dry qt. (U.S.) = 57.75 cu. in.
One gallon water (U.S.) weighs 8.323 lbs. and contains 231 cu. in.
A cubic foot of water contains 7½ gallons = 1728 cu. in. and weighs 62½ lbs.
To find diameter of a circle, multiply the circumference by .31831.
To find the circumference of a circle, multiply diameter by 3.1416.
To find area of a circle, multiply square of diameter by .7854.
Doubling the diameter of a pipe increases its capacity four times.
One cubic foot of Anthracite coal weighs about fifty-three pounds.
One cubic foot of Bituminous Coal weighs about forty-seven to fifty pounds.
To find the number of tons of coal in a bin, find the number of cubic feet it occupies and multiply by the weight of a cubic foot of coal and divide by 2000.