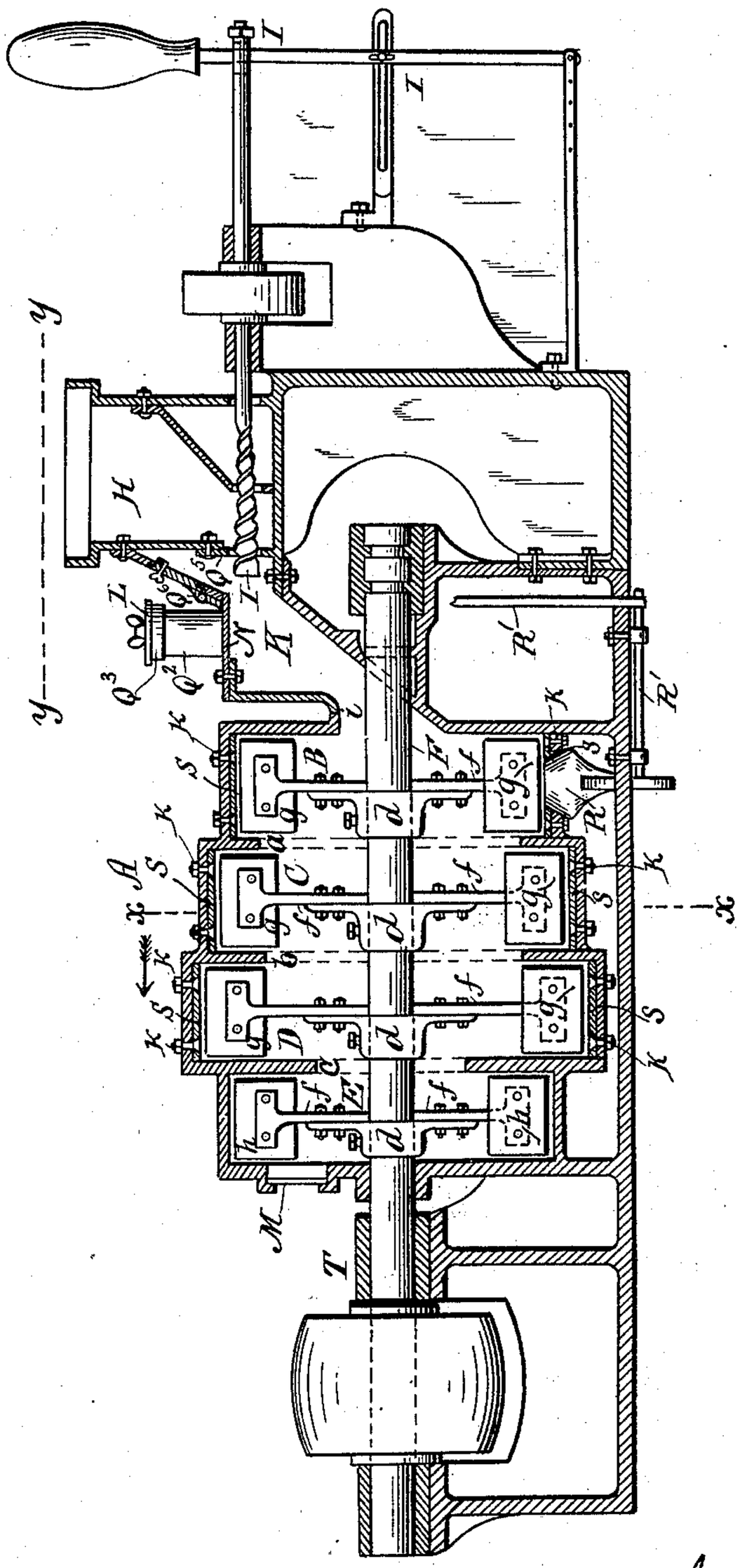
(No Model.) 2 Sheets—Sheet 1.

# J. J. STORER, F. MARTIN & G. O. EATON.

## MACHINE FOR PULVERIZING ORE OR OTHER SUBSTANCES.

No. 580,909. Patented Apr. 20, 1897.

Fig. 1.




WITNESSES:

W. E. Bowers

M. L. Storer

INVENTORS:—

Jacob J. Storer.

Frank Martin.

George O. Eaton.

by Jacob J. Storer.

ATTORNEY

(No Model.) 2 Sheets—Sheet 2.

# J. J. STORER, F. MARTIN & G. O. EATON.

## MACHINE FOR PULVERIZING ORE OR OTHER SUBSTANCES.

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*Fig. 2.*

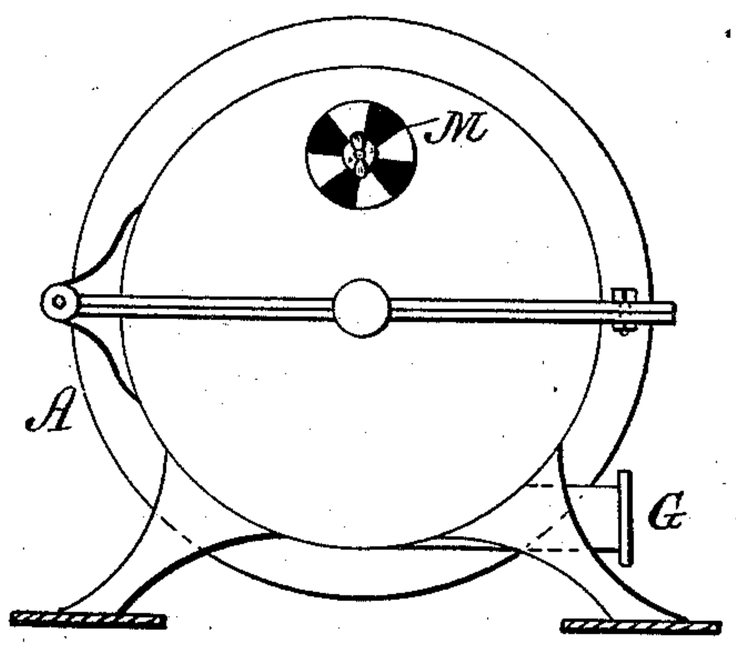



*Fig. 3.*

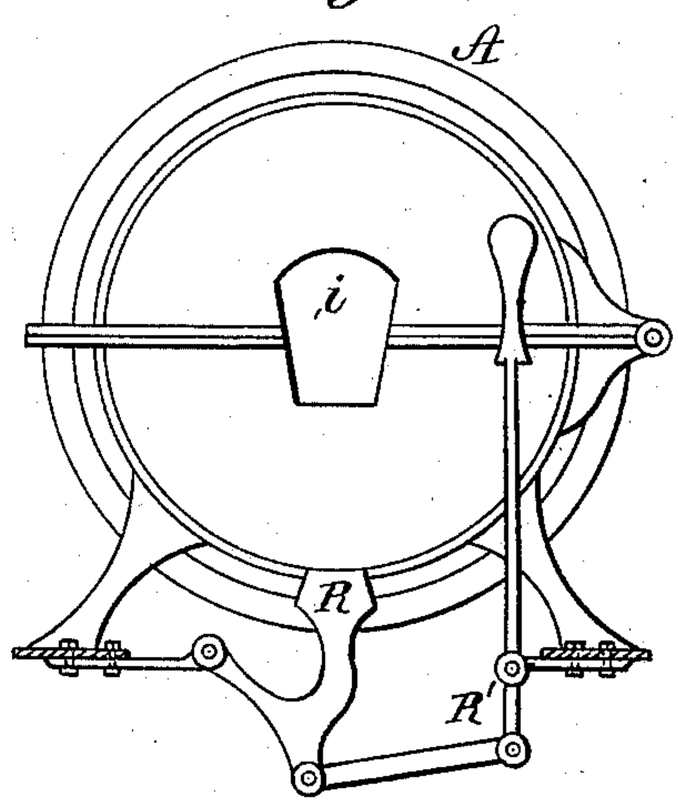



*Fig. 4.*

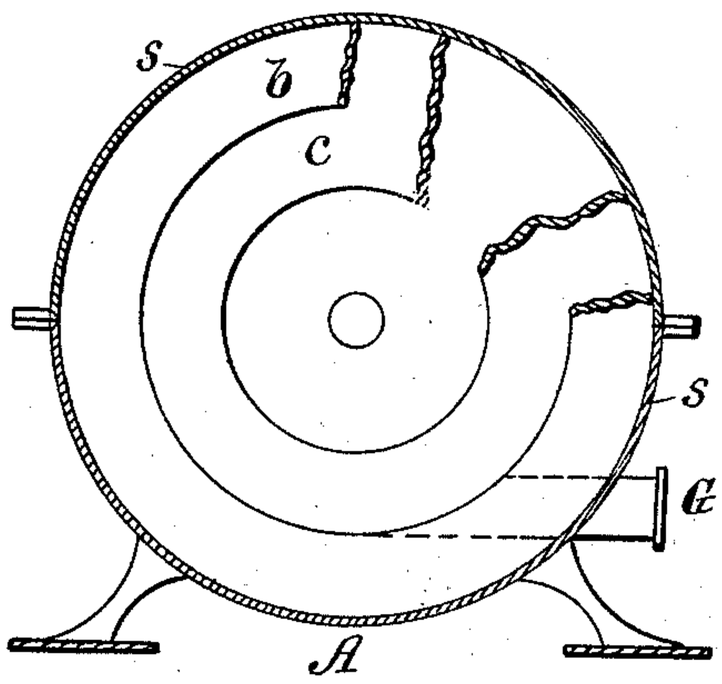



*Fig. 5.*

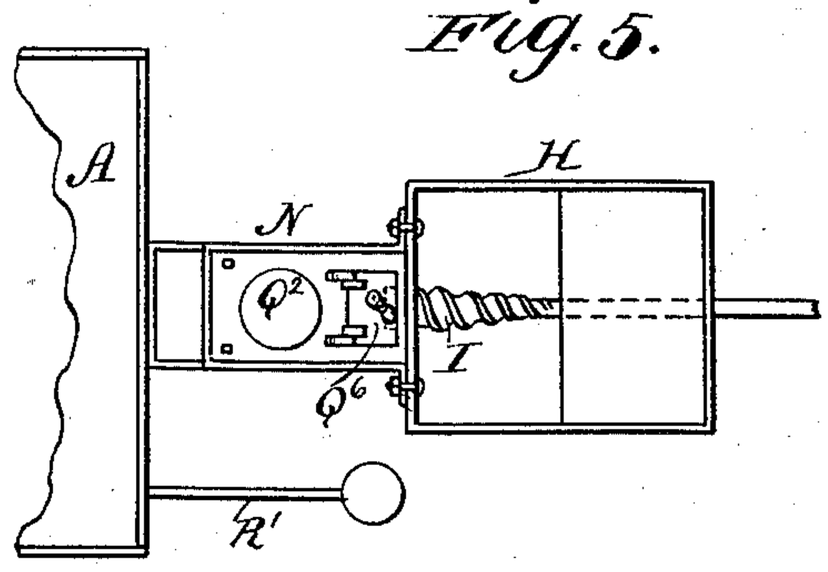



*Fig. 6.*

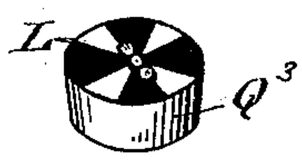
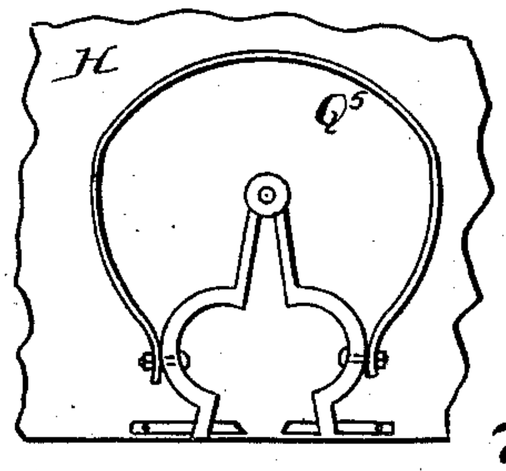



*Fig. 7.*




WITNESSES:

W. E. Bowen
M. L. Storer.

INVENTORS:

Jas. J. Storer.
Frank Martin.
Geo. O. Eaton.
by Jas. L. Storer.
ATTORNEY

# UNITED STATES PATENT OFFICE.

JACOB J. STORER, OF NEW YORK, N. Y., FRANK MARTIN, OF TOWNSEND, MONTANA, AND GEORGE O. EATON, OF NEW YORK, N. Y.; SAID STORER ASSIGNOR TO MARY L. STORER, AND SAID EATON ASSIGNOR TO EMMA C. EATON, OF NEW YORK, N. Y.

## MACHINE FOR PULVERIZING ORES OR OTHER SUBSTANCES.

SPECIFICATION forming part of Letters Patent No. 580,909, dated April 20, 1897.

Application filed February 7, 1896. Serial No. 578,427. (No model.)

*To all whom it may concern:*

Be it known that we, JACOB J. STORER, residing at New York, county of New York, State of New York, FRANK MARTIN, residing at Townsend, county of Meagher, State of Montana, and GEORGE O. EATON, residing at New York, county of New York, and State of New York, citizens of the United States, have invented a new and useful Machine for Pulverizing Ores or other Substances, of which the following is a specification.

This invention is designed as an improvement on the machine for pulverizing ores and other substances for which Letters Patent of the United States, No. 254,403, were granted; and its objects are to secure a finer comminution of ores and other friable substances, to assure a more uniform fineness of the materials pulverized, to prevent the delivery of coarse material from the machine, and to more nearly equalize the work done in the separate pulverizing or working chambers; also to better control the air-supply and in several minor points to improve the construction of the machine, all of which will be hereinafter fully set forth.

The invention consists, chiefly, in increasing the diameters of the working chambers and their respective spiders consecutively from the feed end of the machine to the fan-chamber, whereby with equal axial speeds the peripheral speed of each consecutive spider is increased; and it also embraces improved devices for the introduction and regulation of the air-supply.

In the accompanying drawings similar letters of reference indicate corresponding parts in all the figures.

Figure 1 is a partly-sectional longitudinal elevation of our improved pulverizer. Fig. 2 is an elevation of the delivery end of the pulverizer-cylinder. Fig. 3 is an elevation of the feed end of the pulverizer-cylinder with attachments. Fig. 4 is a sectional elevation of the cylinder on line *x x*, Fig. 1, looking in the direction of the arrow. Fig. 5 is a plan view on line Y Y, Fig. 1. Fig. 6 is a perspective of the cap of the air-supply pipe. Fig. 7 is an elevation showing the clips fixed on the front of the hopper.

In the patent above referred to (No. 254,403) the cylindrical shell of the machine is of a constant diameter from one end to the other, and it is interiorly divided by diaphragms into three working or pulverizing chambers and a fan chamber, all of the same diameter.

In the machine herein shown and described the cylindrical shell A has its working chambers B C D of increasing diameters successively from the feed end of the cylinder to the fan-chamber E, as shown in Fig. 1, these chambers being separated from each other and the fan-chamber by annular diaphragms *a b c*, respectively.

The horizontal revoluble shaft F has fixed upon it four spiders, each of which consists of a hub *d*, having a number of radiating arms *f* secured upon it. Those spiders which revolve in the working chambers have paddles *g* fastened on the outer extremities of the arms, while on the arms of the spider revolving in the fan-chamber plates *h* are secured, making it an exhaust-fan whose function is to draw the dust-laden air through the axial openings in the diaphragms between the chambers and deliver or eject it through the peripheral fan opening or spout G. (Shown in Figs. 2 and 4.)

The operation of the machine is as follows, viz: The shaft being put in revolution at a speed that will impart to the outer edges of the paddles *g* in the first chamber and the fan-plates *h* in the fan-chamber a speed of about two miles a minute, the material to be pulverized is introduced into the hopper H, whence it is fed by a revoluble feed-screw I into the feed-chute K. From the feed-chute it falls through the axial opening *i* in the cylinder-head into the first working chamber B, where it is struck by the first set of paddles, which partly comminute it and, by the centrifugal action of the spider, throw it violently against the inner periphery of the chamber. The outer edges of the paddles run about an inch from the smooth concavity of the shell. The inflowing material quickly fills the space between the paddle edges and the shell, forming a layer of partly-comminuted material, which is held against the shell by the air-pressure created by the rapidly-revolving paddles, a pressure estimated to be about one hundred pounds to the square foot. The belt

of material between the paddles and the shell is kept in grinding motion in the direction of the paddle revolution by the rotating air-current produced by the paddles and by the impact upon and passage through it of new material constantly fed to the paddles and thrown off from them tangentially at great velocity. Under the combined influence of bombardment, disruption, and mutual attrition the material of the peripheral belt is rapidly crushed and abraded, the resulting particles being small and spheroidal.

As the newly-added coarser particles thrown off from the spider force their way through the more comminuted material of the peripheral belt the finer particles thereof are forced inward toward the paddles until they are brought within the influence of the vortices behind the paddles. Into these paddle-created vortices the finer materials composing the inner face of the belt are drawn, to be whirled about and still further reduced by mutual attrition until they are fine enough to be carried by the axial air-current, which is continuously drawn through the pulverizer by the exhaust-fan and the spiders revolving in the chambers C D.

Of course some fine dust is produced by the first fracture of the entering material when struck by the paddles in the first chamber, and these dust-atoms, being too light to be much affected by the centrifugal throw of the paddles, escape the rotary air-current and are at once taken up and borne onward by the axial air-current.

Speaking generally, the primary comminution or reduction of the materials is effected by impact and attrition in the space between the shell and the paddle edges. The final and ultimate reduction is effected by attrition in the vortices behind the paddles.

By the continuous axial air-current (the volume and force of which may be regulated at will by the adjustment of the air-supply register L and the counter-current register M) the finer particles of material are drawn away from the action and influence of the paddles in the first working chamber into the second chamber C, by the action of whose higher-speed paddles they are further comminuted. Thence they are carried by the axial air-current into the succeeding chamber D, where pulverization to an almost impalpable powder is completed before the material is drawn into the fan-chamber to be expelled from the machine through its peripheral exit-pipe G.

Although all the air enters and leaves the working chambers axially, a portion of it is diverted constantly, though temporarily, and is given a centrifugal motion by the revolving paddles, so that it may be said that there are two constant air-currents in each chamber, the axial and the centrifugal, and while the actual force of the former most affects the quality of the yield of material and the actual force of the latter the quantity of the yield it is upon their relative values that the efficiency of the machine greatly depends.

In the patented machine above referred to, because the working chambers are of equal diameters and the spiders therein are also of like diameters, the paddle-created air-currents are of equal force or power in each chamber and together form the centrifugal air-current.

It will be seen, then, that if there be, as in this case of the patented machine referred to, three working chambers, the axial air-current on issuing from the first and second chambers successively has only to counteract and overcome the influence of a constantly-diminishing centrifugal air power or current, and consequently becomes relatively stronger as it approaches the fan-chamber. For this reason a pulverizer having all its working chambers of the same diameter is defective in operation. The centrifugal force of each set of paddles is the same, and an axial current which draws particles of a given size from the first working chamber draws them more readily and quickly from each succeeding chamber, so that they cannot remain under the influence of the second and third sets of paddles for a sufficient time. As a consequence many particles are drawn into and discharged from the fan-chamber of a size and shape (not spheroidal) which shows that they have been only or but briefly under the influence of the first set of paddles and either escaped the others or remained for too short a time subject to their action.

In our improved pulverizers we make the first working chamber and the fan-chamber of like diameter, as in the machine above referred to; but the diameters of the second and third working chambers and their respective spiders are increased, so that with the same axial speed (for instance, a speed that will give to the outer edges of the first-chamber paddles a peripheral velocity of about two miles a minute) the paddle edges in the second and third chambers will in the same time respectively move about one thousand and two thousand feet faster and create in their respective chambers proportionally-increased air-pressure and vortical actions. They will also give increased initial velocities to the particles of material thrown off from them, and (the power of the exhaust-fan being equal in both cases) the paddles will hold the particles of material under their comminuting influence for a longer time or until they are more finely pulverized.

It will be observed that as the working chambers successively increase in diameter the chamber-separating diaphragms, including the diaphragm separating the last working chamber from the fan-chamber, relatively increase in depth toward the discharge end of the cylinder, that the axial openings in the first two diaphragms are of the same area, though the second diaphragm is deeper, and that the axial opening in the third diaphragm,

which separates the last working chamber from the fan-chamber, is much smaller than the preceding ones. This construction tends greatly to prevent the escape of any but the finest particles from the third chamber.

The air that is permitted to enter the machine axially through the air-supply register is violently drawn in by the combined centrifugal action of the three sets of working paddles and the fan, but it is expelled, together with the pulverized material, by the action of the fan alone. The action of the fan and the three sets of working paddles together in sucking air through the supply-register must obviously be greater than the exhaust action of the fan and two sets of paddles, which combine to draw air and partly-pulverized material from the first working chamber. In like manner the velocity of the axial current must diminish on leaving the second chamber, and still more after the centrifugal force of the third set of paddles has ceased to affect it. Hence it will be seen that the force of the axial current diminishes from the feed end of the machine to the fan-chamber, although the centrifugal action of each succeeding set of working paddles increases; also that while the pulverizing action increases in each successive working chamber the force of the exhaust therefrom decreases, conditions which are the reverse of those obtaining in the patented machine above referred to. By virtue of the improved action in our new machine the material acted upon must become more finely reduced in each succeeding working chamber before it can be exhausted therefrom, since it is longer subjected to the abrading forces and the forces are more powerful. These novel conditions are of vital importance in a pulverizer designed for the most minute and uniform pulverization of material and in which the reduction must be effected chiefly by the action of air-currents.

In the patented machine above referred to a considerable supply of air is admitted to the pulverizer through a register located in the head of the machine at some distance from the axial center. This is found to be a defective construction, inasmuch as the entering air is thereby caused to operate more locally than generally, and the evil is increased by the circumstance that the eccentric inrush of air is thrown tangentially from the first spider-hub into the peripheral belt of more or less comminuted material as a local current on the side where the air enters, lifting and carrying into the second chamber, and even into the fan-chamber, coarse particles which should be, and are with a concentric axial air-feed, more evenly distributed and longer retained under the action of the paddles.

In our improved machine the axially-entering air immediately impinges centrally against the first spider-hub, by whose rapid rotation, aided by the centrifugal throw of the paddles, it is distributed with the entering material evenly around the inner periphery of the first working chamber in such a way that neither in the first nor the subsequent chambers is the axial current at any point locally intensified or greater in volume or more forcible than at all other points.

With a direct axial air-feed and a gradually-diminishing axial exhaust-current our improved machine produces results superior to those which can obtain in the earlier machine. The superior centrifugal force of the air-current in the second working chamber holds there for further reduction most of the particles withdrawn from the first working chamber by the axial current proper, and the still superior force in the third working chamber holds there for yet finer reduction much of what the axial current draws from the second chamber. In fact the material in the third chamber is there retained until the particles become so fine and light that they are no longer affected by the centrifugal force and submit to and become part of the constant dust-laden axial current flowing into the fan-chamber. It is obvious that these most important and desirable conditions cannot obtain in a machine of this type whose working chambers are all of equal diameter or in which the pulverizing-chambers and their spiders do not successively increase in diameter from the feed end of the machine to the fan-chamber.

It is obvious, too, that while the exhausting force of the fan in our machine relatively decreases in comparison with the successively-increasing centrifugal forces in the working chambers, so that comparatively coarse particles cannot be carried into the fan-chamber by the axial current, the superior centrifugal forces of the second and third chambers, in combination with the axial current, must constantly draw from the first chamber for finer pulverization much material that is only partially reduced, thus unremittingly making room in that chamber for a larger constant supply of material, thus relieving the first set of paddles from excessive work and giving the other sets more to do, thereby equalizing the work of all the chambers.

We do not confine ourselves to three working chambers, but may employ two or more without departing from the principles involved in our invention.

Another improvement upon the old machine relates to the air-supply. In that machine the ore or other material to be introduced into the pulverizer is conveyed from the feed-hopper by a revolving screw over a short open chute, whence it falls into a feed-box attached to the pulverizer through a partially-adjustable opening in the top of the feed-box; but as this opening must always be kept large enough to readily admit the continuous supply of introduced material and to avoid becoming accidentally clogged (the material fed in usually varying in size from fine sand to pieces three-quarters of an inch

across) the opening must be of greater area than the inflowing stream in cross-section, allowing a very considerable volume of air to enter the pulverizer with the ore-supply. This uncontrolled inflow of air becomes greatly out of proportion to the material when the latter is intentionally or accidentally introduced slowly and in small quantity. We remedy this defect by applying a hood or cover N, extending from the feed-hopper H to the farther upper edge of the feed chute or box K, covering that part of the feed-screw I which extends beyond the hopper and the chute K, making an air-tight covered way over them. In the top of this cover is an opening in which is fitted a vertical pipe $Q^2$, having on its top a removable cap $Q^3$, in which is a register L, by adjustment of which (best shown in Fig. 6) the amount of air entering the axial opening *i* in the head of the pulverizer through the feed-box may be readily and absolutely regulated and controlled and always supplied in quantity properly proportional to the amount of material fed into the machine. As the amount of air entering the machine with the material to be pulverized controls in the greatest measure the fineness of the product, this improved construction will be seen to be of vital importance. In the sloping part of the hood N is another opening, through which the operator may examine at will the action or working of the screw I and the clips $Q^5$. This opening is at all other times kept closed by a hinged cover $Q^6$, as shown in Figs. 1 and 5.

The feed-screw I and its attachments and the clips $Q^5$ are the same in construction and function as those shown and described in the patent above referred to. These clips consist of two legs pivoted together at their upper ends on a bolt which holds them to the hopper-front. From their opposing edges a semicircle is cut out, about which is a lip extending forward at right angles. When in place, these clips cover the opening in the hopper-front, which opening is of greater diameter than the feed-screw, and embrace said screw, which projects through the circular opening in them, and the clip-spring normally holds the said clips about the screw, so that the latter can deliver from the hopper only what material may be engaged in the screw-grooves.

Should large pieces of material, nuts, bolts, pick-points, or the like accidentally get into the hopper and under the action of the feed-screw, the said screw or the clips would be thereby broken were the latter held rigidly in place, and hence they are arranged to yield laterally, and were the hopper-front opening only of the diameter of the feed-screw the latter would break or its revolutions be stopped were anything to become jammed between it and the edges of said opening. Hence said opening is made larger than the diameter of said screw.

The construction and functions of the plug or stopper R, removably fitted into a corresponding opening in the bottom of the first working chamber of the pulverizer, are also the same as that of the machine referred to, except that it is opened and closed by a compound lever R′, the handle of which is fixed within easy reach of the operator.

The steel-plate linings S of the working chambers are secured in place by the counsunk screws *k* and serve to prevent wear of the cylinder-shell. They will endure through several months of constant use, and when worn may be easily removed and replaced.

By the addition of the third journal-box T vibration is prevented and a steadier running of the machine is assured.

The counter air-register M in the discharge end of the cylinder is, in combination with the air-supply register L, an important feature. When it is nearly or quite open, the volume of air entering through it effects, in conjunction with the partial closing of the register L, a great reduction of the axial current entering the feed end of the machine. In this way when desirable, as it is when pulverizing some substances, the entire product of the machine can be made to consist only of the finest floated powder. Such a result is not obtainable in the patented machine above referred to, for the reason that it is impossible in that machine to regulate the axial air-supply with sufficient delicacy.

Of course when material is to be reduced to floated powder the quantity fed in within a given time must be less than when reduction of the normal character is required.

Having thus described our invention, we claim as new and desire to secure by Letters Patent—

1. A cylindrical ore-pulverizer constructed substantially as herein shown and described, with two or more pulverizing-chambers communicating with each other through axial openings in the separating-diaphragms, said chambers being of increasing diameters from the feed end toward the discharge end of the cylinder, as set forth.

2. A horizontal cylindrical ore-pulverizer constructed substantially as herein shown and described, with two or more revoluble pulverizing-spiders, the diameters of which are successively increased from the feed end toward the discharge end of the cylinder, as set forth.

3. An ore-pulverizer constructed substantially as herein shown and described, with a horizontal cylinder or shell interiorly divided by annular diaphragms into two or more working or pulverizing chambers and an exhaust-fan chamber, the pulverizing-chambers being of successively-increasing diameters from the feed toward the discharge end of the cylinder, and all of them being made to communicate with each other by means of axial openings through the diaphragms, said cylinder being provided with a revoluble shaft extending through its axis and having fixed

upon it pulverizing-spiders arranged to work in the pulverizing-chambers, and a fan-spider to operate in the fan-chamber, said pulverizing-spiders being of successively larger diameters, as are the chambers, and being provided with suitable peripheral working paddles; the fan-spider being provided with suitable fan-plates, substantially as set forth.

4. An ore-pulverizer constructed substantially as herein shown and described, with a horizontal fixed cylinder or shell interiorly divided by annular diaphragms into two or more communicating pulverizing-chambers and an exhaust-fan chamber having a peripheral delivery, the diameter of the first working chamber and the fan-chamber being alike, while the diameters of the other working chambers increase successively toward the discharge end of the cylinder, as set forth.

5. In an ore-pulverizer constructed substantially as herein shown and described, provided with an axial feed-opening, with two or more pulverizing-chambers and a fan-chamber communicating with each other through axial openings, and an attached feed-chute between said axial feed-opening and feed-hopper, an air-tight hood or cover covering the opening in the top of said chute and extending to and covering the discharge-opening of the feed-hopper, as set forth, whereby all excess of air is prevented from entering the cylinder along with the material fed into it.

JACOB J. STORER.
FRANK MARTIN.
GEORGE O. EATON.

Witnesses to signatures of Jacob J. Storer and George O. Eaton:
E. C. EATON,
M. L. STORER.
Witnesses to signature of Frank Martin:
DANIEL MCCENTTY,
L. B. JOBB.