No. 642,717. Patented Feb. 6, 1900.

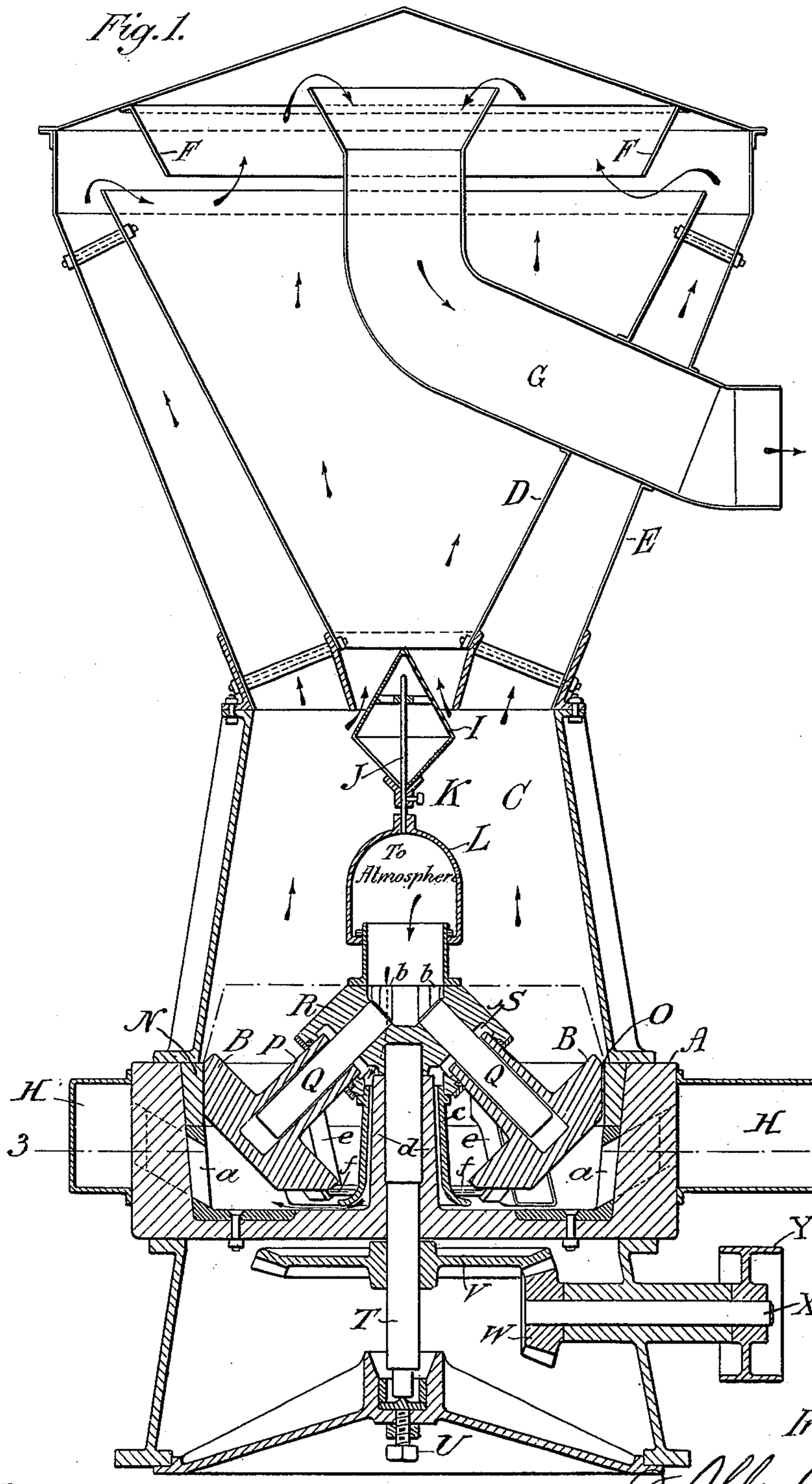
A. RAYMOND.

PULVERIZING MILL.

(Application filed May 6, 1898.)

(No Model.) 4 Sheets—Sheet 1.

Fig. 1.



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(No Model.) 4 Sheets—Sheet 2.

Fig. 2.

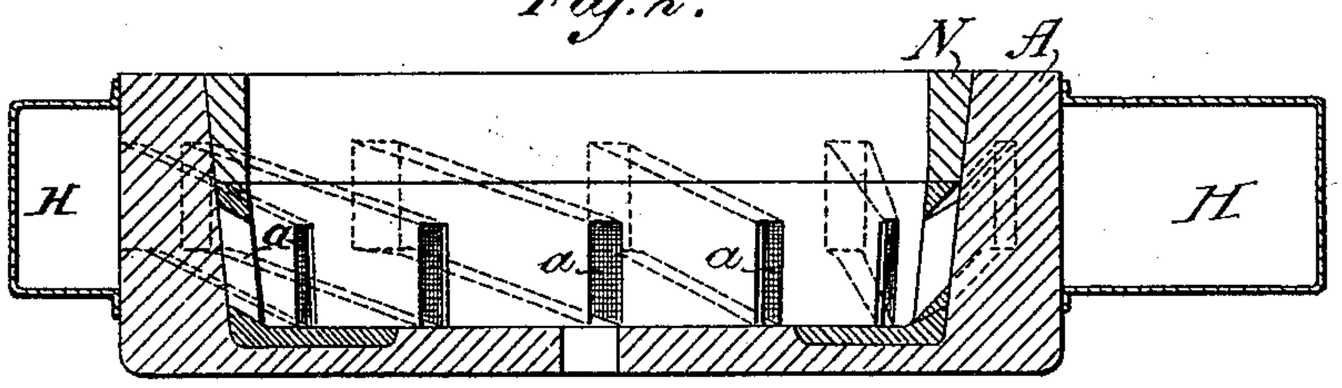
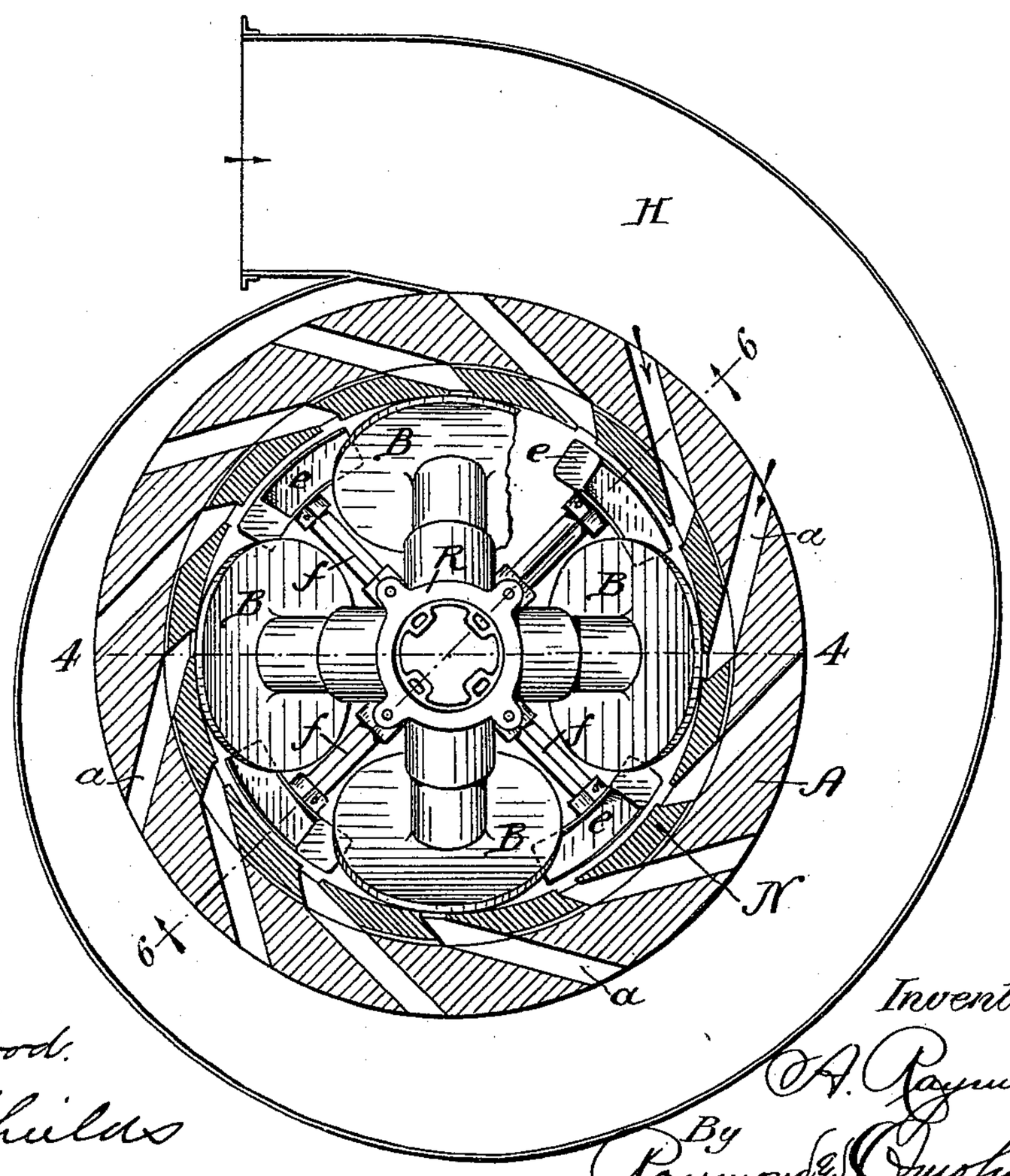


Fig. 3.



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(No Model.)

4 Sheets—Sheet 3.

Fig. 4

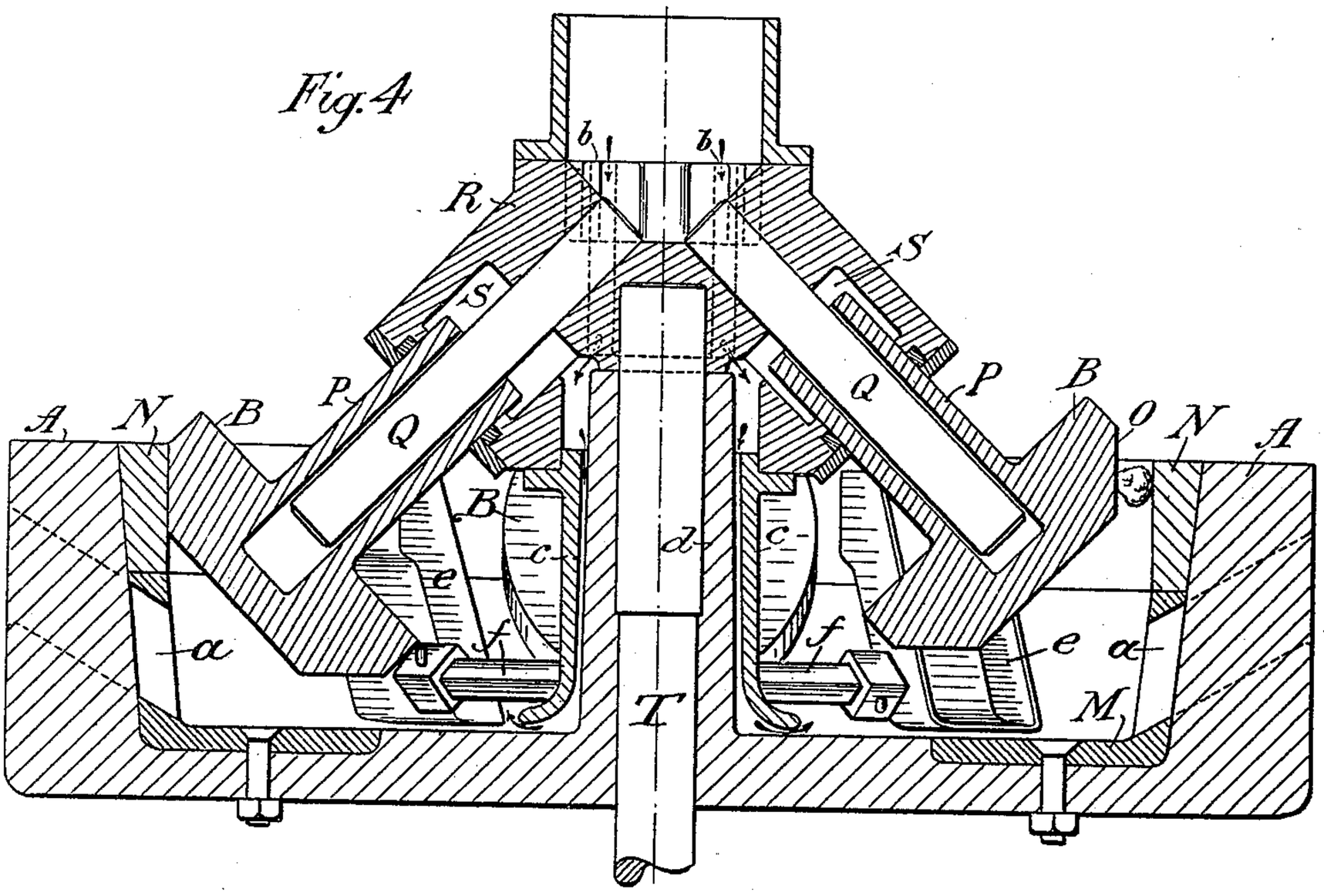
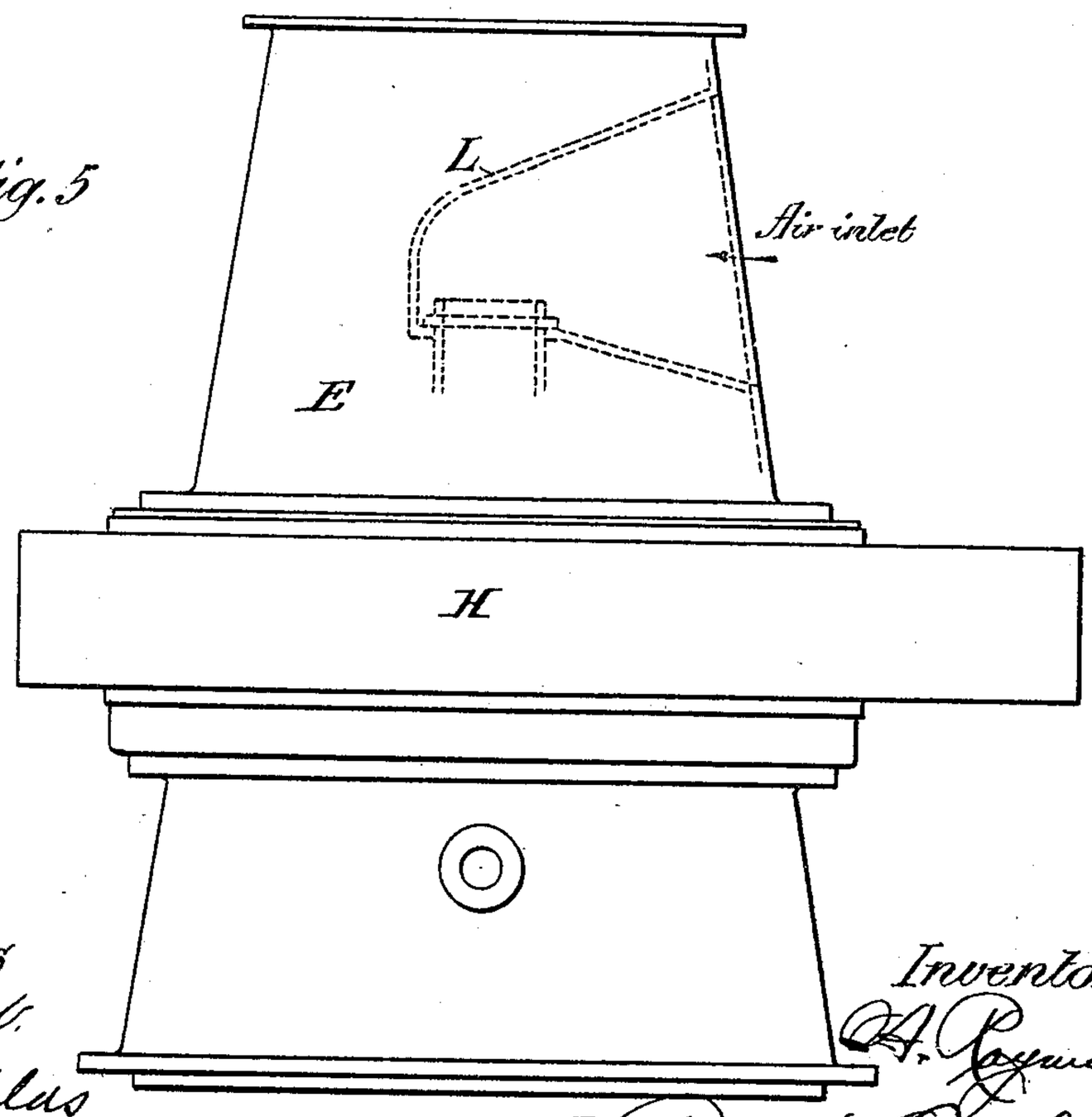


Fig. 5



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(Application filed May 6, 1898.)

(No Model.) 4 Sheets—Sheet 4.

Fig. 7.

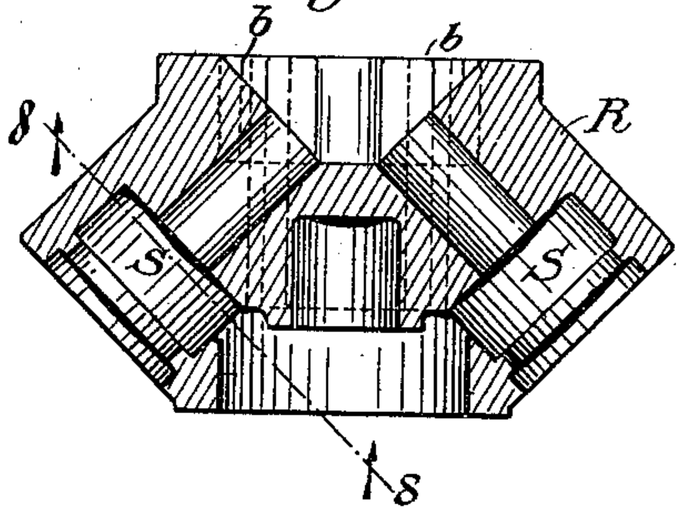


Fig. 9.

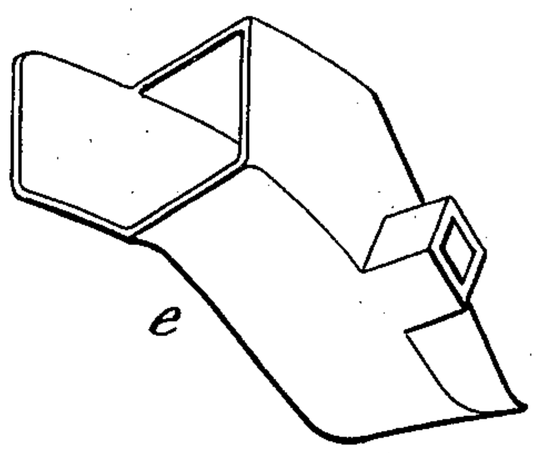


Fig. 8.

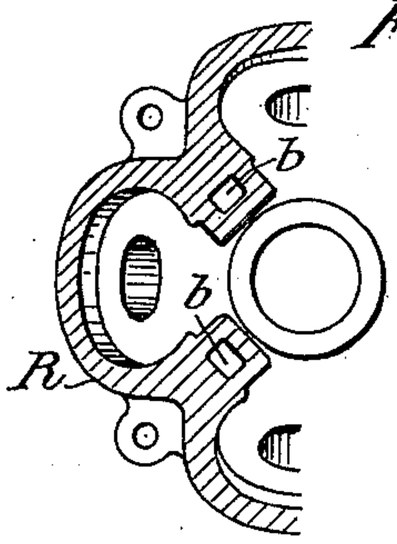


Fig. 10.

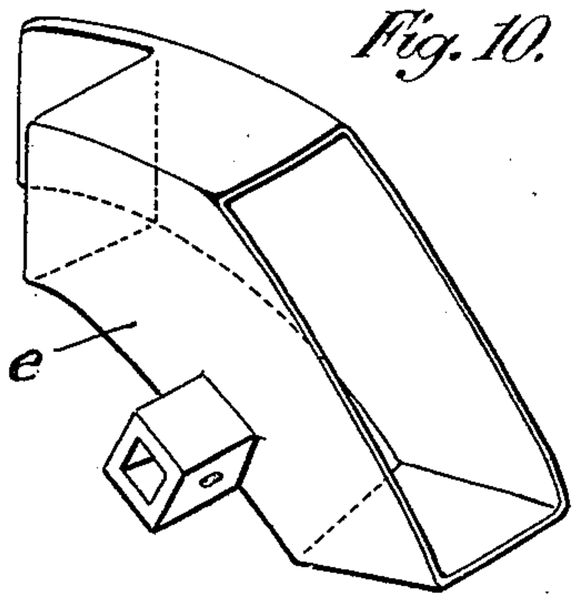
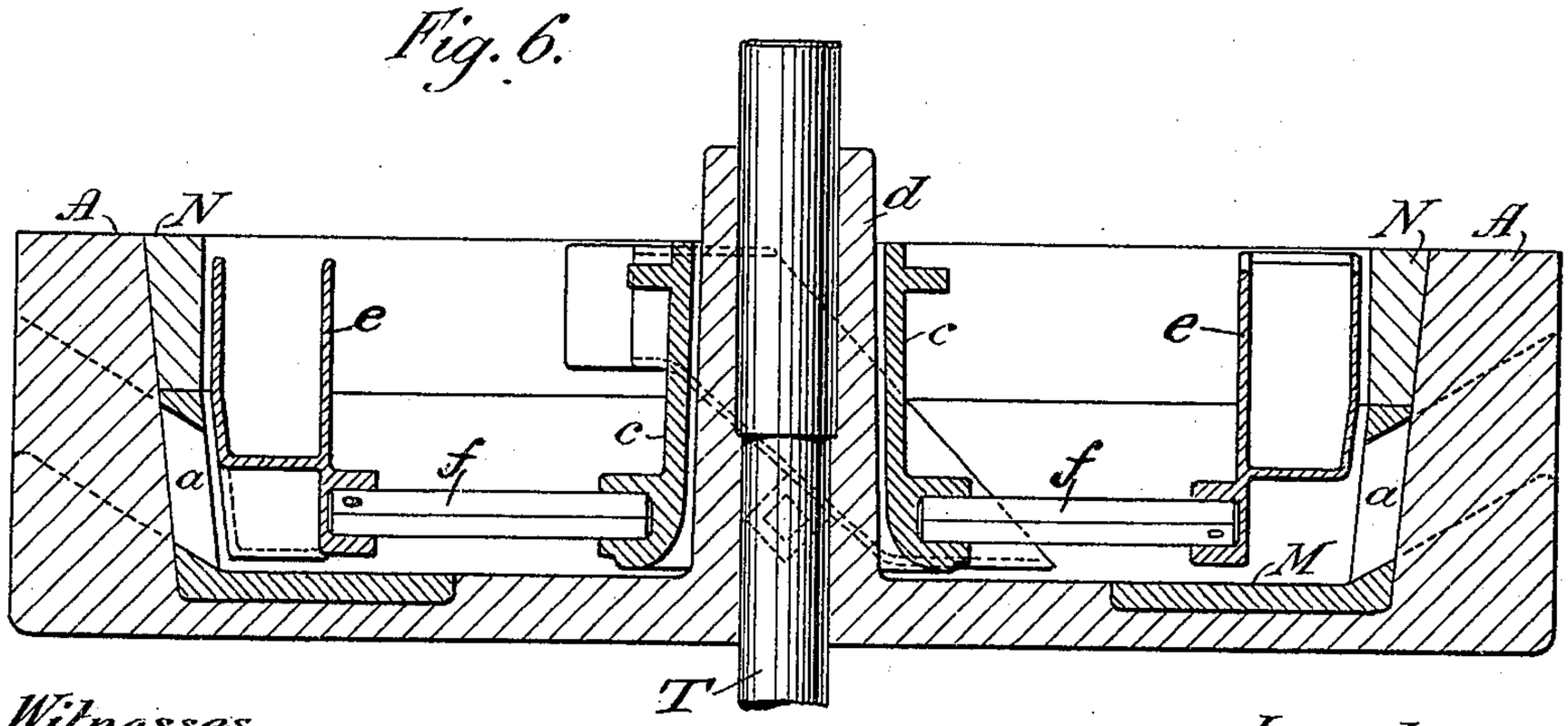


Fig. 6.



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UNITED STATES PATENT OFFICE.

ALBERT RAYMOND, OF CHICAGO, ILLINOIS.

PULVERIZING-MILL.

SPECIFICATION forming part of Letters Patent No. 642,717, dated February 6, 1900.

Application filed May 6, 1898. Serial No. 679,907. (No model.)

To all whom it may concern:

Be it known that I, ALBERT RAYMOND, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Pulverizing-Mills, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming part of this specification.

This invention relates to improvements in pulverizing-mills especially adapted to the reduction of cement and similar substances to impalpable powder, the particular class of pulverizing-mills to which my invention more particularly relates being that in which the pulverizing is accomplished by a combined crushing and grinding action of rollers having a bodily revolution as well as an axial rotation.

The prime object of my invention is to have the revolving crushing-rollers capable of free and unrestrained axial rotation and bodily movement parallel with the axis of rotation and at the same time provide a mill that shall be cheap and simple in construction, economical of operation, and that shall have the maximum capacity and efficiency.

Another object is to have the grinding-faces of the rollers and bowl in such a machine substantially parallel at all times, regardless of the distance of the roller from the crushing-ring of the bowl, and hence regardless of the size of the material being operated upon.

A further object is to utilize to the maximum the gravity, as well as the centrifugal force, of revolving rollers in the crushing and grinding operation, whereby is avoided the bounding and skipping of the rollers in action, while the efficiency of the machine is greatly promoted.

Other objects are to insure the prompt discharge of the dust from between the grinding-rollers and the bowl without allowing the same to settle into the bowl, to protect the bearings of the rollers against the lodgment of dust thereon, which would otherwise seriously interfere with the operation of the machine, and to provide certain novel details for the carrying out of these objects.

The foregoing and such other objects as may hereinafter appear are attained by the devices illustrated in the accompanying drawings, in which—

Figure 1 represents a central vertical section through a crushing-mill embodying my invention, showing the "Raymond" air-separator applied thereto. Fig. 2 represents a central vertical section through the bowl of the mill. Fig. 3 represents a horizontal section through the mill, taken on the line 3 3 of Fig. 1. Fig. 4 represents an enlarged vertical section on the line 4 4 of Fig. 3. Fig. 5 represents a detail side elevation more particularly illustrating the atmospheric port leading to the bearings. Fig. 6 represents a vertical section through the bowl on the line 6 6 of Fig. 3 looking in the direction indicated by the arrows, but showing the rollers removed. Fig. 7 represents a detail sectional view of the crusher-head. Fig. 8 represents an oblique section thereof on the line 8 8 of Fig. 7 looking in the direction indicated by the arrows. Figs. 9 and 10 represent detail perspective views of the plows.

Similar letters of reference indicate the same parts in the several figures of the drawings.

So far as relates to the broad idea of my invention I may here state that it is immaterial how the impalpable powder or dust produced by my mill is removed therefrom, but for the purposes of illustration I have shown in Fig. 1, in connection with the mill, the air-separator for which Letters Patent of the United States No. 580,145 were granted me on the 6th day of April, 1897, which apparatus is automatic in its operation when once the machine is set in motion.

Referring by letter to the accompanying drawings, and more particularly to Fig. 1, the machine consists in general of a bowl A and rollers B, between which the cement is pulverized, the dust passing up through the cylindrical chamber C between the double cones D and E under the deflector F and out through the discharge-pipe G, the direction of the dust being equally illustrated by the arrows. The dust is drawn out by an exhaust-fan, the induction-port of which is connected with the pipe G and the eduction-port of which is connected with a dust-collector

of any suitable construction. From the collector the cleaned air is returned to the spiral air-duct H surrounding the bowl of the mill, and thence into the mill and out again in the manner previously described, but dust-laden, thus making a complete circuit. It is not deemed necessary to illustrate either the fan or any dust-collector, for so far as concerns the broad idea of my invention it is immaterial how the air-laden dust is drawn out of the mill or out of the pipe G, and it is equally immatrial what becomes of the dust-laden air and whether the same is returned after separating the dust therefrom to the mill, or whether fresh air is continuously supplied to the mill through the supply air-duct H, as before described.

The combination of my previously-patented air-separator with my new mill is particularly advantageous, however, because the heavy particles that are not carried out of the separator by the air and which represent the "tailings" of the separator fall back directly into the mill for regrinding without any other handling, some of such heavy particles falling back after entering the space between the cones D and E and others falling back after passing over and into the cone D, where they come in contact with the annular deflector F. This latter portion of the heavy particles must of course have means for escape from the cone D, and in my former machine flap-valves were provided in a discharge leading to the bottom of said cone, which would open in one direction only. In my present machine I have improved upon this arrangement by providing a cone-valve I, adapted to enter and find a seat upon the lower end of the cone D. This valve is adjustably supported upon a rod J and may be set at any desired point by means of a set-screw K to provide a suitable opening between the valve and the cone. Obviously part of the dust-laden air, as illustrated by the arrows, must necessarily pass through this valve-opening and of course opposes the fall of the smaller and lighter pulverized particles of cement which pass over into the cone D, but are temporarily checked by the deflector F. By a proper adjustment of the valves in the opening the quantity of air passing through this channel may be readily adjusted so as to insure the continuous rise and discharge of the dust out through the exhaust or discharge pipe G, while at the same time it will not be sufficiently strong to force any of the smaller pulverized particles from the cone D upward and into the discharge-pipe.

The rod J of the valve I may be supported in any suitable manner upon any stationary part of the machine; but because of its convenience I prefer to support said rod upon the dome L of the atmospheric inlet provided for supplying air to prevent the lodgment of dust on the roller-bearings, as will be described in detail farther on, such dome and inlet being clearly illustrated in dotted lines in Fig. 5.

The bowl A of the mill, which is stationary, is provided with a suitable annular lining M along the bottom and part way up the side walls thereof and with a wearing-ring N reaching from about the center of depth to the upper edge of the bowl, which ring constitutes the crushing and grinding face of the bowl against which the roller B works. The inner periphery of the ring N, it will be observed, is substantially in a vertical plane, and the working face of the roller B is beveled, as at O, so as to extend obliquely to the axis of the roller and substantially parallel with the face of the ring O. It is manifest that the working face of the ring N might be at an angle instead of vertical, and the bevel or incline of the working face of the roller may be correspondingly changed so as to lie parallel therewith.

There may be any desired number of crushing-rollers, four being shown in the drawings, but all of them are arranged to rotate on an oblique axis, and as each roller is capable of endwise movement or bodily movement parallel with its axis the opposing grinding-faces of said rollers and the ring N will remain always substantially parallel, no matter how near together or far apart such faces may be and regardless of whether these grinding-faces are in a vertical plane or at any angle between the horizontal and vertical. To accomplish this, the rollers are preferably provided with comparatively long hubs P, which are loosely sleeved upon fixed stud-shafts Q, secured in the crusher-head R, so that when the latter is rotated the rollers will be caused to revolve about the axis of rotation of the head which is coincident with that of the bowl and crushing-ring. The hubs of the rollers enter freely into recesses S in the crusher-head, which recesses are of sufficient depth to allow of considerable endwise movement of the hubs upon the stud-shafts. The hubs are prevented from leaving the stud-shafts and coming entirely out of the recesses by the contact of the rollers with the ring N. In Fig. 4 the left-hand roller is shown in its extreme outward position, while the right-hand roller is shown partly retracted from the ring, as it would be when forced back by the inner position of the material being operated upon between it and the ring.

The crusher-head is axially supported upon a vertical shaft T, to which the head is keyed or otherwise rigidly secured, the lower end of said shaft being stepped in a suitable bearing at the bottom of the machine, the bearing shown being the conical end of a threaded bolt U, projecting into the cavity of the step and engaging the central depression in the end of the shaft. This shaft may be caused to revolve in any suitable manner, such as by means of the beveled gear V, keyed thereon,

meshing with a corresponding beveled pinion W, mounted upon a power-shaft X, driven by a pulley Y or any other suitable manner. It will thus be observed that when the shaft T is rotated the crusher-head R rotates with it, and through the intermediary of the stud-shaft Q, entering loosely in the hubs P of the rollers, causes the latter to revolve about and within the bowl, the said rollers being forced to impact against the crushing face or ring of the bowl under the combined influence of centrifugal force and the gravity of the rollers. Consequently the maximum possible crushing force is exerted by the rollers, and this of course greatly enhances the certainty of continuous and practically uninterrupted rotation of the rollers, which though free to move away from the crushing-face of the bowl when large lumps or masses of the material being operated upon are interposed between the rollers and the bowl, yet such movement of the rollers is opposed by the combined gravity and centrifugal force thereof, and hence there will be no slipping or uneven action thereof. In fact, such action of the rollers will reduce the material being operated upon to an impalpable powder in an unprecedented short space of time.

To insure the prompt removal of the dust or powder produced by the rollers, I propose to introduce through lateral ports *a* in the walls of the bowl, at different points along the periphery thereof, jets of air which enter at the bottom of the bowl below the crushing-ring N and which under the influence of the suction applied to the discharge-pipe G forms a continuous upward current across the rollers and across crushing-faces thereof, carrying off the dust as rapidly as it is formed. I prefer to admit the air to these lateral ports *a* from the single spiral duct H, to which the air may be supplied to any suitable source, but obviously there may be separate pipes and separate sources of supply for each port.

To prevent the lodgment of the dust upon the bearings of the rollers, I provide for the establishment of a current of air in the chambers S, in which the hubs of the rollers work, which chambers, as will be more clearly seen in Fig. 4, have open connection with the passage through which the air is conducted. To accomplish this, I provide vertical ducts *b* in the crusher-head, which are open to the atmosphere through the dome L and which lead down through an annular passage formed by an apron *c*, depending from the crusher-head and surrounding the hub *d* of the bowl. The course of the air in its passage through the mill is plainly illustrated by the arrows in Fig. 4. There is no place of ingress for the dust into the chambers S and into the hubs of the rollers except at the ends of the bearings of the crusher-head, where protection is afforded by a packing of ordinary character. By setting up the current past the chamber S and down within the apron *c* the rising of the dust to reach this chamber is absolutely prevented, because there will at all times be a strong current downward through the apron induced by the suction at the discharge end of the machine.

To prevent the accumulation of the larger and heavier particles of the material being worked upon in the bottom of the bowl, which might to some extent interfere with the action of the crushing-rollers, and also to insure the more rapid and thorough pulverizing of the material, I propose to have a constant delivery of the material from the bottom of the bowl to the crotch formed between each roller and the bowl, which operation shall be continuous, notwithstanding the revolution of the rollers about the bowl. To this end I provide in front of each roller a plow *e*, which is preferably tubular with an inclined floor and curved longitudinally to conform to the arc of the bowl. These plows, as more clearly illustrated in Fig. 6, are supported upon arms *f*, radiating from the apron *c*, and as the apron is rigidly secured to and depends from the crusher-head it of course rotates in unison therewith, and thus carries the plows along in advance of the rollers. There is one plow for each roller so disposed that the material is picked up thereby from the bottom of the bowl and forced up the inclined floor of the plow and discharged from the upper end thereof into the crotch between the crushing-roller and the ring or jaw. It will thus be seen that by the use of these plows in advance of one roller, or one or more of them, as may be preferred, there can be no accumulation of the material in the bottom of the bowl, and so long as there is any material in the bowl the rollers will not be idle, although operating above the bottom of the bowl, because the material will be forcibly lifted up and discharged by the plows into the crushing-jaws formed by the roller and bowl. It is therefore obvious that the effectiveness of the machine will be greatly promoted and the product thereof greatly increased by the use of these plows, which, though not essential to the broad idea of my invention, are at the same time desirable for the reasons above mentioned.

A pulverizing-mill embodying my invention possesses numerous advantages over such machines as heretofore constructed, chief among which may be mentioned the simplicity and economy of construction, the readiness with which worn or broken parts may be removed, the effectiveness thereof for pulverizing to almost any degree of fineness, even to the production of an impalpable powder at a comparatively slow speed, and the utilizing to the fullest extent the grinding and pulverizing force resulting from the operation of the machine combining gravity with centrifugal force, whereby the successful operation of the machine may be accomplished with the minimum expenditure for power operating the same.

It is obvious that numerous changes may

be made in the construction and mode of operation of a pulverizing-mill embodying my invention, the construction herein illustrated being simply one form of embodiment; but all such changes are contemplated by and would fall within the purview of my invention. For instance, while I have shown and described rollers as having a free axial rotation and bodily movement on an axis oblique to the plane of its orbit—that is, upon stud-shafts extending downwardly from the horizontal—obviously the degree of inclination of the stud-shafts is immaterial and will be varied according to the work to be performed by the mill.

While my invention broadly contemplates a machine in which the crushing-rollers are capable of a free axial rotation upon fixed axes—a free bodily movement parallel with the axes thereof, but toward and away from the crushing-face of the bowl while traversing their orbits—it is to be observed as a peculiarity of the present machine that the axes of the crushing-rollers have a downward and outward inclination with reference to the main vertical axes around which the rollers travel in their orbital movement; that the downward and outward inclination of the axes of the rollers is constant or unchangeable, and that in consequence of this fact the crushing-faces of the rollers maintain under all conditions their parallelism with the inner surface or crushing-face of the ring or bowl against which they act. It is to be further observed that owing to the downward and outward inclination of the axes of the rollers the downward movement of the rollers under the influence of gravity has the effect of carrying or urging the rollers outward toward the inner surface or crushing-face of the bowl. It is also to be noted that owing to the inclination of the axes the centrifugal force developed by the rapid movement of the rollers in traversing their orbits has a further tendency, or a tendency in addition to that of gravitation, to carry the rollers outward toward the surrounding ring or bowl. In consequence of the facts above stated the rollers are free to rise and recede from the inner surface or crushing-face of the bowl in a manner which admits of their adjusting themselves easily to the varying coarseness of the material under treatment, while at the same time this material is subjected at all times to the crushing and grinding action between surfaces which are parallel and from rollers which are free to rotate upon their axes, which are free to move toward and away from the material being operated upon while traversing their orbits, and which during the operation of the machine are at all times subjected to the combined influence of gravity and centrifugal force tending to drive them against the crushing-face of the bowl.

Having thus fully described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In a pulverizing-mill, the combination with a stationary bowl provided with a crushing-face on its inner periphery, of one or more rollers capable of a free axial rotation upon fixed axes and a free bodily movement parallel with the axes thereof, but toward and away from the crushing-face of the bowl and means for imparting an orbital travel to said roller or rollers, each of said rollers having a single crushing-face oblique to its axis of rotation and parallel with the crushing-face of the bowl, substantially as described.

2. In a pulverizing-mill, the combination with a stationary bowl provided with a crushing-face on its inner periphery, of one or more rollers having axes of fixed inclination and capable of a free axial rotation and a free bodily movement parallel with the axes thereof, but toward and away from the crushing-face of the bowl and means for imparting an orbital travel to said roller or rollers, each of said rollers having a single crushing-face oblique to its axis of rotation and parallel with the crushing-face of the bowl, substantially as described.

3. In a pulverizing-mill, the combination with a stationary bowl provided with a crushing-face on its inner periphery, of one or more rollers having fixed axes downwardly and outwardly inclined with reference to the axis of the bowl and capable of a free axial rotation and a free bodily movement parallel with the axes thereof, but toward and away from the crushing-face of the bowl and means for imparting an orbital travel to said roller or rollers about the axis of the bowl, each of said rollers having a single crushing-face oblique to its axis of rotation and parallel with the crushing-face of the bowl, substantially as described.

4. In a pulverizing-mill, the combination with a stationary bowl, of one or more rollers having fixed axes oblique to the vertical and capable of a free axial rotation and a free bodily movement parallel with the axes thereof, but toward and away from the crushing-face of the bowl and means for imparting an orbital travel to said roller or rollers about a vertical axis, substantially as described.

5. In a pulverizing-mill, the combination with a stationary bowl provided with a crushing-face, of one or more rollers having fixed axes oblique to the vertical and capable of a free axial rotation and a free bodily movement parallel with the axes thereof, but toward and away from the crushing-face of the bowl and means for imparting an orbital travel to said roller or rollers about a vertical axis, said rollers each having a single crushing-face oblique to its axis of rotation and parallel with the crushing-face of the bowl, substantially as described.

6. In a pulverizing-mill, a driving-head rotating on a vertical axis, gravitating conical

crushing-rollers carried by said head, their axes having a downward and outward inclination with reference to the axis of the head and an encircling ring or bowl against which said rollers act, substantially as described.

7. In a pulverizing-mill, downwardly and outwardly gravitating rollers having axes of fixed downward and outward inclination and arranged to travel orbitally around a vertical axis, in combination with a horizontal ring or bowl against the inner surface of which said rollers are arranged to act, whereby the rollers are permitted to recede from the inner surface of the ring or bowl, but urged constantly toward the same both by gravity and by centrifugal force, substantially as described.

8. In a pulverizing-mill, a horizontal ring or bowl having a vertical or substantially vertical inner surface, in combination with conical crushing-rollers arranged to travel around the inner surface of said ring, said rollers being each mounted on an axis of fixed inclination whereby it is permitted to slide axially downward and outward toward the ring or bowl and vice versa without destroying the parallelism between its surface and the surface of the ring or bowl, substantially as described.

9. In a pulverizing-mill, the combination of the following elements: a fixed ring or bowl having a vertical or substantially vertical inner surface, a central vertical driving-shaft, a head or carrier mounted on said shaft and a series of crushing-rollers carried by said head and arranged to travel around the interior of the ring, their axes having a downward and outward inclination and the rollers being free to gravitate in the direction of their axes, whereby they are caused to slide downward and outward toward the interior surface of the ring under the influence of gravity, substantially as described.

10. In a pulverizing-mill, the combination with a stationary bowl having an upright crushing-face, of one or more rollers loosely mounted upon the ends of fixed downwardly and outwardly extending oblique shafts, and means for imparting to said rollers a free axial rotation, a free bodily movement parallel with the axes thereof and a bodily revolution, each of said rollers having a single crushing-face oblique to its axis but parallel with the crushing-face of the bowl, substantially as described.

11. In a pulverizing-mill, the combination with a stationary bowl having an upright crushing-face, of one or more rollers loosely mounted upon the ends of fixed downwardly and outwardly extending oblique shafts and capable of a free axial rotation and bodily movement parallel with the axes thereof, means for imparting an orbital travel to said roller or rollers, said rollers having oblique crushing-faces parallel with the crushing-face of the bowl, and means for admitting air to the bowl at a point below the contacting surfaces of the roller and bowl, substantially as described.

12. In a pulverizing-mill, the combination with a stationary bowl having an upright crushing-face and an exhaust-chamber above the bowl, of one or more rollers loosely mounted upon downwardly and outwardly extending oblique stud-shafts and capable of a free axial rotation and a free bodily movement parallel with the axes thereof, said rollers having oblique crushing-faces parallel with the crushing-faces of the bowl, means for imparting an orbital travel to said roller or rollers and means for admitting air to the bowl at a point below the contacting surfaces of the roller and bowl, substantially as described.

13. In a pulverizing-mill, the combination with a stationary bowl, an upright shaft extending axially through said bowl, the crusher-head secured to said shaft, and one or more fixed stud-shafts projecting downwardly and outwardly from said head, of a roller loosely mounted on each of said shafts and capable of free bodily movement parallel with the axes thereof, and means for rotating the upright shaft, substantially as described.

14. In a pulverizing-mill, the combination with a stationary bowl having an upright crushing-face, an upright shaft extending axially through said bowl, a crusher-head rigidly secured to said shaft, and one or more fixed stud-shafts extending downwardly and outwardly from said head, of a roller loosely mounted on each of said shafts and capable of a free bodily movement parallel with the axes thereof, each of said rollers having oblique crushing-faces parallel with the crushing-face of the bowl, substantially as described.

15. In a pulverizing-mill, the combination with a stationary bowl, an upright shaft extending axially through said bowl, a crusher-head rigidly secured to said shaft, and stud-shafts extending obliquely from said head, of a roller loosely journaled upon each of said shafts and capable of bodily movement parallel with the axes thereof, an apron depending from said head and opening into the bottom of the bowl, means for exhausting air from the bowl, means for admitting air to the bowl below the contacting surfaces of the rollers and bowl, ducts extending through the crusher-head and opening within said apron, the bearings of the rollers being open to said ducts and said ducts being open to the atmosphere, and means for rotating the upright shaft, substantially as described.

16. In a pulverizing-mill, the combination with a stationary bowl, crushing-rollers and means for imparting to said rollers an orbital travel about the bowl, of a series of tangentially-arranged air-ducts opening into the bowl below the crushing-face thereof, substantially as described.

17. In a pulverizing-mill, the combination with a stationary bowl having an upright

crushing-face, an upright shaft extending axially through said bowl, a crusher-head rigidly secured to said shaft and one or more conical rollers carried by said crusher-head, each of said rollers having oblique crushing-faces parallel with the crushing-face of the bowl, of a spiral air-duct surrounding the bowl and a series of tangential air-passages connecting said duct with the interior of the bowl in a plane below the crushing-face thereof, substantially as described.

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