No. 677,702. Patented July 2, 1901.

W. M. RUSSELL & F. P. BIXON.

PULVERIZING MILL.

(Application filed Aug. 20, 1897. Renewed Dec. 10, 1900.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1.

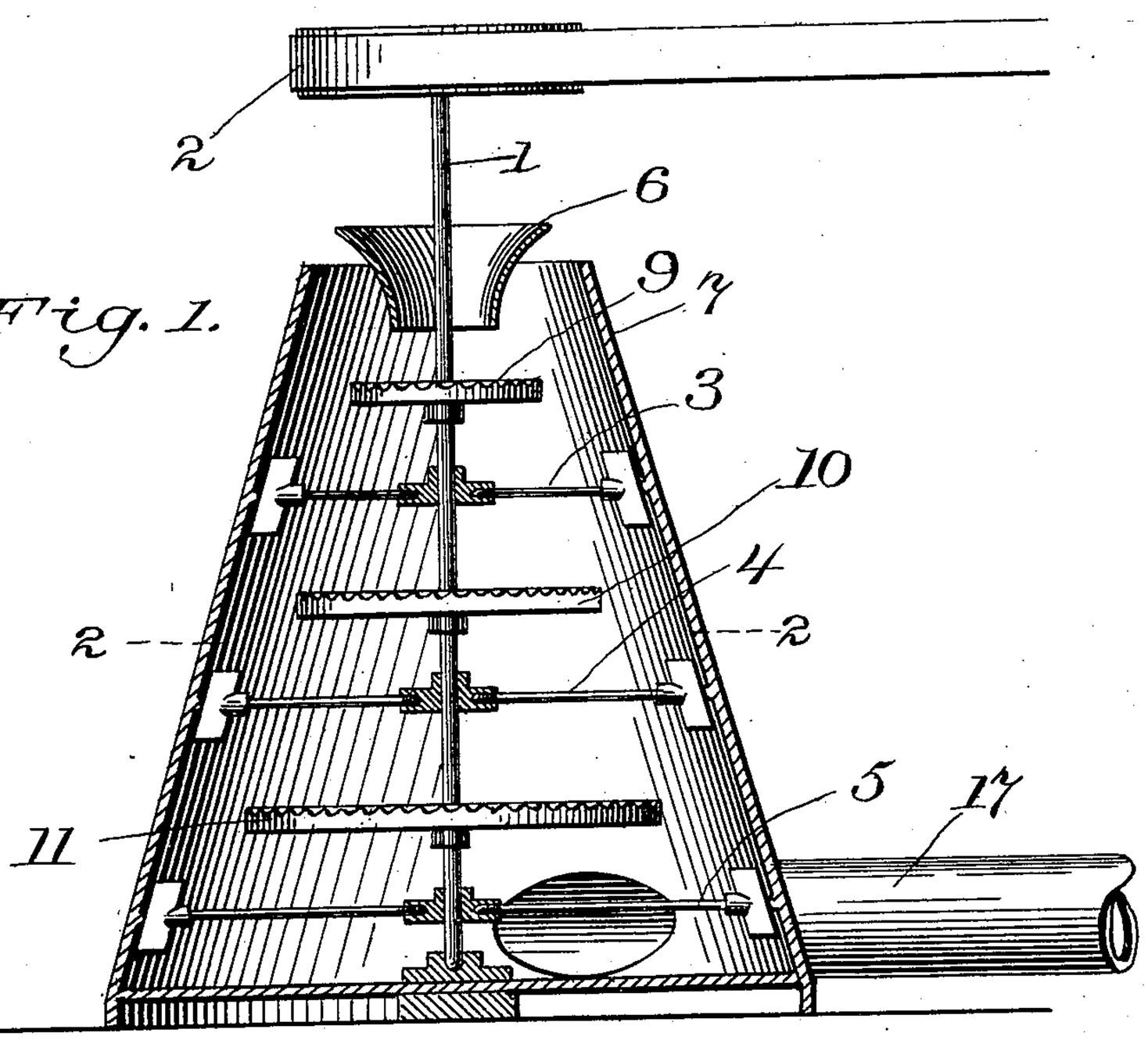

Fig. 2.

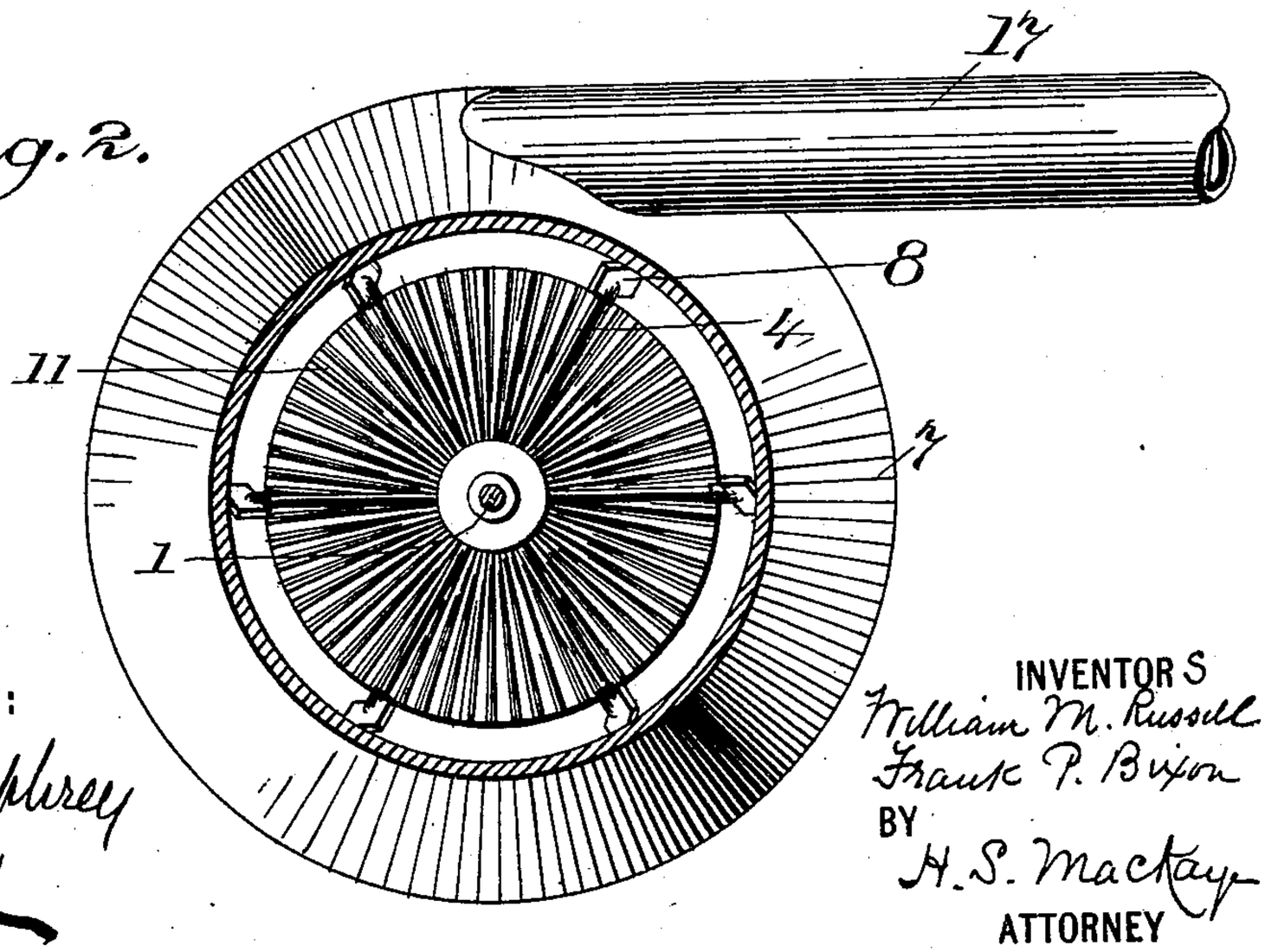

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Fig. 3.

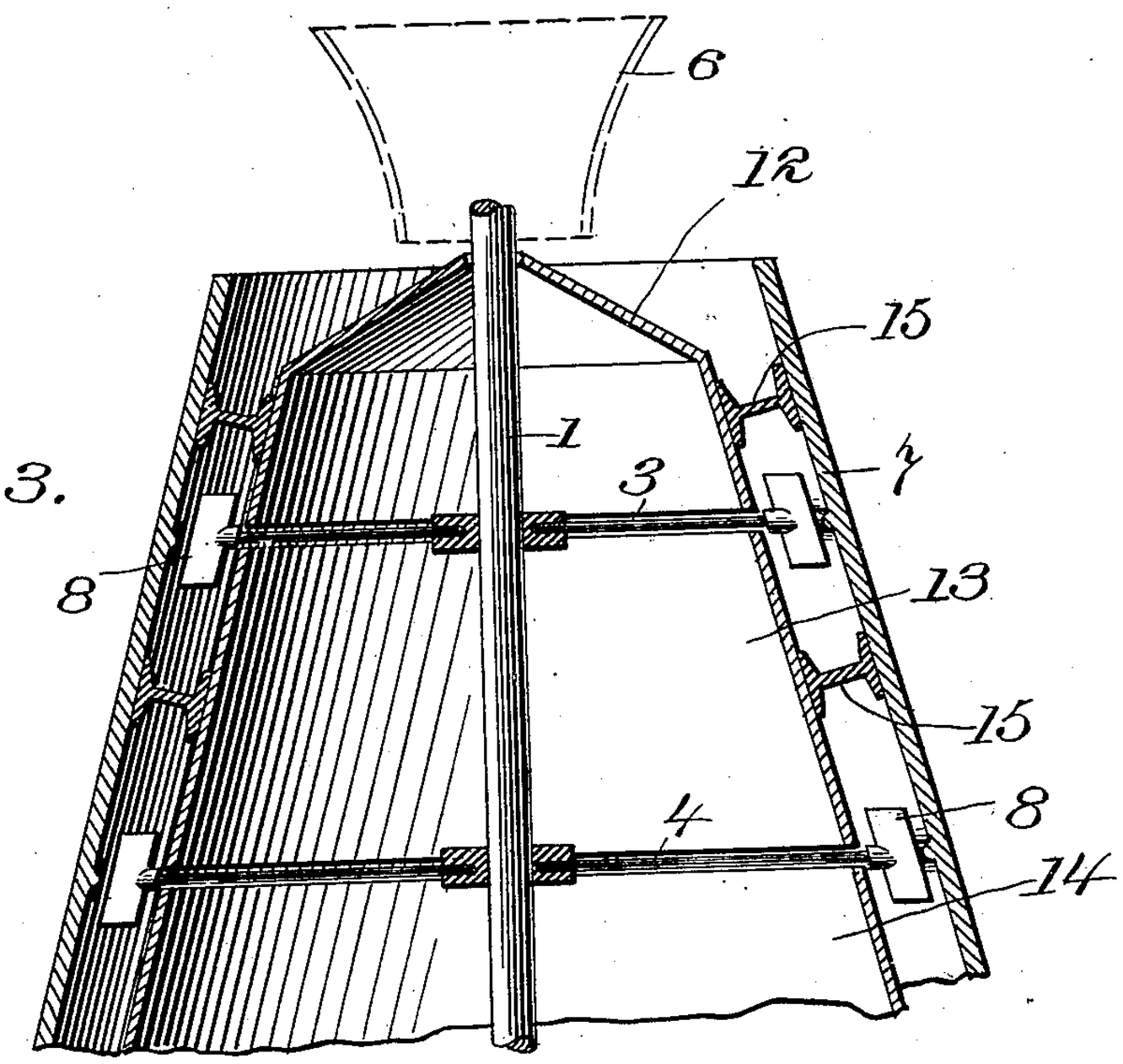
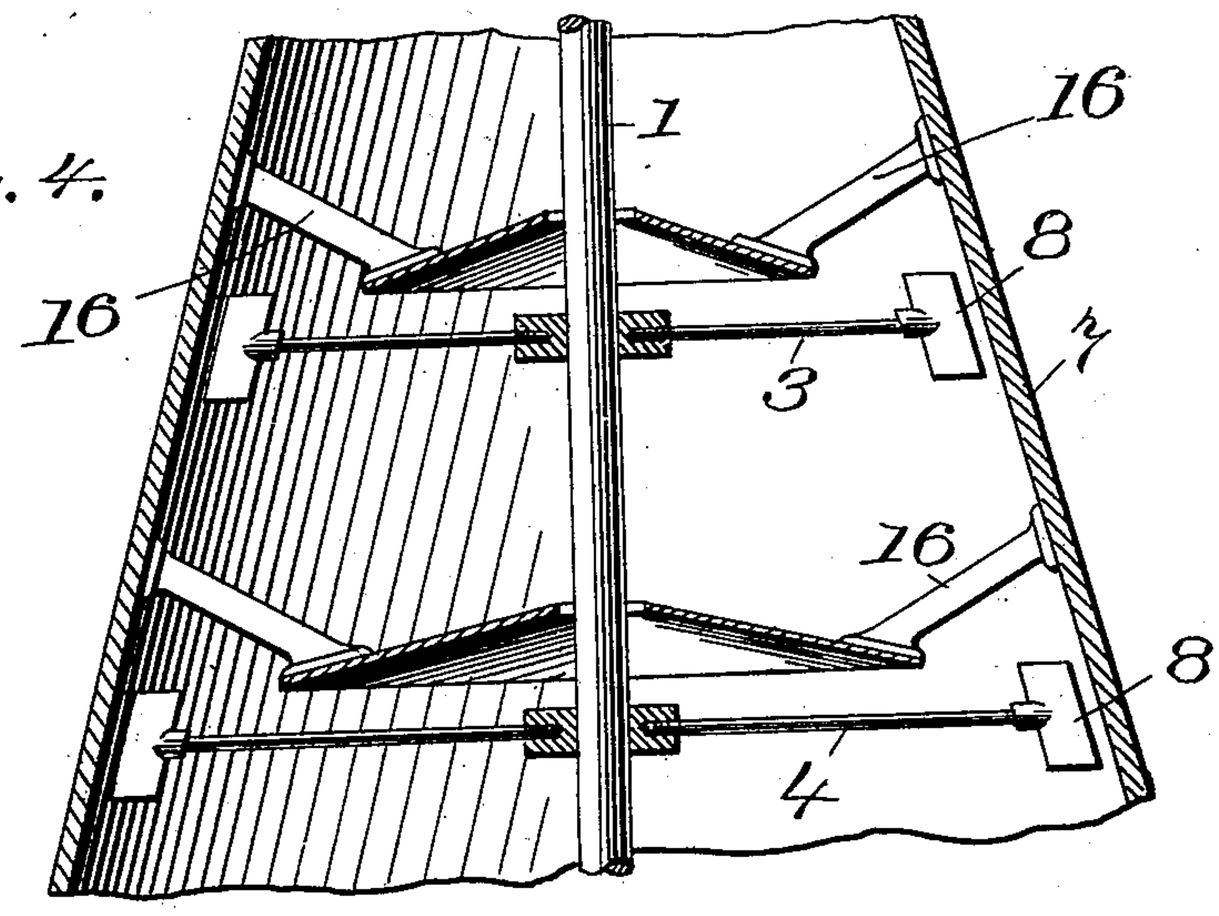


Fig. 4.



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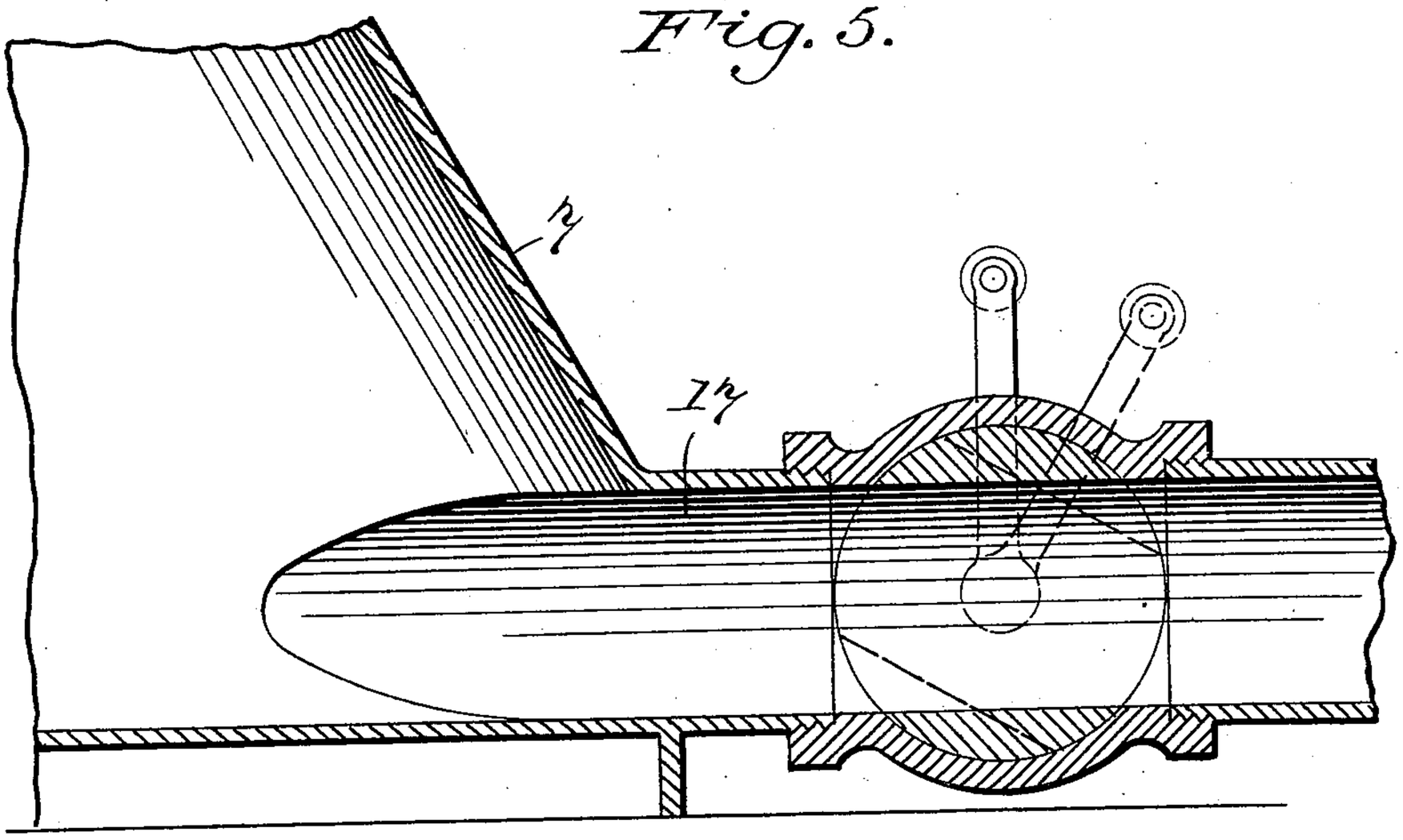
(No Model.) 3 Sheets—Sheet 3.

Fig. 5.



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WILLIAM M. RUSSELL AND FRANK P. BIXON, OF NEW YORK, N. Y.

PULVERIZING-MILL.

SPECIFICATION forming part of Letters Patent No. 677,702, dated July 2, 1901.

Application filed August 20, 1897. Renewed December 10, 1900. Serial No. 39,280. (No model.)

To all whom it may concern:

Be it known that we, WILLIAM M. RUSSELL and FRANK P. BIXON, residing in the city, county, and State of New York, have invented a certain new and useful Improvement in Pulverizing-Mills, of which the following is a specification.

Our invention has relation to pulverizing-mills in general, and particularly to such as are adapted to pulverizing coal or other fuel and delivery of the same mixed with air for the purposes of rapid combustion.

The main object of our invention is the production of a form of mill wherein the utmost efficiency and reliability of flame may be commanded and which may be driven with the greatest economy of power. In obtaining a reliable and efficient flame it is important that the correct proportion of fuel and air shall be supplied at the burner. To accomplish this, we have devised a mill which acts mechanically and positively to mingle the fuel and the air. Furthermore, by the use of our machine proper variations in proportions are easily obtained to suit various fuels. In order, on the other hand, that the greatest economy of power may be obtained, we avail ourselves of the continuous force of gravity in producing the feed during the process of pulverization, and at the same time, by the form of our device, we avoid all waste of power by conflicting efforts of various parts of the mill. This element of merit in our machine applies to its use for the pulverizing of all materials.

Our improvements are adapted for use in vertical mills, or those wherein the axis of revolution of the disintegrating agent is substantially vertical. This relation of the parts to the horizon has three advantages—first, it permits of a proper-balanced action and of uniform wear, rendering quite unnecessary all devices for recentering or otherwise compensating for wear, such as have been hitherto devised; second, it relieves the disintegrating agent of all effort in lifting the material acted upon, since this agent in its revolution moves in a plane at right angles to the direction of gravity, and, third, it permits us to avail ourselves of the action of gravity in producing the positive forward or axial movement of the material.

Our present invention is therefore the result of an attempt to produce a construction which shall conform to the conditions presented by a vertical mill and at the same time to adapt such a mill to the attainment of the special objects heretofore named.

We shall proceed to describe a preferred form of our invention as shown by illustrative example in the accompanying drawings, wherein—

Figure 1 is a vertical section of our preferred form of mill as made in conical shape. Fig. 2 is a horizontal sectional view of the mill shown in Fig. 1 on the line 2 2 of Fig. 1. Fig. 3 is a section of a portion of a modified form of mill covered by our invention. Fig. 4 is a vertical section of a portion of still another modification, and Fig. 5 is a section of a preferred form of valve as used by us near the mill.

We prefer to employ a substantially vertical shaft 1, driven by any desired means, as by the pulley and belt 2, upon which shaft are mounted a series of rotating spiders 3, 4, and 5 at convenient distances apart on said shaft. As shown in Fig. 2, each spider consists of a number of radiating arms, and each arm carries at its extremity a hammer or bat, which is relied upon to effect the necessary disintegrating action upon the material to be pulverized. The disintegrating action of our mill depends partly upon the blows delivered by the rotating bats and partly upon mutual attrition set up between particles in contiguous zones of unlike velocities, as will be later described. Above this series of spiders, with their bats or hammers, is placed the usual feed-hopper or other means for supplying the material to the mill, as shown at 6. As shown in the drawings, the shape preferred by us is that of a cone or frustum of a cone; but it is within the spirit of our invention to use any surface of revolution having the necessary expansion from the feed end of the mill. As will be made clearer hereinafter, this feature of our invention is adapted to horizontal mills. We do not limit ourselves to a construction wherein this form of shell is placed vertically,

although the vertical arrangement is the one we prefer. In order to conform to this shape of shell, the successive spiders 3, 4, and 5 are made of successively greater diameters, as shown.

We prefer in many cases to place the bats on the ends of the spider-arms, so as to have a backward inclination, as shown in the drawings at 8. In other words, these bats are so placed that the blows delivered by them have a component upward or in opposition to gravity. Furthermore, this inclination of the bats is important in that it acts to resist the influence of gravity on the passage of the fuel or material downward through the casing, as the bats so arranged act as moving shelves, the rapid rotation of the bats causing them to follow each other so quickly as to present obstruction to the free passage of the material. The importance of this will be apparent when it is considered that a mixture of fine fuel and air is to be delivered from the mill in condition for combustion in the form of a flame, and such combustion can only take place properly, to avoid smoke and waste, when the fuel is reduced to a very fine state and mixed with the proper proportion of air and such mixture expelled from the casing. The bats, therefore, have four important functions. They reduce the fuel to a fine state, retard its progress through the casing until it is reduced to the proper condition for combustion, mix it with the proper proportion of air to produce the best combustion, and expel such mixture from the mill. The amount of fine fuel produced and the amount of air mixed with such fuel is proportioned by the speed of the bats, and this is important, because if the mixture is not properly proportioned improper combustion will occur, and smoke and waste will be the result.

Between the feed-hopper or other entrance to the mill and the first spider we place a partition 9, which serves to direct the stream of entering material upon the circular path of the bats. In our preferred form of mill, as shown in Fig. 1, we employ a partition between every pair of spiders, as shown at 10 and 11, and where the spiders of successively-increasing diameter are used the successive partitions are also made of greater diameters. We prefer to so proportion these diameters as to produce a substantially uniform width of path between the outer shell and an imaginary surface of similar shape uniting the circumferences of the successive partitions 9, 10, and 11.

The limiting of the path of movement of the material pulverized may be accomplished by means of the construction shown in Fig. 3 without departing from the spirit of our invention. In this figure the spiders revolve between separate inner casings 12, 13, and 14, which inner casings just clear the spider-arms and are supported, as by the fastenings 15, to the outer casing.

As shown in Fig. 1, we prefer to use the disks 9, 10, and 11 and to fasten them to the rotating shaft 1, so that they will revolve with the spiders. Disks may be used, however, which do not revolve, as shown in Fig. 4, without departing from the spirit of our invention. It is also clear that disks are not the only form of shield which may be used attached to the rotating shaft.

In the case shown in Fig. 3 the disks are supported from the outer casing, as by the fastenings 16, and there is a clearance between the shaft 1 and the successive disks. An inclination should be given to the disks in this case, and, indeed, may be in some cases useful with any form of disks as used with our invention.

The disks used, as shown in Fig. 1, are preferably roughened in some way in order to give them a greater purchase on falling particles, and we have shown for this purpose a construction involving the use of corrugated metal having radial ridges. Other roughening means are within our invention.

At 17 in Figs. 1 and 2 we have shown the form of discharge which we prefer. The tube or passage through which the material passes, after reaching the bottom of the mill, should, for production of the best effect, be substantially tangential to the shell to which it is connected. A portion or all of this opening may be on the same level with the lowest spider, as shown; but this level may be varied according to circumstances.

An examination of the construction as so far described will show that it accomplishes the end stated of adaptation to the conditions present in a vertical mill.

First. The tendency of gravity is to produce a rapid and accelerated movement in the direction of the shaft. Means must therefore be adopted whereby this axial feed may be retarded, so as to keep the material within the sphere of action of the mill sufficiently long to accomplish proper disintegration. One means adopted by us for this purpose is the inclination of the direction of the bats, as described and shown, whereby the blows delivered tend to some extent to throw the material upward. Another influence which helps this retarding action lies in the friction arising from the direction given the material and is connected with the condition next following.

Second. Inasmuch as the feed action of gravity is at right angles to the planes of movement of the disintegrating-bats this action cannot be relied upon to keep the material within the sphere of action of said bats. Other means must be used, such as the inner casing 12 13 14 or the fixed or rotating disks. These instrumentalities act to prevent all movement of material acted on through the center of the machine. Our mill therefore belongs to a class entirely distinct from those whose action depends upon the removal through the center of the fine dust by fan-action as fast as formed.

Third. Only the finer particles in any section or within the influence of any given spider must be fed forward. It is therefore necessary to provide feeding means which shall act to retard the larger pieces and to pass the finer particles along, at the same time avoiding the movement through the center, as heretofore stated.

It should be here stated that our mill acts to gradually disintegrate the material acted upon simultaneously with admixture of the same with air. This admixture is accomplished mechanically and in proportion as the process of disintegration and pulverization proceeds. In this our construction is superior to those mills wherein the motive power which removes the fine particles is a rush of air produced by a fan. This latter construction results in the removal of the particles as soon as they are fine enough to float near the center of the machine and be sucked out axially, thus preventing pulverization beyond a certain degree of fineness. Morever, in order to supply motive power for removal and delivery to the flame, as well as the necessary oxygen for combustion, a surplus of air is necessarily employed, and the result is a cooling of the flame and imperfect combustion.

The means which we use to retard the coarse particles and pass on the fine particles positively and at the same time confine all feeding action to the path occupied by the successive spiders is the disks, either rotating or stationary. The stationary disks shown in Fig. 4 catch all particles which are crowded toward the center and divert them back to the circumference by their inclination, as shown. As centrifugal force acts more forcibly on the heavier particles, these parts which fall onto the disks and are sent downward will be the finer ones. When the stationary disks are used with spiders of progressively-increasing diameters, as shown and preferred by us, this action is aided by the tendency of the air to move forward to the lower plane of greater centrifugal effect. The current thus set up aids in selecting the finer from the coarser particles and bringing them forward and downward faster. We prefer the form shown in Fig. 1, however, wherein the disks which separate the spiders are fastened to and rotate with the shaft. In this case the coarser particles which are often crowded toward the center with the finer are struck by the rough surface of the rapidly-revolving disks and thrown back again into the sphere of the upper bats, whence they only return when in a finer state. The finer particles, on the other hand, when thus struck are retarded and affected by the air, whether stationary or sucking downward, and turn over the edge of the disk, seeking the more advanced plane of the next spider. This is the effect, whether used with a vertical or horizontal type of mill, and we are not limited in our broadest claim having reference to the use of spiders of increasing diameters in combination with the disks to the use of this combination with a vertical mill. Another advantage residing in the use of intermediate partitions or disks, rotating or otherwise, is found in the fact that the forward revolution of the material is somewhat retarded by contact with said partitions. The result is that the next bats which strike these particles are opposed by an increased inertia, and thus exert a greater breaking force.

A large part of the work of disintegration will be accomplished in our mill by mutual attrition occurring at the point of transfer from the plane of travel of one set of bats to that of the next. It will be evident that owing to the difference in speed of the particles moving in two contiguous zones of rotation the particles in the upper or slow-moving zone will be brought by gravity into the midst of particles in the lower zone moving more rapidly. The result will be the violent friction during the process of imparting increased speed to the particles newly arrived in the zone of greater speed. The consequence of this action will be a great saving of wear on the machine, since the wearing action is a mutual one between the particles acted on instead of involving only the moving bats. This action, together with the intimate and progressive admixture of air for the support of combustion, makes our mill peculiarly useful for the preparation and delivery of pulverized fuel mixed with air. The result can only be obtained by the use of a tight casing so shaped that the particles in one zone of movement pass directly into the midst of particles in a speedier zone, for the purposes above described. The same result cannot be obtained where cylindrical chambers of successively-increasing diameter are substituted for a true surface of revolution—as, for instance, a cone. Where successive chambers are used, the particles drop from one zone to another parallel with the shaft, and therefore into a new zone of equal speed, since where one shaft is used all lines parallel to the shaft must intersect the spider-arms at points moving at equal speeds. The use of a tight casing is also essential to our invention, as otherwise all the contents of our mill would escape before they reached the point of delivery. Moreover, it is found that where a tight casing is thus used in combination with the other elements of our invention as claimed the air forms an opaque cushion between the moving particles of fuel and the inside of the casing, whereby the latter is entirely protected from the wearing action of the moving fuel particles. The saving due to this cause alone is obvious.

Fourth. As the fine particles are thus passed on by the action of gravity the disintegrating mass takes up the air with which it is being beaten up much as the white of an egg does when beaten. It therefore acts in the same way and by absorption of air swells, occupying a greater space and requiring more room. To provide this increase of room, as well as for the other reasons pointed

out herein, the expansion progressively toward the delivery end of the shell is provided. This expansion has a peculiar function in our form of mill in contradistinction to mills of that class wherein the fine parts as fast as formed are drawn away through the center. In this latter form there can be none of that swelling action which is above mentioned, since the fine parts are removed by the air-current, leaving only the coarser parts to be further treated. The main superiority of our system over that just named is that we mix the air positively and gradually with the fuel and are thus able to assure the surrounding of every particle with oxygen for the very best combustion and at the same time are enabled to adjust and regulate the proportion of air thus mixed in accordance with the needs of various fuels. This adjustment may be accomplished either by use of various numbers of spiders or by various inclinations being given to the bats either as a whole or in different parts of the mill.

Fifth. In vertical mills where gravity aids in accomplishing the movement in an axial direction this axial movement alone is too slow to answer the purposes of practice. We therefore rely upon centrifugal force to accomplish the final delivery. In order to insure the utmost economy of energy in the practice of this method of feed and delivery, we provide a gradually-increasing speed, and consequently increasing centrifugal force, in connection with a constantly-increasing diameter of shell. We thus avoid doing useless work upon our material by drawing the same periodically toward the center, as must be done in those forms of mill wherein a succession of chambers is used divided by circumferential annular partitions. We also prefer to finally deliver the material from the widest portion of the shell, as this is the point of maximum speed, and a return to a narrower diameter before delivery implies a considerable exertion of work.

It will be seen that by the use of the shell widening toward the point of delivery and the spiders having corresponding diameters, said spiders being mounted on the same shaft, we obtain a continual increase of speed from feed to delivery, and this increase being gradual we do not encounter the difficulties incident to opposing suddenly to a maximum speed the inertia of particles of a maximum size, as would be the case with spiders of uniform diameter.

Any construction involving the use of bats having a progressive increase of speed is within our invention when used in the combinations claimed hereinafter, whether such bats are carried by spiders mounted upon a common shaft or not. Again, as the material gradually becomes finer, and consequently each particle opposes a smaller inertia to the blows delivered, the increase of speed insures a continuance of disintegrating action, since a relatively quick blow is necessary for breaking a relatively light body when floating in a comparatively non-resistant medium.

It will be observed that our improved mill is capable of adjustment to suit different classes of material to be pulverized by adjustment of the amount of clearance between the bats and the outer casing. In the treatment of some materials this clearance becomes important, although where soft coal is to be pulverized for the purposes of fuel the amount of clearance may be reduced to a minimum so far as the material is concerned. In order to accomplish this adjustment of clearance, it is only necessary to raise or lower the driving-shaft, and with it the spiders and disks. The symmetrical expanding-casing remaining stationary and the corresponding spiders moving upward, the clearance will be diminished, whereas a downward movement will of course act to increase the clearance. This question of clearance may become important in some cases on account of the means employed for driving the shaft and the adaptation of the mill to those means.

While we have shown in the drawings spiders carrying six arms each, it will be understood that any convenient number may be used. The form and weight of the bats will be a matter of judgment, and many other details may be the subject of modification without departing from the spirit of our invention.

It should be understood that while we have shown a number of improvements, which, as above explained, coöperate to produce a better result, it is nevertheless within our invention to use one or more of these improved features separately or with other auxiliary elements than those shown herein. For instance, the bats used with a backward inclination in a vertical mill will act alone to retard the axial movement without the use of central disks. Our use of spiders of progressively-increasing diameters used with means to prevent movement through the center of the mill is useful in horizontal as well as in vertical mills. Also the use of a gradually-expanding symmetrical shell with rotating spiders corresponding in length at different situations on the shaft is not inconsistent with the placing of such a mill in a horizontal position. Other modifications could be suggested which would be within the spirit of our invention, which is not to be limited by terms not included in the language of our respective claims. It will be also understood that the use of our invention as part of a mill will be none the less an infringement of our claims because combined with further parts not within their terms.

What we claim is—

1. In a pulverizing-mill, the combination of a substantially vertical imperforate casing which expands gradually downward and the inner walls of which are straight, said casing having an inlet at the upper part and an outlet at the lower part, a vertically-disposed

shaft journaled in said casing, arms extending from said shaft in groups or series, the arms of one group or series being shorter than those of the group or series next below, bats carried by said arms, the bats of one group or series being nearer the shaft than those of the series next below, and obstructions within the casing located between the groups or series of arms and above the upper group or series, the outer surface or periphery of one obstruction being nearer the shaft than that of the obstruction next below and also within the plane of the bats next below and at a distance from the walls of the casing, whereby material passing downward through the casing is caused to move outward and away from the shaft, substantially as set forth.

2. In a pulverizing-mill, the combination of a substantially vertical imperforate casing which expands gradually downward and the inner walls of which are straight, said casing having an inlet at the upper part and an outlet at the lower part, a vertically-disposed shaft journaled in said casing, arms extending from said shaft in groups or series, the arms of one group or series being shorter than those of the group or series next below, bats carried by said arms, the bats of one group or series being nearer the shaft than those of the series next below, said bats being inclined from the vertical to act as an obstruction to the passage of material downward through the casing, whereby the bats pulverize material, retard its passage through the casing, mix it with air and expel the mixture from the casing, substantially as set forth.

3. In a pulverizing-mill, the combination of a substantially vertical imperforate casing which expands gradually downward and the inner walls of which are straight, said casing having an inlet at the upper part and an outlet at the lower part, a vertically-disposed shaft journaled in said casing, arms extending from said shaft in groups or series, the arms of one group or series being shorter than those of the group or series next below, bats carried by said arms, the bats of one group or series being nearer the shaft than those of the series next below, and disks or plates carried by the shaft above the upper group or series of arms and between the other groups or series of arms, the diameter of one disk or plate being less than that of the arms and of the disk or plate next below, and the diameter of said disks or plates being less than the diameter of the casing, substantially as set forth.

In witness whereof we have hereunto set our hands this 10th day of August, 1897.

WILLIAM M. RUSSELL.
FRANK P. BIXON.

Witnesses:
LLOYD MORTIMER HOWELL,
HAROLD S. MACKAY.