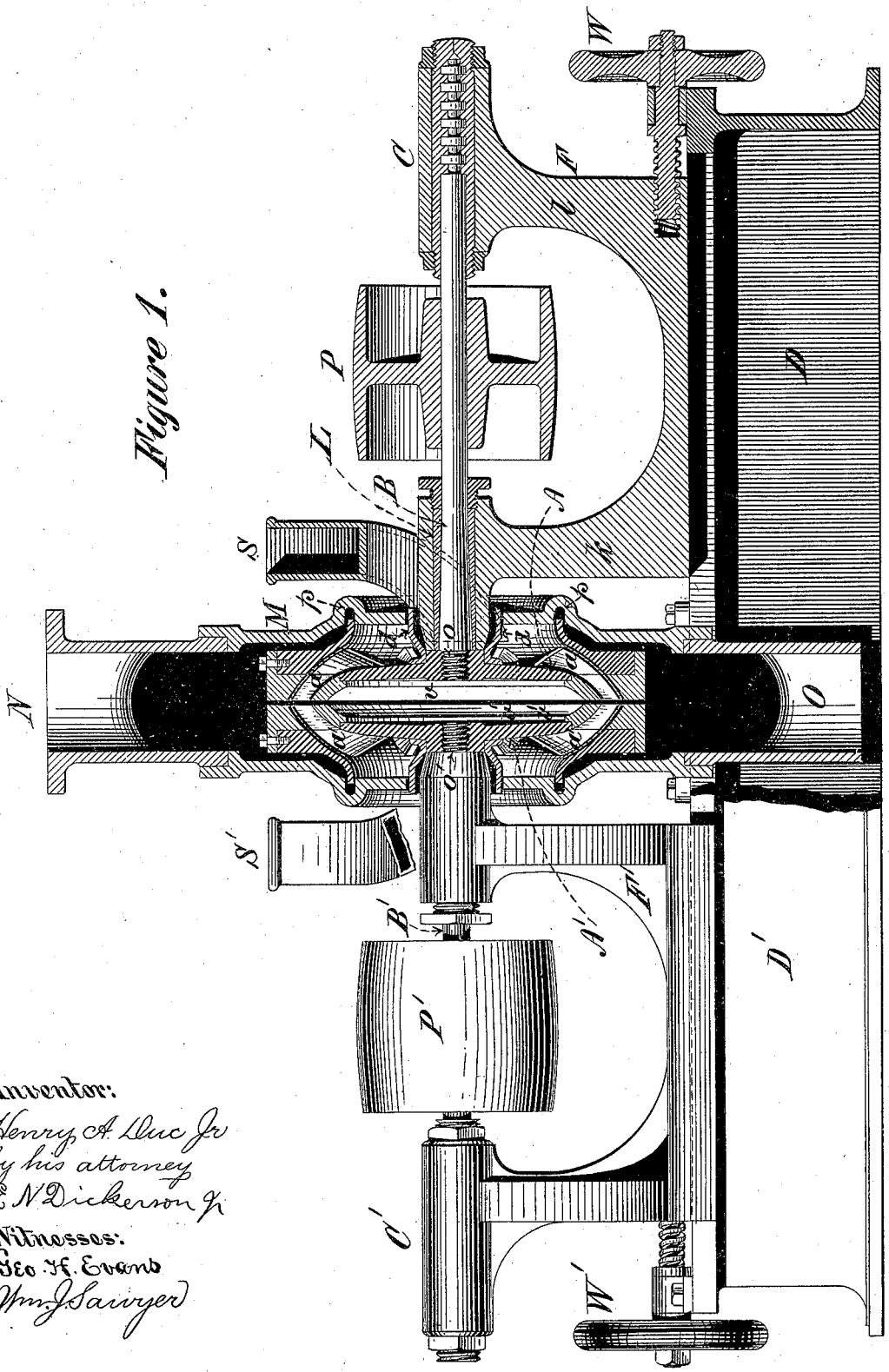
3 Sheets—Sheet 1.

H. A. DUC, Jr.

Attrition-Mill.

No. 214,243. Patented April 15, 1879.

Figure 1.

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3 Sheets—Sheet 2.

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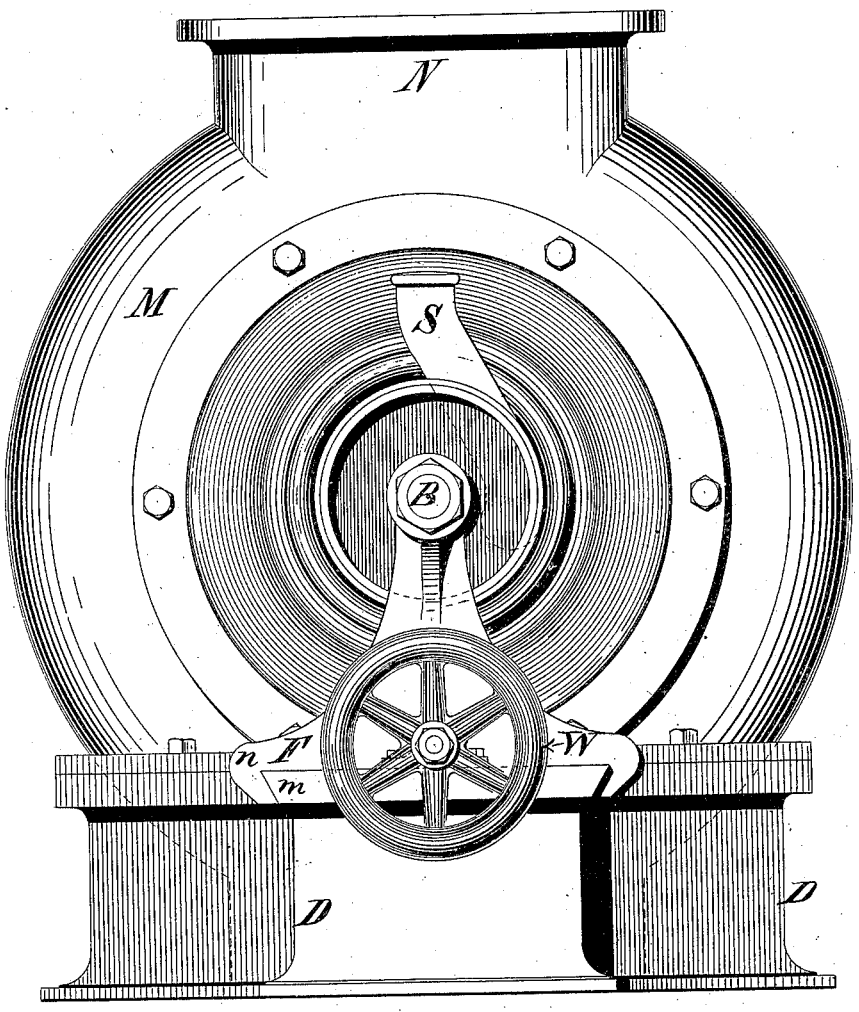
Attrition-Mill.

No. 214,243. Patented April 15, 1879.

*Figure 2.*

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3 Sheets—Sheet 3.

# H. A. DUC, Jr.

## Attrition-Mill.

No. 214,243. Patented April 15, 1879.

*Figure 3.*

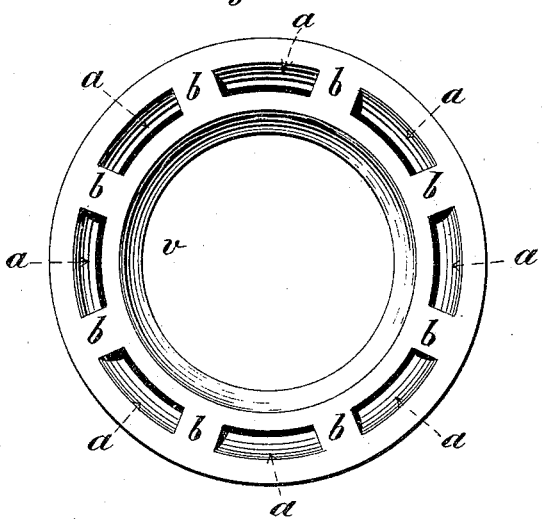



*Figure 4.*

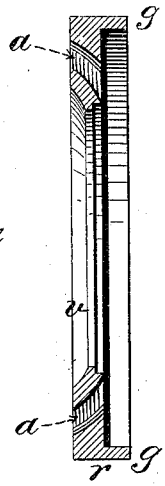



*Figure 5.*

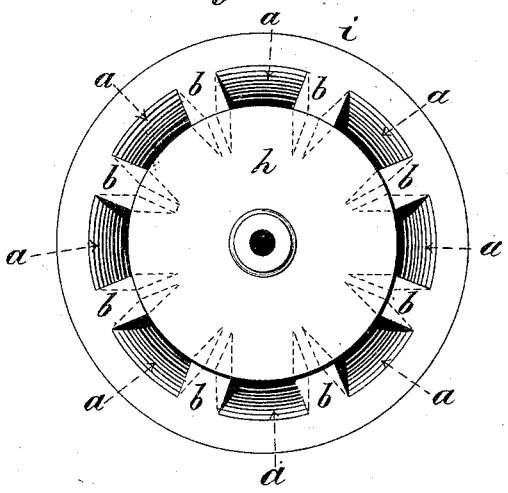
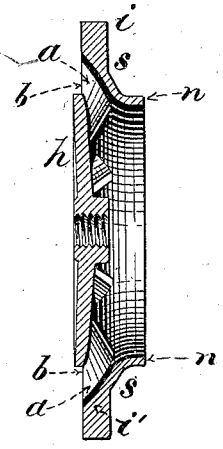



*Figure 6.*

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# UNITED STATES PATENT OFFICE.

HENRY A. DUC, JR., OF CHARLESTON, SOUTH CAROLINA.

## IMPROVEMENT IN ATTRITION-MILLS.

Specification forming part of Letters Patent No. 214,243, dated April 15, 1879; application filed November 9, 1877.

*To all whom it may concern:*

Be it known that I, HENRY A. DUC, JR., of the city of Charleston, State of South Carolina, have invented a new and useful Improvement in Attrition-Mills, of which the following is a full, true, and exact description, reference being had to the accompanying drawings.

My invention relates to that class of mills in which the grinding or pulverizing of the material to be ground is accomplished by the impact and rubbing of particles or portions of such material against each other, and is thereby distinguishable from those mills in which the grinding is done between two permanent wearing-surfaces.

It is no doubt true that in all grinding-mills whatsoever a portion of the grinding is done by the particles themselves, as well as by the rubbing-surfaces; but in the present invention the grinding is exclusively done between the particles of the material passing through the mill, in which respect it differs from any of the usual forms of grinding or attrition mills now in use.

I am aware that many forms of attrition-mills have been made; but, so far as I know, in all these mills the substance to be ground has been caused to impinge against a surface permanently attached to the machine, so that the grinding or attrition in these mills is produced by two causes: first, the impinging of the substances passing through the mill against a surface permanently attached thereto; second, by the movement or impact among the particles or portions of the substance which is passing through the mill.

The attempt which I have made in this apparatus is, so far as is possible, to avoid the first of these causes, and to accomplish the grinding exclusively by the impact or friction between the particles of the substance passing through the mill. I thereby obtain a very important result, namely: I avoid the necessary wearing away of the grinding or impact surfaces which have been previously employed in attrition-mills, and I substitute for such permanent surfaces a constantly-renewed surface or body of the material itself, and I use my apparatus simply as a means for giving motion to the substances to be ground, and not as in any way tending or aiding in the pulverization of such particles, except as I have just described.

An analogous case to this invention would be that of a millstone having a constantly-renewed surface, which surface was itself composed of the material to be ground.

The construction of my apparatus is simple, and consists generally of a series of revolving tubes or channels fixed in a wheel revolving about the central axis through which the material to be ground is constantly passing and is constantly being delivered at the ends of such tubes against a corresponding body of the material to be ground, which is simultaneously passing through a series of channels and revolving in the opposite direction.

Centrifugal force causes a body revolving about a fixed center to fly off at a tangent to its arc of revolution and to seek to retreat as far as possible from such revolving axis. In my apparatus I utilize this force for the purpose of forcing the stream of material to be ground against the grinding-surface. The material so acted upon by this centrifugal force is not allowed to escape freely from the center, as is usually the case, but is confined in guiding-channels, where it is retained till the end of the column which is passing through such channel is pulverized by its attrition against another similar grinding-surface, and the material only advances in the confined channel with the same rapidity as it is ground off or allowed to escape from the delivery end of such channel.

This retaining of the material within the mill till it is ground sufficiently fine to escape—which fineness is automatically determined by the mill, as will be hereinafter described—I consider one of the most important features of my invention, for in all other mills with which I am acquainted a considerable quantity of material is delivered at once to the mill, and is acted upon by the apparatus as a whole till it has been reduced to a sufficiently fine condition to meet the requirements of the case. In my mill, on the other hand, no matter how much material is fed to it, only a small surface is acted upon at once, utilizing the whole force of the mill in grinding a small portion

of the substance passing through it, so that no matter how much material may be fed to the mill it will only require about the same power to operate it. This is manifestly untrue of any other of these mills, for in them a mass of material, whatever it may be, is acted upon as soon as it is delivered through the hopper, and the greater the mass of material so acted upon the greater the force necessary to operate the mill.

My invention is clearly set forth in the accompanying drawings, in which similar letters of reference refer to similar parts, in which—

Figure 1 represents a general view of my apparatus, the right side being shown in cross-section, the left side in perspective. Fig. 2 represents a lateral elevation, showing the feeding-hopper and adjusting-wheel. Fig. 3 represents a plan view of the delivery end of my revolving wheel, showing the removable ring. Fig. 4 is a cross-section of the same. Fig. 5 represents a view of the body of my wheel, showing clearly the channels through which material is passing. Fig. 6 represents a cross-section of the same.

In my complete apparatus a detachable wearing-ring, Fig. 4, is attached to the main wheel-frame (shown in Fig. 6) by means of screw-bolts, which are shown in Fig. 1, so that the channel, as it is shown in Fig. 4, becomes a continuation of the channel *a*, Fig. 6.

My mill is supported generally upon a bed-plate, D D′. Upon this bed-plate there rest the sliding supporting-frames F F′, which support the revolving operation of my mechanism. These sliding supporting-frames F are supported and guided by means of the tongue and groove *m n*. (Shown clearly in Fig. 2.) The position of this sliding frame F is determined by the wheel W, which acts in a thread cut in the said frame, and is itself supported by a collar attached to the bed-plate D. Attached to the center of the bed-plate D is the main casing M of my apparatus. This has two delivery-passages, N O, one above and one below.

Supported by the two arms *k l* of the sliding frame F is the revolving shaft B, which is put in motion by means of the pulley P, and has two bearings, C *h*. Attached to the shaft, and revolving in the bearing C, are a series of rings, technically known as "thrust-rings," for the purpose of preventing any longitudinal movement of the shaft B in the bearing C. Attached to the inner end of this shaft is a revolving wheel-frame, A, which is attached firmly to the revolving shaft B by means of the screw *o*. This wheel A consists of a revolving cylindrical body, and is composed, generally, of two parts, which are represented in Figs. 4 and 6, and are lettered *r s*.

*s* consists of a wheel-frame or revolving plate, *h*, which is screwed to the revolving shaft B. Attached to this revolving wheel or plate by means of the webs or radial partitions *b* is a circular inclosing surface, *i*, leaving an annular opening between the wheel *h* and the surrounding and inclosing surface which is represented by the channel *a* in Fig. 5, while the webs *b* are shown in Fig. 5, dividing the annular space into the annular openings *a a a*.

The ring *r*, having a flange, *g*, is placed upon the wheel *s*, as shown clearly in Fig. 1. This flange, surrounding the circumference of *i*, to which it is firmly bolted by means of the screw-bolts, is shown in Fig. 1. When this wearing-ring *r* is attached to the wheel *s* the entire apparatus assumes the shape shown in Fig. 1, having the channels *a a* passing completely through said revolving wheel. The outer surface of these channels is a curved surface, as may be clearly seen from the drawings.

The center portion of the wheel A is removed, as shown at *e*, for a purpose to be hereinafter explained. Forming part of the wheel *s* is the annular flange *n*, which flange revolves in an interior channel in the casing M. (Shown clearly in Fig. 1.)

Surrounding the central shaft P, and attached to the wheel *s*, is the cylindrical sleeve *d*, which revolves with the shaft within a central aperture in the casing M, as is clearly seen in Fig. 1. The purpose of the channel *p* and the cylindrical sleeve D is to confine the material fed to the apparatus within the channels *a* and prevent its escape to any other portion of the apparatus, while they allow of the lateral adjustment of the revolving wheels.

Entering the casing M is the hopper S, which delivers close to the central shaft, as is seen in Fig. 1. By means of this hopper S the material to be ground is fed to the apparatus.

The parts just described are duplicated on the other side of the apparatus, and are represented there by similar letters, the only difference between the two sides being the direction of revolution of the shafts B and B′, which revolve in opposite directions.

The operation of the apparatus can now be clearly understood. The shaft B is put in revolution at a high velocity by means of the pulley P, rotating the wheel A, with its various detachable portions. The shaft B′ is similarly revolved in an opposite direction. If the material be fed through the hopper S S′, it will fall by gravity into the revolving channels *a a′*, and will, by means of the radial partitions *b*, have the velocity of the revolving wheel imparted to it. Owing to the centrifugal force thereby imparted to it, it will tend to advance through the channels *a*, and in passing through such channels it will gradually have the direction of its motion changed till it escapes from the delivery ends of such channels, having a motion at an angle to that which it would have had it been free to escape from the wheel A. This change of motion is communicated to it by means of the curved surfaces forming the outside of the channel *a*, which exterior surface guides the material and causes it to change the direction of its motion till it es-

capes at the circumferential openings of said channels, as above described. In its passage to the delivery-opening of the channels *a* the material has not been ground or pulverized in any way, excepting what slight pulverization may have been occasioned by its first impact with the revolving partitions *b*, and it is only at the circumferential openings in the channels *a* that any practical grinding or attrition is done.

If the wheel A were revolving against a permanent surface and were held closely against it, it is obvious that no material could escape from the delivery end of the channels *a;* but, the material to be ground passing through the channels *a*, and being forced through those channels by the great centrifugal force due to the rapid revolution of the apparatus, it is obvious that that portion of the material to be ground which was in contact with the fixed surface would be ground and rubbed by it to powder. If, now, the revolving wheel were withdrawn half an inch from the fixed surface, it is obvious that only such particles of the material to be ground as were less than half an inch in diameter could escape between the fixed surface and the revolving wheel. In other words, the distance between the revolving wearing-ring *r* and the suppositious fixed surface against which it was revolving would determine the fineness of the particles which could escape from this apparatus, and all particles greater in size than the annular opening between the revolving wheel and the fixed surface would necessarily be retained within the apparatus till they were reduced to a size sufficiently small to escape through the annular opening just described. In other words, this annular opening would serve as a regulator of the fineness of the particles which were delivered from this machine, and would take the place of a sieve or similar contrivance for separating particles or bits of different size, but would have the additional advantage, owing to the fact that it is in rapid motion, that the escaping particles could not clog or choke up the opening, as they might do the meshes of a sieve.

It is with the object of regulating the size of the particles which are to be delivered from this machine that I have provided the sliding frame F and the regulating-wheel W, whereby the distance between the revolving wheel A and the opposite grinding-surface can be varied to admit of the various degrees of fineness of delivered material required.

From this explanation it is apparent that my machine might be a practically operative one even if half only were used; but this would not accomplish the principal object which I have in view, which is the avoidance of any grinding-surfaces permanently attached to the machine. I therefore duplicate my apparatus, as above described, and feed to both sides of it by means of the hoppers S S′ approximately equal amounts of the material to be ground. This material entering the chamber between the revolving-wheel and the stationary casing of the machine comes, as has been previously described, in contact with one of the revolving radial partitions, and passes through the channels *a′*.

It is obvious that the number of partitions or webs employed to connect the exterior with the interior frame of the revolving wheel is a matter of convenience, and, provided the material to be acted upon by centrifugal force had the velocity of the rotation of the wheel-frame communicated to it, it is unimportant how many of such webs were used, and it is possible that a single one might be satisfactorily employed.

The less the number of radial partitions and the less their thickness the greater will be the grinding-surface at the circumferential delivery-openings of the revolving wheel, and therefore it is, to a certain extent, an advantage to reduce the number of these partitions as far as possible.

Sufficient material is fed through the hoppers S S′ to both sides of the apparatus to keep the revolving channels practically full. The centrifugal force acting upon the material contained in these channels forces it forward in them and gives it a tendency to escape at the circumferential openings, as has been previously described. When the material arrives at these openings it meets a similar stream of material striving to escape in a similar way through the opposite channels *a′*, and these two streams of material are, therefore, pressed and ground against each other, the pressure with which they are forced against each other being due to the centrifugal force which they have acquired from the rapidity of their revolution, in which respect this mill differs from two millstones, between which a substance may be ground, because the pressure tending to grind the substance contained between two millstones is due to the weight of the millstones, while the pressure tending to grind the materials passing through this mill is due to a centrifugal force, the direction of which has been altered by the exterior guiding-surfaces of the channel *a*, so that the two streams of material may be forced against each other, which could not be conveniently done if the centrifugal force were allowed to carry off the material at a tangent to the axis of its original revolution. But it is possible that a machine might be constructed having a series of channels at right angles to the revolving axis, through which the material to be ground could be fed; but this material might be caused to surround this revolving wheel, and thereby an apparatus could be made which would embody substantially my invention, although only one revolving wheel was used.

It is plain, likewise, that the angle at which the material escapes from the circumferential openings of the channels *a* is immaterial, and it is simply a question of experience and convenience what this angle may be; but

the less the angle at which the currents of material escaping through the opposite wheels meet, the greater will be the pressure between these two streams of material. The pressure between these two streams or surfaces of grinding material can also be regulated by the speed of revolution of the two revolving wheels just as the weight between two millstones could be increased by using heavier stones; and by regulating the speed of revolution and the size of the annular opening between the revolving wheels, the proper conditions for reducing any substance to any required degree of fineness can be obtained. The two streams of material meeting at the annular opening, as has just been described, tend to escape therefrom laterally, and to fly out from the circumference of the two revolving wheels.

In the passage of the material between these two revolving surfaces it is obvious that a certain amount of wear will be occasioned; but this wear is not due to a grinding of the materials in the sense in which a permanent grinding-surface is worn in the ordinary mill, since these revolving surfaces are but little more than conductors or regulators of the size of the particles passing between them. To meet, however, any wear which may result from the passage of the material which is already ground between them, I have made such surfaces alterable, and can readily substitute one wearing-ring for another, as is shown in Figs. 4 and 6.

After the particles have once left the annular circumferential openings they pass immediately through the annular opening between the revolving wheels, and are not retained there for the purpose of further reducing them, while in the ordinary millstones in which the material is fed to the center and delivered at the periphery it may be thoroughly ground at a very slight distance from the center, but, nevertheless, is obliged to continue between the grinding-stones until it reaches the periphery and escapes therefrom, which may be a slow process, thereby causing unnecessary wear to the grinding-surfaces and possibly injuring the material to be ground; while in this apparatus the instant a particle has been reduced to a size sufficiently small to pass through the annular opening between the revolving wheels, it instantly escapes therefrom and passes out into the casing M, from which it will escape either by means of the delivery-opening N or O. The lighter particles will escape at the opening N; the heavier ones will fall by gravity through the opening O.

The object of the circular cavity *v*, previously described, is twofold. In the first place it reduces the weight of the revolving wheels by removing therefrom a body of metal which is of no practical utility. In the second place, in case any of the material passing through the mill should drop between the two revolving wheels toward their axes, which might be possible during the temporary stoppage of the machine, then such material would not clog or stop the machine, for the reason that the material so falling between the contiguous surfaces of the revolving wheels would fall into the larger space formed by the adjacent circular cavities *v* and *v'*.

An automatic arrangement might be readily devised for keeping the two revolving wheels at an equal distance from each other, and thereby counteracting the effects of any wear upon the alterable rings *r* previously described.

From the foregoing description it is plain that the principle of my invention consists in the use of, practically, two surfaces composed of the material to be ground, which surfaces are automatically pressed against each other as if by the weight of a millstone, and which surfaces are so constructed and combined with guiding-channels or containing-surfaces that the particles of material ground or abraded between the contiguous grinding-surfaces just described cannot escape from the apparatus until they have been reduced below a certain size and have attained a certain fineness.

The revolving portions of my machine consist simply of a series of conductors and containing controlling or guiding surfaces, by means of which the result above described is accomplished; and no permanent parts of my machine are used for the purpose of grinding or abrading any of the substances passing through them, and any such abrasion is only an incidental result, and one which it is desirable, so far as possible, to avoid; in which respect my machine differs from any heretofore constructed with which I am acquainted.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. In a grinding-mill, a revolving wheel provided with a closed radial channel, which channel has its delivery-opening nearer the periphery than the receiving-opening, for the purpose of receiving and passing through the wheel the substance to be ground, thereby giving to it the same rotation as that with which the wheel is revolving, and delivering it at an angle to the plane in which the wheel is revolving.

2. The improvement in the process of grinding, consisting in reducing the substance to be ground by impact and friction against itself solely, as distinguished from the process of reducing a substance partially by impact and friction against a permanent surface, and partially by impact and friction against itself, substantially as described.

3. In a grinding-mill, a revolving wheel having a closed channel cut through such revolving wheel, which channel has its entrance on one side of the wheel and its delivery-aperture on the other side of the wheel, its delivery-aperture being situated farther from the axis of rotation than its entrance, substantially as described.

4. The combination, in a grinding-mill, of mechanism whereby two surfaces of the material to be abraded are formed, and mechanism

for forcing these surfaces to travel past and against each other, substantially as described.

5. The combination, in a grinding-mill, of a channel or channels for receiving the material to be ground, a grinding-surface proximate to the delivery-port of said channel, and mechanism forcing the material to be ground by centrifugal force through the channel, whereby each particle of the material to be ground is subjected to the grinding-surface until it is sufficiently reduced to escape through an opening of a determined size, substantially as described.

6. The improvement in the process of grinding grain and other materials, consisting in causing two suitably-guided distinct streams of the material to be ground to impinge against each other, thereby grinding and abrading the particles composing the two streams, substantially as described.

7. The improvement in the art of grinding, consisting in forcing two distinct streams of the material to be ground against each other while given an adverse movement transverse to their flow, substantially as described.

8. In a grinding-mill, two rotating wheels revolving around the same axis, and each having closed channels passing through said wheels, which channels have corresponding outlets, substantially as described, whereby two streams of the material to be ground are caused to impinge against each other.

9. The combination, in a grinding-mill, of a closed channel or channels for receiving and regulating the escape of material, and mechanism for forcing the material by centrifugal force into and through said channels, substantially as described.

10. In a grinding-mill, a revolving wheel, A, having a closed channel, *a*, passing through the frame of said wheel, and provided with the alterable wearing-surface *r*, through which the channel *a* is continued, substantially as described.

11. In a grinding-mill, the combination of two independent wheels revolving in opposite directions, and provided with closed channels, having adjacent corresponding openings, which openings are provided with alterable wearing-surfaces, substantially as described.

12. A grinding-mill provided with two opposed sets of revolving channels, which sets revolve independently around a common axis, and have their corresponding delivery-openings situated at the same distance from the central axis, substantially as described.

13. A grinding-mill provided with two wheels revolving in opposite directions, which wheels are provided with the closed channels *a* and *a'*, and the central cavities *v*, substantially as described.

14. The combination of a revolving wheel, having a closed channel or channels for the passage of a stream of grain or other material, and a grinding or attrition surface in immediate proximity to the delivery-port of said channel, whereby the material to be reduced is retained in said revolving channel until it is sufficiently reduced to escape through an opening of a determined size, and is then allowed to escape immediately into the delivery, thereby avoiding unnecessary abrasion and unnecessary expenditure of power, substantially as described.

15. The process of reducing substances hereinbefore described, which consists in delivering the material to the mill within a closed channel, which material is subsequently passed through two revolving channels, and is by them compacted into two grinding-surfaces, which are forced together by the pressure of the gradually-advancing material, and are caused to pass over each other.

16. In a grinding-mill, the two wheels A and A', provided with channels *a* and *a'*, and mounted upon two adjustable sliding frames, F and F', whereby the distance between said revolving wheels may be varied, substantially as described.

17. In a grinding-mill, the combination of two wheels, A and A', revolving in opposite directions, supported on the adjustable frames F and F', and provided with the alterable wearing-surfaces *r* and *r'*, substantially as described.

18. In a grinding-mill, two wheels A and A', revolving in opposite directions, which wheels consist of a central revolving wheel or disk, *h*, provided with partitions or webs *b*, which connect it with the exterior surface, *i*, between which webs the material is passed to be ground at the delivery-apertures *a* of the channels, substantially as described.

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