No. 689,561. Patented Dec. 24, 1901.

C. F. McKENNA.

MEANS FOR MAGNETICALLY SEPARATING DIFFERENT SUBSTANCES FROM EACH OTHER.

(Application filed Dec. 7, 1896.)

(No Model.)

Fig. 1.

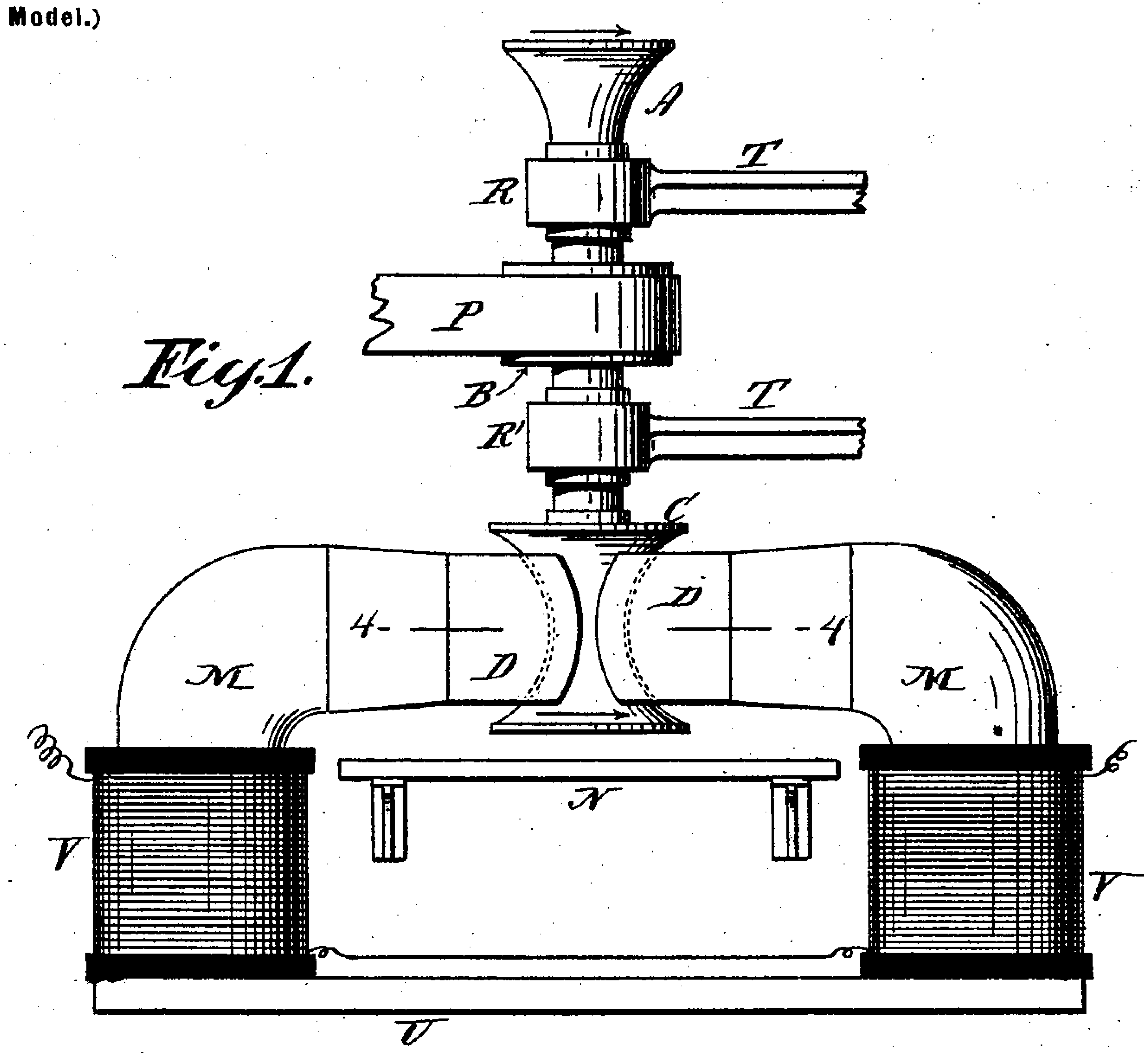


Fig. 2.

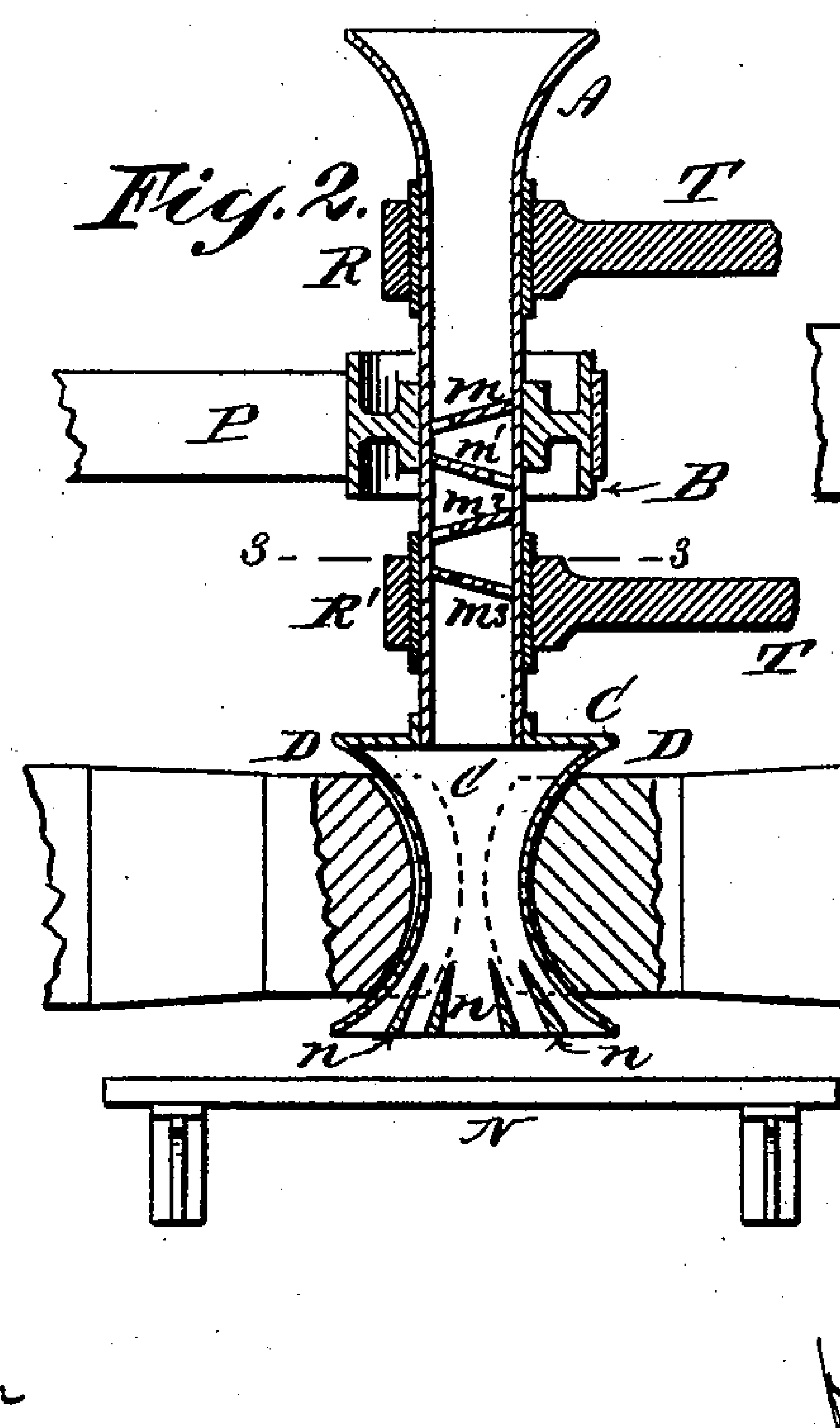


Fig. 3.

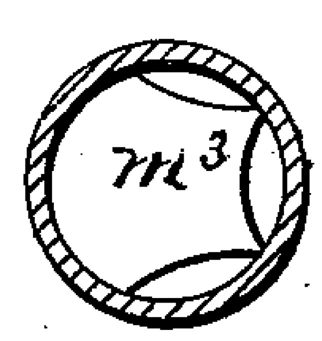
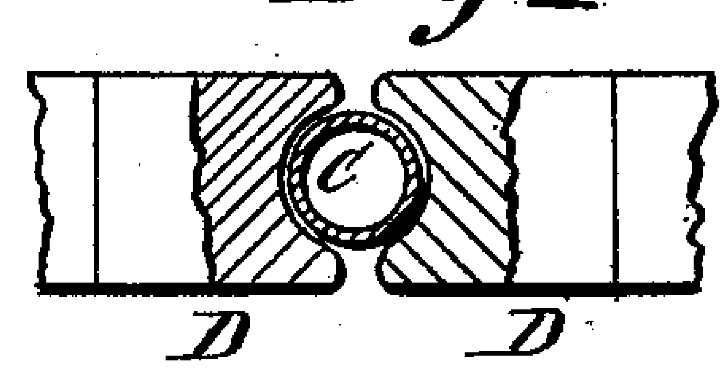


Fig. 4.



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UNITED STATES PATENT OFFICE.

CHARLES F. McKENNA, OF NEW YORK, N. Y.

MEANS FOR MAGNETICALLY SEPARATING DIFFERENT SUBSTANCES FROM EACH OTHER.

SPECIFICATION forming part of Letters Patent No. 689,561, dated December 24, 1901.

Application filed December 7, 1896. Serial No. 614,679. (No model.)

To all whom it may concern:

Be it known that I, CHARLES F. McKENNA, a citizen of the United States, and a resident of New York city, New York, have invented certain new and useful Improvements in Means for Magnetically Separating Different Substances from Each Other, of which the following is a specification.

The object of my invention is, among other things, to produce improved methods and means whereby not only two, but, if required, three or even more, substances may be treated in larger quantities than heretofore and separated from each other by substantially one treatment and a single operation.

My invention consists in new methods of treating the substances operated upon in magnetic fields and in the construction, assemblage, and operation together of the hereinafter-described devices for the application of such methods.

I attain the objects of my invention by the treatment which I shall hereinafter describe and by the use of the apparatus and devices shown in the accompanying drawings, in which—

Figure 1 represents in elevation some of the principal parts of said apparatus and devices. Fig. 2 is a central vertical transverse section of Fig. 1; Fig. 3, a detail showing the arrangement of the plates in the feeding-tube; Fig. 4, a sectional view on the line 4 4 of Fig. 1.

M M represent an electromagnet supported in any convenient manner and actuated in the usual way, U being the yoke and V V the energizing-coils. D D are the pole-pieces of such magnet.

C is a shell, the walls of which are made as thin as is consistent with rigidity and constructed of brass or other suitable material having the requisite stiffness and strength. The shell C is, as shown in the drawings, supported so as to be held in position between the said pole-pieces, the contours of the terminal surfaces of which are accurately fitted to the curved outlines of the shell. The shell C may be tubular, flaring slightly at either or both ends; but the shape which I prefer is one whose vertical central cross-section shows the walls of the shell approaching each other toward the center and receding from the center toward their exterior edges in curved lines of circular, elliptic, parabolic, hyperbolic, or similar outline. The shell is supported in any convenient manner so as to rotate, together with its connection, around its central vertical axis—as, for instance, shown in the drawings—rotating in fixed bearings R R', supported by the bracket T in the required fixed relation to the pole-pieces and provided with a pulley B, through which power is transmitted through the belt P.

The feeding-tube A is of substantially cylindrical interior and preferably provided with the plates $m' \, m^2 \, m^3$. (See Figs. 2 and 3.) It is secured to the shell and revolves with it.

N is a floor or other receptacle situated below the shell for the purpose of receiving the materials separated after they have been operated upon.

The operation of my invention is as follows: The electromagnet is first energized in the usual way and the shell, with its connections, caused to rotate. Next the materials to be treated—for instance, pulverized ore containing a mixture of minerals and substances of different magnetic attractability—are fed in any convenient manner into the top of the feeding-tube A. This tube is preferably provided with the series of platforms or plates $m \, m' \, m^2 \, m^3$, upon and from which the materials fall in their transit through the feeding-tube and toward the shell and are thereby retarded in their descent, forced outwardly toward the walls and away from the center of the feed-tube, and the transference to them of the rotary movement of the feed-tube and shell facilitated. The plates are preferably set at a slight angle below the horizontal and cover a considerable portion of the cross-section of the feed-tube, leaving, of course, sufficient orifice for the passage of the materials. Their size, number, and arrangement will depend upon the rapidity of feed desired. They may be entirely dispensed with or as many as four, or even more, inserted, as shown in the drawings. The materials will thus receive such retardation and agitation and will acquire such outwardly and rotary movement as experience shall demonstrate is desirable in each different case. Passing out of the feed-tube the materials enter the shell C and pass farther into the field of the magnet. Here the materials, in consequence of their aforesaid outwardly and rotary motion and in proportion to their different magnetic attractability, will be moved from the center of the shell and toward its sides in the direction of the most intense portion of the magnetic field. Thus in degrees corresponding to their respective magnetic permeability the different minerals or other substances possessing such permeability contained in the mixture passing or falling through the shell will be restrained or diverted from the vertical line of fall and pulled or thrown off in different trajectories, while those materials possessing substantially no such permeability, such as the gangue of the ore, will be comparatively uninfluenced and will complete their fall in substantially vertical directions. The substances possessing magnetic attractability will, after they have passed out of the most intense portion of the magnetic field, continue the outward movement there stimulated, and their deflection toward the outwardly-flaring sides of the shell C will still continue, and as the magnetic attraction diminishes in proportion as they pass out of the magnetic field their tendency to move outwardly will be supplemented and continued by the centrifugal force and they will finally descend and fall in trajectories which will widely separate them from the gangue and other comparatively non-magnetic materials descending vertically. Thus in a mixture of powdered ore containing, for instance, magnetite and gangue, the latter will fall upon the floor N and be accumulated there substantially at or directly beneath the more central portions of the shell, while the magnetite will be carried outwardly and deposited and accumulated in a concentric circle lying quite outside of such center.

My aforesaid method and devices for accomplishing separation thus enable two or more different substances to be separated from each other at a single operation or passage through the magnetic field. Thus in proportion to their magnetic permeability different substances constituting the mixture operated upon will be distributed and accumulated on the receiving floor in different deposits at different relative distances from the center, or the magnetomotive force may be so increased as to catch and detain stationarily against the sides of the shell nearest to the most intense portion of the magnetic field one material or element possessing the greatest magnetic attractability—as, for instance, the magnetite in the mixture—while a second material, possessing comparatively less magnetic permeability—as, for instance, franklinite—in the mixture will be dealt with and separated by being thrown off outwardly, as aforesaid, from the gangue falling vertically.

I have not illustrated or described the various systems of hoppers and chutes for feeding the mixtures or catching and carrying off the respective products of the separation, since these will vary according to requirement, and any of the present well-known types may be employed or special forms of particular utility in connection with the process here described, my intention being in this specification to confine myself to the separation of the materials and the method and apparatus of accomplishing that without detailing subsequent steps or devices by which treatment and use of the product may be facilitated.

By the use of my method and apparatus as here described the feeding action and treatment of the mixture operated upon may be extremely rapid. Strong or weak fields may be arranged according to requirement, and these may be unipolar, bipolar, or multipolar. It may also be noted that this system and apparatus permit either wet or dry working, or a mixture of both.

In those cases in which is necessitated the stationary retention of one constituent (the strongest magnetically) against the revolving shell the removal and permanent separation of such constituent involves the intermittent stoppage of the feed, the turning off of the current as soon as the other constituents have finished falling, and the consequent dropping of the magnetically-strongest constituent into or upon any convenient receptacle or supporting-surface—as, for instance, an apron—caused to pass below the shell only during the intervals in which the current is shunted off.

It will be apparent that the principle of operation here described may in certain instances be advantageously applied successively first to a certain mixture and afterward to the residuum thereof. Thus it is possible to arrange two and even three shells or centrifugals in fields where the pole-pieces lie below one another, so that one shall feed the middlings or tailings directly into another below it. Again, for very speedy work, in which it is desired to feed the mixture in large and rapid streams, a multipolar circular field may be arranged, all the pole-pieces terminating toward a common center in which operates a correspondingly-larger shell or centrifugal. I preferably so shape the pole-pieces that while their abutting surfaces are, in general terms, concave their upper and lower lines shall diverge from the center or waist line of the shell. The lower portions of the shell may be also provided with up and down ridges or corrugations *n n*, which will intensify their rotary effect upon the constituents with which they engage and correspondingly increase the centrifugal movement of the latter. The shell is preferably, though not necessarily, flared in its upper half, the flare on its lower half being for the purpose of assisting in the leading of the constituents away from the center and particularly in their outward projection as they leave the shell.

It will be observed that the rotation of the crushed ore or other material and the check in its fall and the propulsion thereof caused by the floor or floors $m\ m'$, &c., assist materially in sorting and arranging the respective particles so as to bring those having the greatest specific gravity, and thus usually the more metallic ones—as, for instance, the magnetite—toward the outside of the descending mass and in the position in which they will be most advantageously acted upon relatively to the others upon entering the magnetic field. Thus as the particles swirl downward from the feeding-tube into the shield they are not falling vertically, but are already describing as they move a more or less helical path, having the heavier and thus usually the more metallic and magnetic particles preponderating on the outside and the lighter gangue on the inside. This greatly facilitates the subsequent action of the magnetic influence in completing the separation, the more permeable particles thus by the action of my devices being preliminarily sorted and fed more or less separately toward the intensest parts of the field instead of picked up and carried out of a uniformly mixed and moving mass. It will further be observed that by reason of the peculiar shape and operation of my devices in those cases in which my shield is provided, as is preferable, with an upward as well as a downward flare or expansion the heavier or more permeable particles thus descend upon the aforesaid flaring surfaces and find temporarily partial support and still further arrestation of downward or falling motion, while the gangue at the center of the falling mass tends to pass on without much, if any, such support, and thus to fall still more vertically and rapidly proportionally. By the time, then, that the particles have entered the most intense portion of the field it will be observed that separation of the magnetic from the non-magnetic portion of the particles has already been to some extent effected and the latter are dropped directly out of the way, thus avoiding all danger of clogging and enabling large quantities of ore to be treated with greater rapidity than heretofore.

The magnetic particles enter the field while moving forward in a descending helical path, being pressed outwardly by centrifugal force, and thus partially supported against the sides of the tube and the shield, and therefore to some extent carried around by the latter as they rotate. The magnetic particles are thus also retarded in their descent by reason of the outwardly-flaring shape of that portion of the shield which extends above the intensest part of the magnetic field and which, although not invariably essential, is in many cases preferable. I thus bring into the center of magnetic attraction the magnetic particles while moving slowly compared to the gangue and in proportion to their relative permeability. It will be observed that owing to the shape of the pole-pieces D D and their correspondence in form so as to fit and embrace the shield the intensest portions of the field will be situated opposite the most projecting portions of the pole-pieces, (see Figs. 2 and 4,) and the magnetic particles will not tend to be swept past these by centrifugal force, nor, on the other hand, by gravity, but, on the contrary, any centrifugal impulse communicated by the rotation of the shield will assist in holding these particles against the walls of the shield and to retard or assist in holding them up toward the said centers of magnetic attraction. I am thus enabled to check the movement of the particles having the greatest magnetic permeability and finally hold them stationary, notwithstanding the rotation of the shield, and accumulate them in groups in the most intense portions of the magnetic field ready to be permanently separated and collected, as aforesaid, on the stoppage of the feed and the turning off of the current. As to the particles which though magnetic are not sufficiently permeable to be held stationary, as aforesaid, these will be led away from the falling gangue by the combined action of the gradually-increasing centrifugal force and the gradually-diminishing attraction of the magnets. Here again it will be observed that the shapes of my shield and pole-pieces and their aforesaid relation to each other coact to assist in the uniformly-graded separation of the magnetic particles according to their permeability. The shape of the shield is such that a given point on its inner surface will be distant from its central vertical axis inversely as the magnetic attraction at that point, and so that the centrifugal force communicated to the magnetic particles by their rotation with the shield shall serve not merely to carry them outward and away from particles of less weight and permeability, but shall also coact with and assist the retaining and upholding effect of the magnets upon them. I thus utilize not only an intense magnetic field for one object, but also a gradually-diminishing magnetic field for another kindred object, all simultaneously and as incidental to the operation of my special devices, as aforesaid.

I am aware that centrifugal motion has been imparted to mixtures of various kinds for the purpose of sorting or separating their constituents. I am also aware that a shield septum screen or apron has been described for the purpose of separating magnetic particles from the magnets and that such have been rotated for the purpose of moving off the attracted particles, none of which features of the prior art constitute any part of my present invention or are intended to be covered by the following claims.

What I claim as new, and desire to secure by Letters Patent, is the following:

1. In a magnetic separating apparatus, the combination of a magnet with an upright circular horizontally-rotating shell or shield, the latter so shaped as to present its least horizontal cross-section nearest to the intensest magnetic field of said magnet, and its inferior or underlying horizontal cross-sections in size substantially inversely proportionate to the

intensity of the respective magnetic fields opposite which they are respectively situated, substantially as and for the purposes described.

2. In a magnetic separating apparatus, the combination of a magnet with an upright circular horizontally-rotating shell or shield, the latter so shaped as to present its least or smallest horizontal cross-section nearest to the intensest magnetic field of said magnet, and its inferior or underlying, and also its superior or overlying horizontal cross-sections in size substantially inversely proportionate to the intensity of the respective magnetic fields opposite which they are respectively situated, substantially as and for the purposes described.

3. In a magnetic separating apparatus a magnet having polar extremities or pole-pieces, whose horizontal cross-section presents a concavity and whose central vertical cross-section presents a convexity, and in combination therewith an upright, circular rotatory shell or shield conformably fitted to said pole-pieces, substantially as and for the purposes described.

4. In a magnetic separating apparatus the combination of a magnet and an upright circular rotatory shell or shield, said magnet having polar extremities or pole-pieces, whose horizontal cross-section presents a concavity to embrace said shell, and whose central vertical cross-section presents a convexity, the said shell being shaped so as to conformably fit the said pole-pieces; said shell having its least horizontal cross-section opposite to said convexity and thus in the intensest part of the magnetic field, and thence downwardly increasing in horizontal cross-section through the diminishing magnetic field, substantially as and for the purposes described.

5. In a magnetic separating apparatus the combination of a magnet and an upright or rotary circular shell or shield, the horizontal cross-section of said magnet presenting a concavity to embrace said shell, and the central vertical cross-section of said magnet presenting a convexity and the said shell conformably fitted to said convexity and concavity and having its least horizontal diameter in the intensest magnetic field, and therefrom increasing in horizontal diameter upwardly and downwardly through the diminishing magnetic field, substantially as and for the purposes described.

6. In a magnetic separating apparatus, an upright rotary feed-tube in combination and rotating with an upright rotating shell or shield, said tube being transversely divided into superimposed chambers by a series of transverse floors attached to the inner walls thereof, rotating therewith and provided with openings between their outer edges and the inner walls of said tube, substantially as and for the purposes described.

7. In a magnetic separating apparatus, the combination of a magnet having the pole-piece D D, the rotary shell C, rotatory feed-tube A, having partial transverse platform m^3, substantially as and for the purposes described.

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