J. WEATHERBY.

MAGNETIC SEPARATOR.

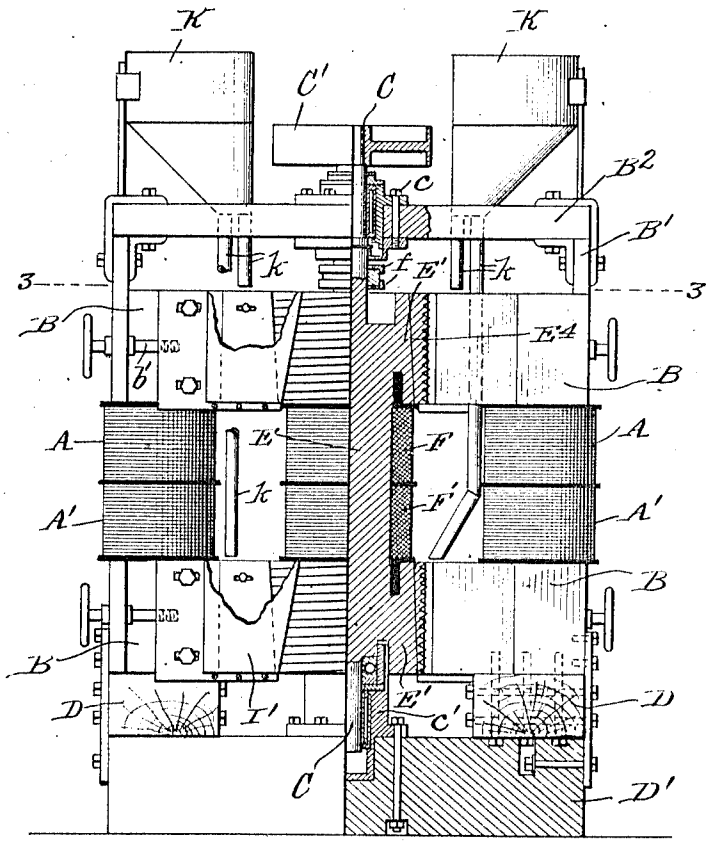
APPLICATION FILED JAN. 11, 1912.

1,071,838.

Patented Sept. 2, 1913.

2 SHEETS—SHEET 1.

Fig. 1.



Witnesses

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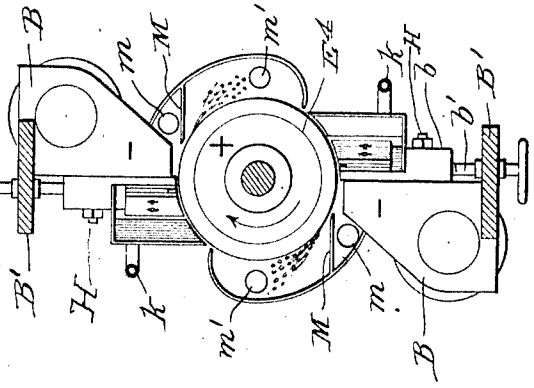


Fig. 3.

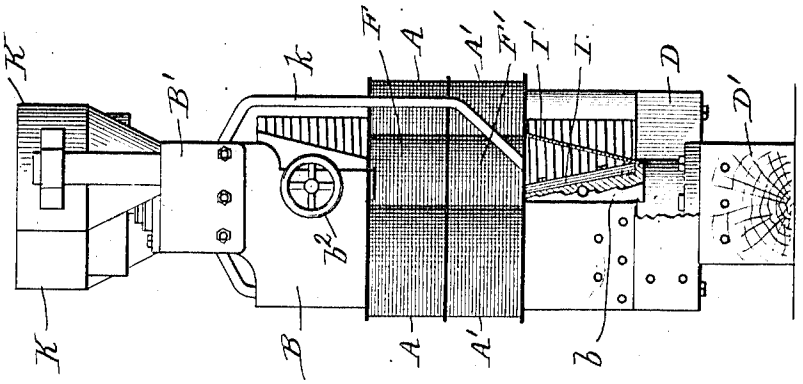


Fig. 2.

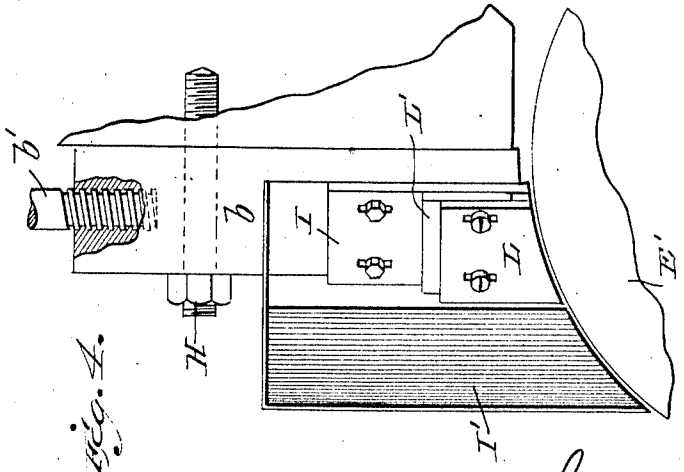


Fig. 4.

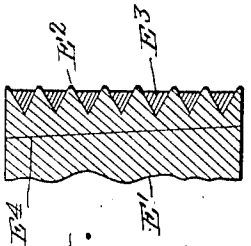


Fig. 5.

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UNITED STATES PATENT OFFICE.

JOSEPH WEATHERBY, OF NEW CUMBERLAND, PENNSYLVANIA, ASSIGNOR, BY MESNE ASSIGNMENTS, TO ELECTRIC ORE SEPARATOR COMPANY, OF NEW CUMBERLAND, PENNSYLVANIA, A CORPORATION OF DELAWARE.

MAGNETIC SEPARATOR.

1,071,838. Specification of Letters Patent. Patented Sept. 2, 1913.

Application filed January 11, 1912. Serial No. 670,621.

To all whom it may concern:

Be it known that I, JOSEPH WEATHERBY, a citizen of the United States, residing at New Cumberland, in the county of Cumberland and State of Pennsylvania, have invented certain new and useful Improvements in Magnetic Separators; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming part of this specification, and to the figures and letters of reference marked thereon.

This invention relates to magnetic separators and more especially to that type designed for operating upon comminuted ores for the separation or classification of the materials of which the ores are composed, in accordance with the so-called magnetic susceptibility or permeability of the materials.

The machine of the present invention is more especially designed for the separation or classification of ores, the ingredients of which have a very low magnetic susceptibility or permeability, or which differ but slightly from each other in their magnetic susceptibility or permeability, such as zinc, chalcopyrites, tin, manganese, silver, gold, etc., etc., and in which ores it is found that the more susceptible ingredients are practically non-magnetic and will not jump to or be materially deflected when in motion, by a proximate magnetic pole piece, even when caused to traverse a highly concentrated or dense magnetic field in proximity to the pole piece.

In operating upon and separating ores of the character above referred to I have discovered that, if the ore particles, when free from momentum or velocity, are subjected to a rubbing contact with the moving pole piece of a magnetic circuit in which the lines of magnetic force are highly concentrated, the more susceptible particles will adhere to the said moving pole piece and may be conveyed thereby through and out of a highly concentrated or dense magnetic field, while the lesser susceptible particles will, in passing through and out of such a field, be free to discharge or escape under the influence of gravity or other force tending to move them away from the more susceptible material.

One of the objects of the invention is to provide a machine which will operate on a commercial scale and take advantage of the discovery above referred to without the introduction of a complicated construction or the use of parts which will deteriorate rapidly in use.

Referring to the accompanying drawings,—Figure 1 is a front elevation of a magnetic separator embodying the present improvements, portions being broken away to show underlying parts, one half of the rotor with a portion of the frame being shown in central longitudinal section. Fig. 2 is an elevation, looking at one end of the machine shown in Fig. 1, portions being broken away and in section to enable underlying parts to be seen. Fig. 3 is a section in a horizontal plane substantially on the line 3—3 of Fig. 1, looking downwardly. Fig. 4 is a detail plan view of one of the hoppers in which the ore is held in contact with the movable pole piece, this view being on an enlarged scale and with a portion broken away to show one of the adjusting screws. Fig. 5 is a detail section of a portion of the rotor or movable pole piece showing the spiral forming the projections and the non-magnetic filling.

The machine in the form illustrated in the drawings embodies four fixed pole pieces and two rotary pole pieces in the magnetic circuit, the gaps between the fixed and rotary pole pieces forming exceedingly dense or concentrated magnetic fields and providing an arrangement whereby separation of the ore may be effected at four separate points, to wit: at each of the gaps in the magnetic circuit. The arrangement is preferably such that the two rotary pole pieces are of opposite polarity and each is located between two fixed pole pieces of the same polarity, but of a polarity of opposite sign from that of the rotary pole piece between them. As an economical construction the pole pieces are arranged in vertical relation and the upright portions of the machine are formed by the cores of the field

magnets or fixed pole pieces, which cores are inclosed, as shown in the accompanying drawings, by coils, each core preferably having two coils A and A′ thereon, whereby the strength of the field may be varied in the well understood manner, and if necessary, should one coil be short circuited, the other will be left in condition for effective operation. Above and below the coils, A, A′ the cores are provided with heavy fixed pole pieces B, the lower pole piece resting on and being firmly bolted to short transverse timbers D, which in turn rest on a single heavy timber D′ extending across the machine from one side to the other. At the top the pole pieces B are provided with upwardly extending projections B′, to which a timber B^2 is connected by suitable angle iron brackets and extends across the machine parallel with the bottom timber D′. The timbers B^2 and D′ are provided with centrally arranged bearings c, c', in which the shaft extensions C of the rotor E are journaled. Said bearings are preferably roller bearings for preventing radial movement, and a ball thrust bearing for supporting the rotor against downward movement. Suitable oil wells are provided for each of the bearings, the details of which form no part of the present invention, and the rotor is preferably rotated by the application of power to the upper end of its shaft as, for instance, through a belt pulley C′. Intermediate its ends the rotor is provided with magnetizing coils F, F′, which are supplied with current through commutator rings f, and above and below the magnetizing coils F, or in position immediately opposite the fixed pole pieces B, the rotor is provided with pole pieces E′ of cylindrical form. Each rotor pole piece has its periphery provided with a spiral projection E^2, the pitch of the spiral being comparatively small, whereby each cylindrical face presents a series of projections to its fixed pole pieces. During rotation the projections are brought in proximity to every portion of the face of the fixed pole pieces, and the lines of magnetic intensity are therefore constantly sweeping up or down, depending upon the direction of rotation, but the convergence of the lines of force is always toward the movable pole piece, and therefore tends to move any magnetic or susceptible material toward or to hold the same in contact with the movable pole.

The spaces between the projections or the valley formed by the spiral of each of the movable poles are preferably filled by a non-magnetic material or metal indicated at E^3 in Fig. 5, so as to leave only the ends of the projections exposed, whereby the movable pole pieces will present substantially a plain cylindrical face and the ore being separated cannot find lodgment and be retained between the projection. The valley is not completely filled, however, as it is desirable to leave some clearance to allow gangue material passage room to escape without dislodging the ore held by the projections. Inasmuch as the projections or spiral on the rotor pole piece is subjected to wear and it is also desirable to employ projections differently spaced for separating different kinds of ore, provision is made for changing the face of the rotor pole. This is preferably accomplished by making the face of the rotor pole in the form of a sleeve as indicated by the line E^4 in Figs. 1, 3 and 5. The sleeve and end of the rotor preferably have a taper fit which prevents longitudinal displacement of the sleeve in one direction and insures a tight joint with little magnetic resistance.

In order to provide a means whereby the air gap between the fixed and movable pole pieces may be adjusted and to effect a greater concentration of the lines of force at that edge of the fixed pole pieces toward which the rotary poles move, the fixed pole pieces are provided with adjustable noses b preferably of wedge-shape or wider at the bottom than at the top, as best seen in the lower portion of Fig. 2, which nose pieces b are adjusted toward and from the rotor by screws b' having hand wheels b^2 at their outer ends and are clamped in adjusted position by clamping bolts H. While there is an enormous pull between each pole piece and the rotor when the machine is in operation, the effect of the pull by any one pole piece tending to draw the rotor out of plumb is overcome or neutralized by the oppositely disposed pole piece, with the result that the rotor is practically free to rotate with little resistance.

To the inclined face of each of the nose pieces b there is adjustably secured a secondary nose piece or concentrating plate I which may be adjusted toward and from the rotary pole piece and which, should wear upon its projecting end occur, may be readily replaced or renewed at slight cost. This secondary nose piece I is preferably a plate which rests squarely against the inclined face of the nose piece b so as to make good magnetic contact therewith, and its projecting edge occupies a position diagonal with respect to the axis of the rotary pole piece. The nose pieces are designed to form one side of downwardly converging hoppers into which the material to be separated is fed. The opposite sides of the hoppers are formed by corresponding but oppositely inclined walls I′ which are also of magnetic material, usually thin plate iron suitably mounted upon and adjustable with the nose pieces b. The form of hopper will be read-

ily understood from an inspection of the lower portion of Fig. 2, and the top plan views Figs. 3 and 4, there being one hopper at the side of each of the fixed pole pieces with means whereby each may be supplied with comminuted ore in quantity sufficient to maintain a body of ore constantly in contact with the face of the rotary pole pieces. The ore is usually supplied from bins K located above the machine and from which it is fed down to the hoppers through pipes *k*.

As above stated, each of the hoppers is preferably kept sufficiently full of comminuted ore to insure a rubbing contact between the body of ore and face of the rotary pole piece, but in order to prevent grinding and wear between said face and the face of nose piece of the fixed pole, a wiper is provided in advance of the supplemental nose piece. This wiper permits only a thin layer of the ore to pass out of the hopper in contact with the face of the rotary pole piece, and is preferably formed by a soft rubber plate L adjustably secured to a filling block L′, of wood or other suitable material, clamped to the face of the supplemental nose piece I. With this construction it is found that the ore drawn out of the hopper by the rotary pole piece is not only evenly distributed, but the particles are forced into intimate relation or rubbing contact with the movable pole piece and each of the more susceptible particles is afforded an opportunity not only to position itself in the most favorable relation to the face of the pole piece, but is brought into such intimate contact and such a relation established between the two that it will be held by the movable pole in passing through the highly concentrated magnetic field. The lesser susceptible particles are, however, free to be discharged by the combined action of gravity and centrifugal force, which will tend to cause them to fly or drop away from the pole piece as soon as the gap between the fixed and movable pole pieces is sufficiently large. The more susceptible particles will be carried a greater distance, and it, therefore, becomes a simple matter to separate or classify the material as by the interposition of partitions or diaphragms M (Fig. 3) with openings such as *m* for discharging tailings, and openings such as *m′* for discharging the concentrates or heads.

It will be noted that the pole pieces on the rotor are of constant polarity, that is to say, one is positive and the other negative at all times, with the result that there is no tendency of the pole pieces to become heated by changes in polarity, as would be the case were one side of each pole positive and the other negative, as in some magnetic separators which have heretofore been proposed. Furthermore, it is found in practice that with this construction, while the separation or classification of ores having the characteristics hereinbefore referred to is facilitated and made possible on a commercial scale the machine is not adapted for use in the separation and classification of the so-called magnetic ores, for the reason that magnetic particles, when once brought into contact with the movable pole pieces will adhere thereto so strongly as to prevent their discharge after the concentrated field of magnetic intensity has been passed.

In operation it is found that a considerable percentage of the tailings will escape from the hoppers on the opposite side of the same from the fixed pole pieces, but owing to the fact that the side wall of the hopper is of magnetic material it is found that only a negligible percentage of the more susceptible particles will escape from the hopper at these points. In effect there is a rough separation at the points mentioned with the escape of only tailings which contain no susceptible material, this result being due in part to the magnetic action and in part to the fact that the rotary pole piece constantly tends to move the material into instead of out of the hopper. The mechanical effect of the rotor or rotary pole piece in moving the material out of the hopper is entirely confined to that side of the hopper which is formed by the fixed pole piece and its adjustable nose pieces. The mass of material or comminuted ore which is presented to the movable pole piece at each of the hoppers it will be noted is entirely free from momentum, there being therefore no tendency of the material to rebound from the surface of the pole piece, and, in fact, while each of the particles is free to adjust itself to such surface it is held against the same with a rubbing contact as sharply distinguished from machines wherein the material is allowed to fall by gravity upon a movable member or is in constant motion independently of the movable member or pole piece, for it is found that where the latter conditions pertain, the attraction between the susceptible particles and the pole piece can not be established with sufficient certainty to give effective separation.

With many of the ores where the present machine will effect satisfactory separation or classification, machines of prior construction will not operate to separate and classify the same at all. The difference, as I have before pointed out, is, so far as I can now determine, due to the fact that a rubbing contact establishes a more effective attraction between the pole piece and the susceptible particles, and when this condition is established, the particles will, if undisturbed, adhere to the pole piece during their

passage through and out of the concentrated field of magnetic intensity, and for a sufficient distance to enable the classes of material to be discharged on opposite sides of a diaphragm or partition.

The movable pole piece is preferably rotated at a speed which will cause the ore to leave its surface under the influence of centrifugal force, thus centrifugal force combined with the action of gravity will cause the lesser susceptible particles to leave the pole piece sooner than the more susceptible particles, and it is obvious that by regulating the magnetic attraction of the pole pieces and density of the concentrated field, materials of but slightly different magnetic susceptibility can be separated from each other. While the capacity of any one of the separating fields may be small as compared with machines designed for operating on magnetic ores, by the provision of four separating fields without material increase in complication, or power required to operate the machine, the total capacity is greatly increased so that a machine of moderate size will separate ores on a commercial scale without difficulty.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States, is:—

1. In a magnetic separator, the combination with fixed and rotary pole pieces having a vertically elongated air gap between them, of means for maintaining a body of comminuted material in rubbing contact with the movable pole piece at one side of and in proximity to the fixed pole piece and air gap between the pole pieces.

2. In a magnetic separator, the combination with fixed and movable pole pieces having a vertically elongated air gap between them, of a hopper for comminuted materials to be separated, one side of which is formed by the movable pole piece at a point in proximity to and at one side of the fixed pole piece, whereby the materials discharged from the hopper by the movement of the movable pole piece will be carried transversely through the air gap.

3. In a magnetic separator, the combination with a rotor forming one pole piece in a magnetic circuit, and a fixed pole piece arranged in proximity thereto and inclined to the horizon, of means for maintaining a body of comminuted materials to be separated in contact with the rotor in proximity to the upper inclined side of the fixed pole piece, whereby materials of lesser susceptibility discharged from the hopper at the top will fall under the influence of gravity without contacting with material of greater susceptibility carried by the rotor from the bottom portion of the hopper.

4. In a magnetic separator, the combination with a rotor mounted on a vertical axis and having a cylindrical pole piece forming one terminal of the magnetic circuit, and a fixed pole piece arranged in proximity thereto, and forming another terminal of the magnetic circuit, whereby the concentrated magnetic field is established between said pole pieces, of a hopper located at one side of the fixed pole piece, with its feed opening at one side and extending vertically, one wall of said hopper being formed by the pole piece of the rotor whereby a body of ore will be supported in rubbing contact with said pole piece and will be fed thereby laterally through the concentrated magnetic field for the separation of the ore particles having different magnetic susceptibility.

5. In a magnetic separator, the combination with a rotor mounted on a vertical axis and having a cylindrical pole piece forming one terminal of a magnetic circuit and a fixed pole piece arranged in proximity thereto and forming another terminal of the magnetic circuit, one face of said fixed pole piece being inclined to the axis of the rotor, of a hopper, one wall of which is formed by the pole piece of the rotor at a point in proximity to the inclined face of the fixed pole piece whereby the ore will be transferred by the rotor through the magnetic field between the two pole pieces, substantially as described.

6. In a magnetic separator, the combination with a rotor having cylindrical pole pieces at its opposite ends, said pole pieces being of constant opposite sign, and a field magnet having pole pieces arranged in proximity to said rotor pole pieces and of opposite sign therefrom, of hoppers located in proximity to said field magnet pole pieces and having one side open to the rotor pole pieces and each having an upwardly extending discharge opening between one wall and the rotor, whereby bodies of ore will be supported in rubbing contact with the rotor pole pieces in proximity to the concentrated fields of magnetic intensity between the rotor and field magnet pole pieces and will be discharged laterally from the hopper by the movement of the rotor.

7. In a magnetic separator, the combination with a rotor mounted on a vertical axis and having cylindrical pole pieces at its ends, field magnets arranged on diametrically opposite sides of the rotor and having pole pieces extending in proximity to the rotor pole pieces, the pole pieces of the rotor being of constant and opposite sign from the pole pieces of the field magnet, whereby magnetic reversals in the rotor pole pieces are avoided, and hoppers arranged in proximity to each of the field magnet pole pieces, one side of each of said hoppers being open to the rotor pole pieces and each having a

vertically elongated discharge opening between one wall and the rotor whereby bodies of comminuted ore will be held in rubbing contact with the rotor pole pieces and will be fed thereby through the concentrated magnetic field between the pole pieces.

8. In a magnetic separator, the combination with a rotor mounted on a vertical axis and having a cylindrical pole piece provided with a peripheral spiral projection, of a field magnet having a vertically elongated pole piece arranged in proximity to the rotor pole piece and spaced therefrom to form a vertically extending hopper discharge opening and a hopper at one side of the field pole piece, one wall of the hopper being formed by the rotor, whereby a body of ore may be supported in position to be fed through the space between said pole pieces by the rotation of the rotor.

9. In a magnetic separator, the combination with a rotor mounted on a vertical axis and having cylindrical pole pieces provided with a peripheral spiral forming a plurality of projections longitudinally of the rotor and a fixed pole piece arranged in proximity to said rotor pole piece and having a face inclined to the axis of the rotor, of a hopper one wall of which is formed by the rotor at a point in proximity to said inclined face whereby the ore is held in position to be fed between the pole pieces by the rotary movement of the rotor.

10. In a magnetic separator, the combination with a rotor mounted on a vertical axis and having a cylindrical pole piece provided with a peripheral spiral forming a plurality of projections longitudinally of the rotor, a field magnet having a vertically elongated pole piece projecting in proximity to the rotor pole piece, a vertically elongated nose piece mounted on said field magnet and adjustable toward and from the rotor, of a hopper located at one side of the field magnet pole piece, and having one wall formed by the rotor pole piece, whereby ore from the hopper will be fed transversely through the concentrated field between the pole pieces by the movement of the rotor.

11. In a magnetic separator, the combination with a rotor mounted on a vertical axis, cylindrical pole pieces at the upper and lower ends of said rotor, each of said pole pieces being provided with peripheral projections with non-magnetic filling between said projections, a field magnet having vertically elongated pole pieces projecting in proximity to the rotor pole pieces and hoppers located on one side of each of the field magnet pole pieces, said hoppers being open on the side toward the rotor pole pieces and having vertically elongated discharge openings at the sides, whereby comminuted ore from the hoppers will be fed by the rotation of the rotor transversely from the hopper through the concentrated field between the pole pieces.

12. In a magnetic separator, the combination with the rotor mounted on a vertical axis and having cylindrical pole pieces at its upper and lower ends, said pole pieces being provided with peripheral projections and non-magnetic filling material between said projections, of field magnets arranged on diametrically opposite sides of the rotor, said field magnets having vertically elongated pole pieces extending in proximity to the rotor pole pieces, and hoppers arranged in proximity to the sides of the field magnet pole pieces, said hoppers being open at one side to the rotor pole pieces and having vertically elongated discharge openings at the side whereby the material from said hoppers will be fed by the rotation of the rotor transversely from the hoppers through the magnetic fields between the pole pieces.

13. In a magnetic separator, the combination with a rotor having a cylindrical pole piece and a field magnet having a vertically elongated pole piece projecting in proximity to said rotor pole piece, of a hopper for supporting a body of material at one side of the field magnet pole piece in position to be fed transversely through between the pole pieces by the rotation of the rotor, and a vertically extending adjustable gate located in proximity to the side of the field magnet pole piece for regulating the quantity of material fed from the hopper by the movement of the rotor.

14. In a magnetic separator, the combination with a rotor having a cylindrical pole piece, the field magnet having a vertically elongated pole piece projecting in proximity to the cylindrical pole piece, and a hopper at one side of the field magnet pole piece for supporting a body of ore in position to be fed by the rotor through the magnetic field between the pole pieces, of a vertically elongated resilient gate in proximity to the side of the field magnet pole piece for regulating the quantity of material fed from the hopper by the movement of the rotor.

15. In a magnetic separator, the combination with a rotor having a cylindrical pole piece, a field magnet having an elongated pole piece extending in proximity to the rotor pole piece, to form a concentrated magnetic field and a hopper one wall of which is formed by the rotor for supplying material to the rotor, of a gate formed of elastic resilient material supported parallel with the field magnet pole piece in proximity to the rotor and in advance of the concentrated magnetic field, whereby the quantity of material fed through said field by the rotor is regulated, and abrasion of the faces of the pole pieces prevented.

16. In a magnetic separator, the combination with a rotor mounted on a vertical axis and having a cylindrical pole piece, and a field magnet having a vertically elongated pole piece extending in proximity to the rotor pole piece, of a hopper having downwardly converging walls and having one wall formed by the rotor pole piece at a point in proximity to the magnetic field between the pole pieces, whereby comminuted ore will be fed transversely from the said hopper by the rotation of the rotor and the lesser susceptible particles will be permitted to drop between the rotor and converging hopper walls, substantially as described.

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