No. 762,753. PATENTED JUNE 14, 1904.

C. Q. PAYNE.

APPARATUS FOR MAGNETIC SEPARATION.

APPLICATION FILED OCT. 3, 1903.

NO MODEL. 2 SHEETS—SHEET 1.

FIG. 1.

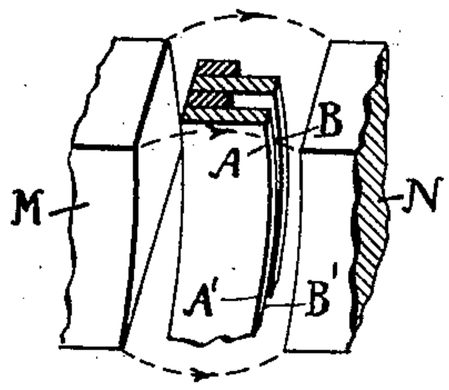


FIG. 2.

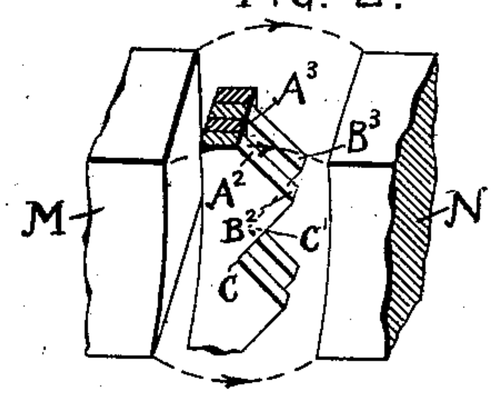
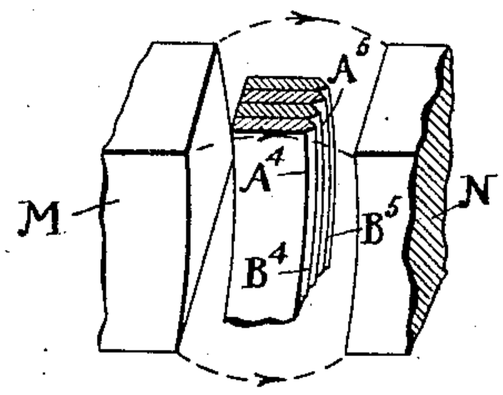


FIG. 3.



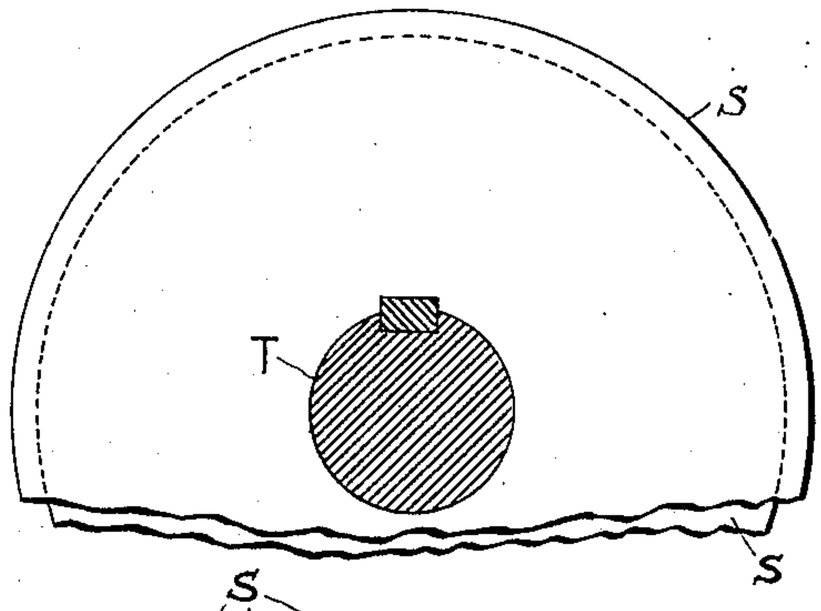


FIG. 4.

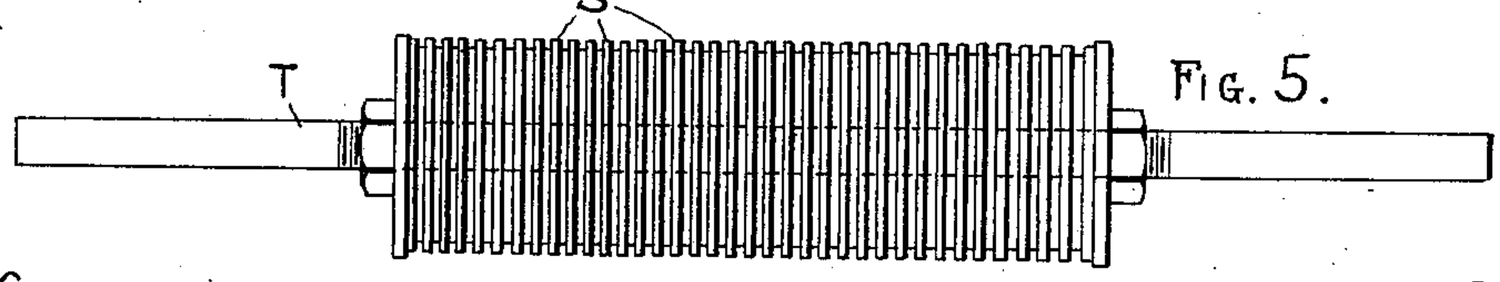


FIG. 5.

FIG. 6.

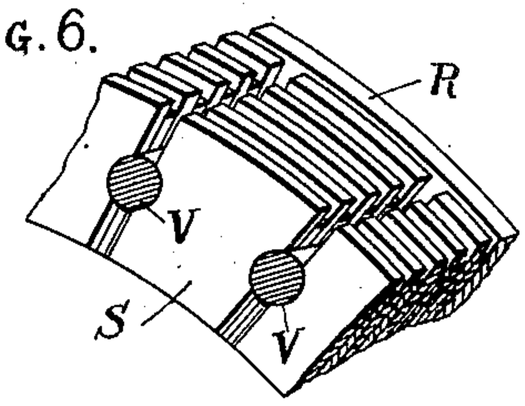


FIG. 7.

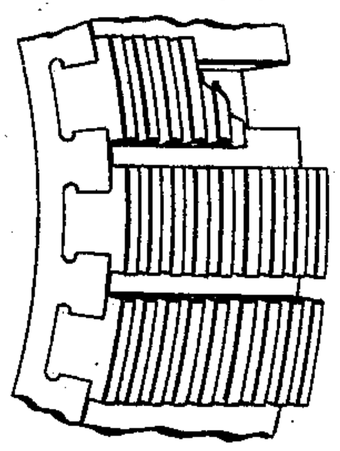


FIG. 8.

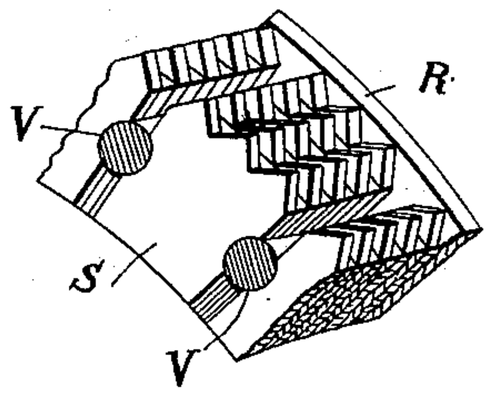
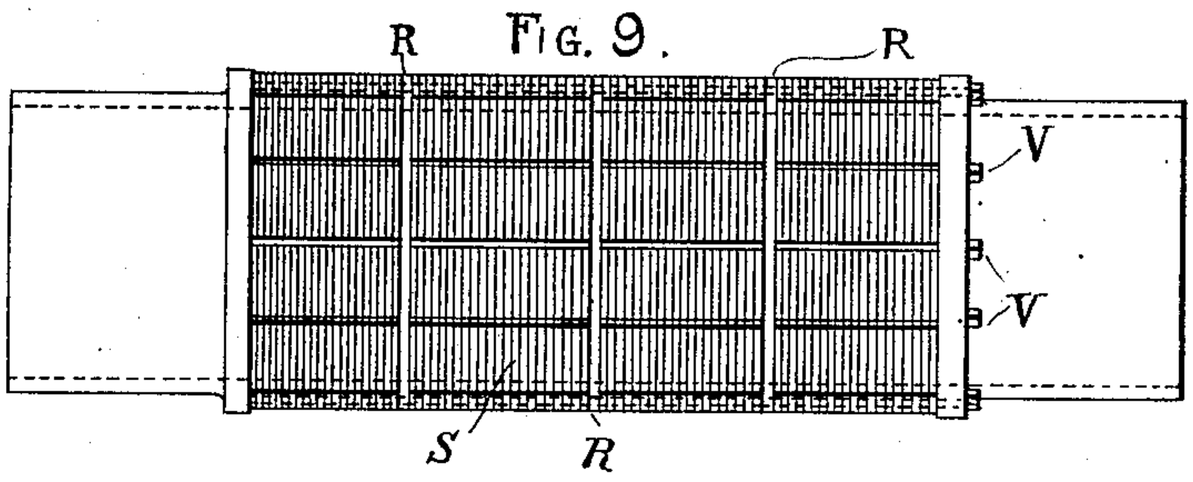


FIG. 9.



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NO MODEL. 2 SHEETS—SHEET 2.

FIG. 10.

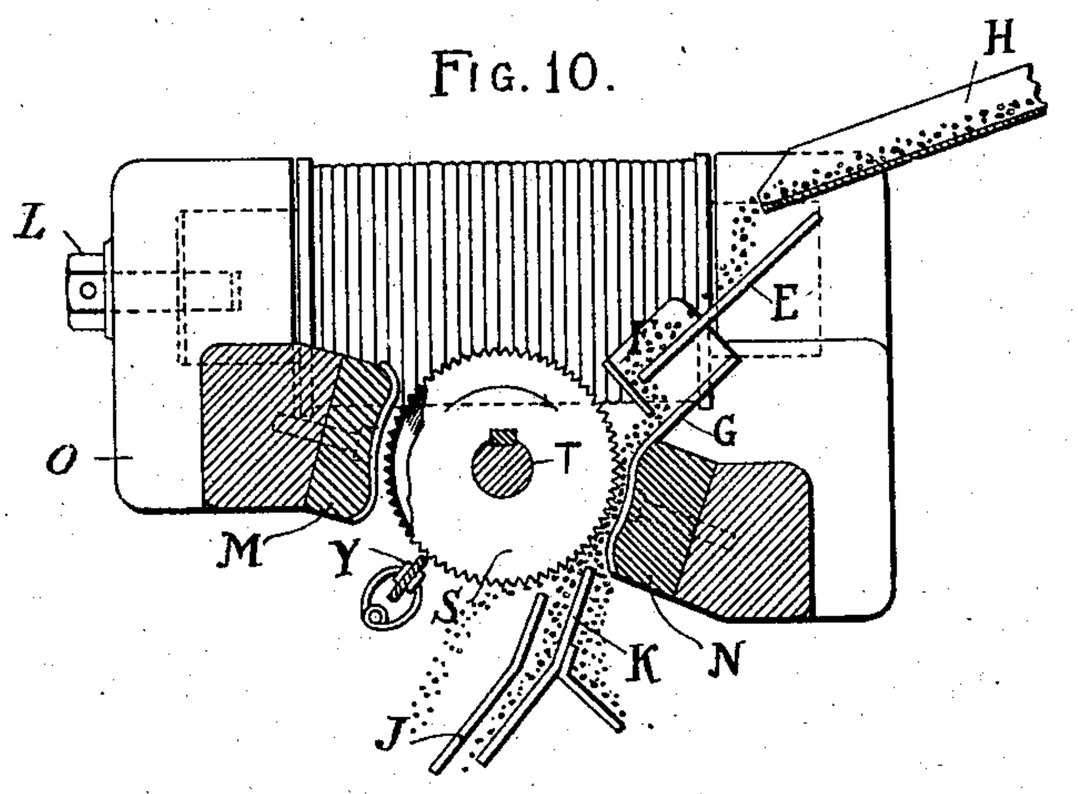
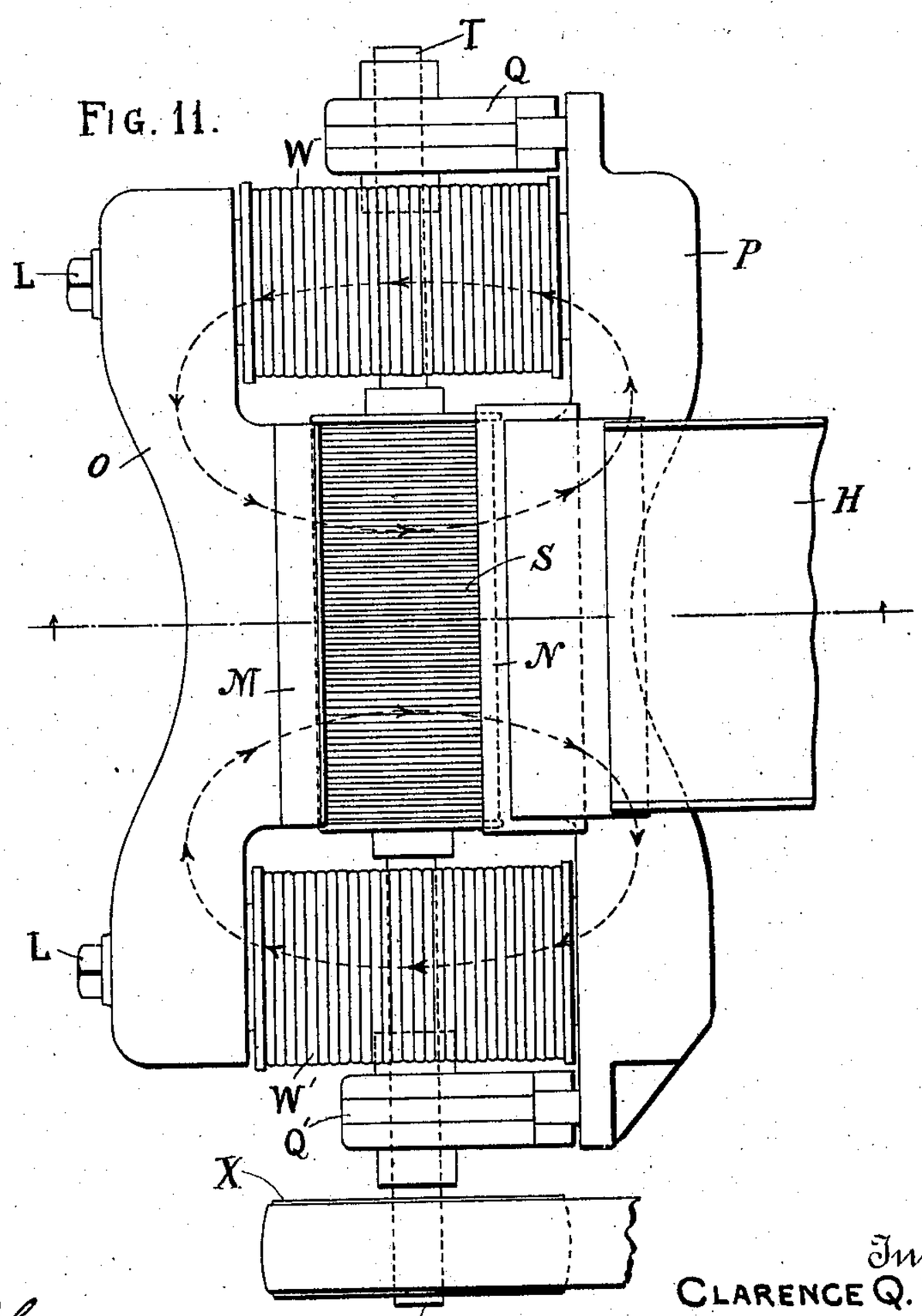


FIG. 11.



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No. 762,753. Patented June 14, 1904.

UNITED STATES PATENT OFFICE.

CLARENCE Q. PAYNE, OF STAMFORD, CONNECTICUT.

APPARATUS FOR MAGNETIC SEPARATION.

SPECIFICATION forming part of Letters Patent No. 762,753, dated June 14, 1904.

Original application filed February 2, 1902, Serial No. 141,402. Divided and this application filed October 3, 1903. Serial No. 175,597. (No model.)

To all whom it may concern:

Be it known that I, CLARENCE Q. PAYNE, a citizen of the United States, and a resident of Stamford, in the county of Fairfield, State of Connecticut, (having a post-office address at 99 John street, in the borough of Manhattan, city and State of New York,) have invented certain new and useful Improvements in Apparatus for Magnetic Separation, of which the following is a full and true specification, reference being had to the accompanying drawings, wherein similar letters refer to like parts in the several views.

My invention relates to improvements in magnetic ore-separators for the concentration of substances of all degrees of magnetic permeability, and more especially to improvements in that type of separator in which the magnetic field is formed between opposing magnetic surfaces.

In an application for United States Letters Patent filed February 2, 1902, Serial No. 141,402, of which the present application is a division, I have, among other things, described and claimed a novel form of ore-separating apparatus wherein toothed plates or laminæ are so disposed in the separating carrier or cylinder of said apparatus that the teeth of the adjacent laminæ are brought out of alinement, and thus expose a large number of points and lines of the toothed edges of said laminæ to the ore particles undergoing separation, whereby very beneficial effects may be exerted, especially upon those ore particles which are feebly magnetic. In my present invention I am able to accomplish the same results by other dispositions or arrangements of the toothed plates or laminæ, and I am also enabled to make use of plates or laminæ having smooth edges, whereby important advantages are secured.

My invention also consists of a novel form of separating-cylinder, and it is shown as applicable to a complete ore-separating machine in which a single magnetic field is formed upon two magnetic circuits.

In the accompanying two sheets of drawings, Figures 1, 2, and 3 illustrate by diagrammatic sections through a magnetic field the use for the purpose described of plates or laminæ whose edge faces are made to project in such a way that the adjacent outer edges of said laminæ are wholly out of contact with each other. Figs 4 and 5 show the application of my invention to a novel form of cylindrical separating-carrier. Figs. 6, 7, 8, and 9 illustrate applications of my invention to various forms of a hollow cylindrical or annular separating-carrier. Figs. 10 and 11 show in section and plan an ore-separating machine in which a single magnetic field is formed upon two magnetic circuits and in which my new type of separating-cylinder is employed.

In accomplishing the purpose of my present invention I preferably make use of a series of thin iron or soft-steel plates or laminæ, which are placed transversely to the axis of the separating cylinder or carrier in order to completely suppress Foucault or eddy currents which would otherwise be generated in the carrier and offer a resistance to its motion when caused to travel through a strong magnetic field. The edge faces of these plates, which wholly or in part form the separating-surface of the carrier, may be smooth, as shown in Figs. 1, 4, 5, 6, and 7. They may be part smooth and part toothed, as shown in Figs. 2 and 3, or they may all be toothed or beveled, as shown in Fig. 3. In any case it is the purpose of my present invention to so assemble the plates that their adjacent outer edges shall be out of contact with each other, either by beveling their edge faces or by causing the latter to alternately project so that they expose to the ore particles undergoing separation a series of strongly-magnetized edges and edge faces or a combination of magnetized points, edges, and edge faces, whereby a proper separating effect may be obtained by the control which they thus exert over the positions of the lines of force within the magnetic field.

In Fig. 1 magnetizable plates or laminæ, all having smooth edges, are so assembled that their adjacent edge faces are at different levels or alternately project in order that the adjacent outer edges shall be wholly out of con-

tact with each other. When brought within a magnetic field formed between the surfaces M and N, the lines of force within the field will then be strongly diverged or "dispersed" from the bounding edge face A A′ B B′ of the plate and from its outer edges toward the opposing surface N. By the use of plates which are quite thin and a field of high magnetic density I have found that not only the bounding edges, but the edge faces themselves, may be employed to attract and hold magnetic ore particles of even slight permeability while separating them from non-magnetic particles.

Another application of my invention is shown in Fig. 2. Here the magnetizable plates or laminæ have alternately toothed and smooth edges and are so assembled that the former are exposed, overlap, or project beyond the latter. The outer or toothed edges A^2 B^2 C A^3 B^3 C′ of the plates are thus out of contact with each other.

Fig. 3 shows another application of my invention. Here the edges of the plates are provided with the equivalent of teeth by beveling them longitudinally and are so assembled that the adjacent outer edges A^4 B^4 A^5 B^5 of the plates are wholly out of contact with each other and are thus available for the purpose of separation.

Various other combinations of these elements or arrangements of plates may also be made within the scope of my invention.

In Figs. 4 and 5 I have shown a novel form of cylindrical separating-carrier in which I have embodied that application of my invention which is illustrated in Fig. 1, although it will be readily understood that any of the other applications of my invention (shown in Figs. 2 and 3) may also be combined with this form of separating-cylinder. A series of thin iron or soft-steel circular plates or disks S, (shown in part section in Fig. 4,) the plates of greater diameter being spaced apart by those of less diameter, are mounted upon a shaft T and clamped together in any convenient way—as, for instance, by means of a key and compression-flanges, as shown in the illustration. When so assembled, it is evident that the edges of the plates project radially beyond those of their adjacent plates with respect to the cylinder. This form of separating-cylinder can be revolved with great ease through a magnetic field which is formed between magnetic surfaces placed on opposite sides of the cylinder, since it completely suppresses the Foucault or eddy currents by its subdivision into thin plates and forms, in effect, a laminated armature-bar.

My invention may also be applied to other widely-different forms of separating carriers or cylinders, and I have shown in Figs. 6, 7, 8, and 9 for the purpose of illustration further applications of my invention to hollow cylindrical or annular separating-carriers. These forms of cylinders are found to be desirable when one of the two opposing magnetic surfaces or pole-pieces between which a magnetic field is formed is placed on the inside and the other on the outside of the cylinder. In the construction shown in Figs. 6, 8, and 9 the plates which may form any of the various combinations shown in Figs. 1, 2, and 3 are preferably clamped together by tie-rods V V, which support flanged drum-heads at their ends. These tie-rods. which should be made of metal or alloy of high electrical resistance, such as manganese-bronze, &c., are maintained in proper position by means of tie-rings R R, placed at intervals. The plates when assembled thus form, in effect, an annular laminated armature-ring and are preferably interrupted or made in sections in order to introduce air-gaps, and thus avoid weakening the field by short-circuiting a portion of it in the direction of the circumference of the cylinder. In this way I am also able to suppress Foucault or eddy currents when this form of cylinder is caused to travel through a strong magnetic field.

In Fig. 7 I have shown another form of separating-cylinder, as especially described in my application, Serial No. 72,322, filed August 17, 1901, whereby the results above described may be accomplished by means of any of the various combinations of plates al ready referred to in connection with Figs. 1, 2, and 3 by inserting them in grooves in the surface of a hollow or annular non-magnetic cylinder instead of clamping them together in the manner shown in Fig. 9.

In the various constructions above described, in which the projecting plates are spaced apart by smaller plates, the latter may be magnetic, or, as described and claimed in the application Serial No. 175,598, filed simultaneously herewith, they may be non-magnetic, whether of the same or of smaller size.

In Figs. 10 and 11 I have shown my invention embodied in a complete operating machine and in connection with the particular form of separating-cylinder shown in Figs. 4 and 5. The coils are so wound and connected that when they are charged with an electric current, preferably from a dynamo-electrical machine, the magnetic flux generated in the cores of the magnet form two circuits, as shown by the broken lines and arrow-heads in Fig. 11. A magnetic field is thus established in the space between the opposing magnetic surfaces of the pole-piece M and N, as shown in Fig. 10. The cylindrical separating-carrier S T is placed centrally between the pole-pieces M N and at a short distance from their surfaces, which are made approximately concentric with the separating-cylinder for a portion of their lengths, as shown in Fig. 10.

The apparatus is preferably provided with means for retaining the material undergoing separation in close proximity to a consider-

able segment of the cylinder. For this purpose pole-piece N is preferably extended along a considerable segment of the cylinder's surface below its horizontal diameter, so as to form a guide-surface for the ore mixture while passing through the field. The surface of the pole-piece may also be provided with a lining-plate or wearing-plate, as shown in Fig. 10, although such a plate is not essential to the proper operation of the machine.

To increase or diminish the air-gap between the separating-surface of the cylinder S and the pole-piece N, the shaft T is supported in hinged bearings Q Q and the yoke O is provided with screws L L, so that it may be moved along the core ends of the magnets W W′.

In operating the apparatus the magnetic field is charged and the separating-cylinder is caused to revolve through the field in the direction indicated by the arrow by means of a pulley X, keyed to one end of the shaft T, driven by a belt connected with any convenient source of power. The means employed to revolve the separating-cylinder are, however, not important, since the suppression of all Foucault or eddy currents by the construction of the cylinder permits it to be revolved with an expenditure of very little power, and by varying the diameter of the driving or driven pulleys the speed of the cylinder may be readily adjusted to the requirements of the material undergoing separation.

The material to be separated after crushing, if necessary to unlock the minerals to be separated, is introduced from any convenient source of supply H by means of the guide-plates E F G into the magnetic field between the cylindrical carrier S and the pole-piece N. The magnetic ore particles of the mineral are then attracted and held to the surface of the carrier S until by the continued rotation of the carrier they are conveyed out of the field. During their passage through the field the surface of the pole-piece N, which is preferably made approximately concentric with the cylinder S, and its relative position to the cylinder serve to retain the ore particles in close proximity to the surface of the cylinder along a considerable segment thereof below its horizontal diameter, and while the non-magnetic or non-attracted particles are thus readily discharged from the surface of the cylinder the magnetic or attracted particles are at the same time prevented from escaping beyond the range of attraction of the inductively-magnetized surface of the cylinder while within the field. Upon successive local demagnetization of the plate edges of the cylinder as the former revolve through and out of the field the attracted ore particles are released and discharged over the edge of the division-plate K, thus effecting their separation from the non-magnetic or non-attracted ore particles, which on leaving the field are guided by the division-plate K into a separate receptacle. (Not shown in the drawings.)

In case it is desired to divide an ore mixture into products known in ore-dressing as "heads," "middlings," and "tailings," or where the crude material contains several magnetic materials which differ in their magnetic susceptibility, it may be desirable to use two or more division-plates to classify the magnetic material as it is discharged from the separating-carrier, as shown in Fig. 10. If the ore contains a certain amount of strongly-magnetic material, it may also be desirable to employ a light brush, as shown at Y, Fig. 10, in order to prevent such particles from remaining attached to the surface of the cylinder during a complete revolution.

While Figs. 10 and 11 show, for purpose of illustration, my invention applied to a single magnetic field formed upon two circuits of the magnetic flux, I do not desire to confine my invention to this form of application, as various modifications within the claims of my invention will suggest themselves to those skilled in the art.

What I claim is—

1. In a magnetic separator, a transversely-laminated separating-carrier provided with a plurality of contacting magnetizable laminæ whose outer edges are wholly out of contact with those of their adjacent laminæ, in combination with two opposing magnetic surfaces both placed external to said carrier and between which said carrier is arranged to travel, and means for feeding the material to be separated, substantially as described.

2. In a magnetic separator, a transversely-laminated separating-cylinder provided with a plurality of contacting magnetizable laminæ, a series of whose outer edges project radially beyond those of their adjacent laminæ, in combination with two opposing magnetic surfaces, both placed external to said cylinder and between which said cylinder is arranged to revolve, and means for feeding the material to be separated, substantially as described.

3. In a magnetic separator, the combination of a separating-cylinder provided with a plurality of transversely-disposed magnetizable laminæ, a series of whose outer edges project radially beyond those of their adjacent laminæ; two opposing pole-pieces placed approximately concentric with said cylinder and between which said cylinder is arranged to revolve, and means for feeding the material to be separated, substantially as described.

4. In a magnetic separator, the combination of a separating-cylinder provided with a plurality of transversely-disposed magnetizable circular disks, a series of whose outer edges are wholly out of contact with those of their adjacent disks; two opposing magnetic surfaces both placed external to said cylinder and between which said cylinder is arranged

to revolve, and means for feeding the material to be separated, substantially as described.

5. In a magnetic separator, the combination of a separating-cylinder provided with a plurality of transversely-disposed magnetizable circular disks, a series of whose outer edges project radially beyond those of their adjacent disks; two opposing pole-pieces placed approximately concentric with said cylinder and between which said cylinder is arranged to revolve, and means for feeding the material to be separated, substantially as described.

6. In a magnetic separator, the combination of a separating-cylinder provided with a plurality of transversely-disposed magnetizable laminæ, a series of whose outer edges project radially beyond those of their adjacent laminæ; means for magnetizing said cylinder, and means for retaining the material undergoing separation in close proximity to the cylinder along a considerable segment thereof below it horizontal diameter, substantially as described.

7. In a magnetic separator, the combination of a separating-cylinder provided with a plurality of transversely-disposed magnetizable circular disks, a series of whose outer edges project radially beyond those of their adjacent disks; means for magnetizing said cylinder, and means for retaining the material undergoing separation in close proximity to the cylinder along a considerable segment thereof below its horizontal diameter, substantially as described.

8. In a magnetic separator, the combination of a separating-cylinder provided with a plurality of transversely-disposed magnetizable laminæ, a series of whose outer edges project radially beyond those of their adjacent laminæ; two opposing pole-pieces between which said cylinder is arranged to revolve, and a guide-plate formed partly by one of said pole-pieces and partly by an upward extension added thereto, substantially as described.

9. In a magnetic separator, the combination of a separating-cylinder provided with a plurality of transversely-disposed magnetizable circular disks, a series of whose outer edges project radially beyond those of their adjacent disks; two opposing pole-pieces between which said cylinder is arranged to revolve, and a guide-plate formed partly by one of said pole-pieces and partly by an upward extension added thereto, substantially as described.

10. In a magnetic separator, the combination of a separating-cylinder provided with a plurality of transversely-disposed magnetizable laminæ, a series of whose outer edges project radially beyond those of their adjacent laminæ; two opposing pole-pieces between which said cylinder is arranged to revolve, and a guide-plate formed partly by one of said pole-pieces and partly by an upward extension added thereto, substantially as described.

11. In a magnetic separator, the combination of a separating-cylinder provided with a plurality of transversely-disposed magnetizable circular disks, a series of whose outer edges project radially beyond those of their adjacent disks; two opposing pole-pieces between which said cylinder is arranged to revolve, and a guide-plate connected with one of said pole-pieces, having an extension above the horizontal diameter of said cylinder, substantially as described.

12. In a magnetic separator, the combination of a transversely-laminated separating-cylinder provided with a plurality of magnetizable laminæ whose outer edges have toothed outlines and which project radially beyond the peripheral edges of their adjacent laminæ; means for magnetizing said cylinder, and means for feeding the material to be separated, substantially as described.

13. In a magnetic separator, a transversely-laminated separating-cylinder provided with a plurality of magnetizable circular disks, a series of which have toothed edges which project radially beyond the peripheral edges of their adjacent disks, in combination with two opposing pole-pieces between which a magnetic field is formed and between which said cylinder is arranged to revolve, and means for feeding the material to be separated, substantially as described.

14. In a magnetic separator, the combination of a transversely-laminated separating-cylinder provided with a plurality of magnetizable laminæ, whose outer edges have toothed outlines and which project radially beyond the peripheral edges of their adjacent laminæ; means for magnetizing said cylinder, and means for retaining the material undergoing separation in close proximity to the cylinder along a considerable segment thereof, below its horizontal diameter, substantially as described.

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