No. 791,494. PATENTED JUNE 6, 1905.

C. Q. PAYNE.

APPARATUS FOR MAGNETIC SEPARATION.

APPLICATION FILED FEB. 2, 1903.

3 SHEETS—SHEET 1.

Fig. 1.

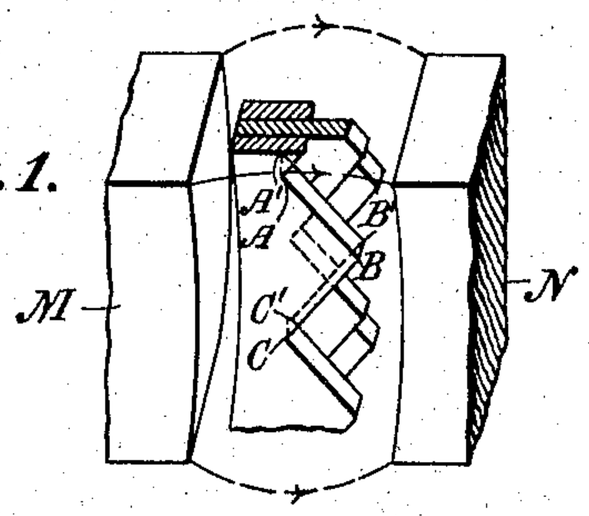


Fig. 2.

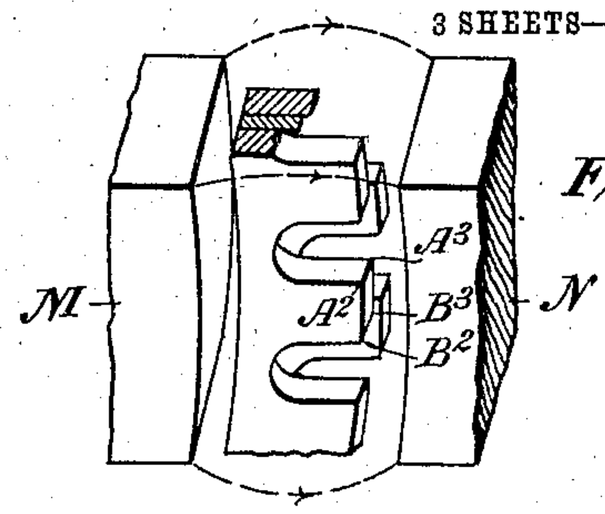


Fig. 3.

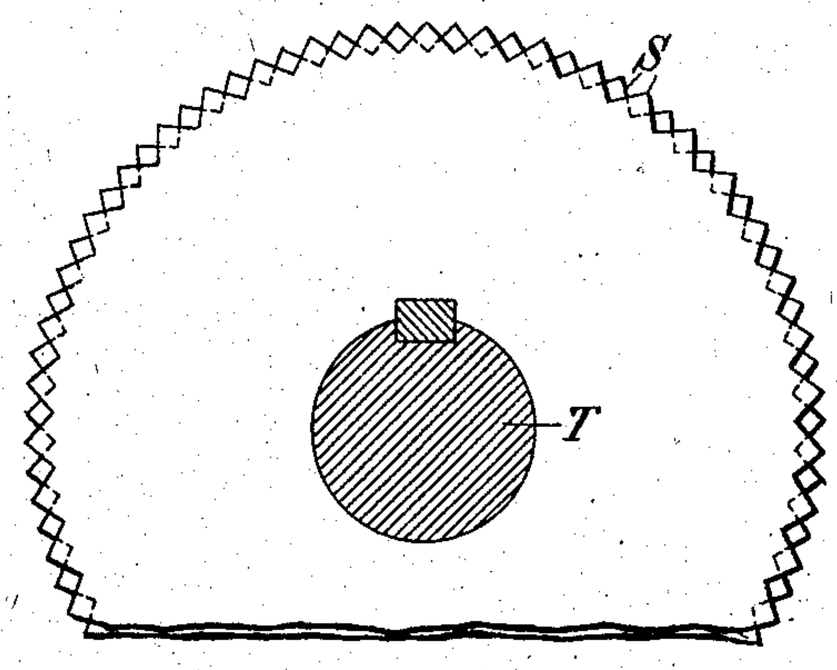


Fig. 4.

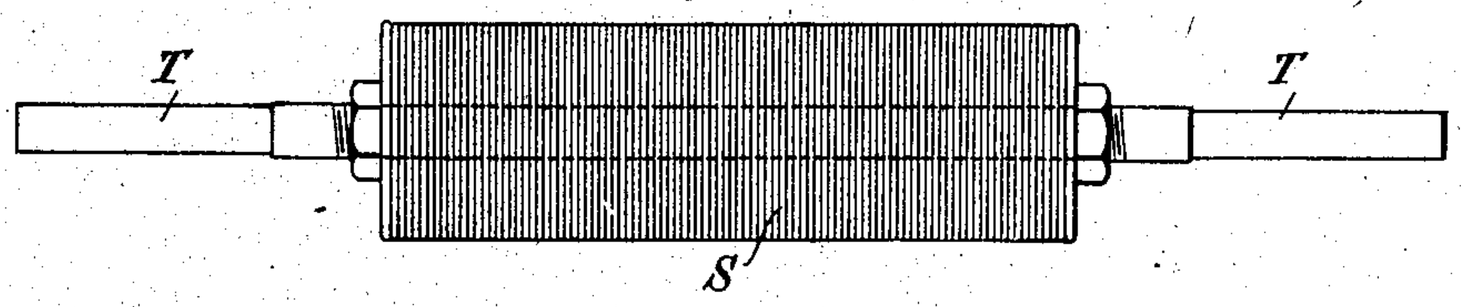


Fig. 5.

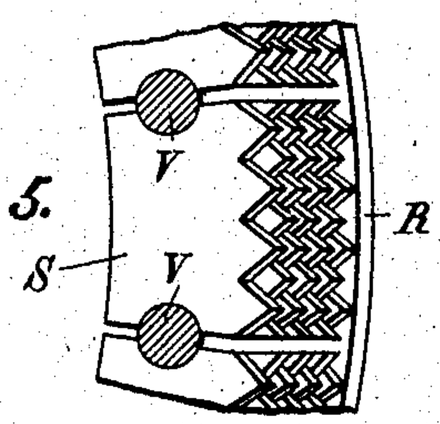
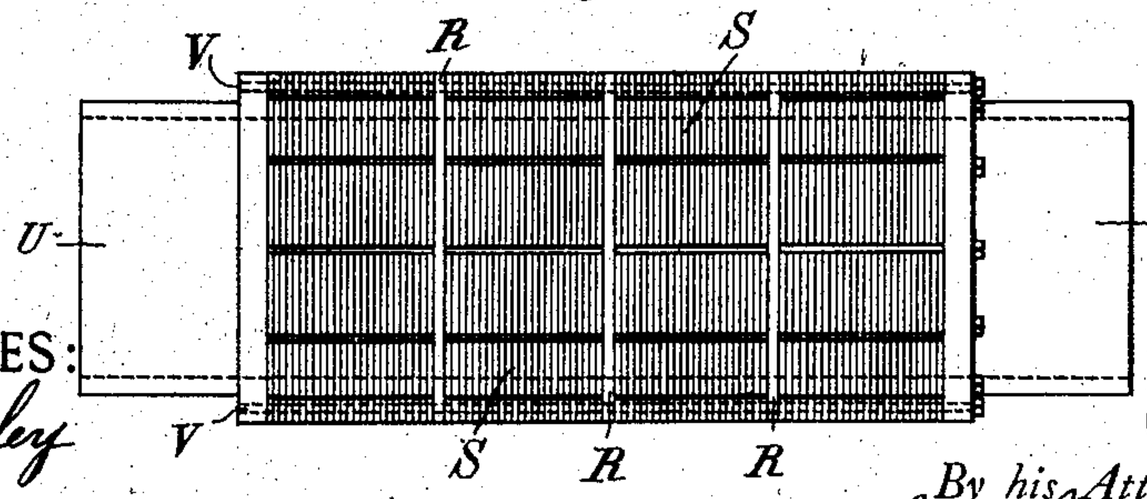


Fig. 6.



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3 SHEETS—SHEET 2.

Fig. 7.

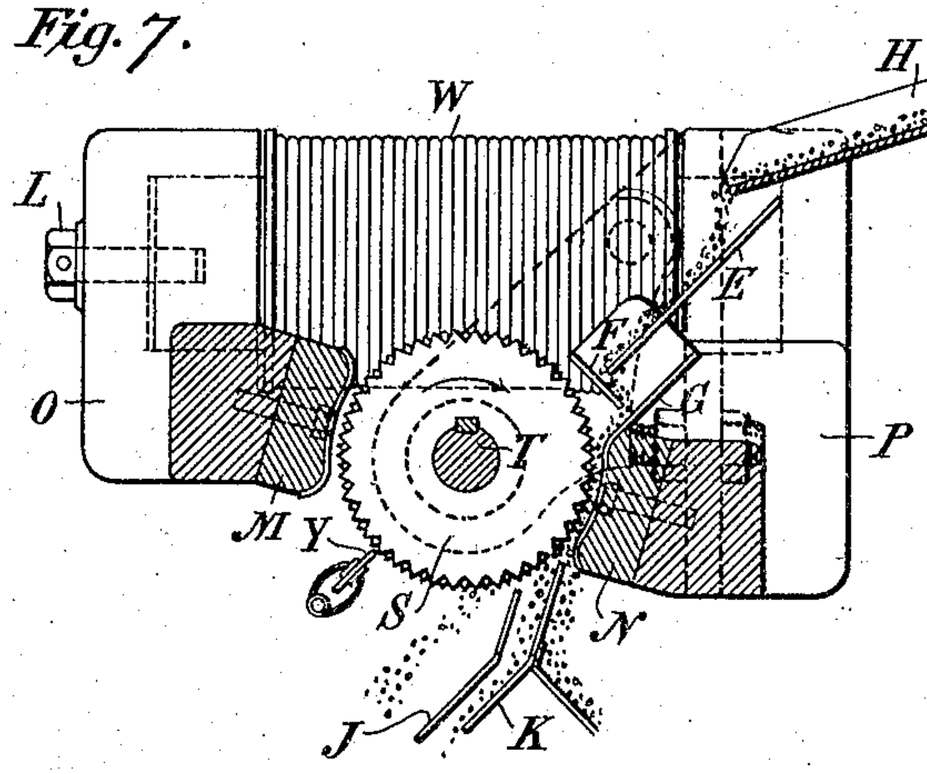
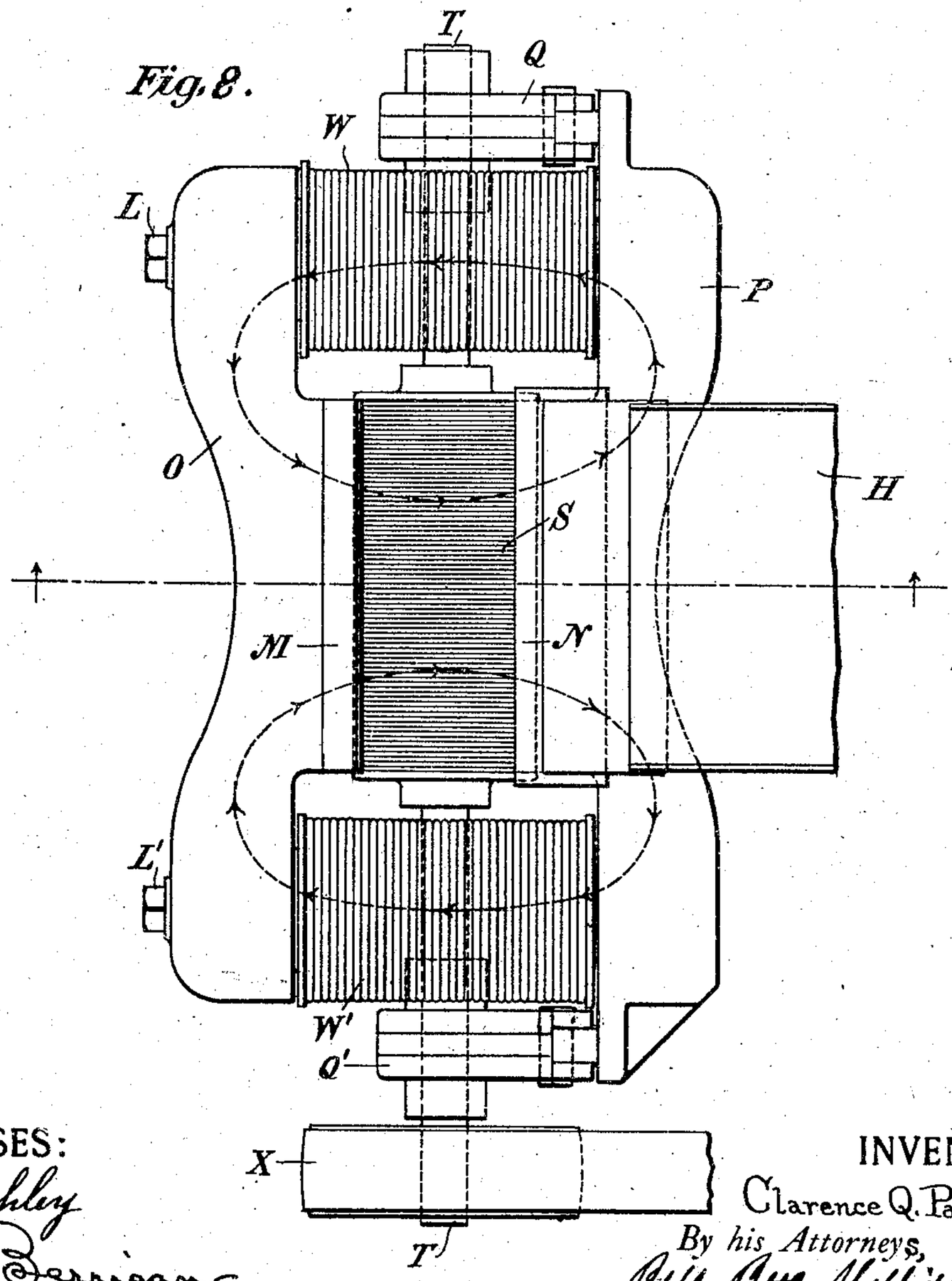


Fig. 8.



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APPARATUS FOR MAGNETIC SEPARATION.

APPLICATION FILED FEB. 2, 1903.

3 SHEETS—SHEET 3.

Fig. 9.

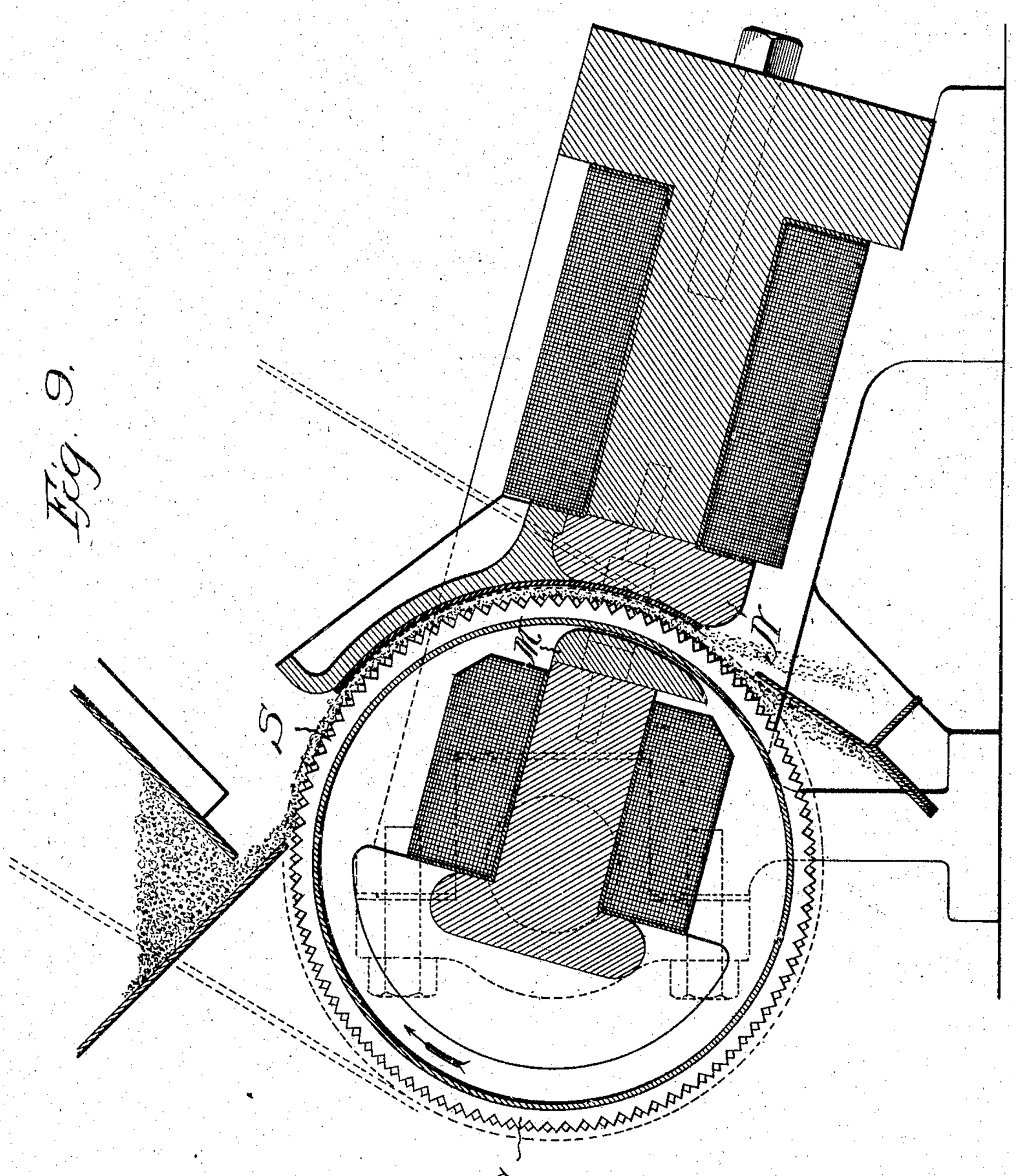

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PHOTO-LITHOGRAPHED BY SACKETT & W. SHELMS LITHO & PTG. CO. NEW YORK.

No. 791,494. Patented June 6, 1905.

UNITED STATES PATENT OFFICE.

CLARENCE Q. PAYNE, OF STAMFORD, CONNECTICUT, ASSIGNOR TO THE INTERNATIONAL SEPARATOR COMPANY, A CORPORATION OF NEW JERSEY.

APPARATUS FOR MAGNETIC SEPARATION.

SPECIFICATION forming part of Letters Patent No. 791,494, dated June 6, 1905.

Application filed February 2, 1903. Serial No. 141,402.

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 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, clear, concise, and exact description.

My invention relates more particularly to improvements in magnetic separators of the general type described in Letters Patent Nos. 641,147, 641,148, and 641,220, granted to me January 9, 1900.

The present invention consists in further improvements in the construction of the cylinder or separating-carrier with a view to an increase of its efficiency and simplification of its structure.

It consists, further, in an improved structure for obtaining "line dispersions" of the flux density in the magnetic field and also "point" and line dispersions thereof jointly, in the latter case without any accompanying decrease of the available positions for attachment of the ore particles undergoing separation, a further feature being that the surface of the carrier is so formed that the falling ore particles cannot escape the point and line dispersions of the flux density.

I will describe my invention by reference to the accompanying drawings, in which—

Figures 1 and 2 illustrate, broadly, by diagrammatic sections through a magnetic field, the novel means employed to secure point and line dispersions of the magnetic flux therein, the machine being of the type in which a hollow separating-cylinder is arranged to revolve between opposing magnetic surfaces, one of which is outside and one inside of said cylinder. Figs. 3 and 4 illustrate another form of separating-carrier adapted to be used in connection with a machine having pole-pieces external to the carrier, which therefore in such case need not be hollow. Figs. 5 and 6 illustrate another and the preferred manner of constructing a hollow separating-cylinder adapted for use in the types of machines illustrated in my previous patents above referred to. Figs. 7 and 8 show in section and in plan, respectively, a type of separating-machine in which a separating-carrier such as shown in Figs. 3 and 4 may be used. Fig. 9 is a sectional elevation of another type of machine having a hollow separating-cylinder and opposing magnet-poles arranged one inside and one outside of said cylinder.

The same letters of reference indicate the same parts wherever they are shown.

In the application for Letters Patent, Serial No. 72,322, filed August 17, 1901, I have shown and claimed, broadly, a novel type of separating-cylinder in which magnetizable plates or laminæ having projecting edge faces are employed to secure certain important advantages. In my present invention I also make use of a series of thin iron or soft-steel plates in the construction of the transversely-laminated separating-carrier. Such laminated construction of the cylinder lends itself readily to the provision of teeth to produce point or line dispersions of the magnetic flux and is also of advantage in that Foucault or eddy currents are suppressed, so that the cylinder can be turned in a strong magnetic field with comparatively little expenditure of energy.

In accordance with the present invention the edges of the plates are arranged to overlap, so that the edges of contiguous or adjacent plates are brought out of alinement with each other or are exposed. These edges may be wedge-shaped, as shown in Figs. 1, 3, and 5, or they may have parallel sides and blunt ends, as shown in Fig. 2, or they may have any intermediate forms or modifications of these shapes. In general I have found that the most intense magnetic effect upon ore particles for the purpose of separation is produced by placing a series of teeth of proper shape along the edges of the plates. The relative arrangement of the magnetizable plates or laminæ is preferably such that while the plates or laminæ are contacting the adjacent

outer edges of the plates are substantially out of contact with each other—that is, out of contact over nearly all of their extent.

Considering the effect of a single wedge-shaped edge or tooth, as A B C, Fig. 1, upon the magnetic lines of force within the field between the pole-pieces or magnetic surfaces M and N, it is evident that the magnetic density will be greatest just within and the magnetic divergence or dispersion will be greatest just without the points or corners B and B′ of the wedge-shaped tooth A B C, since they are each formed by the intersection of three planes and also because they are on the line B B′, which is nearest to the magnetic surface N. At B and B′, therefore, point dispersions of the magnetic flux are thus formed within the field, and these points are centers of the strongest attracting force for the ore particles in the field. The line joining the points B and B′, formed by the intersection of two planes, secures here line dispersions of the flux density within the field and by its position exerts the longest and strongest attracting force upon ore particles placed along its length. Line dispersions of the magnetic flux are also obtained along the lines A B, A′ B′, B C, and B′ C′, which form the bounding edges of the wedge-tooth A B C, Fig. 4; but the attracting force decreases along these lines as the distance from the points B and B′ increases.

When the teeth are formed, as shown in Fig. 2, with a face or edge of some little area, point and line dispersions of the magnetic flux will be obtained at the corners and bounding edges of the teeth; but there will be a slight leakage of lines of force between the flat face of the tooth and the magnet-pole N, which will not be directly available for attracting ore particles, especially those of slight magnetic susceptibility. I therefore prefer the form of tooth illustrated in Fig. 1.

In applying my invention to an operating-machine I make use of a series of thin iron plates having teeth upon their outer edges, and which are so mounted and assembled that the teeth of adjacent plates overlap or are brought out of alinement with each other, as shown most clearly in Figs. 2 and 5. It is possible to secure by my invention in this way a far greater intensity of magnetic effect upon feeble magnetic materials undergoing separation and a more efficient distribution of the lines of force at the surface of the separating-carrier than has heretofore been attained. It will also be evident that these advantages are secured without any reduction of any of the available positions for attachment of the ore particles along the points and edges of the teeth; but, on the contrary, the number of available positions for attachment is increased when the ends of the teeth are offset but in contact at their bases, as above described. In the form of machine illustrated in Figs. 1 and 2 the separating-carrier or hollow cylinder is built up of thin iron or soft-steel circular plates, rings, or disks, the cylinder being arranged to revolve between two opposing magnetic surfaces or pole-pieces, between which a magnetic field is formed, one of said pole-pieces being on the inside and the other on the outside of the cylinder. This form of separating-carrier, due to its laminated construction, can be revolved with great ease through the magnetic field, since Foucault or eddy currents are suppressed by the subdivision of the cylinder into thin iron plates. In the preferred form of my invention, however, where the machine is of the hollow-cylinder type, with one pole inside and the other outside of the cylinder, the cylinder is preferably subdivided longitudinally as well as transversely, as shown in Figs. 2, 3, and 6, for the purpose of preventing undue leakage of the magnetic lines from the inner pole-piece around the circumference of the cylinder. Such a cylinder is preferably built up of segmental plates having toothed edges of suitable form, the plates being fitted between and supported by longitudinal tie-rods V V. Said tie-rods are supported in end plates or drumheads at the ends of the cylinder in such a way as to make a sort of cylindrical squirrel-cage frame, and said tie-rods may be further supported at intervals along the length of the cylinder by means of tie-rings R R. The segmental plates or laminations are recessed at their ends, so as to fit in between the tie-rods and the frame, and in this way the cylinder may be built up by slipping these plates along the rods before one of the drumheads is secured to said rods. When the cylinder is thus built up, the drumheads will be tightened upon the laminated plates by means of nuts screwing upon the ends of the tie-rods which project through said drumheads. The tie-rods should be made of non-magnetic metal or alloy of high electrical resistance, such as manganese-bronze. The cylinder when thus built up forms an annular laminated armature-ring the magnetic circuit of which is interrupted in the direction of its circumference by means of the air-gaps between the successive rows of segmental plates and is also interrupted in the direction of the length of the cylinder by reason of its transversely-laminated structure. The segmental plates by which such a cylinder is built up may be provided with any desired form of teeth, and the plates may be so constructed that when assembled between the tie-rods the teeth of adjacent disks will be out of alinement or staggered. By this construction I am able to secure the advantages already pointed out, in that Foucault or eddy currents are suppressed and a greater control of the positions of the lines of force in the field is secured, the laminated construction lending itself with great facility to the provision of

the surface of the cylinder with the most effective dispositions of lines and points from which the magnetic flux is dispersed or upon which said flux is concentrated. As shown in the drawings, the relative arrangement of the magnetizable plates or laminæ is such that while the plates or laminæ are in contact the adjacent outer edges of the plates—that is, the teeth—are substantially, but not wholly, out of contact with each other, the extreme points of the teeth being free.

The form of separating-carrier shown in Figs. 3 and 4, which is intended to be used in a machine of the general type shown in Figs. 7 and 8, is built up by assembling a series of thin iron or soft-steel circular plates or disks upon a shaft T, said disks being clamped together in any convenient way—for example, by means of a key and compression-flanges, as shown in the illustrations. My invention can be applied to such a form of separating-carrier without difficulty, since the laminations or disks may easily be assembled upon the shaft in such a manner as to present the teeth of adjacent disks in staggered relations at the surface of the cylinder thus built up, the key upon the shaft serving to prevent the disks from relative rotation. In Figs. 7 and 8 I have shown a complete operating-machine with its separating-carrier constructed in accordance with my invention. The magnet-coils W W′ are placed on the sides of the machine, and their cores are connected by means of the yokes O and P. The coils are so wound and connected that when they are charged with an electric current, preferably from a dynamo-electric machine, the magnetic flux generated in the cores of the magnet forms two circuits, as shown by the broken lines and arrow-heads in Fig. 8. A magnetic field is thus established in the space between the opposing magnetic surfaces of the pole-pieces M and N, as shown in Fig. 7. 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 approximately concentric with the separating-cylinder for a portion of their lengths, as shown in Fig. 7.

The apparatus is preferably provided with means for retaining the material undergoing separation in close proximity to a considerable segment of the cylinder. For this purpose the 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. 7, 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 arrows 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 material are then attracted and held to the points and edges of the toothed surfaces 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 demagnetization of the carrier-teeth as the latter leave 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. 7. 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. 7, in order to prevent such particles from remaining attached to the surface of the cylinder during a complete revolution.

While Figs. 7 and 8 show, for the 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 embodiment, as modifications within the claims of my invention will suggest themselves to those skilled in the art. Among various modifications attention is called to the forms described and shown in my application, Serial No. 175,597, filed October 3, 1903, and in my application, Serial No. 175,598, filed October 3, 1903, as divisions of my present application.

In Fig. 9 I have illustrated my invention as applied to the form of machine shown in my prior patent, No. 762,752, dated June 14, 1904, in which the separating-cylinder is hollow and the opposing magnet-poles are arranged one inside and one outside of said cylinder. The separating-cylinder here shown is built up of continuous rings or annular disks of sheet-iron, with serrated teeth upon their edges, as shown in Fig. 1.

I claim—

1. In a magnetic separator, a transversely-laminated separating-cylinder, composed of a plurality of magnetizable circular disks having toothed edges, in combination with means for magnetizing said cylinder, substantially as described.

2. In a magnetic separator, a transversely-laminated separating-cylinder, composed of a plurality of magnetizable circular disks having teeth upon their edges, said disks being relatively so placed that the teeth of the adjacent disks are out of alinement, in combination with means for magnetizing said cylinder, substantially as described.

3. In a magnetic separator, a transversely-laminated separating-carrier, provided with a plurality of magnetizable laminæ, whose edge faces are provided with projecting portions which create a series of point and line dispersions of the flux density on the surface of said cylinder, in combination with means for magnetizing said cylinder, substantially as described.

4. In a magnetic separator, a laminated separating-cylinder, provided with a plurality of transversely-disposed magnetizable plates having teeth upon their edges, said plates being relatively so placed that the teeth of the adjacent plates are out of alinement, in combination with means for magnetizing said cylinder, substantially as described.

5. In a magnetic separator, a laminated separating-cylinder, provided with a plurality of transversely-disposed magnetizable plates having edge projections, said plates being relatively so placed as to provide the separating-surface with transversely and longitudinally projecting edges, in combination with means for magnetizing said cylinder, substantially as described.

6. In a magnetic separator, a laminated separating-carrier provided with a plurality of transversely-disposed magnetizable laminæ, the edge faces of said laminæ being relatively so placed as to provide the surface of the carrier with transversely and longitudinally projecting edges, in combination with means for magnetizing said carrier, substantially as described.

7. In a magnetic separator, a transversely-laminated separating-cylinder, provided with a plurality of magnetizable plates having teeth upon their edges, said plates being relatively so placed that the teeth of the adjacent plates are out of alinement, in combination with two opposing magnetic surfaces between which a magnetic field is formed, and between which said cylinder is arranged to move, substantially as described.

8. In a magnetic separator, a transversely-laminated separating-cylinder composed of a plurality of magnetizable circular disks having teeth upon their edges, said disks being relatively so placed that the teeth of the adjacent disks are out of alinement, in combination with two opposing magnetic surfaces, between which a magnetic field is formed, and between which said separating-cylinder is arranged to move, substantially as described.

9. In a magnetic separator, the combination of a transversely-laminated separating-cylinder provided with a plurality of magnetizable plates having teeth upon their edges, said plates being relatively so placed that the teeth of the adjacent plates are out of alinement, two opposing pole-pieces between which said cylinder is arranged to move, and a guide-plate connected with one of said pole-pieces and extending above the horizontal diameter of said cylinder, substantially as described.

10. In a magnetic separator, the combination of a transversely-laminated separating-cylinder provided with a plurality of magnetizable laminæ having teeth upon their edges, said laminæ being relatively so placed that the teeth of adjacent laminæ are out of alinement, and means for magnetizing said cylinder and for retaining the material undergoing separation in close proximity to said cylinder along a considerable segment thereof below its horizontal diameter, substantially as described.

11. In a magnetic separator, a transversely-laminated separating-carrier, provided with a plurality of magnetizable laminæ, having alternately-projecting edges, in combination

with means for magnetizing said carrier, substantially as described.

12. In a magnetic separator, the combination of a transversely-laminated separating-cylinder composed of a plurality of magnetizable circular disks having teeth upon their edges, said disks being relatively so placed that the teeth of the adjacent disks are out of alinement, two opposing pole-pieces placed approximately concentric with said cylinder, and between which said cylinder is arranged to move, and a guide-plate connected with one of said pole-pieces and extending above the horizontal diameter of said cylinder, substantially as described.

13. In a magnetic separator, the combination of a transversely-laminated separating-cylinder provided with a plurality of magnetizable circular disks having teeth upon their edges, said disks being relatively so placed that the teeth of adjacent disks are out of alinement, and means for magnetizing said cylinder and for maintaining the material undergoing separation in close proximity to said cylinder along a considerable segment thereof below its horizontal diameter, substantially as described.

14. In a magnetic separator, a transversely-laminated separating-cylinder provided with a plurality of magnetizable laminæ relatively so placed that the successive edges of said laminæ project circumferentially beyond those of their adjacent laminæ, in combination with means for magnetizing said cylinder, substantially as described.

15. In a magnetic separator, a transversely-laminated separating-cylinder provided with a plurality of magnetizable circular disks relatively so disposed that successive edges of said disks project circumferentially beyond those of their adjacent disks, in combination with means for magnetizing said cylinder, substantially as described.

16. In a magnetic separator, a transversely-laminated separating-cylinder provided with a plurality of magnetizable laminæ having toothed edges relatively so placed that the teeth of said laminæ project circumferentially beyond those of their adjacent laminæ, in combination with two opposing pole-pieces, between which a magnetic field is formed, and between which said cylinder is arranged to move, substantially as described.

17. In a magnetic separator, a transversely-laminated separating-cylinder provided with a plurality of magnetizable circular disks having toothed edges relatively so placed that the teeth of said disks project circumferentially beyond those 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 move, substantially as described.

18. In a magnetic separator, a transversely-laminated separating-cylinder provided with a plurality of magnetizable laminæ relatively so placed that successive edges of said laminæ project circumferentially beyond those of their adjacent laminæ, in combination with two opposing pole-pieces placed approximately concentric with said cylinder, and between which said cylinder is arranged to move, substantially as described.

19. In a magnetic separator, a transversely-laminated separating-cylinder provided with a plurality of magnetizable circular disks relatively so placed that successive edges of said disks project circumferentially beyond those of their adjacent disks, in combination with two opposing pole-pieces placed approximately concentric with said cylinder, and between which said cylinder is arranged to move, substantially as described.

20. In a magnetic separator, the combination of a transversely-laminated separating-cylinder provided with a plurality of magnetizable laminæ having toothed edges relatively so placed that the teeth of said laminæ project circumferentially beyond those of their adjacent laminæ; means for magnetizing said cylinder and for maintaining the material undergoing separation in close proximity to the cylinder along a considerable segment thereof below its horizontal diameter and within the magnetic field, substantially as described.

21. In a magnetic separator, the combination of a transversely-laminated separating-cylinder provided with a plurality of magnetizable circular disks having toothed edges relatively so placed that the teeth of said disks project circumferentially beyond those of their adjacent laminæ, two opposing pole-pieces between which said cylinder is arranged to move, and a guide-plate connected with one of said pole-pieces, having an extension above the horizontal diameter of said cylinder, substantially as described.

22. In a magnetic separator, the combination of a transversely-laminated separating-cylinder provided with a plurality of magnetizable circular disks having toothed edges relatively so placed that the teeth of said disks project circumferentially beyond those of their adjacent disks, two opposing pole-pieces between which said cylinder is arranged to move, and a guide-plate formed partly by one of said pole-pieces and partly by an upward extension added thereto, substantially as described.

23. In a magnetic separator, the combination of a transversely-laminated separating-cylinder provided with a plurality of magnetizable circular disks having toothed edges relatively so placed that the teeth of said disks project circumferentially beyond those of their adjacent disks, two opposing pole-pieces between which said cylinder is arranged to move, and a guide-plate connected with one

of said pole-pieces, having an extension above the horizontal diameter of said cylinder, substantially as described.

24. In a magnetic separator, a transversely-laminated and segmentally-divided armature-cylinder comprising longitudinal rods supported upon end plates to constitute a squirrel-cage frame, and segmental iron plates or laminæ having their ends recessed to fit between said rods and build up the body of the armature.

In witness whereof I have hereunto signed my name this 30th day of January, 1903.

CLARENCE Q. PAYNE.

In presence of—
ALFRED M. GOW,
ALBERT R. LEDOUX.