No. 823,302. PATENTED JUNE 12, 1906.

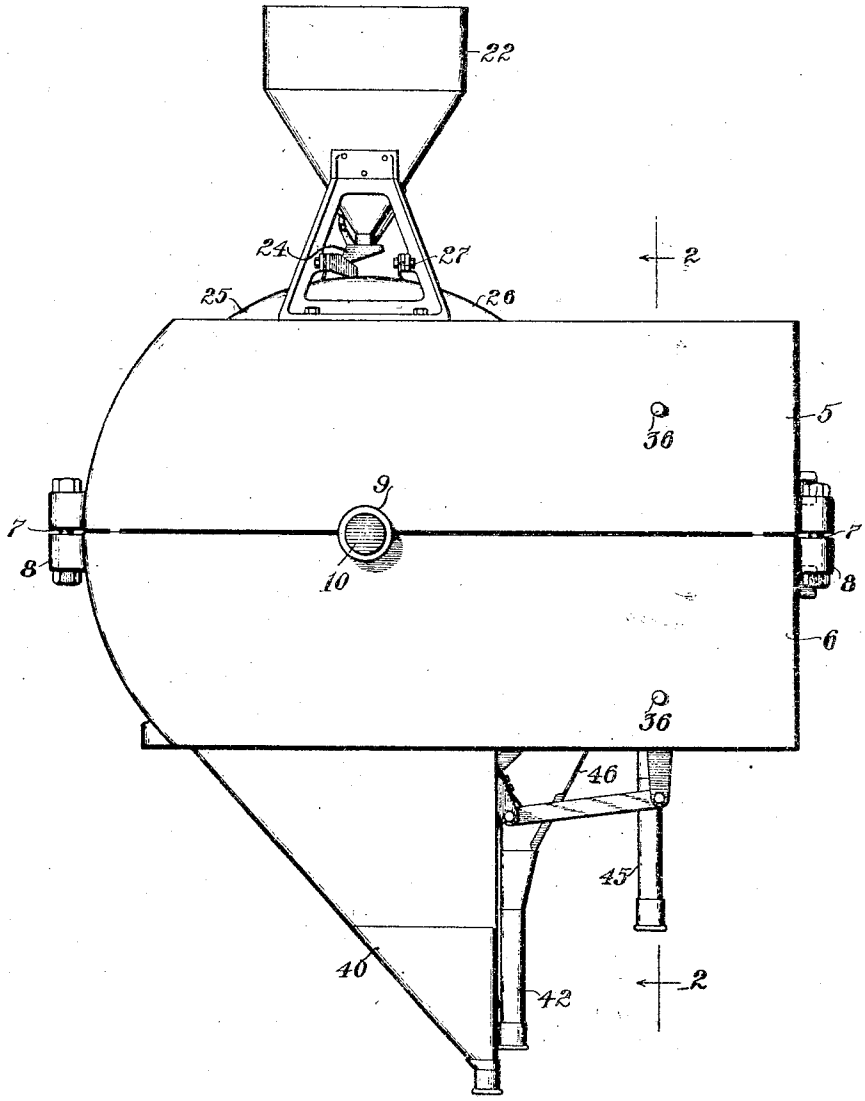
F. T. SNYDER.

MAGNETIC SEPARATOR.

APPLICATION FILED NOV. 28, 1902.

4 SHEETS—SHEET 1.

Fig. 1.



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Attorney

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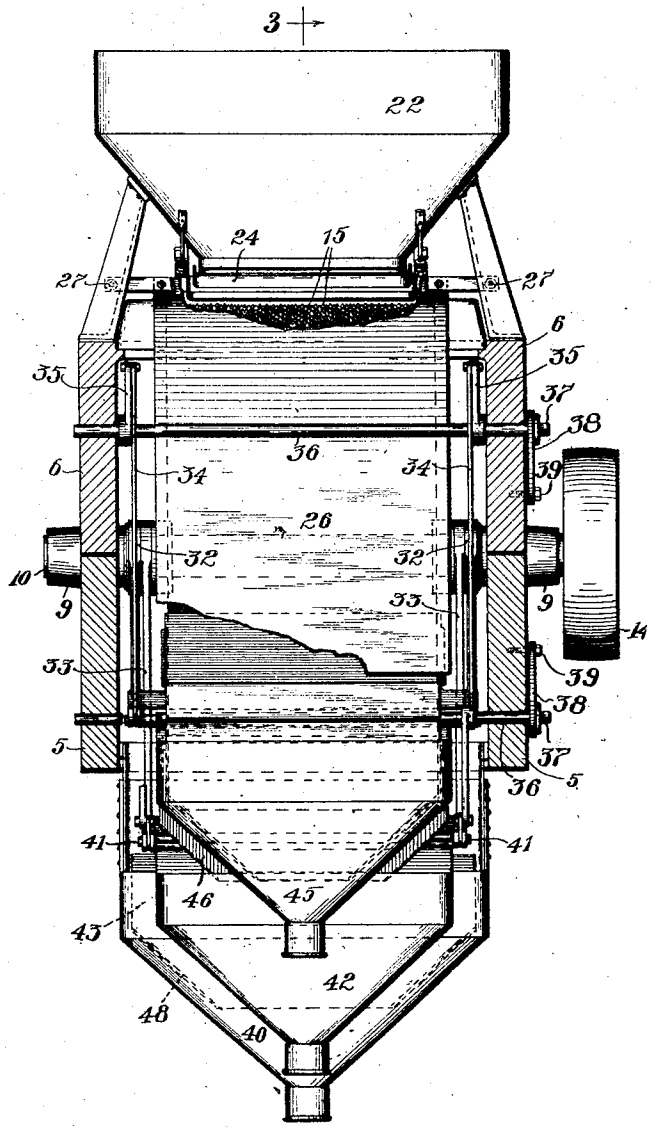
4 SHEETS—SHEET 2.

Fig. 2.



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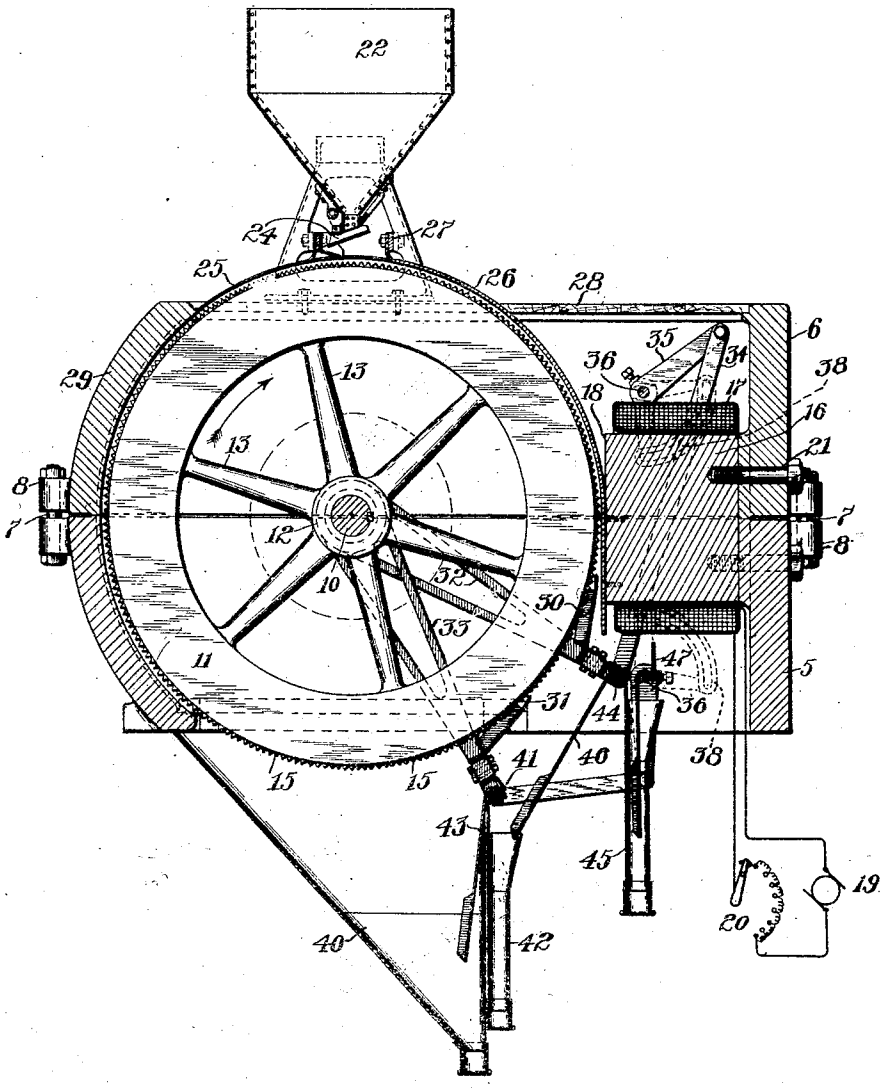
4 SHEETS—SHEET 3.

Fig. 3.



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4 SHEETS—SHEET 4

Fig. 5.

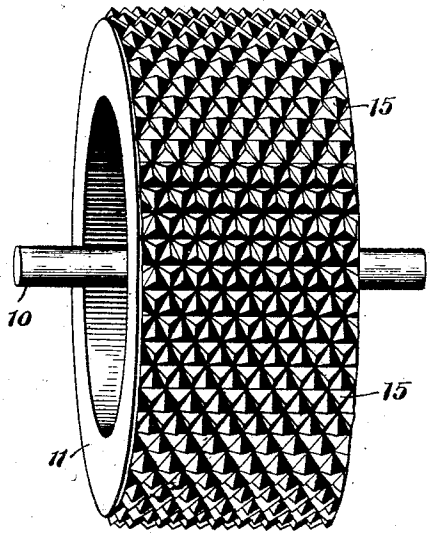
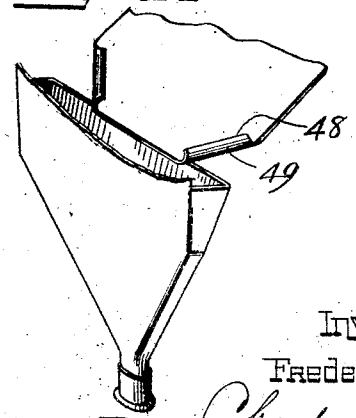


Fig. 4.



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UNITED STATES PATENT OFFICE.

FREDERICK T. SNYDER, OF OAK PARK, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO INTERNATIONAL SEPARATOR COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF NEW JERSEY.

MAGNETIC SEPARATOR.

No. 823,302. Specification of Letters Patent. Patented June 12, 1906.

Application filed November 28, 1902. Serial No. 133,006.

To all whom it may concern:

Be it known that I, FREDERICK T. SNYDER, a citizen of the United States, residing at Oak Park, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Magnetic Separators, (Case No. 2,) of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to improvements in magnetic separators for the separation of materials of different degrees of magnetic permeability.

Broadly stated, my invention relates to improvements in magnetic separators whereby the forces effective in making the separation are more efficiently controlled in strength and in direction.

My invention further includes improvements and novel features adapted to decrease the cost of construction and add convenience in the operation of such separators.

The result of my invention is a more perfect and economical separation than has heretofore been possible.

The invention herein described and claimed is made the basis of method claims incorporated in the application, Serial No. 133,342, filed by me December 1, 1902.

My present invention is also more or less closely allied with inventions described and claimed in my copending applications, Serial No. 133,393, filed December 1, 1902; Serial No. 134,117, filed December 6, 1902; Serial No. 136,004, filed December 20, 1902; Serial No. 136,005, filed December 20, 1902, and Serial No. 201,381, filed April 4, 1904.

A magnetic separator embodying my invention is shown in the accompanying drawings, in which—

Figure 1 is a front elevation. Fig. 2 is a sectional view taken on the plane of line 2 2 of Fig. 1. Fig. 3 is a central longitudinal sectional view taken on the plane of line 3 3 of Fig. 2. Fig. 4 is a perspective view showing the construction and operation of the telescoping hoppers. Fig. 5 is a perspective view showing the shape and arrangement of the pyramidal projections on the armature.

Like characters of reference indicate like parts throughout the several figures.

I have shown a field-magnet consisting of the two halves 5 and 6; held together by the bolts 7 7, passing through the lugs 8. Formed and clamped between the two halves of the neutral sides of this field-magnet are the bearings 9 9, in which the shaft 10 is mounted. The armature of comparatively large diameter, which comprises the rim 11, the hub 12, and the arms 13 13, is keyed to the shaft 10, and thereby journaled on the field-magnet. A belt (not shown) serves to drive the armature by means of the pulley 14. The armature being hollow provides a cylindrical path of high magnetic permeability between the pole-pieces, the lines of force in passing from one pole-piece to the other traversing the rim of the armature, and thus occupying a position substantially parallel with the periphery or surface of the armature itself. The surface of the armature is formed of pyramidal projections 15 15. The preferred shape and arrangement of these projections are illustrated in Fig. 5, where I have shown pyramids having triangular bases, each side of each pyramid being in contact with another. These pyramids are desirably arranged in staggered rows, whereby the rotation of the armature causes one pyramid to be moved into the space formerly lying between two adjacent pyramids.

Substantially opposite the axis of rotation of the armature on a horizontal line therewith is placed the electromagnet-core 16, upon which is wound the energizing-coil 17. The pole 18 may desirably be made a plane vertical surface, at least below the place thereon to which the armature projections most closely approach. This pole is thus formed below the horizontal plane through the axis of the armature to lie behind and beyond a vertical plane tangent to the armature.

A preferably continuous current supplied from the dynamo (diagrammatically illustrated at 19) and regulated by the rheostat 20 is utilized to energize the winding 17. This winding is desirably placed near the air-gap, which is utilized for separating purposes, thus bringing the neutral point on the magnet within the coil adjacent to this air-gap and concentrating the flux at the desired point. The core 16 may be bolted to the frame parts 5 and 6, as shown. The re-

moval of the upper bolt 21 and the bolts 7 will permit the raising of the upper half 6 of the magnet-frame to permit the removal of the armature, while the split in the frame introduces no reluctance to the useful magnetic flux. Substantially diametrically opposite the pole 18 is placed, the pole 29. Since the space between the pole 18 and the armature is to be utilized for the purposes of separation, it is desirable to make this pole of relatively small area in order to correspondingly increase the flux density at this point. Since the function of the pole 29 is largely that of affording a complete magnetic circuit of low reluctance, I have found it desirable to make the embrace of this pole large, thereby increasing its area to correspondingly reduce the flux density therefrom. This pole 29 may also be placed very close to the periphery of the armature. The difference in the areas of the two poles causes a corresponding difference in the areas of the induced poles on the armature. It is one of the particular features of my invention that the two poles of the magnet be placed on substantially diametrically opposite sides of the armature, whereby the magnetic traction on the armature is substantially balanced, thereby preventing the pressure which would otherwise fall on the armature-bearings.

A feed-hopper 22 is placed above the armature-cylinder, as shown. An adjustable slide and chute 24 regulate the feed of an even supply of materials to the top of the armature. In order to prevent the escape of materials, the inclosing sheet-brass housing 25 is provided on one side, while on the other side a shield 26, of highly permeable material, as iron or steel, is secured to the hopper-frame at 27 and to the face of the pole 18. A housing 28 serves, further, to inclose the interior mechanism.

The operation of my improved separator will now become apparent. The coil 17 being energized by an electric current, a magnetic flux is set up through the core 16, the upper and lower halves 5 and 6 of the field-magnet frame, the pole-piece 29, and the rim 11 of the armature-magnet. A path of high magnetic permeability is thereby provided which, however, is interrupted by the air-gap of low permeability between the pole 18 and the adjacent side of the armature. This air-gap is locally shortened by the projecting pyramidal teeth 15, whereby the flux is caused to converge toward each of the said teeth. I have found that the shape and the size of the pyramidal projection relative to the width of the air-gap is of great importance. By decreasing the solid angle of these projections I find that the distance through which particles may be attracted from the pole 18 may be increased. In practice I find it necessary to make the width of the air-gap such as to properly accommodate the layer of materials to be separated therein and the shape and the size of the projections may be varied as necessary in order that particles may be attracted from the pole 18. For every set of conditions which may arise in practice there is a certain proper distance at which the projection should be placed from the pole, and this distance can be simply ascertained by experiment.

The plane pole-surface being vertically disposed, as shown, causes a gradually-increasing density of flux from each of the teeth as it approaches a horizontal plane through the axis of rotation. Also the downwardly-projecting part of the pole-face causes an induction of prolonged duration through the armature-teeth as they pass below the horizontal plane. It will be seen that the pole 18, which, however, is faced with a part of the iron shield 26, is so disposed as to permit the free fall of non-magnetic particles from points in the air-gap on a horizontal plane through the axis of rotation.

The armature being rotated in the direction indicated by the arrow, materials to be separated are fed from the hopper and feed-chute to the top of the armature, when they are carried around between the periphery of the cylinder and the shield 26. As the projecting teeth approach the upper corner of the inducing pole-piece 16 a convergent flux of increasing density is induced from each tooth. These convergent fluxes of increasing density attract the more permeable particles within the material to be separated. Since the speed of rotation of the armature is desirably made such that the centrifugal force causes the material to bear very lightly on the surface of the armature, this attraction of the permeable particles causes a partial stratification of the two classes of materials before the point of greatest density is reached. Upon reaching the horizontal plane through the axis of rotation the unattracted particles are free to fall vertically under the force of gravity. The more permeable particles are retained on the periphery of the armature-magnet by the prolonged flux from the teeth, whereby these particles, in addition to the vertical component of their motion at the point of separation, are given a gradually-increased horizontal component, thereby effectively separating the two classes of materials. As the armature-teeth recede from the pole 18, forming one boundary of the air-gap, the magnetic fluxes through the receding teeth are gradually weakened until the teeth reach a neutral point on the armature, upon passing through which the fluxes reverse their polarity. My present invention is distinguished from certain other separators of the prior art in that the armature-teeth

are moved between poles toward and through a neutral plane or place at which the polarity of the flux reverses.

My improved separator may be used to separate materials of varying degrees of magnetic susceptibility from non-magnetic materials, the permeable materials being retained in contact with the teeth for varying lengths of movement, depending upon their degree of permeability.

In order to divide the permeable particles from the non-magnetic particles and, further, to subdivide the permeable particles into different grades, I provide the divider-plates 30 and 31, which may desirably be carried by the frames 32 and 33, rotatably mounted upon the shaft 10, whereby the dividing edges of the divider-plates may be adjusted without necessarily altering the distance between the divider edge and the periphery of the armature. The links 34 34, the cranks 35 35, and the shafts 36 36 provide mechanism by which the position of the dividers may be adjusted by means of a crank or wrench applied to the shafts at 37 37 without causing torsional strain in the divider or its carrying-frame. The quadrants 38 38 and cap-bolts 39 39 provide means for clamping the dividers in position when satisfactorily adjusted. The divider-plate 30 is adapted to divide sharply the freely-falling non-magnetic particles from all permeable particles retained upon the teeth 15, while the divider-plate 31 serves to make a division between particles of two grades of magnetic permeability. Any particles which have not previously been dropped from the teeth are deposited upon reaching the neutral point, where no lines of force emanate from the teeth and where the polarities of the convergent fluxes are reversed.

Associated in movement and adjustment with each of the divider-plates 30 and 31 are a hopper and a hopper-apron. Each hopper and its apron are constructed to telescope, so that no matter what the adjustment of the dividers may be all the non-magnetic particles shall pass into one given hopper. All the permeable particles deposited between the dividers 30 and 31 shall pass into another hopper, and all the particles deposited after passing the divider 31 shall pass into a third hopper. This third hopper 40 may be rigidly connected with the frame of the separator, as shown. The frame 33 is provided with a shaft or roller 41, upon which are hung the hopper 42 and the apron 43, which projects into the hopper 40. Similarly, the frame 32 is provided with a roller 44, upon which are hung the hopper 45 and the apron 46. The adjusting-shaft 36 is conveniently placed, upon which to hang the apron 47.

If the frame 33 and the divider 31 be swung around toward the frame 32 and its divider-plate 30, the hopper 42 is carried upon the shaft 41 in a path striking an arc of a circle around the axis of rotation of the separator-armature. This causes the hopper 42 to slip up around the apron 46, whereby the communication of the opening between the dividing-plates 30 and 31 with the hopper 42 is maintained. At the same time the apron 43 is carried in an arc of a circle with the shaft 41. The hopper 40 being stationarily mounted, the apron 43 is withdrawn from this hopper and up over the edge of the same, so that the apron 43 directs any material which would otherwise fall outside the hopper 40 into the same. Similarly, if the carrier-frame 32 be swung downwardly in a clockwise direction the apron 46 is adapted to telescope into the hopper 42, while the hopper 45 is carried to the left and downward. During this movement the apron 47 is adapted to maintain a complete channel for the passage of the non-magnetic particles from the point of separation to the hopper 45.

As best illustrated in Fig. 2, the hoppers 40, 42, and 45 are tapered downwardly toward their discharge-openings. Therefore the aprons associated with these hoppers must be correspondingly tapered in order to permit them to telescope within the hoppers as illustrated. As best illustrated in Fig. 4, the tapering sides 48 of these aprons are curled up to form guiding-walls 49. When an apron is considerably withdrawn from its hopper, as the apron 46 is withdrawn from the hopper 42, Fig. 3, these walls 49 serve to guide material falling upon the apron toward its center, where it is of sufficient length to direct the materials into the associated hopper.

The general plan of the magnet of my improved separator may be said to be that of a box which is open at the top and bottom and through which the materials to be separated are passed in a generally vertical direction. The magnet thus forms an inclosing and supporting frame for the separator mechanism to which the various parts are attached.

While I have herein shown and particularly described one embodiment of my invention, it will be apparent to those skilled in the art that many changes and modifications therein might profitably be employed, and I therefore do not wish to limit myself to the precise disclosure herein set forth; but,

Having described my invention, I claim as new and desire to secure by Letters Patent—

1. In a magnetic separator, the combination with a magnet, of a pole on said magnet, a cylindrical armature adapted to rotate by said pole, a divider mounted to rotate about the axis of said armature, links attached to said divider, means for moving said links and means for feeding material to be separated to said armature.

2. In a magnetic separator, the combination with a magnet, of poles of constant but opposite polarity, a hollow cylindrical arma-

ture mounted between said poles, and means for feeding material to be separated between said armature and one of said poles.

3. In a magnetic separator, the combination with a magnet, of a pole on said magnet, a shaft adapted to revolve before said pole, an armature mounted upon said shaft, dividers mounted adjustably upon said shaft, a hopper hinged to one of said dividers, an apron hinged to another of said dividers and engaging with said hopper, and means for feeding material to be separated to said armature.

4. In a magnetic separator, the combination with an axially-rotatable cylindrical armature, of an electromagnet having two pole-pieces of opposite polarity external to said armature and facing the same, one of said pole-pieces having its face of lesser area than the face of the other pole-piece, and a magnet-winding concentrated upon the pole-piece of lesser area, the other pole-piece having no winding thereon.

5. In a magnetic separator, the combination with a magnet, of a pole on said magnet having magnetizable pyramids at its surface, said pyramids being arranged in staggered rows and formed to present the angles of the pyramids of one row to the space between the pyramids of the preceding row, means for feeding material to be separated to said pyramids, and means for removing the attracted material.

6. In a magnetic separator, the combination with a magnet pole-piece, of a cylindrical iron armature mounted to rotate before said pole-piece, said cylinder having its surface provided with magnetizable pyramids arranged in staggered rows each of said pyramids being in contact with an adjacent pyramid at its base, said pyramids being formed and disposed to present the angles of the pyramids of each row to the space between the pyramids of the preceding row and means for feeding material to be separated between the armature and said pole.

7. In a magnetic separator, the combination with a hollow magnet, open at top and bottom, of bare poles of opposite polarity on said magnet, the face of one of said poles being vertical, a shaft adapted to revolve between said poles, bearings on said shaft mounted on neutral sides of said magnet, an armature, mounted upon said shaft, permeable projections on the surface of said armature, said projections being of such shape and spaced from said vertical pole such a distance, that material will be attracted from said pole to said projections, a divider mounted adjustably on said shaft, links attached to said divider, means for moving said links, means for rotating said armature, and means for feeding material to be separated to said armature.

8. In a magnetic separator, the combination with a hollow magnet, open at top and bottom, of bare poles of opposite polarity on said magnet, the face of one of said poles being vertical, a shaft adapted to revolve between said poles, having bearings mounted on neutral sides of said magnet, an armature, mounted upon said shaft, permeable projections on the surface of said armature, said projections being of such shape and spaced from said vertical pole such a distance, that material will be attracted from said pole to said projections, a divider mounted adjustably on said shaft, a hopper hinged to said divider, an apron hinged to said divider, and engaging another hopper, links attached to said divider, means for moving said links, means for rotating said armature, and means for feeding material to be separated to said armature.

9. In a magnetic separator, the combination with a hollow magnet, open above and below, of bare poles of opposite polarity on said magnet, the face of one of said poles being vertical, a horizontal shaft adapted to revolve between said poles, having bearings mounted on neutral sides of said magnet, a cylindrical armature, mounted upon said shaft, permeable projections on the surface of said armature, said projections being of such shape and spaced from said vertical pole such a distance, that material will be attracted from said pole to said projections, a divider mounted adjustably on said shaft between said vertical pole and said armature, the edge of said divider lying substantially in a vertical plane tangent to the periphery of said armature.

10. In a magnetic separator, the combination with a hollow magnet, open above and below, of bare poles of opposite polarity on said magnet, the face of one of said poles being vertical, a horizontal shaft, adapted to revolve between said poles, having bearings mounted on neutral sides of said magnet, a cylindrical armature, mounted upon said shaft, permeable pyramidal projections on the surface of said armature, each side of each projection being in contact with an adjacent projection, said projections being of such shape and spaced from said vertical pole such a distance, that material will be attracted from said pole to said projections, a divider mounted adjustably on said shaft, between said vertical pole and said armature, the edge of said divider lying substantially in a horizontal plane passing through the axis of said armature, a hopper hinged to said divider, an apron hinged to said divider, and engaging with another hopper, links attached to said divider, means for moving said links, means for rotating said armature, and means for feeding material to be separated to said armature.

11. In a magnetic separator, the combination with a hollow electromagnet, open above

and below, of bare poles of opposite polarity and unequal area on said electromagnet, the face of the pole of lesser area being vertical, the winding of said electromagnet being concentrated near said vertical pole, a horizontal shaft, adapted to revolve between said poles, having bearings mounted on neutral sides of said electromagnet, a cylindrical armature mounted upon said shaft, permeable pyramidal projections on the surface of said armature, each side of each projection being in contact with an adjacent projection, said projection being of such shape and spaced from said vertical pole such a distance, that material will be attracted from said pole to said projections, a divider mounted adjustably on said shaft, between said vertical pole and said armature, a hopper hinged to said divider and engaged with another hopper, links attached to said divider, means for moving said links, means for rotating said armature, and means for feeding material to be separated to said armature.

12. In a magnetic separator, the combination with a hollow electromagnet, open above and below, of bare poles of opposite polarity on said electromagnet, the face of one of said poles being vertical, the winding of said electromagnet being concentrated near said vertical pole, a horizontal shaft, adapted to revolve between said poles, having bearings mounted on neutral sides of said electromagnets, a cylindrical armature, mounted upon said shaft, permeable pyramidal projections on the surface of said armature, each side of each projection being in contact with an adjacent projection, said projection being of such shape and spaced from said vertical pole such a distance, that material will be attracted from said pole to said projections, a divider mounted adjustably on said shaft, between said vertical pole and said armature, a hopper hinged to said divider, an apron hinged to said divider and engaging with another hopper, links attached to said divider, means for moving said links, means for rotating said armature, and means for feeding material to be separated to said armature.

13. In a magnetic separator, the combination with a cylindrical armature, of means for rotating said armature about a horizontal axis, an electromagnet having poles of different areas located on substantially diametrically opposite sides of said armature and having a winding adjacent to the air-gap between the armature and the pole of lesser area, means for feeding material to be separated between said armature and said pole of lesser area, pyramidal projections formed on the surface of said armature, said projections being of such shape and spaced from said pole of lesser area such a distance that a portion of the material to be separated may be attracted from said pole to said projection.

14. In a magnetic separator, the combination with a cylindrical armature, of means for rotating said armature about a horizontal axis, an electromagnet having poles of different areas located on substantially diametrically opposite sides of said armature and having a winding adjacent to the air-gap between the armature and the pole of lesser area, means for feeding materials to be separated between said armature and said pole of lesser area, and triangular pyramidal projections in staggered rows formed on the surface of said armature, said projections being of such shape and spaced from said pole of lesser area such a distance that a portion of the material to be separated may be attracted from said pole to said projections.

15. In a magnetic separator, the combination with a cylindrical armature, of means for rotating said armature about a horizontal axis, an electromagnet having poles of opposite polarity and of different areas located on substantially diametrically opposite sides of said armature and having the winding adjacent to the air-gap between the armature and the pole of lesser area, means for feeding materials to be separated between said armature and said pole of lesser area, triangular pyramidal projections in staggered rows formed on the surface of said armature, said projections being of such shape and spaced from said pole of lesser area such a distance that a portion of the materials to be separated may be attracted from said pole to said projections, and a divider interposed between attracted and non-attracted materials at a point where the direction of the force of attraction is substantially perpendicular to the direction of the force of gravity.

16. In a magnetic separator, the combination with a cylindrical armature, of means for rotating said armature about a horizontal axis, an electromagnet having poles of opposite polarity and of different areas located on substantially diametrically opposite sides of said armature, and having the winding adjacent to the air-gap between the armature and the pole of lesser area, means for feeding materials to be separated between said armature and said pole of lesser area, triangular pyramidal projections in staggered rows formed on the surface of said armature, said projections being of such shape and spaced from said pole of lesser area such a distance that a portion of the materials to be separated may be attracted from said pole to said projections, and a divider interposed between attracted and non-attracted materials at a point where the direction of the force of attraction is substantially perpendicular to the direction of the force of gravity, said pole of lesser area being formed to permit the free fall of material not attracted.

17. In a magnetic separator, the combination with a magnet, of a smooth pole on said

magnet, a second pole opposite said smooth pole, the surface of said second pole being formed into triangular pyramidal projections arranged in staggered rows and disposed so as to present the angles of pyramids of one row to the spaces between the pyramids of the preceding row, and means for passing the material to be separated between said smooth pole and said projections, whereby it may be attracted to said projections, and means for removing the separated material.

18. In a magnetic separator, the combination with a magnet, of a pole on said magnet, a cylindrical armature mounted to rotate before said magnet-pole, the peripheral surface of said armature being formed into pyramidal projections, the side of each pyramid being in contact with the side of another pyramid, said pyramids being arranged in staggered rows in relative positions to present the angles of the pyramids of one row to the space between the pyramids of the preceding rows, and means for feeding materials to be separated between said pole and said armature.

19. In a magnetic separator, the combination with a magnet of an armature, means for rotating said armature, means for feeding materials to be separated to the bare surface of said armature, dividers adapted to rotate on the axis of said armature, means for adjusting said dividers, and means for clamping said dividers in adjustment.

20. In combination, a magnet, means for rotating the magnet, means for feeding material to be separated to the magnet, deflectors suspended in position to rotate about the axis of the magnet and means for adjusting the deflectors.

In witness whereof I hereunto subscribe my name this 25th day of November, A. D. 1902.

FREDERICK T. SNYDER.

Witnesses:
LYNN A. WILLIAMS,
HARVEY L. HANSON.