No. 832,820. PATENTED OCT. 9, 1906.

F. T. SNYDER.

MAGNETIC SEPARATOR.

APPLICATION FILED DEC. 20, 1902. RENEWED JUNE 9, 1906.

4 SHEETS—SHEET 1.

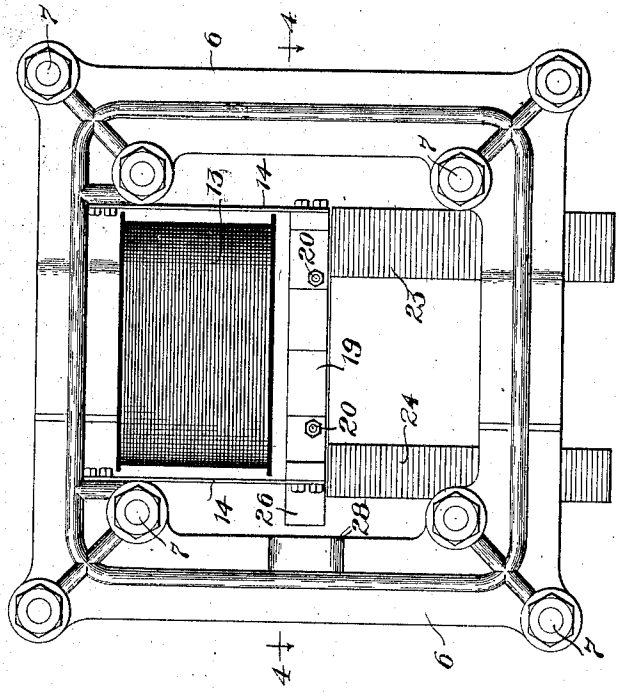


Fig. 1.

Witnesses:
Leonard W. Novander.
Lynn A. Williams

Inventor:
Frederick T. Snyder
By Charles A. Brown
Attorney

THE NORRIS PETERS CO., WASHINGTON, D. C.

No. 832,820. PATENTED OCT. 9, 1906.

F. T. SNYDER.

MAGNETIC SEPARATOR.

APPLICATION FILED DEC. 20, 1902. RENEWED JUNE 9, 1906.

4 SHEETS—SHEET 2.

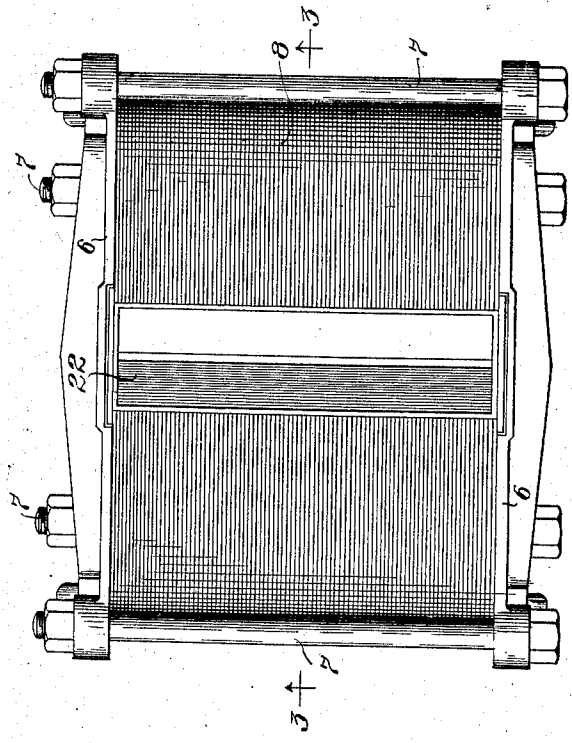


Fig. 2

Witnesses:
Leonard W. Novander,
Lynn A. Williams

Inventor
Frederick T. Snyder
By Charles A. Brown
Attorney

THE NORRIS PETERS CO., WASHINGTON, D. C.

No. 832,820. PATENTED OCT. 9, 1906.

P. T. SNYDER.

MAGNETIC SEPARATOR.

APPLICATION FILED DEC. 20, 1902. RENEWED JUNE 9, 1906.

4 SHEETS—SHEET 3.

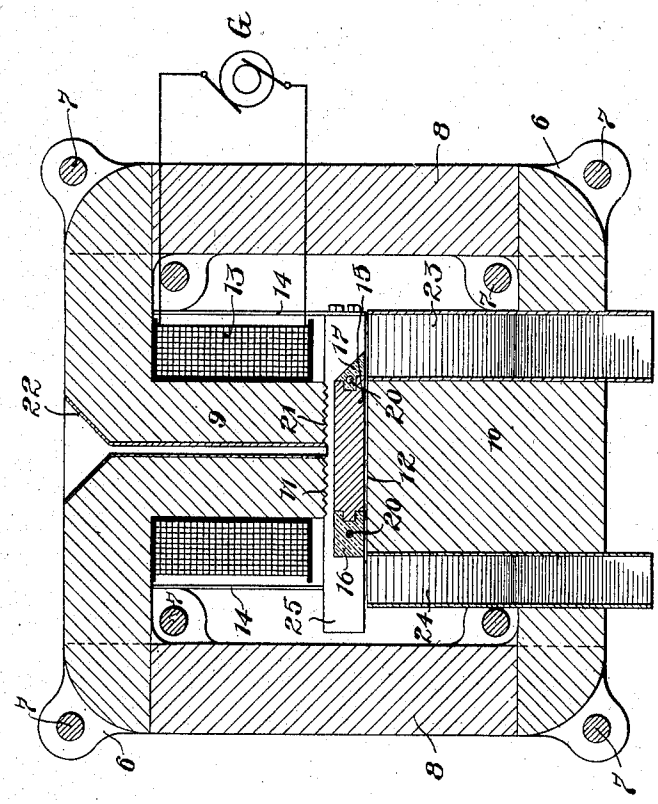


Fig. 3.

Witnesses:
Leonard W Alexander.
Lyman A. Williamson

By

Inventor.
Frederick T. Snyder
Charles A. Brown
Attorney.

THE NORRIS PETERS CO., WASHINGTON, D. C.

No. 832,820. PATENTED OCT. 9, 1906.

F. T. SNYDER.

MAGNETIC SEPARATOR.

APPLICATION FILED DEC. 20, 1902. RENEWED JUNE 9, 1906.

4 SHEETS—SHEET 4.

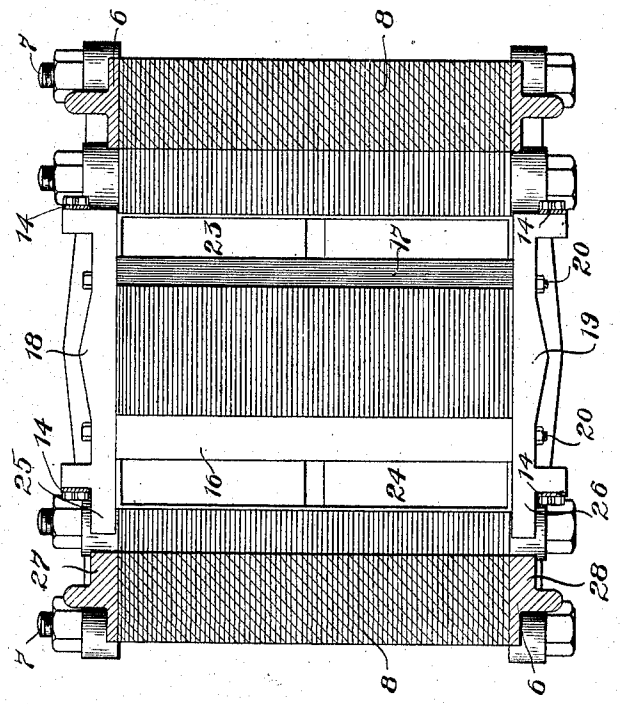


Fig. 4.

Witnesses:
Leonard W. Novander.
Lyman A. Williams

Inventor
Frederick T. Snyder:
By Charles A. Brown
Attorney

THE NORRIS PETERS CO., WASHINGTON, D. C.

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. 832,820. Specification of Letters Patent. Patented Oct. 9, 1906.

Application filed December 20, 1902. Renewed June 9, 1906. Serial No. 321,040.

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. 6,) 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 materials to be separated are repeatedly subjected to the action of the forces effective in making the separation.

My invention further includes improvements and novel features adapted to decrease the cost of construction and to 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.

In the following specification I refer to a mass of permeable material through which at times there is a magnetic flux, as a "magnet." The magnetic flux is considered to comprise a number of lines of force, each of which is a complete ring. The flux is considered as being in a definite direction along each ring, the result of which is magnetic polarity. If the magnet is not in the form of a complete ring, the complete rings of the lines of force will pass across the gap in the continuity of the magnet. The places at which the lines of force leave and enter the magnet in crossing such a gap are referred to as "poles." A pole may be moved in two ways—either with reference to the material of the magnet or with reference to a point outside the magnet. Unless otherwise specified, I consider the movement of a pole as referred to a point outside the magnet, which movement may or may not be accompanied by a movement with reference to the material of the magnet. The portion of the lines in the gap between the poles is referred to as the "magnetic field." A separate mass of permeable material forming a path of low reluctance for lines in a magnetic field is referred to as an "armature."

In magnetic separation the strength with which any particular material is attracted depends upon two factors, one being the density of the flux through the material, the other being the rate of change of density in the direction of attraction. This rate of change of density is commonly referred to in terms of the convergence or divergence of the lines of force, the permeable material being attracted toward the point of convergence. A flux divergence may be caused by providing in a field of otherwise parallel lines of force a local path of decreased reluctance, such as that provided by a permeable projection locally shortening an air-gap.

Effective separation requires that the attracted material be removed at least a certain distance from the unattracted material. The strength of attraction toward a permeable projection diminishes rapidly as the projection is departed from, as both the density and the divergence diminish. I have found that the strength of attraction toward a stationary projection is not sufficient to cause the necessary movement of permeable materials in the limited time available in practice. In my invention, therefore, I attain the necessary relative movement between attracted and non-attracted materials by subjecting the more permeable materials to the force of attraction toward successive projections, each projection having a comparatively small movement relative to the non-attracted materials, upon the completion of which movement the attractive force toward the projection is diminished, thereby depositing the attracted materials. Magnetically-attracted materials may be released for deposit by sufficiently reducing either the density or the divergence of the flux passing through the material. Materials deposited from one projection are then attracted to a second projection and given a further relative movement.

In my invention the maximum density of the flux is preferably several times as great as that previously recorded as of use in magnetic separators, while the minimum density of the flux may be secured by reversing the polarity of the flux through the convergence.

the density of the flux at the instant of reversal being zero. At this instant of reversal materials of the greatest permeability will be released.

My invention, while it may be applied to a great variety of the separators, is particularly well adapted to magnetic separators, in which there is a relative reciprocal movement between materials to be separated and highly-permeable projections through which there is a magnetic flux. Such a specific embodiment of my invention will be understood by the accompanying drawings.

The process of separation accomplished by the separator herein described is described and claimed in a separate application, Serial No. 136,005, filed December 20, 1902.

Figure 1 is a front elevation of a separator embodying my invention. Fig. 2 is a plan view upon the same. Fig. 3 is a cross-sectional view taken on line 3 3 of Fig. 2. Fig. 4 is a sectional view taken on line 4 4 of Fig. 1.

I have shown a pair of cast-iron frame-plates 6 6, adapted to be clamped together by the bolts 7 7 to hold in position the laminations of the field-magnet 8. This field-magnet is provided with oppositely-disposed pole-pieces 9 and 10, whose faces respectively constitute poles 11 and 12. An energizing-winding 13 is wound on the field-magnet, desirably about the pole-piece 9. An alternating-current generator G is shown connected to the winding 13 to furnish current thereto. The springs 14 14 support the table or armature 15 between the poles 11 and 12. The armature, like the field-magnet, is desirably made of laminated iron-punchings, as best illustrated in Fig. 4, the punchings being held in position by means of a brass or bronze clamping-frame comprising side rails 16 and 17, having dovetailed connection with the armature laminations, and end rails 18 and 19, to which the supporting-springs 14 are fastened. The bolts 20 20 serve to clamp the frame tightly about the laminations forming the armature. The side rail 17 may desirably have its upper edge beveled, as best illustrated in Fig. 3, the purpose of which will hereinafter more fully appear.

The upper pole 11 is formed into projections 21, which may take the form of wedge-shaped teeth. Through the pole-piece 9 there leads a chute 22, through which materials to be separated are fed to the gap of low permeability between the pole 11 and the armature 15. The tapering hoppers 23 and 24 are placed one on either side of the pole-piece 10 and, as will hereinafter be explained, serve to convey separated materials from the machine.

The operation of my improved separator will now become apparent. A pulsating or preferably alternating current of comparatively low frequency is supplied to the energizing-winding 13. It will be noted that the pole-piece 10 is placed considerably to the left of the iron armature 15, also that the lower edge of the armature extends slightly to the right of the pole-piece 10. The result of this unsymmetrical placement of the armature 15 is that when the field-magnet is energized the magnetic flux in the air-gap between the poles 11 and 12 causes a resultant attraction of the armature 15 toward the left. The supporting-springs 14 permit a movement of the armature to balance the forces of attraction. It will be seen that the successive magnetizations and demagnetizations of the field-magnet on account of the alternating currents supplied to the winding 13 will cause successive attractions of the armature, the resiliency of the springs serving to retract the armature into its normal position between attractive impulses. Thus the armature receives and maintains an oscillatory or reciprocal motion.

Materials to be separated are fed through the chute 22 to the upper surface of the armature 15. One of the purposes of the oscillatory movement of the armature is to cause a mechanical shake or movement of materials to be separated toward the hopper 24. This movement of materials may be secured by a sudden stopping of the movement of the armature toward the left and a consequent rebound or quick return movement toward the right. For this purpose I provide projections 25 and 26 on the armature frame-pieces 18 and 19, these projections being adapted to come into contact with enlargements 27 and 28 on the frame-pieces 6 6. It will be seen that the accelerated movement of the armature toward the left and the abrupt stopping of the same, due to the impact of the projections 25 and 26 upon the enlargements 27 and 28, will cause a shaking movement toward the left of materials resting on the armature. I refer to this peculiar movement of the armature which causes a shaking of materials resting thereupon in one direction as a "differential" movement, and I define a differential reciprocating movement of any form of armature or shaking-table to mean a reciprocal motion, such that materials resting upon said armature or table are given an absolute net resultant movement with respect to such armature or table.

As the pole-pieces become energized there is produced a magnetic flux locally convergent toward each of the projections 21 and correspondingly divergent toward the plane-induced pole constituting the upper face of the armature 15. The projections 21 are so shaped and placed at such a distance from the upper pole of the armature that the more permeable materials fed to the armature are attracted toward the projections. Since there is considerable inertia to be overcome in starting the movement toward the left upon the energization of the field-magnet,

the more permeable materials resting on the upper surface of the armature are attracted toward the teeth 21 before the armature has acquired any considerable movement toward the left. Upon the deënergization of the field-magnet with the reversal of the direction of the alternating current the materials previously attracted to the projections 21 are deposited upon the armature, which shortly thereafter swings toward the right under the elastic influence of the springs 14 14. The mode of separation now becomes apparent. It will be seen that the more permeable materials are attracted to the stationary projections 21 and there held during the movement in one direction of the armature 15. The attracted materials are then deposited, whereafter the armature, with the materials which it carries, receives a movement in the reversed direction. The successive repetition of this cycle of operations results in carrying the more permeable materials in successive steps toward the right. It will be remembered that the movement of the armature toward the left is brought to an abrupt termination, thereby throwing the non-attracted materials resting on the armature toward the outer edge of the clamping-rail 16, over which the materials may fall into the receiving-hopper 24. As the more permeable materials are carried to the right-hand edge of the pole 11 they are attracted toward the teeth projecting from this right-hand edge of the pole, from which position they are released to fall on the beveled or sloping edge of the clamping-rail 17, this sloping edge serving to guide the deposited materials into the receiving-hopper 23.

A direct pulsating current supplied to the winding 13 would have an effect similar to that of the alternating current. It will also be apparent to those skilled in the art that the quick return or bumping motion of the armature might be controlled by mechanical means suitably operated in synchronism with the electrical impulses supplied to the winding 13 and also that a separation might be accomplished by a positive movement of the projections 21.

When a secondary electromagnetic means or a mechanically-operated means is employed to cause the reciprocal movement of the materials with reference to the pole-piece 9, it will be apparent that a table of non-magnetic material might be substituted for the iron armature 15.

Many other modifications and changes may be made without departing from the spirit of my invention, and I do not, therefore, 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 means for causing within the field of said magnet a relative differential reciprocating movement between materials to be separated and said magnet, and means for causing the energization of said magnet during the movements in one direction and the deënergization of said magnet during the movements in the reverse direction.

2. In a magnetic separator, the combination with a magnet, of a pole-piece on said magnet, a permeable projection on said pole-piece, means for causing within the field of said magnet a relative differential reciprocating movement between materials to be separated and said magnet, and means for causing the energization of said magnet during the movements in one direction and the deënergization of said magnet during the movements in the reverse direction.

3. In a magnetic separator, the combination with a magnet, of a pole-piece on said magnet, means for feeding materials to be separated into proximity with said pole-piece, means for causing a relative differential reciprocating movement between said materials and said magnet, and means for causing a magnetization of said magnet during the movements in one direction and a decreased magnetization of said magnet during the movements in the reverse direction.

4. In a magnetic separator, the combination with a magnet, of a pole-piece on said magnet, a permeable projection on said pole-piece, means for feeding materials to be separated into proximity with said projection, means for causing a relative differential reciprocating movement between said materials and said pole-piece, and means for causing the energization of said magnet during the movements in one direction and the deënergization of said magnet during the movements in the reverse direction.

5. In a magnetic separator, the combination with a magnet, of pole-pieces on said magnet, means for feeding materials to be separated between said pole-pieces, means for causing a relative differential reciprocating movement between said materials and one of said pole-pieces, and means for causing the energization of said magnet during the movements in one direction and the deënergization of said magnet during the movements in the reverse direction.

6. In a magnetic separator, the combination with a magnet, of pole-pieces on said magnet, a permeable projection on one of said pole-pieces, means for feeding materials to be separated between said pole-pieces, means for causing a relative differential reciprocating movement between said materials and said projection, and means for causing the energization of said magnet during the movements in one direction and the deënergization of said magnet during the movements in the reverse direction.

7. In a magnetic separator, the combination with a magnet, of a pole-piece on said magnet, means for causing a relative differential reciprocating movement between materials to be separated and said pole-piece, means for causing the energization of said magnet during the movements in one direction and the deënergization of said magnet during the movements in the reverse direction, and a permeable projection on said pole-piece spaced from the materials to be separated a distance such that the more permeable materials may be attracted toward said projection.

8. In a magnetic separator, the combination with a magnet, of a pole-piece on said magnet, means for causing a relative differential reciprocating movement between materials to be separated and said pole-piece, means for causing the energization of said magnet during the movements in one direction and a decrease in the energization of said magnet during the movements in the reverse direction, and a permeable projection on said pole-piece so shaped and spaced from the materials to be separated, such a distance that the more permeable materials may be attracted toward said projection.

9. In a magnetic separator, the combination with a magnet, of a pole-piece on said magnet, means for causing a relative differential reciprocating movement between materials to be separated and said magnet, means for causing the energization of said magnet during the movements in one direction and the deënergization of said magnet during the movements in the reverse direction, and a permeable projection on said pole-piece so shaped that the more permeable materials may be attracted toward said projection.

10. In a magnetic separator, the combination with a magnet, of pole-pieces on said magnet, means for feeding materials to be separated between said pole-pieces, means for causing a relative differential reciprocating movement between said materials and said pole-pieces, means for causing the energization of said magnet during the movements in one direction and the deënergization of said magnet during the movements in the reverse direction, and a permeable projection on one of said pole-pieces spaced from the materials to be separated a distance such that the more permeable materials may be attracted toward said projection.

11. In a magnetic separator, the combination with a movable table and means for imparting a differential reciprocating motion thereto, means for feeding materials to be separated to said table, a magnet pole-piece overhanging said table in position to attract the magnetically permeable materials thereon, and means for periodically exciting said magnet in synchronism with the reciprocations of said table, whereby the permeable materials are caused to travel toward the opposite side of the table from the remainder of the material.

12. In a magnetic separator, the combination with a magnet, of pole-pieces on said magnet, a movable table located between said pole-pieces, means for imparting to said table a differential reciprocating movement, means for feeding materials to be separated to said table, and means for energizing said magnet during the movements of said table in one direction, to attract the more permeable materials from said table during said movements, and for deënergizing said pole-pieces during the movements in the reverse direction, to deposit the attracted materials.

13. In a magnetic separator, the combination with a magnet, of pole-pieces on said magnet, a permeable armature in proximity thereto, means for imparting to said armature a differential reciprocating movement, means for feeding materials to be separated to said armature, and means for causing the energization of said magnet during the movements in one direction, to attract the more permeable materials from said armature during said movements, and for causing the deënergization of said magnet during the movements in the reverse direction, to deposit the attracted materials.

14. In a magnetic separator, the combination with a magnet, of pole-pieces on said magnet, a permeable projection on one of said pole-pieces, a movable armature in proximity thereto, means for imparting to said armature a relative differential reciprocating movement with respect to said pole-pieces, means for feeding materials to be separated to said armature, and means for causing the energization of said magnet during the movements of said armature in one direction, to attract the more permeable materials from said armature during said movements, and for causing the deënergization of said pole-pieces during the movements in the reverse direction, to deposit the attracted materials.

15. In a magnetic separator, the combination with a magnet, of a pole-piece on said magnet, a permeable projection on said pole-piece, a movable table in proximity to said pole-piece, means for imparting to said table a relative differential reciprocating movement with respect to said pole-piece, means for feeding materials to be separated to said table, and means for causing the energization of said magnet during the movements of said table in one direction, to attract the more permeable materials from said table during said movements, and for causing the deënergization of said magnet during the movements in the reverse direction, to deposit the attracted materials.

16. In a magnetic separator, the combina-

tion with a magnet, of pole-pieces on said magnet, a movable table between said pole-pieces, means for imparting to said table a relative differential reciprocating movement with respect to said pole-pieces, a chute for feeding materials to be separated to said table, and means for causing the energization of said magnet during the movements of said table in one direction, to attract the more permeable materials from said table during said movements, and for causing a decrease in the energization of said pole-pieces during the movements in the reverse direction, to deposit the attracted materials.

17. In a magnetic separator, the combination with a magnet, of pole-pieces on said magnet, a movable table located between said pole-pieces in proximity thereto, electromagnetic means for imparting to said table a relative differential reciprocating movement with respect to said pole-pieces, means for feeding materials to be separated to said table, and means for causing the energization of said magnet during the movements of said table in one direction, to attract the more permeable materials from said table during said movements, and for deënergizing said pole-pieces during the movements in the reverse direction, to deposit the attracted materials.

18. In a magnetic separator, the combination with a magnet, of pole-pieces on said magnet, a movable table between said pole-pieces, electromagnetic means for imparting to said table a relative differential reciprocating movement with respect to said pole-pieces, means for feeding materials to be separated to said table, and means for causing the energization of said magnet during the movements of said table in one direction, to attract the more permeable materials from said table during said movements, and for causing a decrease in the energization of said pole-pieces during the movements in the reverse direction, to deposit the attracted materials.

19. In a magnetic separator, the combination with a magnet, of pole-pieces on said magnet, a permeable armature, electromagnetic means for imparting to said armature a relative differential reciprocating movement with respect to said pole-pieces, means for feeding materials to be separated to said armature, and means for causing the energization of said pole-pieces during the movements of said armature in one direction, to hold the more permeable materials during said movements, and for causing the deënergization of said pole-pieces during the movements in the reverse direction, to deposit the attracted materials.

20. In a magnetic separator, the combination with a magnet, of pole-pieces on said magnet, a permeable projection on one of said pole-pieces, a permeable armature, electromagnetic means for imparting to said armature a relative differential reciprocating movement with respect to said projection, means for feeding materials to be separated to said armature, and means for causing the energization of said magnet during the movements of said armature in one direction, to attract the more permeable materials during the said movements, and for causing the deenergization of said pole-pieces during the movements in the reverse direction, to deposit the attracted materials.

21. In a magnetic separator, the combination with a magnet, of a pole-piece on said magnet, a permeable projection on said pole-piece, a movable table in proximity thereto, electromagnetic means for imparting to said table a relative differential reciprocating movement with respect to said projection, means for feeding materials to be separated to said table, and means for causing the energization of said magnet during the movements of said table in one direction, to attract the more permeable materials during the said movements, and for causing a decreased energization of said magnet during the movements in the reverse direction, to deposit the attracted materials.

22. In a magnetic separator, the combination with a magnet, of pole-pieces on said magnet, a movable table between said pole-pieces, electromagnetic means for imparting to said table a relative differential reciprocating movement with respect to said pole-pieces, a chute for feeding materials to be separated to said table, and means for causing the energization of said magnet during the movements of said table in one direction, to attract the more permeable materials from said table during said movement, and for causing the deënergization of said magnet during the movements in the reverse direction, to deposit the attracted materials.

23. In a magnetic separator, the combination with a magnet, of a pole on said magnet, means for causing in the magnetic flux from said pole a convergence toward said pole, means for causing a relative differential reciprocating movement between said convergence and materials to be separated, and means for increasing the density of the flux through said convergence during the movements in one direction, and for decreasing the density of the flux through said convergence during the movements in the reverse direction.

24. In a magnetic separator, the combination with a magnet, of a pole on said magnet, means for causing in the magnetic flux from said pole a convergence toward said pole, means for causing a relative differential reciprocating movement between said convergence and materials to be separated, and means for reducing to zero the density of the flux through said convergence during the

movements in one direction, and for increasing the density of the flux through said convergence during the movements in the reverse direction.

25. In a magnetic separator, the combination with a magnet, of poles on said magnet, a movable table between said poles, means for feeding materials to be separated to said table, means for causing a relative differential reciprocating movement of said table with respect to said pole, means for causing in the magnetic flux from one of said poles a convergence toward said pole, and means for reversing the polarity of the flux through said convergence during the movements in one direction, whereby non-attracted materials are given a net movement in one direction, and attracted materials are given a net movement in another direction.

26. In a magnetic separator, the combination with a magnet and a pole-piece therefor having permeable projections upon its under face, of a laminated iron armature-table mounted to swing to and fro under the face of said pole-piece, means for feeding material to the central portion of said table, a spring yieldingly maintaining said armature in an unsymmetrical position relative to the flux from said magnet pole-piece, whereby said armature is caused to move when the magnet is excited, a stop adapted to suddenly arrest the movement of the armature-table at one end of its travel, to cause the main body of material to travel toward that end of the table, and means for periodically exciting said magnet, whereby the armature is given a corresponding reciprocating movement and the magnetically-permeable particles are caused to travel toward the opposite end of said table.

In witness whereof I hereunto subscribe my name this 9th day of December, A. D. 1902.

FREDERICK T. SNYDER.

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