No. 817,399. PATENTED APR. 10, 1906.

F. T. SNYDER.

PROCESS OF MAGNETIC SEPARATION.

APPLICATION FILED DEC. 20, 1902.

4 SHEETS—SHEET 1.

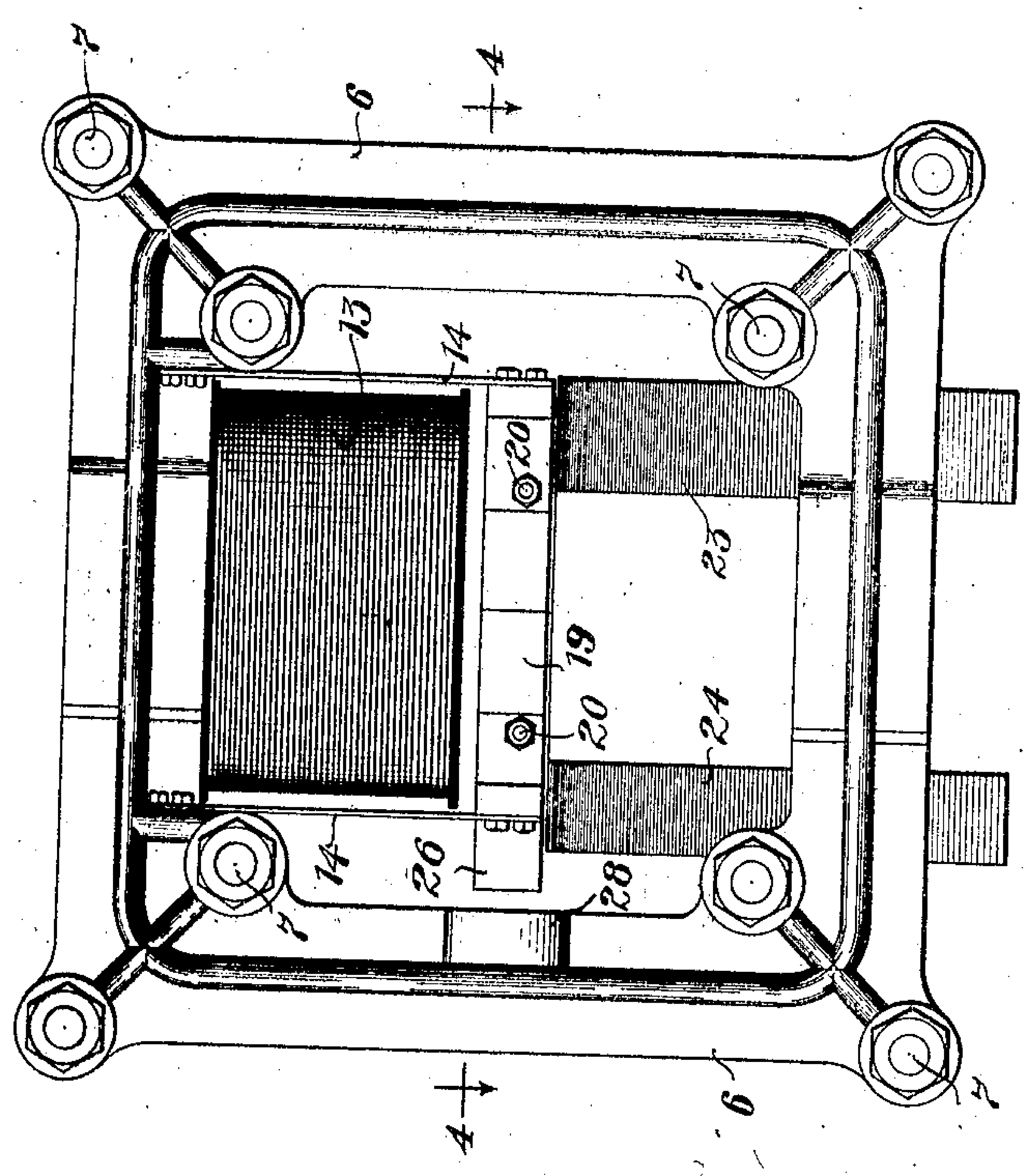

Fig. 1

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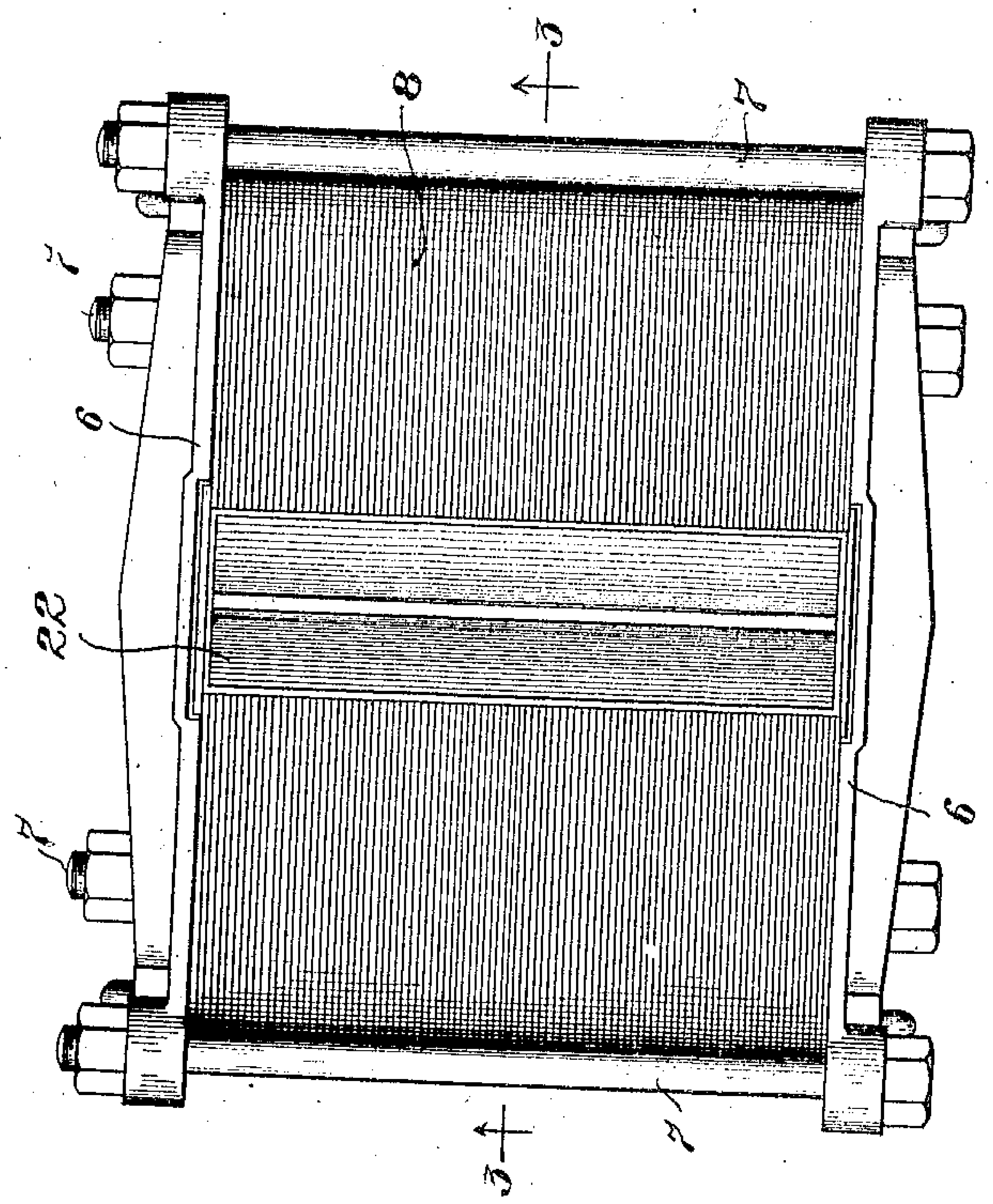

Fig. 2

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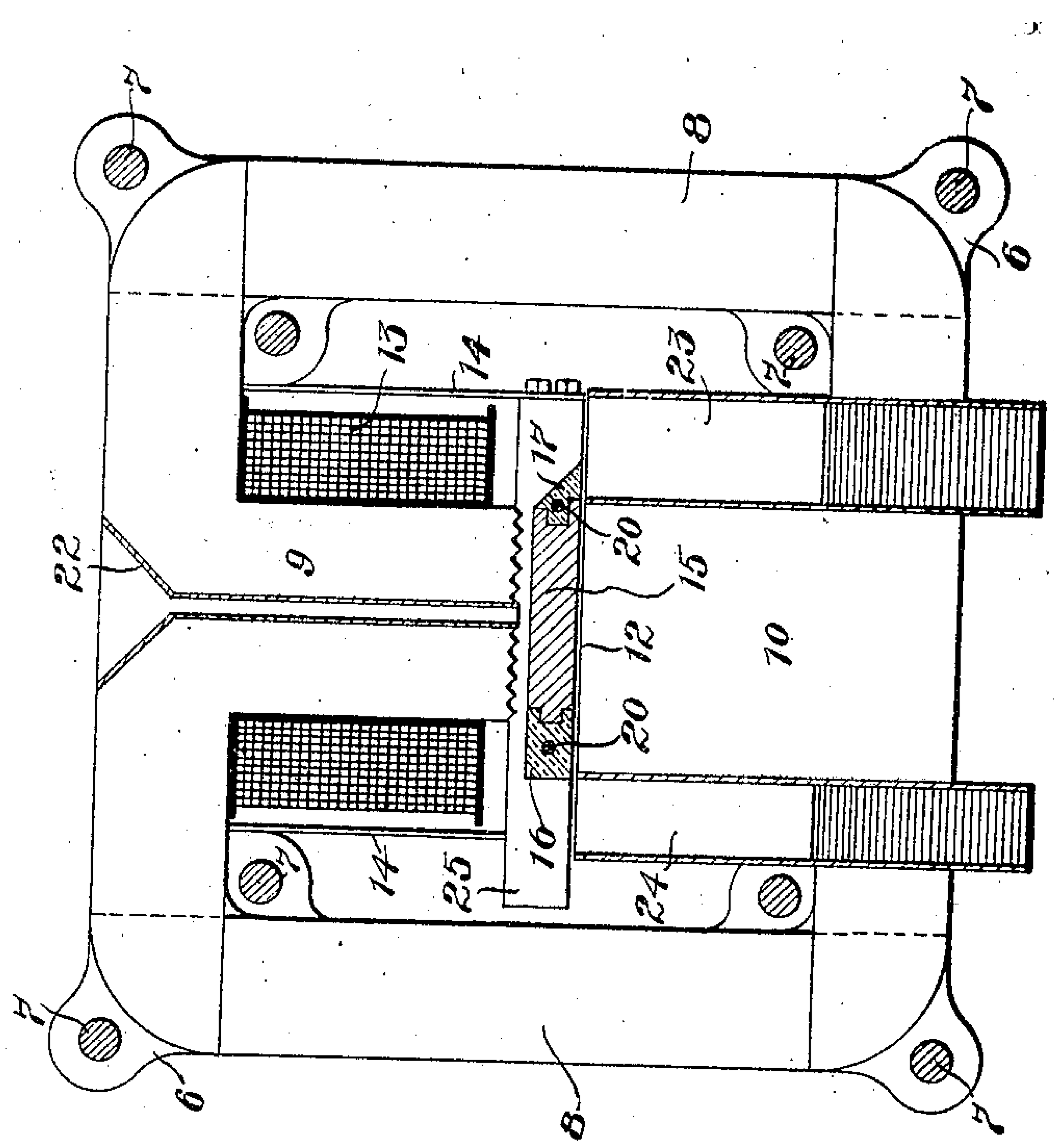

Fig. 3

Witnesses:

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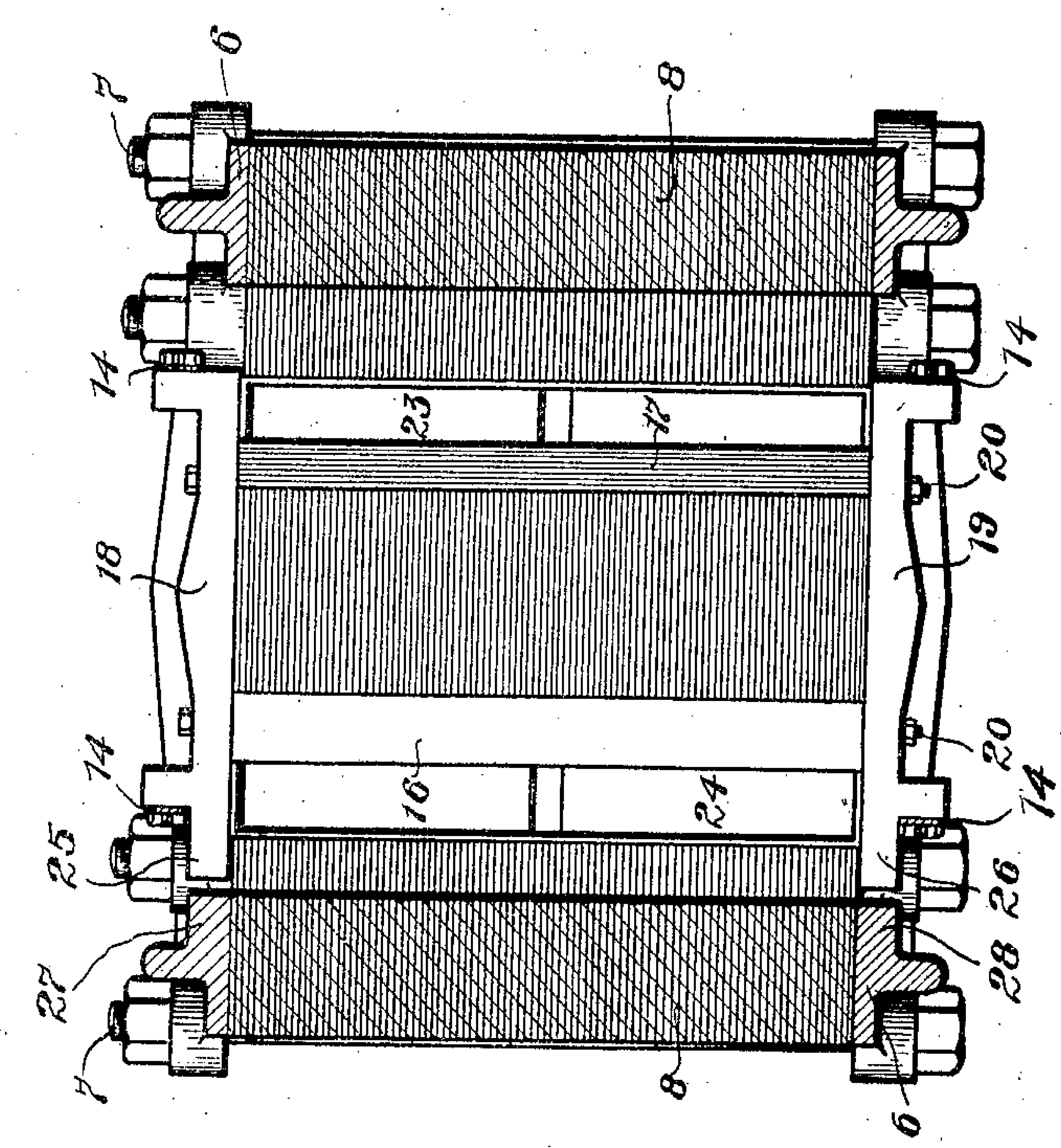

Fig. 4.

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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.

PROCESS OF MAGNETIC SEPARATION.

No. 817,399. Specification of Letters Patent. Patented April 10, 1906.

Application filed December 20, 1902. Serial No. 136,005.

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 Processes of Magnetic Separation, (Case No. 7,) 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 the magnetic separation of materials of different degrees of magnetic permeability.

Broadly stated, my invention provides an improved process of magnetic separation in which the forces effective in making the separation are more efficiently controlled in strength, direction, and duration of application.

In my improved process a mass of materials is subjected to a number of attractive impulses applied in different directions and at different places. The more permeable materials are attracted from the materials to be separated toward the place of convergence of a magnetic flux, the convergence and attracted materials being then given a comparatively small movement relative to non-attracted materials. At the end of the movement the attracted materials are released and deposited by sufficiently reducing either the density or the convergence of the flux passing through the materials. The more permeable materials are then again attracted toward a place of convergence of a magnetic flux and given a second and additional movement. This cycle of operations is repeated until a sufficient relative movement between attracted and unattracted materials is attained.

In practicing my invention I find it desirable to release the attracted materials for deposit by reducing to zero the density of the flux through the convergence. This 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 time of reversal being zero. At this time of reversal materials of the greatest attractability will be released.

My improved process is particularly useful in the separation of materials of very low permeability. In the separation of such materials the necessarily high density of the magnetic force required may be attained in a field between two poles of opposite polarity which closely approach each other.

In a copending application, Serial No. 136,004, filed December 20, 1902, I have illustrated and claimed apparatus adapted to carry out the processes herein more fully described.

The features of my improved process may be explained by reference to a device for carrying out the process illustrated in the accompanying drawings, in which—

Figure 1 is a front elevation of a separator embodying my invention. Fig. 2 is a plan view of 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.

In this apparatus for carrying out my invention 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. 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 reciprocating 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.

It will be seen that due to the quick-return motion of the table the non-attracted materials are given a net movement toward the left, while the step-by-step advancement of the attracted materials results in a net movement toward the right.

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.

Having thus described the method of carrying out my invention, I claim as new and desire to secure by Letters Patent—

1. The process of magnetic separation, which consists in causing a differential reciprocating movement of materials to be separated, attracting the more permeable materials toward a relatively stationary magnet-pole during the movements in one direction, and releasing the attracted materials during the movements in the reverse direction, whereby the attracted materials are given a net movement in one direction, and the non-attracted materials are given a net movement in another direction.

2. The process of magnetic separation, which consists in causing a differential reciprocating movement between materials to be separated, and a convergence of a magnetic flux, decreasing the density of the flux through the convergence during the movements in one direction, and increasing the density of the flux through the convergence during the movements in the reverse direction, whereby the attracted materials are given a net movement in one direction, and the non-attracted materials are given a net movement in another direction.

3. The process of magnetic separation, which consists in causing a differential reciprocating movement between materials to be separated, and a convergence of a magnetic flux, decreasing to zero the density of the flux through the convergence during the movements in one direction, and increasing the density of the flux through the convergence during the movements in the reverse direction, whereby the attracted materials are given a net movement in one direction, and the non-attracted materials are given a net movement in another direction.

4. The process of magnetic separation, which consists in causing a differential reciprocating movement between materials to be separated, and a convergence of a magnetic flux, reversing the polarity of the flux through the convergence during the movements in one direction, whereby the attracted materials are given a net movement in one direction, and the non-attracted materials are given a net movement in another direction.

5. The method of magnetically separating ores, which consists in differentially reciprocating the ores within the influence of a magnet, periodically energizing and deënergizing the magnet, and maintaining synchronism between the reciprocations and the changes in the field of the magnet.

6. The process of magnetic separation, which consists in causing a relative differential reciprocating movement of materials to be separated with respect to the place of convergence of a magnetic flux, reversing the polarity of the flux to said place of convergence during the movements in one direction, and maintaining the continuity of the flux to said place of convergence during the movements in the reverse direction, whereby the attracted materials are given a net movement in one direction and the non-attracted materials are given a net movement in another direction.

7. The process of magnetic separation, which consists in imparting to the mass of materials a differential reciprocating motion, and establishing a periodic magnetic field through said mass in synchronism with the reciprocations thereof and in such phase relation thereto as to retard the more permeable particles during each movement of the mass in the direction of its travel, and to allow said materials to move with the mass during its reverse movement.

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.