Nov. 27, 1928. 1,693,033

J. L. HOPE

PROCESS OF AND APPARATUS FOR SEPARATING SUBSTANCES

Filed Dec. 29, 1924

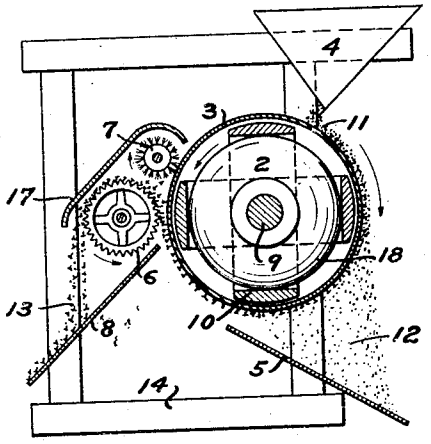


Fig. 1

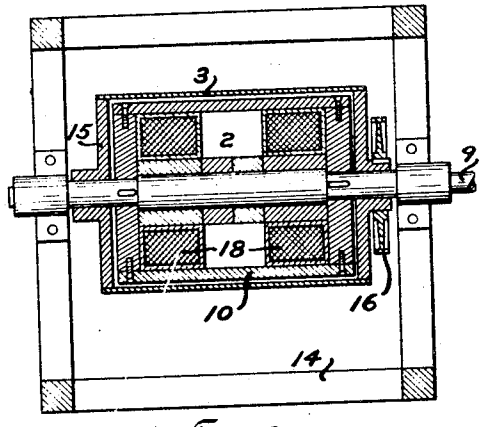


Fig. 2

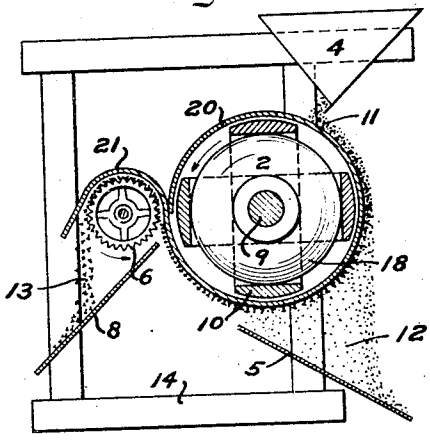


Fig. 3

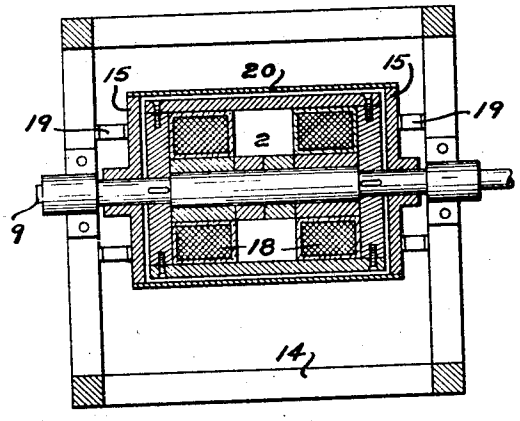


Fig. 4

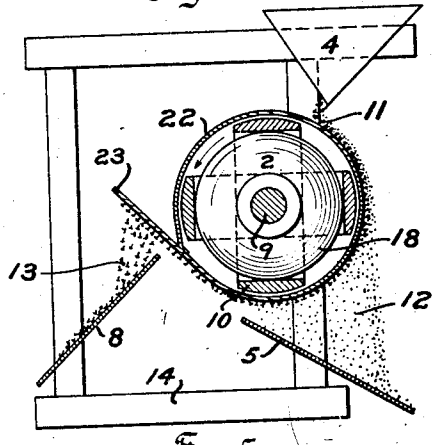


Fig. 5

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UNITED STATES PATENT OFFICE.

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PROCESS OF AND APPARATUS FOR SEPARATING SUBSTANCES.

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This invention relates in general to improvements in the art of separating substances having different characteristics, and relates more specifically to an improved method of and apparatus for separating magnetic from non-magnetic materials constituting a mechanical mixture.

An object of the invention is to provide a new and improved method or process of separating magnetic substances from non-magnetic substances mixed therewith. Another object of the invention is to provide simple and efficient apparatus for effecting commercial exploitation of the improved process of separation.

It has heretofore been common practice to utilize electro-magnetic force to effect separation of magnetic from non-magnetic particles constituting a mixture, by producing a fixed or stationary magnetic field and mechanically advancing the mixture through the field in order to cause the magnetic particles to be retained by magnetic influence while permitting the non-magnetic particles to fall freely therefrom. The advancement of the material through the magnetic field of the prior devices, is caused by movement of a support for the material, relatively to electro-magnets located closely adjacent to the support. The movable support is frequently formed as a rotary drum within which stationary electro-magnets are mounted, the material being advanced by rotating the supporting drum about a horizontal axis. These prior separators besides having insufficient capacity, are difficult to construct due to difficulties encountered in mounting a sufficient number of electro-magnets having sufficient strength, within the rotating drum and of conducting electric current thereto. The rotating drum of the prior devices is moreover a source of danger to the operators, and the construction is also complicated by the relatively great number of electro-magnets required.

The present invention contemplates provision of an improved process of and apparatus for effecting magnetic separation of materials, whereby the defects of the prior devices of this character are substantially eliminated. In accordance with the improved process, material containing intimately mixed particles of magnetic and non-magnetic substance, is admitted to a rapidly moving magnetic field in such a way that the magnetic particles alone are retained and tumbled along within the field by magnetic influence, in a direction opposite to the direction of advancement of the field, being subsequently released from the magnetic retaining force and delivered free from unattached non-magnetic particles. The present invention further contemplates provision of relatively simple, compact, durable and highly efficient apparatus of large capacity for effecting commercial exploitation of the improved process. In the improved apparatus, the support for the material being treated may be mounted stationarily, thus permitting the use of relatively light material to provide a rigid support for large masses, and also eliminating danger of injury to attendants by moving structure. In order to enhance the rate of separation and to permit reduction in the speed of movement of the magnets without reducing the capacity, the support for the material may be moved slowly in a direction opposite to the direction of movement of the magnets. The improved apparatus may also embody relatively few and simple electro-magnets movable at high relative speed in order to effectively separate and advance the material by magnetic force. These and other objects and advantages of the present improvement will be apparent in the course of the following description.

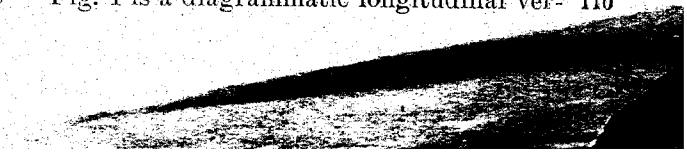
A clear conception of several embodiments of the invention and of the details of construction and operation of several forms of apparatus for effecting commercial exploitation of the improved process, may be had by referring to the drawing accompanying and forming a part of this specification in which like reference characters designate the same or similar parts in the various views.

Fig. 1 is a somewhat diagrammatic transverse vertical section through an improved magnetic separator comprising means for producing a movable magnetic field in close proximity to an oppositely movable material support.

Fig. 2 is a diagrammatic longitudinal vertical section through the magnetic separator illustrated in Fig. 1.

Fig. 3 is a somewhat diagrammatic transverse vertical section through an improved magnetic separator comprising means for producing a movable magnetic field in close proximity to a stationary material support.

Fig. 4 is a diagrammatic longitudinal ver-



tical section through the magnetic separator illustrated in Fig. 3.

Fig. 5 is a somewhat diagrammatic transverse vertical section through another form of improved magnetic separator comprising means for producing a movable magnetic field in close proximity to a stationary material support.

Referring specifically to Figs. 1 and 2, the improved magnetic separator therein illustrated, comprises in general a rotor 2 consisting of a pair of coils 18 and an annular series of four pole pieces 10 mounted upon a rotary horizontal shaft 9; a cylindrical material support or drum 3 embracing the rotor 2; a supply hopper 4 disposed to deliver material 11 comprising a mixture of magnetic and non-magnetic particles, upon the drum 3; a non-magnetic material discharge chute 5 disposed below the drum 3 and hopper 4; means for removing magnetic material 13 from the drum 3 and for delivering such material to a magnetic material discharge chute 8; and a suitable support 14 for the various elements. The rotor 2 is capable of being rapidly revolved in a counter-clockwise direction as viewed in Fig. 1, and the coils 18 are capable of being energized through slip rings during such revolution of the rotor, in a well known manner. The drum 3 is supported upon circular spaced end heads 15 which are rotatably supported upon the rotor shaft 9, and is capable of being revolved in a clockwise direction as viewed in Fig. 1, at relatively slow speed, by means of power applied to a pulley 16. The mixture supply hopper 4 is preferably located above the drum 3 and is capable of discharging the material radially toward the external surface of the supporting drum at a suitable angle. The means for removing magnetic particles from the drum 3 comprises a corrugated iron discharge roller 6 located laterally adjacent to the drum 3 and rotatable in a counter-clockwise direction; and a revolving brush 7 located above the roller 6 and rotatable in a clockwise direction as viewed in Fig. 1. The roller 6 is capable of delivering magnetic particles of material 13 to the discharge chute 8, and the roller 6 and brush 7 may be covered by a guard plate 17 as shown.

During normal operation of the separator of Fig. 1 and 2, the rotor 2, drum 3, roller 6 and brush 7 are being rotated in the direction indicated in Fig. 1 at predetermined proper speeds. The coils 18 are electrically energized and cooperate with the pole pieces 10 and with the drum 3 to produce an annular magnetic field advancing along the outer surface of the supporting drum 3 in a counter-clockwise direction. As the mixture 11 of magnetic and non-magnetic particles is fed upon the revolving drum 3 from the supply hopper 4, it travels downwardly along the surface of the drum 3 until the force of gravity becomes effective to cause the non-magnetic particles 12 to automatically drop away from the drum 3 and upon the discharge chute 5. The magnetic particles are however retained within the magnetic field by magnetic influence, and are caused to advance in a clockwise direction about the drum axis, both by the attraction thereof by the approaching pole pieces 10 and by the movement of the drum 3 itself. When the magnetic particles 13 reach the rapidly revolving corrugated roller 6, they are automatically transferred from the periphery of the drum 3 to the roller 6, by virtue of the fact that the portion of the roller 6 nearest to the drum 3 extends into the magnetic field and is magnetized thereby. The material 13 thus transferred to the roller 6, is carried away from the influence of the magnetic field and is eventually discharged from the roller 6 at a point remote from the drum 3, by centrifugal force, and falls by gravity upon the final discharge chute 8. Any particles of material which may not have been removed by the roller 6, are subsequently brushed from the drum 3 upon the rotating roller 6 by the rapidly revolving brush 7, thus insuring complete removal of all material from the external surface of the drum 3.

Referring specifically to Figs. 3 and 4, the improved magnetic separator illustrated therein, comprises in general a rotor 2 consisting of a pair of coils 18 and an annular series of four pole pieces 10 mounted upon a rotary horizontal shaft 9; a stationary substantially cylindrical material support or drum 20 embracing the rotor 2; a supply hopper 4 arranged to deliver material 11 comprising a mixture of magnetic and non-magnetic particles, upon the drum 20; a non-magnetic material discharge chute 5 located below the drum 20 and hopper 4; a rotary corrugated iron material discharge roller 6 located laterally adjacent to the drum 20; a magnetic material discharge chute 8 located below the roller 6; and a suitable support 14 for the various elements. The rotor 2 is capable of being rapidly revolved in a counter-clockwise direction as viewed in Fig. 3, and the coils 18 are adapted to be electrically energized through slip rings during revolution of the rotor, in a well known manner. The stationary drum 20 is supported upon circular end heads 15 which may be rigidly attached to the support 14 by means of brackets 19. The mixture supply hopper 4 may be located at any convenient place, preferably above the drum 20 and is capable of discharging material radially toward the external supporting surface of the drum. The portion of the drum 20 adjacent to the corrugated roller 6 is preferably extended over the top of the roller 6 to form a guard 21 formed integral with the drum 20 as shown in Fig. 3.

During normal operation of the separator disclosed in Figs. 3 and 4, the rotor 2 and the roller 6 are being rotated in the direction indicated in Fig. 3 at predetermined proper speeds. The coils 18 are electrically energized and cooperate with the pole pieces 10 and with the drum 20 to produce an annular magnetic field advancing along the outer supporting surface of the drum 20 in a counter-clockwise direction. As the mixture 11 of magnetic and non-magnetic particles is deposited upon the stationary drum 20 from the supply hopper 4, it automatically advances downwardly along the surface of the drum 20 until gravity becomes effective to cause the non-magnetic particles 12 to drop away from the drum upon the discharge chute 5. The magnetic particles of material are however retained within the magnetic field by magnetic influence, and are caused to advance in a clockwise direction about the drum axis, by the attraction resulting from the continuously approaching magnetized pole pieces 10. It is found that this advancement of the material is continuous and uniform and that the magnetic particles will not drop by gravity from the magnetic field. When the particles 13 reach the rapidly revolving corrugated roller 6, they are automatically transferred from the stationary drum 20 to the roller 6, and are eventually delivered from the roller 6 by centrifugal force and dropped by gravity upon the final discharge chute 8.

Referring specifically to Fig. 5, the improved magnetic separator illustrated therein has a longitudinal section substantially similar to that shown in Fig. 4, and comprises in general a rotor 2 consisting of a pair of coils 18 and an annular series of four pole pieces 10 mounted upon a rotary horizontal shaft 9; a stationary substantially cylindrical drum 22 embracing the rotor 2; a supply hopper 4 disposed to deliver material 11 upon the drum 22; a non-magnetic material discharge chute 5 located below the drum 22 and hopper 4; a magnetic material delivery plate 23 formed integral with and projecting laterally away from the drum 22; a magnetic material discharge chute 8 located below the plate 23; and a suitable support 14 for the various elements. The rotor 2 is capable of being revolved rapidly in a counter-clockwise direction as viewed in the figure, and the coils 18 are adapted to be electrically energized as the rotor revolves, in a well known manner. The stationary drum 22 is supported upon end heads which may be rigidly attached to the support 14 as shown in Fig. 4. The mixture supply hopper 4 may be located above the drum 22 and is capable of discharging material upon the drum 22 as shown.

During normal operation of the separator disclosed in Fig. 5, the rotor 2 is being rotated in the direction indicated at a predetermined proper speed. The coils 18 are electrically energized and cooperate with the pole pieces 10 and with the drum 22 to produce an annular magnetic field which advances along the outer surface of the drum in a counter-clockwise direction. As the mixture 11 of material is deposited upon the stationary drum 22 from the hopper 4, it automatically advances downwardly along the surface of the drum 22 until gravity becomes effective to cause the free non-magnetic particles 12 to drop upon the discharge chute 5. The magnetic particles of the material are however retained within the magnetic field by magnetic influence, and are caused to continuously advance in a clockwise direction about the drum axis. When the particles 13 reach the plate 23, they travel upwardly along this plate until they have passed beyond the influence of the magnetic field, whereupon the particles drop by gravity upon the final discharge chute 8.

It has been found by actual construction of a machine, that the magnetic particles of material automatically travel along the outer surfaces of the supporting drums 3, 20, 22, in a direction opposite to the direction of rotation of the rotor 2 and that the non-magnetic particles 12 are automatically removed by gravity in the manner described. The various mechanisms for removing the separated magnetic material 13 from the supporting drum, are efficient and automatic in operation. When a stationary supporting drum such as 20 or 22 is employed, a relatively rigid structure is attainable and danger of injury to attendants, is entirely eliminated. The embodiment of the invention illustrated in Figs. 1 and 2, obviously permits enhancement of the rate of separation by virtue of the fact that the material is urged towards its destination by dual influence. The apparatus functions automatically and effectively to exploit the improved process which is capable of efficient separation of any mixture of magnetic and non-magnetic particles.

It should be understood that it is not desired to limit the invention to the exact steps of the process or to the precise details of construction and operation of the apparatus herein shown and described, for various modifications within the scope of the claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:—

1. The method of separating materials, which comprises, producing a movable magnetic field having an upwardly advancing portion and having another portion approaching the lower end of said upwardly advancing portion, precipitating a mixture of magnetic and non-magnetic particles into said upwardly advancing field portion to cause the non-magnetic particles to gravitate

therethrough and to cause the magnetic particles to remain and travel downwardly along said upwardly advancing portion and then along said approaching portion, and subsequently removing the separated magnetic particles from said approaching field portion.

2. The method of separating materials, which comprises, producing a magnetic field revoluble about a horizontal axis, showering a mixture of magnetic and non-magnetic particles into an upwardly advancing portion of said field to cause the non-magnetic particles to gravitate therethrough and to cause the magnetic particles to remain within and to travel successively along and around the bottom of said field in a direction opposite to the direction of revolution thereof, and subsequently removing the separated magnetic particles from the field at a point remote from said upwardly advancing field portion.

3. In combination, a stationary horizontal drum, a magnet revoluble about the axis of said drum, means for revolving said magnet to produce a magnetic field advancing around said drum, a hopper spaced from said drum and disposed to shower a mixture of magnetic and non-magnetic particles upon the side of said drum having the upwardly advancing field portion thereon, and means for removing separated magnetic particles from said field at the opposite side of said drum.

In testimony whereof, the signature of the inventor is affixed hereto.

JAMES L. HOPE.