Nov. 29, 1949 W. BYRD, JR 2,489,264

DRUM TYPE MAGNETIC SEPARATOR

Filed Aug. 4, 1944 2 Sheets-Sheet 1

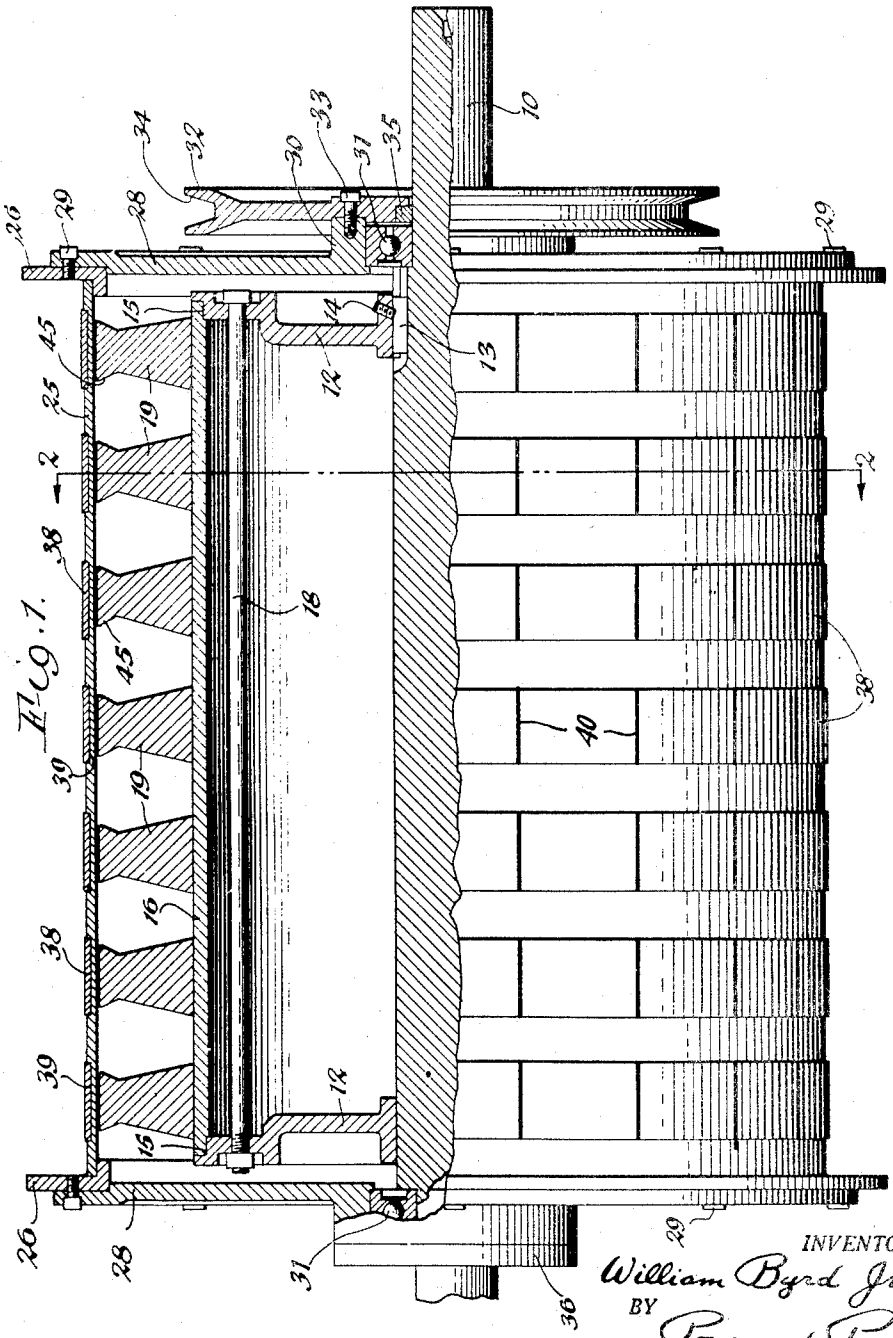


Fig. 1.

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Fig. 3.

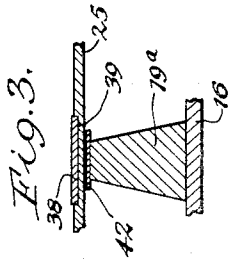


Fig. 4.

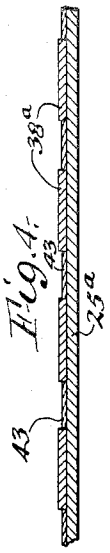
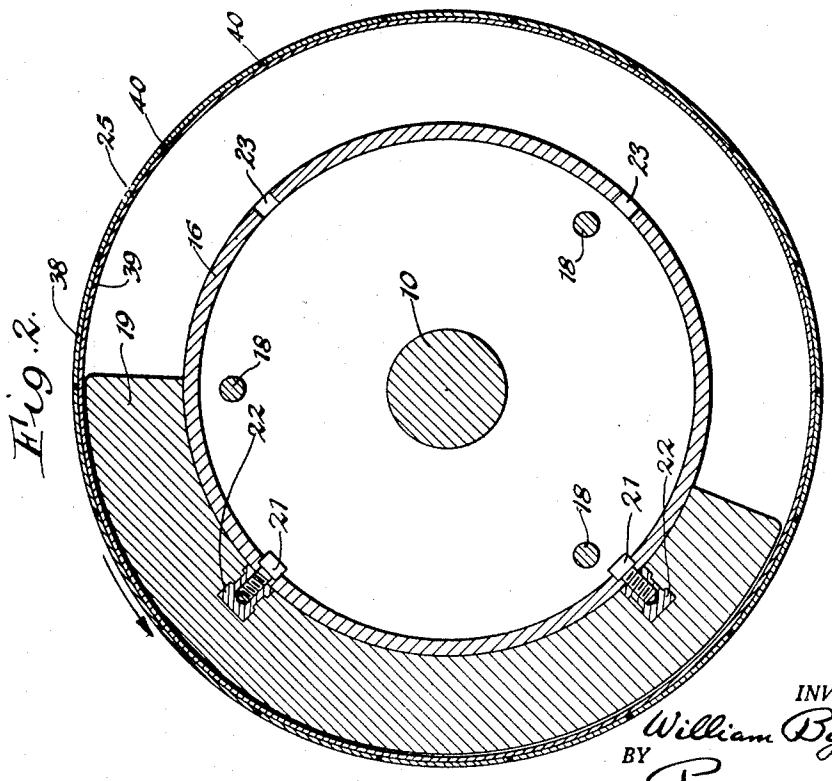


Fig. 2.



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UNITED STATES PATENT OFFICE

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DRUM-TYPE MAGNETIC SEPARATOR

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6 Claims. (Cl. 209—219)

1

This invention relates to a drum type magnetic separator for separating magnetic contaminants from a stream of material, the magnetic contaminants being drawn against the surface of a revolving drum by permanent magnets and subsequently released from the drum as separated material.

One of the principal objects of the present invention is to provide such a drum type permanent magnet separator of high magnetic strength and in which the magnetic field is produced by high coercive force permanent magnets.

Another object is to provide such a drum type permanent magnet separator which will efficiently remove the magnetic contaminants from the stream of materals brought in contact therewith and from which the magnetic contaminants are readily separated.

Other objects are to provide such a drum type permanent magnet separator which is compact in construction, relatively low in cost, and which will stand up under conditions of severe and constant use without loss of strength of the permanent magnets and without requiring repairs.

In the separating process in which the drum type separator embodying my invention is capable of being employed, the material from which magnetic contaminants, such as tramp iron, is to be removed, is fed in a continuous stream to the top of a revolving drum, separators of this type being known commercially as a drum type magnetic separator. Such drum type of magnetic separator provides zones of high flux concentration beginning in the vicinity of the top of the drum and extending in its direction of rotation. Some stray field will exist in the region of the rear or rising half of the drum surface, but it is desirable that this field be reduced to a minimum.

It will be understood that the magnetic contaminants present in the stream of materials will be drawn against the surface of the drum as it revolves through the region of high flux concentration and since this region of flux concentration terminates at the bottom portion of the drum, the magnetic contaminants will be drawn under the drum and discharged from its rising side. Non-magnetic matter will not be attracted to the drum by its magnetic field, but will tend to be thrown outward and downward along its

2

descending side. A continuous separating process is thus achieved.

All commercially successful drum separators of which I have knowledge are of the electromagnetic type. While the advantages possessed by a drum separator energized by permanent magnets are generally appreciated, no one, so far as I know, has heretofore been successful in developing such a separator of adequate strength. My invention accomplishes this by the use of a highly efficient magnetic circuit employing segmental annular magnet castings of high coercive force alloy radially magnetized and mounted on a stationary cylindrical steel tube within and concentric with the revolving drum and pole pieces in the form of circular steel bands forming part of the revolving drum.

For a clearer comprehension of the invention reference is directed to the accompanying drawings which illustrate preferred embodiments thereof and wherein:

Fig. 1 is a front elevation, partly in section, of a drum type permanent magnet separator according to my invention and intended for use in treating material continuously conveyed to its top by a suitable feed device and removed from beneath by suitably placed hoppers and ducts (not shown).

Fig. 2 is a vertical transverse sectional view, taken on line 2—2, Fig. 1, the rotation of the drum being counterclockwise as viewed in this figure.

Fig. 3 is a fragmentary view similar to Fig. 1 and showing a modified form of the stationary magnet assembly.

Fig. 4 is a fragmentary sectional view similar to Fig. 3 and showing a modified form of the revolving drum.

In the form of the invention shown in Figs. 1 and 2, the drum type permanent magnet separator is shown as carried by a horizontal stationary shaft 10, the ends of which can be mounted in any suitable manner. This stationary shaft 10 carries a pair of spaced flanged circular end heads 12 which are restrained from rotating on the shaft 10 as by a key 13 locked in place by a set screw 14. These end heads 12 are stepped or recessed at their peripheries, as indicated at 15, to support the opposite ends of a cylinder 16 of magnetic steel, the exterior surface of this cylinder being coaxial with the sta-

tionary shaft 10. The cylinder 16 and its end heads 12 are locked together by three tie rods 18, these tie rods being spaced at 120° apart.

On one side of the cylinder 16 are mounted a plurality of like segmental permanent magnet castings 19 of high coercive force alloy. These castings are curved to fit the periphery of the cylinder 16 and are mounted in spaced relation to one another axially of the cylinder by machine screws 21 which extend through the wall of the cylinder 16 from the inside thereof and screws into tapped steel inserts 22 of the magnet castings 19. Beginning approximately at the top of the cylinder 16, these permanent magnet castings 19 extend counterclockwise, as viewed in Fig. 2, over an arc of approximately 160°. The permanent magnet castings 19 are spaced at equal distances in an axial direction and their exterior curved surfaces are of common radius, the supporting shaft 10 being their common axis. The holes in the cylinder 16 for the screws 21 are drilled and countersunk through holes 23 provided on the diametrically opposite side of the cylinder 16.

A thin walled rotatable circular drum 25 of non-magnetic material, preferably a non-magnetic steel, encloses the cylinder 16 and is provided at its opposite ends with end rings 26 of brass or other suitable material. The end rings 26 can be secured to the drum 25 by soldering or by any other suitable means and each ring is secured to the rim of a wheel 28 by machine screws 29 or otherwise. The hub 30 of each of the wheels 28 is journaled, as by a ball bearing 31, on the stationary supporting shaft 10. To the hub 30 of one of the wheels 28 is secured a combination sheave and bearing cap 32, as by machine screws 33, this sheave having a rim 34 adapted to receive a drive belt (not shown) and the bearing cap being recessed to carry a dust and grease seal 35. The hub of the other wheel 28 carries a dust and grease seal cap 36 for the adjacent ball bearing 31. The combined sheave and bearing cap 28 and the bearing cap 36 are preferably similarly mounted and capable of interchange.

It will be seen that the ball bearings 31, wheels 28 and rings 26 cooperate to hold the drum 25 coaxial with the stationary shaft 10. By working to close tolerances it is possible to reduce the clearance between the curved faces of the magnet castings 19 and the interior of the drum 25 to $\frac{1}{32}$ inch or less.

Mounted on the exterior of the drum 25 are circumferential bands 38 of magnetic steel which aline with the permanent magnet castings 19 so as to provide revolving pole pieces therefor. These bands are slightly wider than the adjacent pole pieces of the magnet castings 19 and are shown as set into annular recesses 39 which are turned into the drum so that the outer surface of each band has a diameter about $\frac{1}{32}$ inch greater than the periphery of the drum.

The bands 38 may be formed of single strips of magnetic steel of, say, 18 to 20 gage. However, I find it preferable to construct these bands in segmental form using thicker magnetic steel of, say, 14 to 16 gage thickness. These segments are shown as separated at their ends by a small gap 40 which is filled with solder to provide a physically smooth surface. I have found that the use of either continuous bands of 18 to 20 gage or bands of thicker gage broken into about eighteen segments per band, that is, one segment per 20°, limits the flux conveyed by the bands beyond the permanent magnet castings 19 sufficiently to prevent any adverse effect therefrom.

Referring to Fig. 1, it will be understood that all of the permanent magnet castings 19 are radially magnetized and that the magnetization of adjacent castings is in opposite directions. The cylinder 16 being of magnetically permeable material closes the magnetic circuit between the interior polar surfaces of the permanent magnet castings 19. Magnetic leakage between the side walls of adjacent magnet castings 19 is unavoidable. Allowance for leakage flux is made by employing a shape which provides a maximum cross-section to flux at its interior surface. This maximum cross-section to flux at the interior surface of each permanent magnet block can be obtained by providing a magnet casting which tapers uniformly from the interior to the exterior of the polar surface, the total reduction in cross section being of the order of 25 to 50 percent in order to maintain the most efficient flux density within the magnet. A permanent magnet segment having such a cross section is illustrated in Fig. 3. However, I have found that such a magnet construction causes excessive gap losses between each permanent magnet's polar surface and the adjacent band 38 of magnetic material carried by the drum. The result is a diminution in useful flux which is that passing between the bands 38 on the exterior of the drum surface. I show two methods by which these losses can be reduced:

As shown in Fig. 1, the permanent magnet casting 19 can be flared in cross section as indicated at 45 to provide an enlarged polar surface adjacent to the drum 25. The inner part of each permanent magnet casting tapers uniformly from its maximum cross-section at its interior surface to the enlarged polar surface in the order of 25 to 50 percent, the permanent magnet being thereby of generally hourglass shape in cross section. While this construction is simple, it is somewhat wasteful of the magnet alloy, which is costly, and it presents a greater surface which must be brought to finished dimensions usually by the costly and time consuming process of grinding.

To avoid this added cost and manufacturing difficulty, the alternative construction shown in Fig. 3 is provided. In this construction the magnet casting 19*a* has its cross-section to flux tapering uniformly from the interior to the exterior polar surface, the total reduction in cross section being of the order of 25 to 50 percent in order to obtain the most efficient flux density within the magnet as with the permanent magnets shown in Figs. 1 and 2. To provide the desired enlarged polar surface adjacent to the drum I attach a magnetically permeable pole piece 42 to the exterior face of each magnet casting 19*a*, this pole piece presenting an enlarged polar surface to the drum 25.

Instead of recessing the bands or segments 38 into annular recesses 39 in the periphery of the drum, as shown in Figs. 1 and 2, the drum 25*a* can be of uniform outside diameter throughout, as shown in Fig. 4, and covered by alternate bands of magnetic material 38*a* and non-magnetic material 43. As shown in Fig. 4, the non-magnetic bands 43 are preferably of less outside diameter than the magnetic bands 38*a*. In this

construction all of the bands can be replaced as wear takes place. The bands 38a can be of either one piece or segmental as shown in Figs. 1 and 2.

The performance of the separator is dependent to a large degree on the proportional relationship and dimensions of the component parts of the magnetic circuit. I have found that the pole pitch, that is, the distance measured parallel to the axis of the drum between the centers of adjacent magnetic bands, should be about 2 inches for general applications. I have also found that the magnet castings should employ a radial length of from 1½ to 2 inches. Since the magnetic circuit between adjacent bands of the drum travels through two magnets arranged magnetically in series aiding, it will be seen that the length of the circuit through the magnets is of the order of 3 to 4 inches which is materially in excess of the pole pitch. In addition to the preferred pole pitch of approximately 2 inches, I have found that the magnetic bands carried by the drum should be approximately 1¼ inches wide leaving a gap between bands of approximately ¾ of an inch. It has already been stated that the magnet castings are annular and segmental covering an arc of 160 degrees. While the approximate radial length and degree of taper is given, the axial length is not stated because of its dependence on characteristics of the particular magnet alloy employed as will be understood by those familiar with the art. The wall thickness of the cylinder 16 which may be of commercial low carbon steel should be such as to conduct the flux between the interior pole faces of adjacent magnets with relatively small losses. A wall thickness of ¼ to ⅜ inches has been found satisfactory. The rear portion of the cylinder 16 serves the desirable function of acting as a shunt for stray fields at the rising side of the drum 25. The tendency of magnetic material to adhere to the drum in this region is thus minimized. It will be understood that the drum diameter may be varied through substantially wide limits without altering the dimensions given. I have found that drum diameters of 12 to 24 inches give very satisfactory results. It will be appreciated that while the cost of a separator will increase with increase in diameter, larger diameter drums are more efficient and are operable at higher peripheral speeds permitting increased rates of feed. While I have given the dimensions which I have found desirable for general use from the standpoint of efficiency and economy of materials, changes in cost and/or strength of available permanent magnet materials may require alteration of these dimensions. However, by preserving the relative proportions substantially as described, the benefits of my design may be retained.

Attention is invited to the sealed nature of the construction as indicated in Fig. 1. No form of foreign matter can work into the interior of the drum. The bearings are thus protected from grit. Greasing of bearings may be accomplished by providing sheave 32 and bearing cap 36 each with a suitably located grease fitting. Assembly is straight forward and simple, and the replacement of any part may readily be accomplished if necessary.

The separator which I have described is of sufficient strength to give excellent performance and compare favorably with electrically energized separators of this type.

It will be understood that various changes in form, proportion, size and minor details of construction within the scope of the claims may be resorted to without departing from the spirit or sacrificing any of the advantages of the invention and any of the features of my invention may be employed separately if desired.

I claim as my invention:

1. A drum type magnetic separator wherein the magnetic force is derived from stationary permanent magnets, comprising a plurality of coaxial, axially spaced permanent magnets of high coercive force each having an arcuate form and being magnetized in a radial direction, a wall of high magnetic permeability abutting the radial interior surfaces of said permanent magnets, and a drum rotatable about said axis and comprising a non-magnetic body and circumferential bands of magnetic material.

2. A drum type magnetic separator as set forth in claim 1 and having substantially the following proportions: drum diameter 12 to 24 inches; pole pitch 2 inches; width of each band of magnetic material 1¼ inches; radial length of magnets 1½ inches; and circumferential extent of magnets 160°.

3. A drum type magnetic separator wherein the magnetic force is derived from stationary permanent magnets, comprising a stationary shaft, a cylinder of high magnetic permeability arranged coaxial with said shaft, end heads fixing said cylinder to said shaft, a plurality of axially spaced permanent magnets of high coercive force of arcuate form magnetized in a radial direction and fitting one side of said cylinder, means securing said magnets to said cylinder, a drum arranged coaxial with said shaft and comprising a non-magnetic cylindrical body, circumferential bands of magnetic material on said body and each alining with a corresponding permanent magnet and end heads for said body, and bearings interposed between said last end heads and said stationary shaft and rotatably supporting said drum on said shaft.

4. In a drum type magnetic separator wherein the magnetic force is derived from stationary permanent magnets, a stationary permanent magnet assembly comprising a plurality of coaxial, axially spaced permanent magnets of high coercive force each having an arcuate form and being magnetized in a radial direction, and a cylinder of high magnetic permeability abutting the radially interior surfaces of said permanent magnets.

5. In a drum type magnetic separator having an interior array of permanent magnets with poles extending circumferentially about an axis, a drum rotatable about said axis and comprising a non-magnetic body and circumferential bands of magnetic material, each of said bands being composed of a plurality of segments separated from one another by short gaps, the segments of one band being magnetizable inductively by an interior circumferentially extending permanent magnet pole.

6. In a drum type magnetic separator, a fixed cylinder of magnetically permeable material, a plurality of permanent magnets mounted on a part only of the circumference of said cylinder to provide a magnetized region and a non-magnetized region around the circumference of said cylinder, and a drum surrounding said fixed cylinder and mounted to rotate about an axis concentric therewith, said cylinder serving to provide

a low reluctance flux path between the magnets as well as to prevent the occurrence of undesirable fields in said non-magnetized region.

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