May 3, 1955 H. SPODIG 2,707,557

MAGNETIC SEPARATORS

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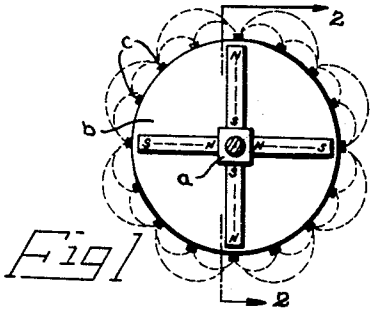


Fig 1

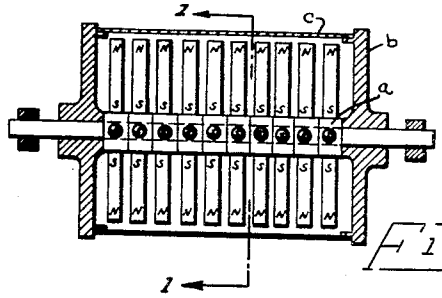


Fig 2

Fig 3

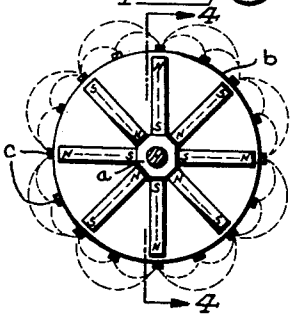


Fig 4

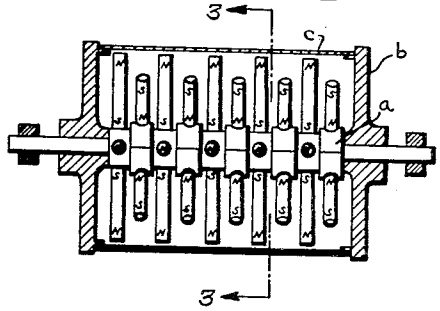


Fig 5

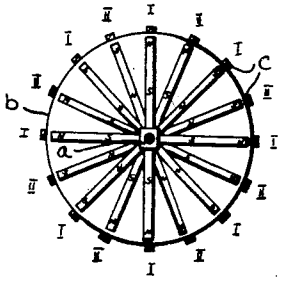


Fig 6

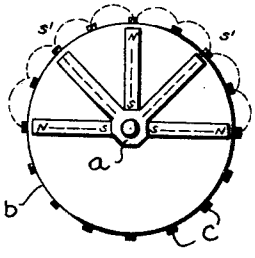


Fig 7

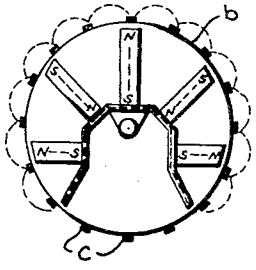


Fig 8

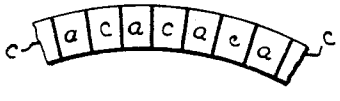
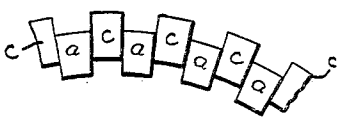


Fig 9



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MAGNETIC SEPARATORS

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10 Claims. (Cl. 209—223)

This invention relates to magnetic separators for separating magnetizable particles such, for example, as iron, iron oxides and the like from sumpy, granular and powdery materials of all kinds such as grain, sand, coal, stone, glass and the like as well as from liquid and pasty media of all kinds, such as oil, water, cooling emulsions for metal working machines, chemical or mechanical suspensions and the like.

Permanent magnetic roll-shaped separators may be used for separating materials in the form of thick layers such as coal and waste products in mines. For this purpose, the separating rollers must have a strong magnetic depth action as well as a uniform magnetic adhesive force at the surface of the rollers. Known magnetic separating rollers do not satisfy these demands.

Known magnetic separators have a fixed permanent magnet system consisting of an even number of rod-shaped permanent magnets and of a sector-shaped ferromagnetic plate which covers a portion of the inside of the drum-shaped separators. The rod-shaped permanent magnets are connected with adjacent dissimilar poles to the sector-shaped ferromagnetic plate in such a manner that the magnetic potential of the plate is substantially zero, while the magnetic circuit is closed through the separating drum or roller from the freely extending dissimilar poles of the magnets or through the material to be separated. The casing or wall of the drum or roller of this magnetic separator consists of individual ferromagnetic portions which may have the shape of a pocket or cup and which are isolated from each other by anti-magnetic material.

This arrangement assures an absolute magnetic null potential and accordingly the dropping-off of the ferromagnetic particles to be separated. On the other hand, the manufacture of the sector-shaped ferromagnetic plates is very expensive and a large mass of iron is required to fill the sector-shaped space in the interior of the drum. Furthermore, it has been found that a comparatively wide magnetic null zone exists at the outer surface of the drum approximately in the middle between the comparatively widely separated dissimilar poles of the freely extending magnetic rods which adversely affects the separation because iron particles which have already been attracted, again drop-off within this zone.

It is, accordingly an object of the present invention to provide improved magnetic separators or separating rollers suitable for various purposes which avoid one or more of the drawbacks of previously known magnetic separators.

A further object of the invention is to provide magnetic separating rollers or drums which will prevent iron particles from falling off the surface of the drum.

Another object of the invention is to provide improved magnetic separating rollers which have an appreciable magnetic depth action.

The magnetic separator of the invention utilizes novel magnetic circuits and magnet arrangements in combination with ferromagnetic iron particles which conduct the magnetic lines of force. The magnet system may be easily and economically assembled and cheaply manufactured.

The magnet system disposed in the magnetic drum consists of magnet sub-assemblies which may be staggered with respect to each other so that the magnetic fields at the surface of the drum are staggered, whereby the iron particles to be separated from another material are forced to move back and forth in the material when the drum is rotated so that they are loosened in the material which greatly facilitates the separation of the magnetizable particles. In this manner it is also possible to bridge the non-magnetic zone in the magnetic circuit between the N and S (north and south) poles so that even this zone along the drum surface becomes partially magnetic whereby iron particles will adhere to this zone and not fall off.

The separating action is further facilitated when the drum consists of ferromagnetic iron rods which are separated from each other by anti-magnetic material. However, it is also possible to manufacture the drum from anti-magnetic material only without using ferromagnetic rods because the staggering of the magnetic fields along the drum already guarantees a sufficient separating action and a safe movement of the iron particles to be separated.

The magnetic depth action extending to the outside of the drum is very large for the separator of the present invention and may amount to approximately 450 to 500 mm. approximately (1.8" to 2").

The invention will be more clearly understood as the description proceeds, taken in connection with the drawings wherein;

Figs. 1 and 2 are cross-sectional views of a modification of a magnetic separator constructed in conformity with the invention;

Figs. 3 and 4 are cross-sectional views of a further embodiment thereof;

Figs. 5, 6, 7 are cross-sectional views of further embodiments of the instant magnetic separator.

Figs. 8 and 9 are fragmentary views of constructional details of the separator drums used in the performance of the invention.

Referring now to the drawings, and particularly to Figs. 1 to 4 a permanent magnetic drum *b* is illustrated which is provided in its interior with a magnet system consisting of 4 (Fig. 1) or 8 (Fig. 3) comparatively long magnet rods having poles N, S. The magnetic rods consist preferably of a magnetic alloy such as Al-Ni, Al-Ni-Co and the like which may be hardened. Dissimilar poles N or S of the magnet rods are concentrically secured by welding, soldering or by screws to a common ferromagnetic iron member *a*, which extends about or within the axis of the drum *b*, so that the entire magnet system forms a single unit. The ferromagnetic member *a* serves as the return connection or conductor for the alternating N and S polarities of the inner poles of the magnet rods NS and accordingly has a magnetic zero potential in the middle of the magnetic drum. Thus the member *a* is completely non-magnetic in the inner zone of the drum about the axis so that only the outer poles adjacent the drum cause a magnetic leakage or lines of force directed at right angles to the direction of the axis and toward the exterior of the drum. This magnetic leakage is short-circuited as illustrated by the dash lines outside of the drum.

The central iron return member *a* may be provided with a bore for accommodating a shaft for the drum. The shaft may also consist of magnetizable material without becoming magnetic because the iron return member *a* has a magnetic zero potential in its central portion. Instead of providing an iron return member *a*, the shaft which may consist of magnetizable material, may carry the magnet rods and may serve as the return connection

without causing the shaft to become magnetic because also in this case there exists a zero potential along the axis.

Instead of utilizing 4 or 8 magnt rods NS it is also feasible to secure any even number of magnet rods in corresponding configuration about the iron return member *a* in a concentric manner. A plurality of such individual magnet systems of the type described having 4, 6, 8, 10, 12 poles and the like may be disposed one after another in any desired number depending on the length of the separating roller or drum. Thus a composite magnet system may be provided within the magnetic drum as shown by way of example in Fig. 2 which illustrates a 4 pole system.

These magnet systems are disposed in a drum *b* consisting of an anti-magnetic material. Magnet poles are developed along the drum which are concentrated in a direction parallel to the axis of the drum and which are short-circuited between N and S at right angles to the direction of the axis as indicated by the outer dashed lines (see Figures 1 and 3). The magnetic density of the lines of force is largest near the poles. Between the relatively distant outer magnet poles along the circumference of the drum, the density of the lines of force decreases particularly toward the middle between the poles in accordance with known magnetic laws while the field in the middle between the poles will have a null potential which is undesirable because the iron particles to be separated may fall off there.

In order to prevent falling off of the particles to be separated, the individual systems of the kind described are staggered with respect to each other to form the entire magnet system of the drum such as shown by way of example in Fig. 5 for a system having 8 poles, while Fig. 4 shows a 4-pole system. By means of this staggered arrangement the non-magnetic zone of the magnetic return circuit between two poles N and S is partially bridged.

A more intensive bridging of the return circuit may be obtained by providing ferromagnetic conducting rods *c* uniformly about the circumference of the drum. The magnetic rods *c* of soft iron are separated from each other by the anti-magnetic drum. The staggered arrangement of the magnet system, as described in combination with the ferromagnetic conducting rods disposed about the circumference of the drum guarantees a safe transport or movement of the magnetizable particles to be separated from a material without the danger that the iron particles may fall off between the poles in the magnetic return circuit.

A portion of the lines of force of the outer magnet poles extends through the drum and the iron conducting rods toward the outside of the drum and tends to short-circuit in a wide arc between the poles N and S while the remainder of the lines of force is short-circuited across the soft iron conducting rods *c* by jumping from N to S. Accordingly, the lines of force from the outer magnet poles are subdivided along the drum. On the one hand, the lines of force extend from the poles deeply into the material thereby to attract even distant iron particles, while on the other hand, the soft iron conducting rods are penetrated by the lines of force jumping from the poles to the drum in order to secure a safe transport of the particles along the drum which have previously been attracted; the staggered arrangement of the individual magnet systems disposed one after another along the axis causes a flow of magnetism even into the non-magnetic zones in the magnetic circuit between the poles and along the iron conducting rods.

Instead of mounting the soft iron rods *c* on the drum, they may be inserted or cast into suitable slots in the drum which may be milled or otherwise provided. It is also feasible to assemble the drum from individual rods separated from each other and consisting of anti-magnetic or magnetizable material having a smooth or an irregular surface as shown for example, in Figs. 8 and 9, respectively, where the iron conducting rods *c* and the the anti-magnetic members *a* are illustrated.

If a corresponding even plurality of magnets NS is utilized, it is also feasible to omit the soft magnetic iron conducting rods which are provided along the circumference of the drum. This may be desirable in some cases because the narrow field and the staggered arrangement of the individual magnet systems guarantees a safe transport along the drum of the magnetizable particles separated from the material. In any case, however, the soft magnetic iron conducting rods disposed about the circumference of the drum facilitate the separation of magnetizable particles in the manner above described.

The separating drums built in conformity with the invention are magnetic along the entire circumference of the drum so that no sector of the drum surface is magnetically neutral. The magnetic systems are disposed in the interior of the drum and may form a rigid unit with the shaft and the drum. Alternatively, the shaft and the magnet system may form a separate, rigid, stationary unit and the drum which is rotatably mounted on the shaft, may be adapted to be rotated about the magnet systems. Such completely magnetic separating drums are suitably and preferably used as drive rollers of the moving belt of a separating arrangement. In this case the non-magnetic material which is moved by the belt falls down when the belt passes around the drive roller, while the magnetizable portion of the material is attracted along the circumference of the magnetic roller until the magnetizable particles fall off when the belt passes below and beyond the separating magnetic drive roller.

It is also feasible to utilize the magnetic separating drum of the invention without a belt, for example, for separating liquid, powdery and granular media, whereby the magnetizable particles are separated by a so-called stripper. In accordance, with the invention, it is also feasible, depending upon the requirements by suitable arrangement and by utilizing a plurality of magnetic fields and polarities of the type described to increase the magnetic effect which is desirable in most cases, or to weaken the magnetic effect which is also suitable for some applications.

Fig. 7 illustrates a separating roller having a rotating drum which, as distinguished from the previously disclosed completely magnetic separating drums, is only partially magnetic along the drum surface while the remaining portion of the drum surface is non-magnetic, that is, magnetically neutral so that in this zone the magnetizable particles contained in the material which are taken along by the magnetic portion of the roller may be automatically removed. These partially magnetic separating rollers have an energizing magnet system which is fixed and connected with the shaft in the interior of the drum while the drum is adapted to be moved about this magnet system.

The separator shown in Fig. 6, is provided with 5, that is, with an odd number of magnet rods NS which are secured with alternate poles of unequal sign to the central iron return member. This arrangement again develops an absolute magnetic zero potential along the drum surface without magnets because the outer poles N of the outer magnet rods NS are of the same polarity and their lines of force cannot, therefore, short-circuit across the drum surface sector without magnets.

Fig. 7 illustrates a magnetic separator having three magnet rods NS and having their S poles secured to a U-shaped iron return member located in the interior of the separating drum. The inner S poles are connected to the drum, on the one hand, by two ferromagnetic iron tongues S′ disposed between two magnet rods NS, and, on the other hand, by the outwardly bent free ends of the iron return member which act as conducting tongues S′. In this construction, accurately defined magnetic and

non-magnetic zones are created along the drum surface.

I claim:

1. A magnetic separator comprising an outer drum of non-magnetic material, a permanent magnet system disposed within said drum and including a ferromagnetic member disposed substantially along the axis of said drum, a plurality of permanent magnet rods, each being magnetized along its length and having two magnet poles at the outer ends thereof, said rods being secured to and extending radially from said member toward the inner surface of the drum, individual groups of said rods being disposed each in a plane substantially at right angles to the axis of said drum, the rods of each group being staggered with respect to the rods of the adjacent group along said axis, and magnetizable conducting elements associated with the surface of said drum, some of said elements being disposed in alignment with the free poles of said rods, the remainder of said elements being disposed between said free poles about said drum substantially within each of said planes, whereby the magnetic flux extends substantially across the entire surface of said drum in an axial direction at right angles thereto and the magnetic lines of force extend between next adjacent ones of said elements as well as between two of said elements across at least one intermediate element.

2. A separator as defined in claim 1, wherein the poles of said rods secured to said member are of the same sign, and wherein ferromagnetic conducting tongues are secured to said member and disposed between said rods and extending radially toward the inner surface of said drum, whereby the free ends of said tongues form poles of a sign opposite to that of the free poles of said rods.

3. A separator as defined in claim 1, wherein said member, said rods and said drum form a rigid unit which is substantially closed.

4. A separator as defined in claim 1, wherein said member consists of a plate having edges extending toward said drum.

5. A separator as defined in claim 4, wherein said plate is of substantially U-shape and wherein said edges extend toward said drum at an angle with respect to the main portion of said plate.

6. A separator as defined in claim 4, wherein said edges form magnetic poles of equal sign.

7. A separator as defined in claim 1, wherein ferromagnetic conducting tongues are secured to said member and disposed between said rods, said tongues extending toward the inner surface of said drum to form free poles

having the same sign as the poles adjacent one of said rods secured to said member.

8. A separator as defined in claim 1, wherein the free poles of adjacent ones of said groups of rods are of equal sign.

9. A separator as defined in claim 1, wherein said elements are provided in recesses of said drum.

10. A magnetic separator comprising an outer drum of non-magnetic material, a permanent magnet system disposed within said drum and including a ferromagnetic member disposed substantially along the axis of said drum, a plurality of permanent magnet rods, each being magnetized along its length and having two magnet poles at the outer ends thereof, said rods being secured to and extending radially from said member toward the inner surface of the drum, at least one group of said rods being disposed in a plane substantially at right angles to the axis of the drum, magnetizable conducting elements associated with the surface of said drum, some of said elements being disposed in alignment with the free poles of said rods, the remainder of said elements being disposed between said free poles about said drum substantially within each of said planes, whereby the magnetic flux extends substantially across the entire surface of said drum in an axial direction at right angles thereto and the magnetic lines of force extend between next adjacent ones of said elements as well as between two of said elements across at least one intermediate element.

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