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(54) MAGNETIC SEPARATOR

(71) I, [Dr Ing] HEINRICH SPODIG, a German Subject of Netteberge 202, 4714 Selm, Federal Republic of Germany do hereby declare the invention for which I pray that a Patent may be granted to me and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to a magnetic separator, particularly for the treatment of liquid, pasty and dry mixtures.

A magnetic separator of this kind for the treatment of liquid mixtures is disclosed in the Austrian Patent No. 180 196. This known magnetic separator is provided with a stationary iron housing and a magnetically permeable iron collecting and discharge roll rotatably mounted in said housing and arranged in the magnetic field of a magnetic system being formed by the housing and at least one permanent magnet body. The collecting and discharge roll is positioned to be magnetically insulated in the iron housing to avoid any magnetic short circuit which would render the magnetic system practically magnetically ineffective. In the magnetic separator of said patent, the magnetic system thereof contains two air gaps, one being located between the collecting and discharge roll and the corresponding opposite part of the housing. This air gap is at the same time the operating air gap through which the material to be separated passes and in which the magnetizable parts of the material to be separated are collected and discharged by the collecting and discharge roll. The other air gap is located in the said magnetic separator at the point where the permanent magnets and/or their pole shoes are located with the poles facing away from the housing ahead of the collecting and discharge roll, their task being that of polarizing the collecting and discharge roll. With this air gap located adjacent to the separation area, it happens that it becomes encumbered with magnetizable impurities from the material to be separated. This causes disturbances, and sometimes even blocking, to the function of the magnetic separators, with the result that operational shut-downs occur not infrequently. Moreover, as is known, dissipation losses occur in air gaps, depending on their position relative to the magnets and on their size, which more or less weaken the magnetic field at the operating air gap, and thus exert an unfavourable influence on the effectiveness of the separating results. Moreover, and apart from said deficiencies of such separators, phenomena of demagnetization also occur in such and other magnetic separators which comprise a magnetic circuit interrupted by an operating air gap, and this contributes to a weakening of the magnet output of the magnetic separators over a period of time of usage of such magnetic separators.

It is the object of the present invention to provide a magnetic separator which effectively overcomes the problems and deficiencies in magnetic separators of the general type described above and as illustrated by magnetic separators such as are shown in the aforesaid Austrian Patent.

In accordance with the invention there is provided a magnetic separator device for separating magnetic material from a liquid, pasty or dry mixture of magnetic and non-magnetic materials, comprising a magnetic system having a magnetic roller form pole piece mounted in a casing of non-magnetic material and rotatably supported on a shaft of magnetic material, a further pole piece extending parallel to the shaft of the roller form pole piece and spaced from this latter to define a separating gap between both pole pieces, a set of permanent magnets disposed on the outside of the casing and magnetic circuit path means connecting these magnets with the pole pieces into a closed magnetic circuit in which the pole pieces are magnetized with opposite polarity.

This provides an effective means for concentrating the lines of force on and in the operating air gap, to keep the external leakage fields as low as possible and to avoid straying

effects outside the effective area of the magnetic separator as far as is reasonably possible.

The magnetic system preferably comprises one or more closed magnetic circuits, where the permanent magnets preferably are located outside the flow-through housing and have a high demagnetization resistance due to the course maintaining the magnetic lines of flux stable in the closed magnetic circuit with a simultaneous high magnetic concentration of the lines of force in the operating air gap. This means that the magnetic separator is practically free from straying effects and is, thus, equipped with the optimal magnetic field for the separation. Depending on the permanent magnetic material used and the soft magnetic iron types available with an iron induction of about 5000 to 6000 Gauss, practically complete saturation of the iron can be achieved at the operating air gap even with quite large gap widths.

The invention will now be described by way of example in conjunction with the embodiments of the invention shown in the accompanying drawings wherein,

Figure 1 is a perspective view, partly in section, showing a magnetic separator in accordance with the present invention, utilizing a separating roll and an antipole body,

Figure 2 is a schematic top view of Figure 1,

Figure 3 is a sectional view taken along the line III—III of Figure 1 looking in the direction of the arrows,

Figure 4 is a perspective view, partly in section, of a magnetic separator generally similar to that of Figure 1, but with a modified number of magnets in the magnetic system,

Figure 5 shows a perspective view, partly in section, of a magnetic separator according to the present invention but utilizing two separating rolls.

Figure 6 and 7 are schematic presentations, partly in section, of the magnetic separator of Figure 5, utilizing separating rolls of different designs,

Figure 8 is a schematic presentation, partly in section, of the magnetic separator of Figures 5 and 9, designed particularly for dry separation, and

Figure 9 is a perspective view of the magnetic separator generally according to Figure 5, but utilizing a further modified embodiment of the magnet system.

The magnetic separator which utilizes a magnetic roll and an antipole body of magnetically permeable material, such as iron, has, in the illustrative embodiment of Figure 1, two rectangular angle irons 1, 2 placed behind one another and also made from a magnetically permeable material, with a block-shaped permanent magnet 3 each arranged on a horizontal leg, and a pole 4 being mounted on the free pole end of each of said permanent magnets 3. The other or vertical legs of the angle irons 1, 2 are arcuately curved at the general level of the pole shoes 4 and toward the side.

The permanent magnets 3 have the same direction of magnetization, so that the pole shoes 4 have a North-polarity and the vertical legs of the angle irons 1 have a South-polarity. The magnetic material shaft 5 of the drum-shaped separating roll 6 is positioned in the pole shoes 4. The drum-shaped separating roll 6 rotates on ball bearings K which are pulled up on the shaft 5. Thus, the shaft 5 connects both pole shoes 4 over a certain distance with each other. At the same distance the free ends of the vertical legs of the angle irons 1, 2 at the level of their curvature are connected to a magnetic bridge 7. As a result of these connections 5, 7, a closed magnetic circuit is produced which extends continuously in each case from the one magnetic pole to the other one whereby the drum-shaped separating roll 6 is provided via the shaft 5 with the one polarity (N) and bridge 7 is provided with the opposite polarity (S). Thereby, the magnetic operating air gap A is located beween the bridge 7 and the separating roll 6. For the practical utilization of the operating air gap A, particularly for the separation of liquid materials, a non-magnetic vat 8 is inserted into the interstice between the angle irons 1, 2 which adheres to the bridge 7 and for the remainder it embraces the separating roll 6 from the side of the bridge 7 as far as the opposite side, in fact approximately as far as half the height to form a flow-through channel 30 for the material to be separated with said distance. At its sides placed transversely to the flow-through channel 30 and at the discharge side of the collected material to be separated, the vat 8 is sealed by non-magnetic panels 9, 10, 11 and cooperating therewith for tight sealing is a sealing ring D. A conventional stripping member or panel 12 is placed on the panel 11 and on the separating roll 6. The liquid to be separated enters the vat 8 at the side of the bridge 7, passes through the flow-through channel 30 and leaves the vat 8 at 13 magnetically purified. The separation takes place in the gap A, where the opposite poles, the separating roll 6 polarized by the segment-shaped shaft 5 and the bridge are most proximally opposite each other. Here the magnetic field, which is completely closed except for the gap A, is practically homogeneous, while in the flow-through direction of the material to be separated it gradually weakens and becomes non-homogeneous. The material collected by the separating roll 6 is discharged in the direction of rotation indicated by the arrow, and stripped by the stripper 12.

Figure 4 likewise shows a magnetic separator with a separating roll 6 and a bridge 7 as an antipole body, but with the difference

that, in place of the angle irons 1, 2 plates 18, conducting the magnetism are provided, an additional permanent magnet 14 being arranged adjacent the permanent magnets 3 with pole shoes 4 on said plates with opposte directions of magnetization. The permanent magnets 14 bear the pole shoes 32. As in the case of the angle irons 1, 2, they are interconnected by the bridge 7. The plate 18 acts as a magnetic short circuit plate, by interconnecting on the one hand the opposite poles of the permanent magnets 3, 14. The presence of the permanent magnets 14 has no effect proper on the described entirely closed magnetic circuit, but serves simply to amplify the magnetic force of the magnetic separator, depending on the requirements to be met by the magnetic forces involved in the separation.

Figure 5 shows another embodiment of a magnetic separator constructed according to the invention where, instead of the separating roll 6 and a bridge 7, two separating rolls are employed. In this embodiment, the bridge 7 has been replaced by the separating roll 16 with the shaft 22 whereby the magnetic system also has on each side of the flow-through housing two permanent magnets 3, 17 likewise arranged on a common base plate 18 of iron material conducting the magnetism, and equipped on the oppohite pole side with the pole shoes 4, 20. Using a corresponding design of the flow-through housing 9, 10, 11 which in this case is not a vat 8, the material to be separated enters the flow-through housing 9, 10, 11 at the inlet port 19. The non-magnetic material leaves the flow-through housing 9, 10, 11 at the discharge port 31. The separating rolls 6, 16 which may have solid shaft 5, 22 (see Figure 7) or segments (see Figure 6) as shafts, about which in a manner known from the prior art the drum-shaped separating rolls 6, 16 made from magnetic or non-magnetic material or alternately from both materials, rotate in the directions of the arrow, also separate the collected magnetic material via strippers 12. In Figure 8 distribution bodies 21 are provided in relation to the separating rolls 6, 16 which are placed opposite each other with likewise segment-shaped shaft 5, 22 of 180° in gap A in a precise manner, and located in the flow-through housing 9, 10, 11. They separate the non-magnetic material, which drops down directly through the gap A, from the magnetic material which is conveyed by the separating rolls 6, 16 out of the magnetic zone where it drops off from the separating rolls 6, 16 where the segments of the shafts 5, 22 are no longer magnetically effective. Then the magnetic material leaves the flow-through housing 9, 10, 11 through the openings 15. The shafts, 5, 22 are adjustable in their bearings from the outside, and so are thus their segments within the area of the gap A.

Finally, for the amplification of the magnetic system or the magnetic separator a modification can be utilized whereby additional permanent magnets 23, 24 are associated on both sides of he flow-through housing on the pole shoes 20, 4 (see Figure 9) in a direction of magnetization opposite to the permanent magnets 3, 17 so that the pole shoes 20, 4 in each case receive a double polarization from two identical magnetic poles. The additional permanent magnets 23, 24 also are covered by an iron plate 25 conducting the magnetism. Then the magnetic system comprises two frame-like individual systems. Each individual system has an individually closed magnetic circuit which is connected via the shafts 22, 5 or the bridge 7 and the shaft 5 to form a double magnetic system and accordingly amplify the magnetic field in the gap A to an even larger extent.

The separating roll 6 and/or the separating rolls 6, 16 are propelled by a conventional drive means (not shown) which may, for instance, comprise a motor and conventional gearing.

The plates 18 located on both sides of the flow-through housing 9, 10, 11 also may be connected between each other in a magnetically conductive manner without thereby changing the prevailing directions of magnetization and/or causing deviations in the course of the magnetic lines of force. Such a connecting plate 33, as indicated by dots and dashes in Figure 4, may be provided below the flow-through housing 9, 10, 11.

A switch 26 is used for controlling the prevailing height of the level of the material to be separated, insofar as it is liquid. It is actuated by contact with liquid, whereby the separating roll 6 or the separating rolls 6, 16 will be put into rotation until the passage cross-section in the flow-through housing 9, 10, 11 again has enlarged due to the discharge of the collected parts, and the fluid level again has dropped below the switch 26.

It is apparent that the magnetic separator described herein may undergo various modifications with reference to the magnetic system and the flow-through housing including, for example, modifications to the dimensions, shapes and cross-sections, as well as in the sizes and number of the magnets, without in any way departing from the principle and teachings disclosed herein.

WHAT I CLAIM IS:—

1. A permanent magnetic separator device for separating magnetic material from a liquid, pasty or dry mixture of magnetic and non-magnetic materials, comprising a magnetic system having a magnetic roller form pole piece mounted in a casing of non-magnetic material and rotatably supported on a shaft of magnetic material, a further pole piece ex-

tending parallel to the shaft of the roller form pole piece and spaced from this latter to define a separating gap between both pole pieces, a set of permanent magnets disposed on the outside of the casing and magnetic circuit path means connecting these magnets with the pole pieces into a closed magnetic circuit in which the pole pieces are magnetised with opposite polarity.

2. A permanent magnetic separator device as claimed in claim 1, wherein the magnetic system includes two permanent magnets disposed on opposite sides of the casing and each being provided with a pole shoe in the form of a bearing for supporting one end of the shaft of said roller form pole piece and the magnetic circuit path means comprises two angle-shaped magnetic support members, each being arranged with one leg thereof extending downwardly from one end of said further pole piece and the other leg thereof extending horizontally and supporting a permanent magnet and pole shoe assembly, the permanent magnets of both said assemblies being arranged with like poles disposed towards the horizontal legs of said support members.

3. A permanent magnetic separator device as claimed in claim 1, wherein the magnetic system includes four permanent magnets arranged in two pairs on opposite sides of the casing, one magnet of each pair on the same side of the casing being provided with a pole shoe in the form of a bearing for supporting one end of the shaft of said roller form pole piece and the other magnets of said pairs each being provided with a pole shoe connecting the magnet to one end of said further pole piece and the magnets of each pair on the same side of the casing are fixed on a rod-shaped supporting member with opposite poles disposed towards said member.

4. A permanent magnetic separator device as claimed in claim 1, 2 or 3, wherein the magnetic system includes eight permanent magnets arranged in two sets of four magnets each on opposite sides of the casing, the four magnets of each set on the same side of the casing being arranged in two pairs, each having a common pole shoe disposed between like poles of the associated magnet pair, said like poles being different for each pair and said common pole shoes connecting the associated magnet pairs to one end of the shaft of the roller form pole piece and one end of said further pole piece respectively and the magnetic circuit path means comprises four rod-shaped supporting members, each being horizontally disposed so as to connect the free opposite poles of two permanent magnets associated with different pole shoes on the same side of the casing.

5. A permanent magnetic separator device as claimed in any preceding claim, wherein said further pole piece is also a magnetic roller form pole piece mounted in said casing and rotatably supported on a shaft of magnetic material, the pole shoes of the magnetic system connecting the permanent magnets to said further roller form pole piece also being in the form of bearings supporting the free ends of the shaft of said pole piece.

6. A permanent magnetic separator device as claimed in claim 2, wherein the horizontal legs of said angle-shaped supporting members are constituted by parallel border portions of a common magnetic mounting plate of the device.

7. A permanent magnetic separator device as claimed in claim 3 or 4 or claim 5 when appendant to claim 3 or 4, wherein the horizontal supporting members of said magnetic circuit path means disposed adjacent to the lower side of the device are constituted by parallel border portions of a common magnetic mounting plate of the device.

8. A permanent magnetic separator device as claimed in any preceding claim, wherein the shaft of each roller form pole piece has a solid cylindrical shape both inside and outside said pole piece.

9. A permanent magnetic separator device as claimed in any of claims 1 to 7, wherein the shaft of each roller form pole piece inside said pole piece has a segmental cross-section.

10. A magnetic separator substantially as hereinbefore described with reference to and as shown in Figures 1 to 4 of the accompanying drawings.

11. A magnetic separator substantially as hereinbefore described with reference to and as shown in Figures 5 and 8 of the accompanying drawings.

12. A magnetic separator substantially as hereinbefore described with reference to and as shown in Figure 6 of the accompanying drawings.

13. A magnetic separator substantially as hereinbefore described with reference to and as shown in Figure 7 of the accompanying drawings.

14. A magnetic separator substantially as hereinbefore described with reference to and as shown in Figure 9 of the accompanying drawings.

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1580833 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG.1

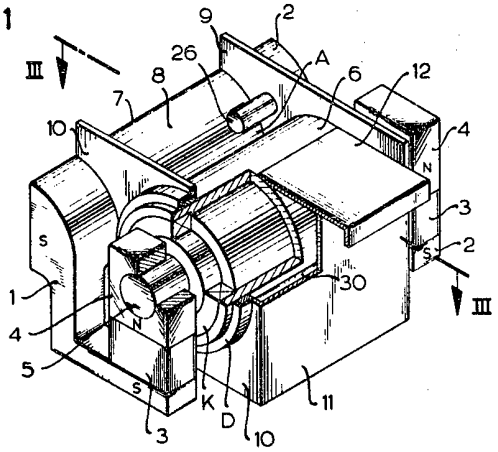


FIG. 2

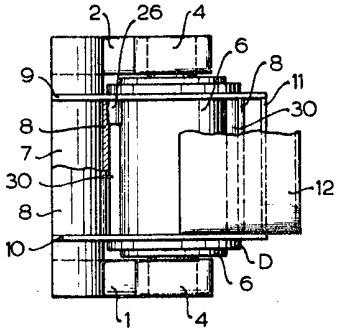


FIG.3

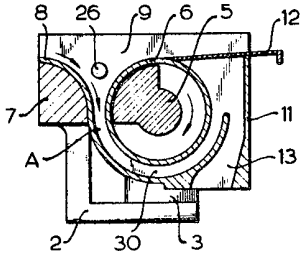
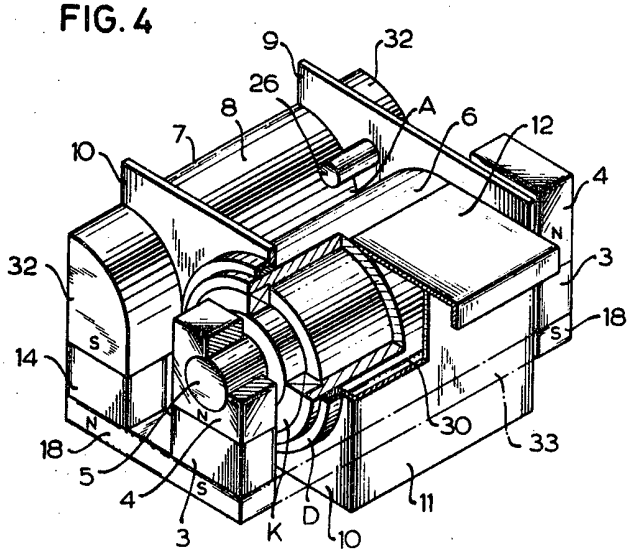


FIG. 4



1580833 COMPLETE SPECIFICATION
4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3

FIG.5

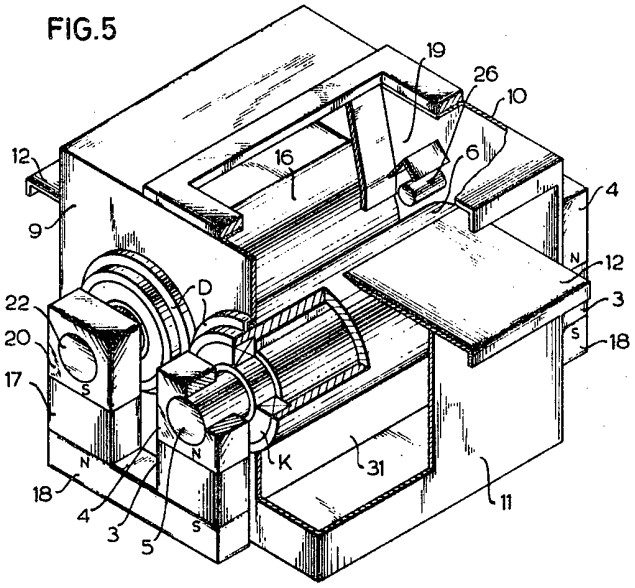


FIG.6

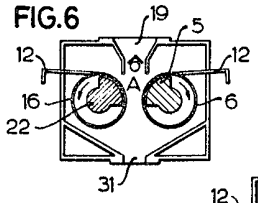


FIG.8

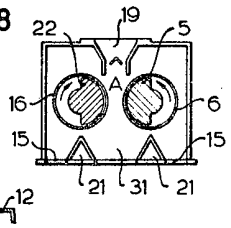


FIG.7

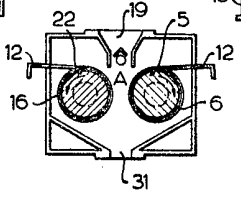


FIG.9