

May 15, 1956

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2,745,549

MAGNETIC SEPARATOR

Filed Aug. 23, 1954

2 Sheets-Sheet 1

Fig 1

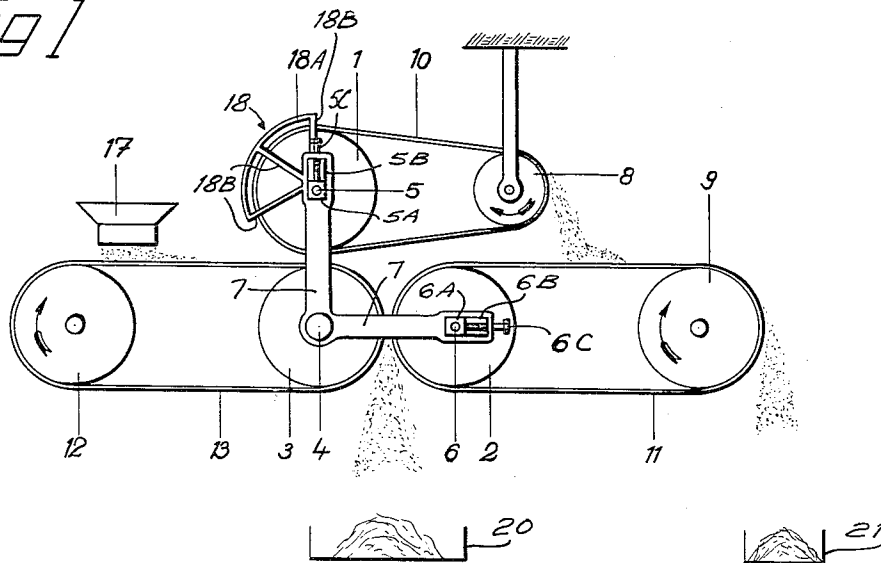
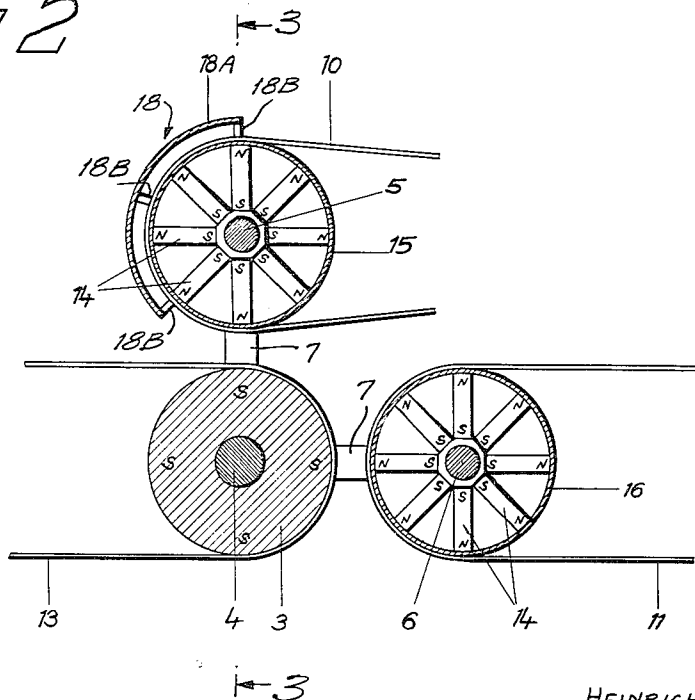


Fig 2



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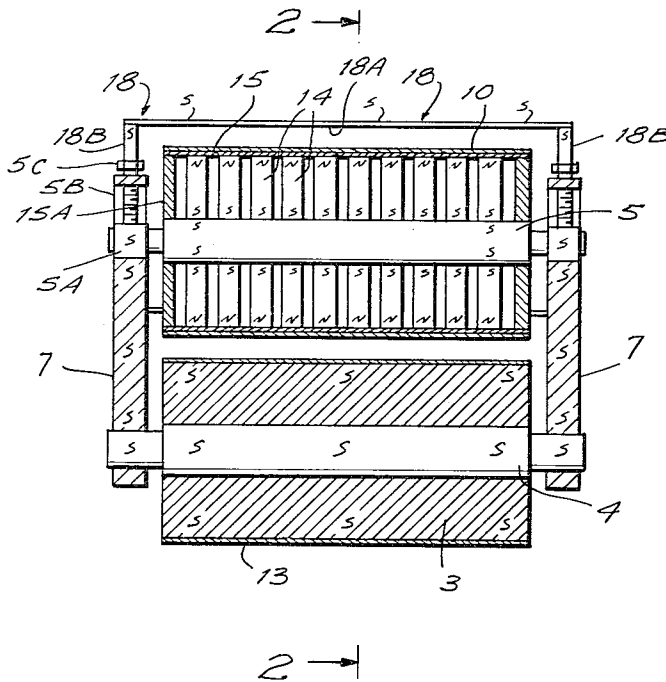
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MAGNETIC SEPARATOR

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2 Sheets-Sheet 2

Fig 3



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MAGNETIC SEPARATOR

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Application August 23, 1954, Serial No. 451,515

16 Claims. (Cl. 209—219)

This invention relates to magnetic separators.

More particularly, this invention relates to a magnetic separator in which conveyor means convey a substance containing magnetic particles to be separated from the substance to an area or space which is under the influence of a magnetic field.

There exist known magnetic separators of the endless-band or conveyor belt type which make use of magnetic rollers having permanent magnets associated therewith. The arrangement is usually such that the periphery portions of the magnetic rollers are exposed to both poles of permanent magnets so that such periphery portions have parts thereof of one magnetic polarity and parts thereof of another magnetic polarity.

A substance containing magnetic particles, i. e. particles of magnetically permeable material, which are to be separated from the substance is passed near the periphery portions of the rollers and is thus exposed to the stray or leakage field generated or induced by such periphery portions. While these magnetic fields may be relatively strong at points near the roller peripheries, they are sharply decreased in strength at points further away from the periphery portions. Consequently, when a substance containing magnetic particles is passed through a magnetic field generated by a magnetic roller of the type used in known separators, magnetic particles lying relatively close to the surface of the substance will be attracted by the magnetic rollers whereas magnetic particles lying more deeply within the substance will not be attracted.

It is, therefore, one of the objects of the present invention to overcome the above disadvantages by providing a magnetic separator wherein a substance containing magnetic particles to be separated from the substance is passed through a closed or self-contained magnetic field.

It is also an object of this invention to provide a magnetic separator capable of separating magnetic particles from non-magnetic particles, which separator is of sturdy construction, yet inexpensive to build and to maintain in operation.

It is another object of this invention to provide a magnetic separator which is extremely efficient in its separation of magnetic particles from non-magnetic particles.

It is still another object of the present invention to provide a roller for a magnetic separator, the outer surface of which roller has a predetermined magnetic polarity.

It is yet another object of the present invention to provide a magnetic separator which is adapted to receive a substance containing magnetic particles to be separated from the substance, to separate such magnetic particles from the substance, and to deliver the magnetic particles to one receptacle and the remaining non-magnetic particles to another receptacle.

Also, one of the objects of the invention is the provision of an adjustable magnetic field for separating magnetic particles from a substance containing such magnetic particles.

This invention further contemplates the provision of a roller for a magnetic separator, the outer surface of which roller has a predetermined magnetic polarity, which roller is furnished with a magnetic structure adapted to increase the force with which magnetic particles are attracted and retained by the roller.

With the above objects in view the present invention mainly consists of a magnetic separator having a mag-

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netic support which supports first, second and third magnetic shafts. The second shaft is spaced from and co-extensive with at least a portion of the first shaft, and the third shaft is spaced from and co-extensive with at least a portion of the second shaft.

A first roller having a periphery portion of one magnetic polarity and a central or axis portion of the opposite magnetic polarity is mounted along the axis portion thereof on the first shaft for rotational movement relative to the support, the first shaft being of this opposite polarity.

A second roller having a periphery portion and a central or axis portion is mounted along the axis portion thereof on the second shaft for rotational movement relative to the support, the magnetic polarity of the periphery portion and axis portion of the second roller being of similar magnetic polarity. The combined radii of the first and second rollers are smaller than the distance between the first and second shafts so that a space is provided between the periphery portions of the first and second rollers. The support transmits the opposite polarity of the first shaft to the second shaft so that the axis portion and periphery portion of the second roller are of the opposite polarity whereby lines of magnetic flux pass through the space between periphery portions of the first and second rollers.

A third roller having a periphery portion of the one magnetic polarity and a central or axis portion of the opposite magnetic polarity is mounted along the axis portion thereof on the third shaft for rotational movement relative to the support, the third shaft being of the opposite polarity. The combined radii of the second and third rollers are smaller than the distance between the second and third shafts so that a space is provided between the periphery portions of the second and third rollers whereby lines of magnetic flux pass through the space between the periphery portions of the second and third rollers.

First adjusting means are operatively associated with the first shaft for varying the distance between the first shaft and the second shaft and consequently the space between the periphery portions of the first and second rollers so as to vary the number of lines of magnetic flux passing through the space between the periphery portions of the first and second rollers.

Also, second adjusting means are operatively associated with the third shaft for varying the distance between the second shaft and the third shaft and consequently the space between the periphery portions of the second and third rollers so as to vary the number of lines of magnetic flux passing through the space between the periphery portions of the second and third rollers.

First conveyor means are operatively associated with the periphery portion of the second roller for passing a substance containing magnetic particles to be separated from the substance, consecutively, through the space between the periphery portions of the first and second rollers and through the space between the periphery portions of the second and third rollers so that when a substance containing magnetic particles is passed through the space between the periphery portions of the first and second rollers magnetic particles will be attracted by the periphery portion of the first roller and when the substance containing magnetic particles is passed through the space between the periphery portions of the second and third rollers magnetic particles will be attracted by the periphery portion of the third roller.

Second conveyor means are operatively associated with the periphery portion of the third roller for conveying away from the periphery portion of the third roller magnetic particles attracted by the periphery portion of the third roller.

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Third conveyor means are operatively associated with the periphery portion of the first roller for conveying away from the periphery of the first roller and to the second conveyor means magnetic particles attracted by the periphery portion of the first roller whereby the magnetic particles attracted by the periphery portions of both the first and third rollers are conveyed by the second conveyor means.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a schematic side view of a preferred embodiment of this invention;

Fig. 2 is a fragmentary schematic sectional view taken along line 2—2 of Fig. 3; and

Fig. 3 is a sectional view taken along line 3—3 of Fig. 2.

Referring now to the drawings, there is shown a support made of magnetic or magnetically permeable material, such as iron, comprising two angular-shaped brackets 7. Three shafts, also made of a magnetic or magnetically permeable material, interconnect the brackets, the shaft 4 being connected to the apexes of the brackets and the shafts 5 and 6 being disposed, in each bracket 7, in slidable supports 5A and 6A, respectively, these supports being movably mounted in elongated slots 5B and 6B formed near the free ends of each bracket 7. By means of screws 5C and 6C the supports 5A and 6A may be moved toward and away from the apexes of the brackets 7.

In the preferred embodiments the arrangement is such that the shafts 4 and 5 lie in a common vertical plane and the shafts 4 and 6 lie in a common horizontal plane. It will be understood, however, that the angular-shaped brackets 7 need not be of right angle configuration, such as is shown in Figs. 1 and 2, and that the shafts 4, 5 and 4, 6 need not necessarily lie in common vertical or horizontal planes.

The shafts 4, 5 and 6 carry rollers 3, 1 and 2 respectively. Rollers 1 and 2, which may be of similar construction, comprise hollow cylindrical or tubular members 15, 16 respectively. A plurality of permanent bar magnets 14 emanate radially from the shafts 5 and 6, and are arranged so that like poles of all the magnets are the inner ends of the spoke-like bar magnets 14 and like poles of all the magnets are the outer ends. In the drawings, the inner ends have been indicated as S and the outer ends have been indicated as N.

The bar magnets may be fixedly mounted to both the shafts 5, 6 and to the tubular members 15, 16. These shafts may be rotatably mounted with respect to the support brackets 7 so that each roller includes a shaft, bar magnets which act as spokes, and a tubular member which acts as the outer portion of the roller. It will be understood, however, that the bar magnets need not act as spokes in that they need not give physical support to the tubular member with respect to the shaft but that this function may be accomplished by additional spokes or spoke-like members (not shown).

Alternatively, the shafts may be fixedly mounted to the support brackets 7 so that the shafts do not rotate with respect thereto. The bar magnets 14 may then either be fixedly secured to the shaft only so that the outer ends of the bar magnets form a supporting surface for rotatably mounting the tubular or cylindrical members, or the bar magnets may be fixedly secured to the tubular or cylindrical members only so that the inner ends of the bar magnets form a hub, or central or axis portion, about which the rollers, which then include the

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tubular or cylindrical members and the bar magnets, may rotate.

The tubular members 15, 16 may also be provided with end faces, such as end faces 15A (see Fig. 3), fixedly secured thereto. These end faces may be rotatably mounted with respect to the shafts so that the tubular members will be supported by the end faces for rotational movement with respect to the support brackets 7. According to this last-mentioned arrangement, the end faces form the sole support means for mounting the tubular members for rotational movement with respect to the supporting brackets 7 so that the bar magnets 14 need not be relied on to provide physical support for providing rotational movement for the tubular members. The bar magnets may therefore be fixedly mounted either to the shafts or to the tubular members.

The roller 3 is a substantially solid roller made of magnetic or magnetically permeable material and is supported by the shaft 4 for rotational movement with respect to the brackets 7. The roller 3 may either be fixedly mounted to the shaft 4 which shaft would then be mounted for rotational movement with respect to the brackets 7, or the roller may be mounted for free rotational movement on the shaft 4 which would then be fixedly secured to the brackets 7.

The combined radii of the rollers 1 and 3 are smaller than the distance between the axis of shafts 4 and 5 so that a space is formed between the periphery portions of these two rollers. The adjustment mechanism 5A, 5B, 5C makes it possible to vary the distance between the shafts 4 and 5 and consequently the space between the periphery portions of rollers 1 and 3. Similarly, the distance between the periphery portions of the rollers 2 and 3 may be varied.

A conveyor band or belt 10 runs about the roller 1 and a driving roller 8, which drives the conveyor band in the direction indicated by the arrow. Another conveyor band 13 runs about the roller 3 and a driving roller 12, and still another conveyor band 11 runs about the roller 2 and a driving roller 9, the driving rollers 12 and 9 driving the bands 13 and 11 in the directions indicated in the drawing. The conveyor bands or belts 10, 11 and 13 may be made of any suitable material, either magnetic or nonmagnetic. Suitable drive means may be used to rotate the driving pulleys 8, 9 and 12.

A substance containing magnetic particles to be separated from the substance is fed from a hopper 17 onto the conveyor band 13 and is moved toward the rollers.

As will be understood by persons skilled in the art, a magnetic field will be generated between the periphery portions of rollers 1 and 3 and between the periphery portions of rollers 2 and 3.

Considering now in particular the magnetic field between rollers 1 and 3, the magnetic polarity of the periphery portion of roller 1, i. e. the outer surface of the tubular or cylindrical member 15 may be designated as N as shown in Figs. 2 and 3. The magnetic polarity of the central or axis portion of the roller 1, and consequently the magnetic polarity of the shaft 5 may therefore be designated as S. The S polarity is transmitted from the shaft 5 through the brackets 7 to the shaft 4 and hence to the roller 3. As a result the magnetic polarity of the periphery portion of the roller 1 is N while the magnetic polarity of the shaft 5, the brackets 7, the shaft 4 and the roller 3, including the periphery portion thereof, is S. Lines of magnetic flux will therefore cross not only the space formed between the periphery portions of rollers 1 and 3 but also the spaces formed between the periphery portion of roller 1 and the shaft 4, the periphery portion of roller 1 and both brackets 7, and the periphery portion of the roller 1 and the shaft 5. It will be obvious that in the plane containing the axes of shafts 4 and 5 a greater number of lines of magnetic flux will cross the periphery portion of roller 1 than will cross the periphery portion of roller 3. The

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N polarity of the periphery portion of the roller 1 will therefore be greater than the S polarity of the periphery portion of roller 3 and consequently any magnetic particles coming under the influence of the magnetic field between the two periphery portions will be attracted by the periphery portion of the roller 1.

In this manner, it is possible to obtain a closed or self-contained magnetic field. By arranging the bar magnets 14, the rollers and the supporting brackets 7 in the manner shown there will be no stray or leakage magnetic field and it is therefore possible to obtain an extremely efficient magnetic separator capable of making the best use of the magnet means relied on for establishing the magnetic field.

It will also be understood that the magnet means may include radially magnetized annular magnet for imparting opposite magnetic polarities to the outer and axis portions of the rollers.

When the substance containing magnetic particles to be separated from the substance is moved through the space formed between the periphery portions of rollers 1 and 3, magnetic particles will be attracted by roller 1 in the manner set forth above. The particles thus attracted by roller 1 are received by the conveyor band 10 and moved clockwise about the axis of the roller 1 and away from the periphery portion of the roller after the particles have reached their uppermost position on the roller 1, as viewed in Figs. 1 and 2.

The substance less the particles attracted by roller 1 is then passed between the space formed between rollers 2 and 3. The periphery portion of roller 2 will attract any remaining magnetic particles that were not attracted by roller 1 as the substance was passed through the space between rollers 1 and 2. The manner in which the periphery portion of roller 2 attracts magnetic particles is similar to that described in connection with roller 1. It will be seen that inasmuch as the substance has begun more or less free fall through the space formed between the periphery portions of rollers 2 and 3, even deeply embedded particles or particles of material of relatively low magnetic permeability will be attracted by roller 2.

As has been described above, the space between the periphery portions of rollers 1, 3 and 2, 3 may be adjusted so that the strength of the magnetic fields between the periphery portions of the rollers may be adjusted, as desired.

The particles thus attracted by roller 2 are received by the conveyor band 11 and moved clockwise about the axis of the roller 2 and away from the periphery portion of the roller after the particles have reached their uppermost position on the roller 2, as viewed in Figs. 1 and 2.

As is clearly shown in the drawing, the non-magnetic particles drop into a receptacle 20 and the magnetic particles attracted by roller 2 are conveyed by conveyor 11 and ultimately drop into a receptacle 21. According to the preferred embodiment, the magnetic particles attracted by roller 1 are conveyed onto the conveyor band 11 so that conveyor band 11 will then convey all of the magnetic particles attracted by both rollers 1 and 2. As a result all magnetic particles are collected in one receptacle.

It will be understood that the arrangement of the conveyor bands can be such that the particles attracted by roller 1 need not be mixed with the particles attracted by roller 2 but may be transported to a separate receptacle. Also, the conveyor bands need not run substantially horizontally but may be disposed to convey the separated particles upwardly, downwardly or diagonally, as may suit the requirement of the particular operation.

The roller 2 together with its conveyor band 11 may be dispensed with and an efficient magnetic separator may be obtained by relying only on the magnetic field existing

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between rollers 1 and 3. If desired, stripping or peeling means may be associated with the conveyor bands so as to insure complete removal of particles therefrom.

In order to increase the magnetic attraction acting on particles already attracted by roller 1 while these particles move from their lowermost position clockwise to the uppermost position on roller 1, a magnetic structure 18 may be provided.

The magnetic structure 18 may be a cage-like arrangement fixedly mounted to the brackets 7 nearer the free ends thereof which support the roller 1. The cage 18 has an arcuate portion 18A having a curved surface concentric with and spaced from the outer periphery portion of the roller 1, which arcuate portion 18A is supported by a plurality of radial support members 18B. The magnetic polarity of the entire cage 18 will be the same as that of the support brackets 7, i. e., S. Consequently, it is obvious that a closed or self-contained magnetic field is set up between the periphery of roller 1 and the cage 18, and that in any radial plane passing through the axis of shaft 5 and cage 18 more lines of magnetic flux will pass through the periphery portion of roller 1 than through the curved surface of the arcuate portion 18A. The N polarity of the periphery of the roller 1 will therefore be greater than the S polarity of the curved surface of the arcuate portion 18A and any magnetic particles already attracted by the periphery portion of roller 1 and carried by the conveyor band 10 will be even more strongly and more firmly held against the band 10.

While a magnetic separator, as described in this application, may be advantageously employed for many functions, it is particularly useful in separations involving granulated material or materials in which it is desired to separate particles having a relatively low magnetic permeability, particularly ceramic materials.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of magnetic separators differing from the types described above.

While the invention has been illustrated and described as embodied in a magnetic separator of the endless band or conveyor belt type, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a magnetic separator, in combination, a magnetic structure having a supporting face; magnet means having a first pole and an opposite pole associated with said magnetic structure for imparting the magnetic polarity of said opposite pole to said magnetic structure, said magnet means being located so that a space is formed between said supporting face of said magnetic structure and said first pole of said magnet means so that lines of magnetic flux cross the space between said supporting face of said magnetic structure and said first pole of said magnet means; and mechanical transport means for passing a substance containing magnetic particles to be separated from the substance through the space formed between said supporting face of said magnetic structure and said first pole of said magnet means so that when the substance containing magnetic particles is passed through the space formed between said supporting face of said magnetic structure and said first pole of said magnet means, the magnetic particles will be attracted by said first

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for passing a substance containing magnetic particles to be separated from the substance through the space between said periphery portions of said first and second rollers so that when the substance containing magnetic particles is passed through the space between said periphery portions of said first and second rollers, the magnetic particles will be attracted by said periphery portion of said first roller.

5. In a magnetic separator, in combination, a magnetic support; a first magnetic shaft supported by said support; a second magnetic shaft supported by said support, said second shaft being spaced from and co-extensive with at least a portion of said first shaft; a third magnetic shaft supported by said support, said third shaft being spaced from and co-extensive with at least a portion of said second shaft; a first roller having a periphery portion of one magnetic polarity and an axis portion of the opposite magnetic polarity, said first roller being mounted along said axis portion thereof on said first shaft for rotational movement relative to said support so that said first shaft is of said opposite polarity; a second roller having a periphery portion and an axis portion, the magnetic polarities of said periphery portion thereof and said axis portion thereof being similar, said second roller being mounted along said axis portion thereof on said second shaft for rotational movement relative to said support, the combined radii of said first and second rollers being smaller than the distance between said first and second shafts so that a space is provided between said periphery portions of said first and second rollers, said support transmitting said opposite polarity of said first shaft to said second shaft so that said axis portion and said periphery portion of said second roller is of said opposite polarity, whereby lines of magnetic flux pass through the space between said periphery portions of said first and second rollers; and a third roller having a periphery portion of said one magnetic polarity and an axis portion of said opposite magnetic polarity, said third roller being mounted along said axis portion thereof on said third shaft for rotational movement relative to said support, said third shaft being of said opposite polarity, the combined radii of said second and third rollers being smaller than the distance between said second and third shafts so that a space is provided between said periphery portions of said second and third rollers, whereby lines of magnetic flux pass through the space between said periphery portions of said second and third rollers.

6. In a magnetic separator, in combination, a magnetic support; a first magnetic shaft supported by said support; a second magnetic shaft supported by said support, said second shaft being spaced from and co-extensive with at least a portion of said first shaft; a third magnetic shaft supported by said support, said third shaft being spaced from and co-extensive with at least a portion of said second shaft; a first roller having a periphery portion of one magnetic polarity and an axis portion of the opposite magnetic polarity, said first roller being mounted along said axis portion thereof on said first shaft for rotational movement relative to said support so that said first shaft is of said opposite polarity; a second roller having a periphery portion and an axis portion, the magnetic polarities of said periphery portion thereof and said axis portion thereof being similar, said second roller being mounted along said axis portion thereof on said second shaft for rotational movement relative to said support, the combined radii of said first and second rollers being smaller than the distance between said first and second shafts so that a space is provided between said periphery portions of said first and second rollers, said support transmitting said opposite polarity of said first shaft to said second shaft so that said axis portion and said periphery portion of said second roller is of said opposite polarity, whereby lines of magnetic flux pass through the space between said periphery portions of said first and second rollers; a third roller having a periphery portion

of said one magnetic polarity and an axis portion of said opposite magnetic polarity, said third roller being mounted along said axis portion thereof on said third shaft for rotational movement relative to said support, said third shaft being of said opposite polarity, the combined radii of said second and third rollers being smaller than the distance between said second and third shafts so that a space is provided between said periphery portions of said second and third rollers, whereby lines of magnetic flux pass through the space between said periphery portions of said second and third rollers; and conveyor means operatively associated with said first, second and third rollers for passing a substance containing magnetic particles to be separated from the substance through the space between said periphery portions of said first and second rollers and through the space between said periphery portions of said second and third rollers so that when the substance containing magnetic particles is passed through the space between said periphery portions of said first and second rollers the magnetic particles will be attracted by said periphery portion of said first roller and when the substance containing magnetic particles is passed through the space between said periphery portions of said second and third rollers, the magnetic particles will be attracted by said periphery portion of said third roller.

7. In a magnetic separator, in combination, a magnetic support; a first magnetic shaft supported by said support; a second magnetic shaft supported by said support, said second shaft being spaced from and co-extensive with at least a portion of said first shaft; a first roller having a periphery portion of one magnetic polarity and an axis portion of the opposite magnetic polarity, said first roller being mounted along said axis portion thereof on said first shaft for rotational movement relative to said support so that said first shaft is of said opposite polarity; a second roller having a periphery portion and an axis portion, the magnetic polarities of said periphery portion thereof and said axis portion thereof being similar, said second roller being mounted along said axis portion thereof on said second shaft for rotational movement relative to said support, the combined radii of said first and second rollers being smaller than the distance between said first and second shafts so that a space is provided between said periphery portions of said first and second rollers, said support transmitting said opposite polarity of said first shaft to said second shaft so that said axis portion and said periphery portion of said second roller is of said opposite polarity, whereby lines of magnetic flux pass through the space between said periphery portions of said first and second rollers; and adjusting means operatively associated with one of said shafts for varying the distance between said first shaft and said second shaft and consequently the space between said periphery portions of said first and second rollers so as to vary the number of lines of magnetic flux passing through the space between said periphery portions of said first and second rollers.

8. In a magnetic separator, in combination, a magnetic support; a first magnetic shaft supported by said support; a second magnetic shaft supported by said support, said second shaft being spaced from and co-extensive with at least a portion of said first shaft; a third magnetic shaft supported by said support, said third shaft being spaced from and co-extensive with at least a portion of said second shaft; a first roller having a periphery portion of one magnetic polarity and an axis portion of the opposite magnetic polarity, said first roller being mounted along said axis portion thereof on said first shaft for rotational movement relative to said support so that said first shaft is of said opposite polarity; a second roller having a periphery portion and an axis portion, the magnetic polarities of said periphery portion thereof and said axis portion thereof being similar, said second roller being mounted along said axis portion thereof on said

second shaft for rotational movement relative to said support, the combined radii of said first and second rollers being smaller than the distance between said first and second shafts so that a space is provided between said periphery portions of said first and second rollers, said support transmitting said opposite polarity of said first shaft to said second shaft so that said axis portion and said periphery portion of said second roller is of said opposite polarity, whereby lines of magnetic flux pass through the space between said periphery portions of said first and second rollers; a third roller having a periphery portion of said one magnetic polarity and an axis portion of said opposite magnetic polarity, said third roller being mounted along said axis portion thereof on said third shaft for rotational movement relative to said support, said third shaft being of said opposite polarity, the combined radii of said second and third rollers being smaller than the distance between said second and third shafts so that a space is provided between said periphery portions of said second and third rollers, whereby lines of magnetic flux pass through the space between said periphery portions of said second and third rollers; first adjusting means operatively associated with said first shaft for varying the distance between said first shaft and said second shaft and consequently the space between said periphery portions of said first and second rollers so as to vary the number of lines of magnetic flux passing through the space between said periphery portions of said first and second rollers; and second adjusting means operatively associated with said third shaft for varying the distance between said second shaft and said third shaft and consequently the space between said periphery portions of said second and third rollers so as to vary the number of lines of magnetic flux passing through the space between said periphery portions of said second and third rollers.

9. In a magnetic separator, in combination, a magnetic support; a first magnetic shaft supported by said support; a second magnetic shaft supported by said support, said second shaft being spaced from and co-extensive with at least a portion of said first shaft; a third magnetic shaft supported by said support, said third shaft being spaced from and co-extensive with at least a portion of said second shaft; a first roller having a periphery portion of one magnetic polarity and an axis portion of the opposite magnetic polarity, said first roller being mounted along said axis portion thereof on said first shaft for rotational movement relative to said support so that said first shaft is of said opposite polarity; a second roller having a periphery portion and an axis portion, the magnetic polarities of said periphery portion thereof and said axis portion thereof being similar, said second roller being mounted along said axis portion thereof on said second shaft for rotational movement relative to said support, the combined radii of said first and second rollers being smaller than the distance between said first and second shafts so that a space is provided between said periphery portions of said first and second rollers, said support transmitting said opposite polarity of said first shaft to said second shaft so that said axis portion and said periphery portion of said second roller is of said opposite polarity, whereby lines of magnetic flux pass through the space between said periphery portions of said first and second rollers; a third roller having a periphery portion of said one magnetic polarity and an axis portion of said opposite magnetic polarity, said third roller being mounted along said axis portion thereof on said third shaft for rotational movement relative to said support, said third shaft being of said opposite polarity, the combined radii of said second and third rollers being smaller than the distance between said second and third shafts so that a space is provided between said periphery portions of said second and third rollers, whereby lines of magnetic flux pass through the space between said periphery portions of said second and third rollers; first adjusting means operatively associated with said first shaft for varying

the distance between said first shaft and said second shaft and consequently the space between said periphery portions of said first and second rollers so as to vary the number of lines of magnetic flux passing through the space between said periphery portions of said first and second rollers; second adjusting means operatively associated with said third shaft for varying the distance between said second shaft and said third shaft and consequently the space between said periphery portions of said second and third rollers so as to vary the number of lines of magnetic flux passing through the space between said periphery portion of said second and third rollers; and conveyor means operatively associated with said first, second and third rollers for passing a substance containing magnetic particles to be separated from the substance through the space between said periphery portions of said first and second rollers and through the space between said periphery portions of said second and third rollers so that when the substance containing magnetic particles is passed through the space between said periphery portions of said first and second rollers the magnetic particles will be attracted by said periphery portion of said first roller and when the substance containing magnetic particles is passed through the space between said periphery portions of said second and third rollers, the magnetic particles will be attracted by said periphery portion of said third roller.

10. In a magnetic separator, in combination, a magnetic structure having a surface; magnet means having a first pole and an opposite pole associated with said magnetic structure for imparting the magnetic polarity of said opposite pole to said magnetic structure, said magnet means being located so that a space is formed between said surface of said magnetic structure and said first pole of said magnet means so that lines of magnetic flux cross the space between said surface of said magnetic structure and said first pole of said magnet means; and mechanical transport means for passing magnetic particles through the space formed between said surface of said magnetic structure and said first pole of said magnet means so that when the magnetic particles are passed through the space formed between said surface of said magnetic structure and said first pole of said magnet means the magnetic particles will be attracted by said first pole of said magnet means.

11. In a magnetic separator, in combination, a magnetic support; a first magnetic shaft supported by said support; a second magnetic shaft supported by said support, said second shaft being spaced from and co-extensive with at least a portion of said first shaft; a first roller having a periphery portion of one magnetic polarity and an axis portion of the opposite magnetic polarity, said first roller being mounted along said axis portion thereof on said first shaft for rotational movement relative to said support so that said first shaft is of said opposite polarity; a second roller having a periphery portion and an axis portion, the magnetic polarities of said periphery portion thereof and said axis portion thereof being similar, said second roller being mounted along said axis portion thereof on said second shaft for rotational movement relative to said support, the combined radii of said first and second rollers being smaller than the distance between said first and second shafts so that a space is provided between said periphery portions of said first and second rollers, said support transmitting said opposite polarity of said first shaft to said second shaft so that said axis portion and said periphery portion of said second roller is of said opposite polarity, whereby lines of magnetic flux pass through the space between said periphery portions of said first and second rollers; and conveyor means including an endless band operatively associated with said first and second rollers for passing a substance containing magnetic particles to be separated from the substance through the space between said periphery portions of said first and second rollers

so that when the substance containing magnetic particles is passed through the space between said periphery portions of said first and second rollers, the magnetic particles will be attracted by said periphery portion of said first roller.

12. In a magnetic separator, in combination, a magnetic support; a first magnetic shaft supported by said support; a second magnetic shaft supported by said support, said second shaft being spaced from and co-extensive with at least a portion of said first shaft; a first roller having a periphery portion of one magnetic polarity and an axis portion of the opposite magnetic polarity, said first roller being mounted along said axis portion thereof on said first shaft for rotational movement relative to said support so that said first shaft is of said opposite polarity; a second roller having a periphery portion and an axis portion, the magnetic polarities of said periphery portion thereof and said axis portion thereof being similar, said second roller being mounted along said axis portion thereof on said second shaft for rotational movement relative to said support, the combined radii of said first and second rollers being smaller than the distance between said first and second shafts so that a space is provided between said periphery portions of said first and second rollers, said support transmitting said opposite polarity of said first shaft to said second shaft so that said axis portion and said periphery portion of said second roller is of said opposite polarity, whereby lines of magnetic flux pass through the space between said periphery portions of said first and second rollers; and conveyor means including an endless band of magnetic material operatively associated with said first and second rollers for passing a substance containing magnetic particles to be separated from the substance through the space between said periphery portions of said first and second rollers, the magnetic particles will be attracted by said periphery portion of said first roller.

13. In a magnetic separator, in combination, a magnetic support; a first magnetic shaft supported by said support; a second magnetic shaft supported by said support, said second shaft being spaced from and co-extensive with at least a portion of said first shaft; a first roller having a periphery portion of one magnetic polarity and an axis portion of the opposite magnetic polarity, said first roller being mounted along said axis portion thereof on said first shaft for rotational movement relative to said support so that said first shaft is of said opposite polarity; a second roller having a periphery portion and an axis portion, the magnetic polarities of said periphery portion thereof and said axis portion thereof being similar, said second roller being mounted along said axis portion thereof on said second shaft for rotational movement relative to said support, the combined radii of said first and second rollers being smaller than the distance between said first and second shafts so that a space is provided between said periphery portions of said first and second rollers, said support transmitting said opposite polarity of said first shaft to said second shaft so that said axis portion and said periphery portion of said second roller is of said opposite polarity, whereby lines of magnetic flux pass through the space between said periphery portions of said first and second rollers; and conveyor means including an endless band of non-magnetic material operatively associated with said first and second rollers for passing a substance containing magnetic particles to be separated from the substance through the space between said periphery portions of said first and second rollers so that when the substance containing magnetic particles is passed through the space between said periphery portions of said first and second rollers, the magnetic particles will be attracted by said periphery portion of said first roller.

14. In a magnetic separator, in combination, a mag-

netic support; a first magnetic shaft supported by said support; a second magnetic shaft supported by said support, said second shaft being spaced from and co-extensive with at least a portion of said first shaft; a third magnetic shaft supported by said support, said third shaft being spaced from and co-extensive with at least a portion of said second shaft; a first roller having a periphery portion of one magnetic polarity and an axis portion of the opposite magnetic polarity, said first roller being mounted along said axis portion thereof on said first shaft for rotational movement relative to said support so that said first shaft is of said opposite polarity; a second roller having a periphery portion and an axis portion, the magnetic polarities of said periphery portion thereof and said axis portion thereof being similar, said second roller being mounted along said axis portion thereof on said second shaft for rotational movement relative to said support, the combined radii of said first and second rollers being smaller than the distance between said first and second shafts so that a space is provided between said periphery portions of said first and second rollers, said support transmitting said opposite polarity of said first shaft to said second shaft so that said axis portion and said periphery portion of said second roller is of said opposite polarity, whereby lines of magnetic flux pass through the space between said periphery portions of said first and second rollers; a third roller having a periphery portion of said one magnetic polarity and an axis portion of said opposite magnetic polarity, said third roller being mounted along said axis portion thereof on said third shaft for rotational movement relative to said support, said third shaft being of said opposite polarity, the combined radii of said second and third rollers being smaller than the distance between said second and third shafts so that a space is provided between said periphery portions of said second and third rollers, whereby lines of magnetic flux pass through the space between said periphery portions of said second and third rollers; first conveyor means operatively associated with the periphery portion of said second roller for passing a substance containing magnetic particles to be separated from the substance, consecutively, through the space between said periphery portions of said first and second rollers and through the space between said periphery portions of said second and third rollers so that when the substance containing magnetic particles is passed through the space between said periphery portions of said first and second rollers magnetic particles will be attracted by said periphery portion of said first roller and when the substance containing magnetic particles is passed through the space between said periphery portions of said second and third rollers magnetic particles will be attracted by said periphery portion of said third roller; second conveyor means operatively associated with said periphery portion of said third roller for conveying away from said periphery portion of said third roller magnetic particles attracted by said periphery portion of said third roller; and third conveyor means operatively associated with said periphery portion of said first roller for conveying away from said periphery portion of said first roller magnetic particles attracted by said periphery portion of said first roller.

15. In a magnetic separator, in combination, a magnetic support; a first magnetic shaft supported by said support; a second magnetic shaft supported by said support, said second shaft being spaced from and co-extensive with at least a portion of said first shaft; a third magnetic shaft supported by said support, said third shaft being spaced from and co-extensive with at least a portion of said second shaft; a first roller having a periphery portion of one magnetic polarity and an axis portion of the opposite magnetic polarity, said first roller being mounted along said axis portion thereof on said first shaft for rotational movement relative to said support so that said first shaft is of said opposite polarity; a second roller having a periphery portion and an axis portion, the magnetic polarities of said periphery portion thereof and said axis portion thereof

being similar, said second roller being mounted along said axis portion thereof on said second shaft for rotational movement relative to said support, the combined radii of said first and second rollers being smaller than the distance between said first and second shafts so that a space is provided between said periphery portions of said first and second rollers, said support transmitting said opposite polarity of said first shaft to said second shaft so that said axis portion and said periphery portion of said second roller is of said opposite polarity, whereby lines of magnetic flux pass through the space between said periphery portions of said first and second rollers; a third roller having a periphery portion of said one magnetic polarity and an axis portion of said opposite magnetic polarity, said third roller being mounted along said axis portion thereof on said third shaft for rotational movement relative to said support, said third shaft being of said opposite polarity, the combined radii of said second and third rollers being smaller than the distance between said second and third shafts so that a space is provided between said periphery portions of said second and third rollers, whereby lines of magnetic flux pass through the space between said periphery portions of said second and third rollers; first conveyor means operatively associated with the periphery portion of said second roller for passing a substance containing magnetic particles to be separated from the substance, consecutively, through the space between said periphery portions of said first and second rollers and through the space between said periphery portions of said second and third rollers so that when the substance containing magnetic particles is passed through the space between said periphery portions of said first and second rollers magnetic particles will be attracted by said periphery portion of said first roller and when the substance containing magnetic particles is passed through the space between said periphery portions of said second and third rollers magnetic particles will be attracted by said periphery portion of said third roller; second conveyor means operatively associated with said periphery portion of said third roller for conveying away from said periphery portion of said third roller magnetic particles attracted by said periphery portion of said third roller; and third conveyor means operatively associated with said periphery portion of said first roller for conveying away from said periphery portion of said first roller whereby the magnetic particles attracted by said periphery portions of said first and third rollers are conveyed by said second conveyor means.

16. In a magnetic separator, in combination, a magnetic cylinder having an outer portion and a central portion; magnet means operatively associated with said outer portion and said central portion of said cylinder for imparting one magnetic polarity to said outer portion and an opposite magnetic polarity to said central portion; a magnetic structure connected to said central portion of said cylinder, said magnetic structure having a surface located opposite said outer portion of said cylinder so that a space is formed between said surface of said magnetic structure and said outer portion of said cylinder whereby lines of magnetic flux cross the space between said surface of said magnetic structure and said outer portion of said cylinder; and conveyor belt means for passing magnetic particles through the space formed between said surface of said magnetic structure and said outer portion of said cylinder so that when magnetic particles are passed through the space formed between said surface of said magnetic structure and said outer portion of said cylinder the magnetic particles will be attracted by said outer portion of said cylinder.

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