Nov. 4, 1947. W. BYRD, JR 2,430,157

MAGNETIC SEPARATOR FOR REMOVING FINELY DIVIDED MAGNETIC MATERIAL FROM LIQUIDS

Filed July 29, 1939 2 Sheets-Sheet 1

Fig. 1.

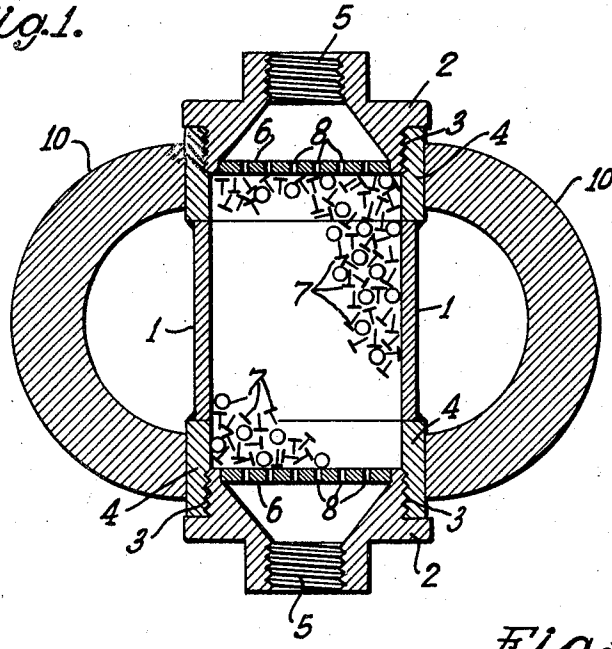


Fig. 2.

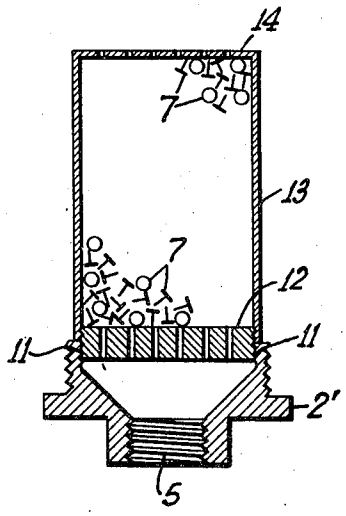
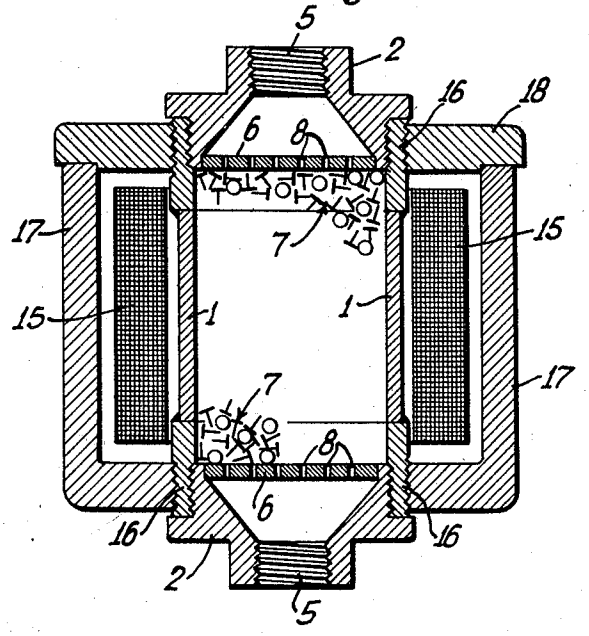


Fig. 3.



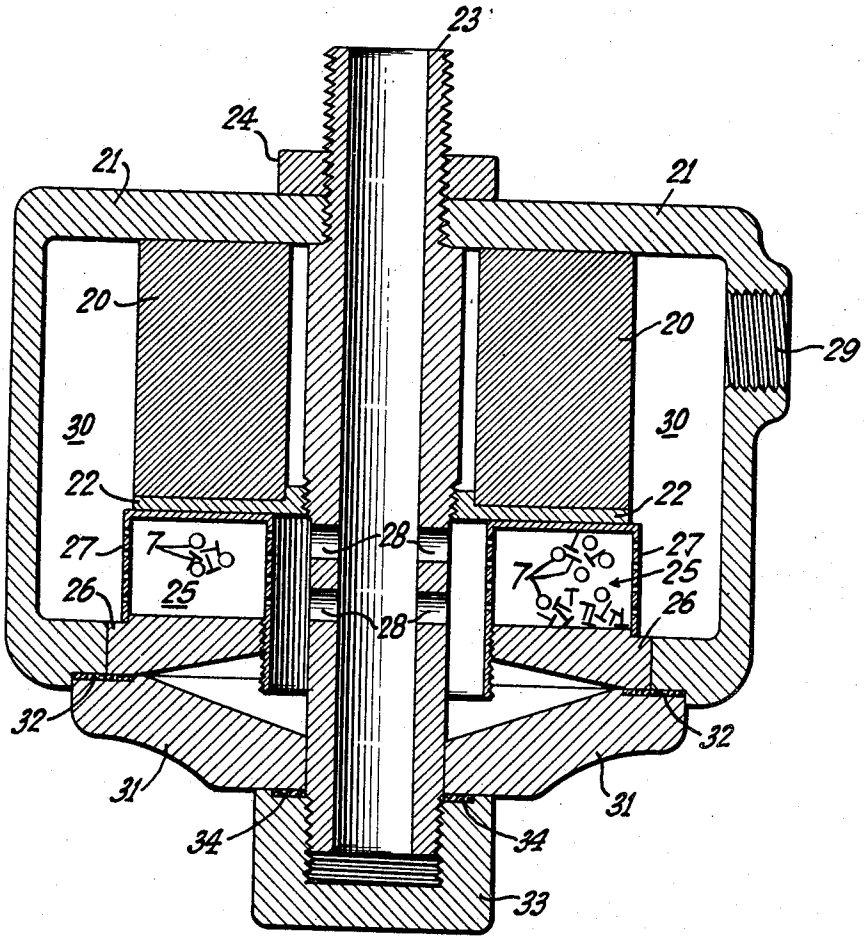
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MAGNETIC SEPARATOR FOR REMOVING FINELY DIVIDED MAGNETIC MATERIAL FROM LIQUIDS

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Fig. 4.



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MAGNETIC SEPARATOR FOR REMOVING FINELY DIVIDED MAGNETIC MATERIAL FROM LIQUIDS

William Byrd, Jr., Princeton, N. J.

Application July 29, 1939, Serial No. 287,211

11 Claims. (Cl. 210—1.5)

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This invention relates to a magnetic separator and particularly to a separator for removing finely divided magnetic material from liquids, sludges and the like.

An object of the invention is to provide an efficient separator of compact and inexpensive construction. Another object is to provide a separator which may be easily and quickly cleaned when it has become clogged and which may contain a replacement part of the simplest and cheapest type.

Separation of particles magnetically from a liquid, sludge, or slurry in which they are suspended is usually accomplished by passing the liquid containing the particles through a container or conduit in which are arranged grids of magnetizable material and subjecting the grids to the influence of a magnetic field. The magnetic field converges to and diverges from the edges of the grids and since magnetic particles tend to travel from regions of less field density to regions of greater field density, the particles migrate toward and are held on the edges of the grids.

Such grids are open to many objections, not the least among which is that they must be especially designed and manufactured to suit the purpose and to fit the separator in which they are employed; therefore both original and replacement costs are high.

It has been suggested in the past that a mass of steel wool or chips might be substituted in place of an array of magnetizable grids, but they have been found to be unsatisfactory for several reasons.

My invention contemplates the use, in place of an array of grids, of a material which, though so far as I am aware it has never been employed for this purpose, is ideally suited therefor. It consists of a mass of small, discrete objects of like size and shape, each of which has one or more sharp points and edges for collecting the smallest particles, and a substantial body portion for conducting the magnetic flux. Cut tacks, or so called "carpet tacks" provide a splendid example of such objects. When placed in a container they arrange themselves naturally and freely into a mass in which the individual tacks lie in random orientations, without the necessity of any pressing or shaking down. Their enlarged heads serve to maintain a spacing between adjacent tacks such that in the mass the iron occupies one third to one half of the total volume and the voids one half to two thirds. This arrangement provides the necessary low reluctance path for the magnetic flux and at the same time leaves a multiplicity of tortuous paths through the mass whose cross sections are great enough to permit the passage of the liquid or sludge without offering excessive resistance to its flow. They have sharp thin points and sharp edges at which the magnetic fields are very dense and divergent even when the magnetomotive force is relatively small. The edges on their heads lie in planes perpendicular to the edges of the shanks, so that whatever the orientation in which a particular tack may lie, edges are presented to the magnetic flux. Furthermore, they are a universal and inexpensive article of commerce.

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A further advantage in the use of a mass of this character lies in the fact that the mass is substantially isotropic, in the sense that a stack of grids cannot be. Both the magnetic properties and liquid capacity of the mass are the same in all directions. By its use, therefore, there is no difficulty in providing for liquid flow in any desired direction relative to the direction of the magnetic field, which is often difficult in the case of grids.

I have found by numerous tests that substantially all of the fine magnetic particles suspended in a liquid are removed by passing the liquid through a separator containing such a mass of tacks.

My invention also contemplates the use of a removable tack-containing cartridge, which may be inserted in the separator with ease and may easily be removed and replaced. Whether in a cartridge or loose in the separator, the tacks are easily and simply washed after they have been removed from the magnetic field and may be reused.

More particularly, the invention consists in the novel construction and combination of parts hereinafter described, illustrated in the accompanying drawings and defined in the claims hereto appended, it being understood that various changes in form, proportion, size and minor details of construction within the scope of the claims may be resorted to without departing from the spirit or sacrificing any of the advantages of the invention.

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

Fig. 1 shows, in cross section, a magnetic separator in which the magnetic flux is derived from permanent magnets;

Fig. 2 shows a modification of a part of Fig. 1 including a removable container or cartridge;

Fig. 3 shows, in cross section, a separator in which the magnetic flux is derived from a coil carrying an electric current;

Fig. 4 shows a different form of permanent magnet separator in which advantage is taken of certain of the subsidiary features of the invention.

Referring now to Fig. 1, a cylindrical container 1 is provided at either end with hollow caps 2. The caps are externally threaded at 3 to fit the ends 4 of the container and internally threaded at 5 to fit pipes for carrying the liquid to and from the separator. Inside each cap 2 is a perforated

metal plate or screen 6. The space defined by the cylindrical walls of the container 1 and the plates 6 is filled with magnetizable tacks 7. The perforations 8 of the plates 6 should be small enough to hold the tacks 7 in place in the cylinder but should otherwise be as great as possible in order to offer a minimum resistance to the flow of liquid.

Two permanent magnets 10 are shown with their poles held magnetically in contact with the ends 4 of the cylinder 1. Additional magnets may be employed, but I find that two provide ample flux when properly designed, and form with the container 1 a compact symmetrical structure.

The ends 4 of the container should be of magnetizable material such as iron, and are preferably of rectangular outside dimensions and ground on two opposite sides to provide smooth, low-reluctance joints with the poles of the magnets 10. The ends 4 may conveniently be fastened to the cylinder 1 by brazing. The caps 2 and perforated plates 6 are likewise preferably of magnetizable material, though when the apparatus has the form shown this is not essential because the flux may pass directly from the magnets 10, through the magnetizable ends 4 of the container into the mass of tacks 7. However, the walls of the cylinder 1 should be of nonmagnetic material, otherwise the flux would pass from pole to pole of the magnets through the walls instead of through the mass of tacks.

For cleaning, either of the screw caps 2 is removed and the container 1 emptied and refilled with clean tacks.

Fig. 2 shows a modification in which one of the end caps 2' has an interior threaded portion 11 of reduced diameter which engages with threads on a perforated cover 12 of a cylindrical container or cartridge 13. The cartridge 13 is filled with tacks 7 and its other end 14 is perforated to allow passage of the liquid. It may be of light sheet metal since great demands will not be made upon its strength. The cross section of its walls may therefore be exceedingly low, and they may be of magnetic material without ill effects. It will be evident that when the end cap 2' is unscrewed from the body of the cylinder 1 and withdrawn, the cartridge 13 containing the tacks and all the magnetic material caught thereon is removed therewith. A fresh cartridge 13 may then be affixed to the cap 2' and the cap and cartridge together be inserted in the cylinder 1.

Fig. 3 shows a modification in which the magnetic field is provided by a coil 15 surrounding the cylinder 1 and carrying an electric current. The cylinder, caps and perforated plates may be identical with those of Fig. 1. The ends 16 are modified to receive a yoke 17, 18 of magnetic material placed outside the coil 15 to provide a low reluctance return path for the magnetic flux. This yoke is made in two parts as shown to permit installation of the coil. From the separating standpoint the operation of Fig. 3 is identical with that of Fig. 1; and moreover Fig. 3 may be modified by the addition of the removable cartridge 13 of Fig. 2.

Fig. 4 shows a modification in which the direction of passage of the magnetic flux through the mass of tacks is perpendicular to the direction of liquid flow. A ring-shaped permanent magnet 20, magnetized in the direction of its axis is held within a hollow casting 21 of magnetic material by a magnetic disc 22 threaded to a nonmagnetic central tube 23 which in turn is screwed to the casting 21 and held fast by a locknut 24. The tacks 7 are placed in the annular space 25 below the permanent magnet 20; and the casting 21 together with a plate 26 and disc 22 provide a return path for the magnetic flux. The tacks 7 are preferably placed in a cartridge 27, having perforated walls, which may be screwed to the plate 26 as shown. The central tube 23 passes from top to bottom of the casting 21 and is provided with openings 28 through its walls at the level of the annular space 25. The liquid is delivered through an opening 29 in the side of the casting 21 into an outer annular space 30 and makes its way to the outer periphery of the cartridge 27 and the mass of tacks, passes radially through the mass and into the central tube 23 through the openings 28 and out of the separator at the top of the tube 23. This construction with its short magnetic path through the mass of tacks and its heavy yoke, provides a high magnetic field strength among the tacks, while at the same time a large cross section is presented to the flow of liquid, particularly at the outer radius of the annular mass of tacks.

It is of particular advantage to provide a large cross section where the liquid first enters the attracting mass, since it is there that magnetic particles are first caught and there that clogging tends to take place. With this radial construction clogging of the inner tacks takes place only by reason of magnetic particles which have not been caught by the outer tacks.

Below the casting 21 is a sealing plate 31 which may be of any material, provided at its inner face with a gasket 32. The whole apparatus may conveniently be held together in liquid-tight fashion by drawing up a cap 33 threaded to the lower end of the central tube 23 and provided with a gasket 34. With the construction of Fig. 4, the tacks, whether in a cartridge or not, may be removed and replaced without undoing the pipe connections.

Though I have described my invention in terms of a separator for removing magnetic particles from liquids, it will be apparent that it will be useful in other applications; for example, when it is desired to remove magnetic particles carried by other fluids such as air.

I claim:

1. A magnetic separator comprising a container, means for passing a fluid bearing magnetic particles through said container, a mass of sharp-shanked, sharp-headed magnetizable tacks in said container and a source of magnetic flux, said mass and said source being so arranged that the mass forms a part of the magnetic circuit of the source.

2. A magnetic separator comprising a container, means for passing a fluid bearing magnetic particles through said container, a mass of sharp-shanked, sharp-headed magnetizable tacks in random orientations in said container and a source of magnetic flux, said mass and said source being so arranged that the mass forms a part of the magnetic circuit of the source.

3. A magnetic separator comprising a container, connections for passing a fluid bearing magnetic particles through said container, a mass of like discrete magnetizable bodies disposed in random orientation in said container, each of said bodies having a sharp point, a sharp edged shank and an enlarged portion having a substantially sharp edge disposed in a plane transverse to the shank, and a source of magnetic flux, said mass and said source being so arranged that the

mass forms a part of the magnetic circuit of the source.

4. A magnetic separator comprising a container, connections for passing a fluid bearing magnetic particles through said container, a mass of like discrete magnetizable imperforate bodies in said container, each of said bodies having a portion including an edge extended in a plane and another portion including another edge extended in another plane transverse to said first-named plane, and a source of magnetic flux, said mass and said source being so arranged that the mass forms a part of the magnetic circuit of the source.

5. A magnetic separator comprising a container, connections for passing a fluid bearing magnetic particles through said container, an isotropic mass of like, discrete, sharp-edged, imperforate magnetizable bodies in random orientations in said container, each of said bodies being of configuration such that a part of said body including an edge is disposed in a plane transverse to another part of said body including an edge, and a source of magnetic flux, said mass and said source being so arranged that the mass forms a part of the magnetic circuit of the source.

6. A magnetic separator comprising a liquid-tight casing of magnetizable material, an annular axially magnetized magnet within said casing, one pole-face of said magnet being in contact with an internal face of said casing, said casing providing a low-reluctance path for the flux of said magnet and being so disposed as to leave an annular airgap space in the magnetic circuit, a mass of like discrete magnetizable bodies in said annular space, and connections to said casing for passing a fluid bearing magnetic particles radially through said mass.

7. A magnetic separator comprising a liquid-tight casing of magnetizable material, an axially magnetized annular magnet within said casing, one pole face of said magnet being in contact with an internal face of said casing, said casing providing a low reluctance path for the flux of said magnet and being so disposed as to leave an annular gap in the magnetic circuit, a removable annular cartridge substantially filled with a mass of like, discrete magnetizable attractor elements occupying said gap, the faces of said cartridge transverse to its axis being of low reluctance for conducting the flux of said magnet axially through said mass, the walls of said cartridge parallel to its axis being permeable to liquid and of relatively high magnetic reluctance, and means for passing a liquid bearing magnetic particles through said permeable faces and radially through said mass.

8. A magnetic separator comprising a liquid-tight casing of magnetizable material formed with an inlet and an outlet, an annular permanent magnet within said casing, one pole of said magnet being in contact with an internal face of said casing, said casing providing a low reluctance path for the flux of said magnet and being so disposed as to leave an annular gap in the magnetic circuit, means for supporting a plurality of removable magnetizable attractor elements in said gap, a duct within said casing leading from said inlet to one side of the said annular gap, and a second duct within said casing leading from the other side of said annular gap to said outlet, said ducts being arranged to convey liquid bearing magnetizable particles through said gap in contact with said attractor elements.

9. A magnetic separator comprising a liquid-tight casing of magnetizable material formed with inlet and outlet passages adjacent one end thereof, an annular permanent magnet within said casing adjacent said end, one pole of said magnet being in contact with an internal face of said casing, said casing providing a low reluctance path for the flux of said magnet and being so disposed as to leave an annular gap in said magnetic circuit, means for supporting a plurality of magnetizable attractor elements within said gap, a duct within said casing disposed axially through said annular magnet and communicating with one of said passages, and a second duct within said casing communicating with the other of said passages, said ducts leading, respectively, to opposite sides of said annular gap for conveying a liquid bearing magnetizable particles through said gap in contact with said attractor elements.

10. A magnetic separator comprising a liquid-tight casing of magnetizable material formed with an inlet and an outlet, an annular permanent magnet within said casing, one pole of said magnet being in contact with an internal face of said casing, said casing providing a low reluctance path for the flux of said magnet and being so disposed as to leave an annular gap in the magnetic circuit, means for supporting a plurality of removable magnetizable attractor elements in said gap, a duct within said casing leading from said inlet to one side of the said annular gap, and a second duct within said casing leading from the other side of said annular gap to said outlet, said ducts being arranged to convey a liquid bearing magnetizable particles through said gap in contact with said attractor elements, said casing being made in separable parts, one part having said inlet and outlet connections and another part comprising a wall transverse to the axis of said annular magnet and removable from said first-mentioned part, said removable wall section being of a diameter greater than said annular gap to permit the removal of said attractor elements without disturbing said inlet and outlet connections.

11. A magnetic separator comprising a casing of magnetizable material formed with an inlet and an outlet, an axially magnetized annular permanent magnet within said casing, one pole of said magnet being substantially in contact with an internal face of said casing, said casing providing a low reluctance path for the flux of said magnet and being so disposed as to leave an annular gap in the magnetic circuit, magnetizable attractor elements in said gap, the magnetic flux through said magnet, gap and attractor elements being substantially parallel to the axis of said magnet, and means for conducting a liquid bearing magnetizable particles from said inlet through said gap and past said attractor elements to and through said outlet.

WILLIAM BYRD, JR.

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Disclaimer

2,430,157.—*William Byrd, Jr.*, Princeton, N. J. MAGNETIC SEPARATOR FOR REMOVING FINELY DIVIDED MAGNETIC MATERIAL FROM LIQUIDS. Patent dated Nov. 4, 1947. Disclaimer filed Apr. 24, 1950, by the assignee, *Samuel G. Frantz.*

Hereby enters this disclaimer to claims 8 to 11, inclusive, of said patent.

[*Official Gazette May 16, 1950.*]