July 5, 1960 C. A. MAYNARD 2,943,739

MAGNETIC FILTER

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Fig. 1

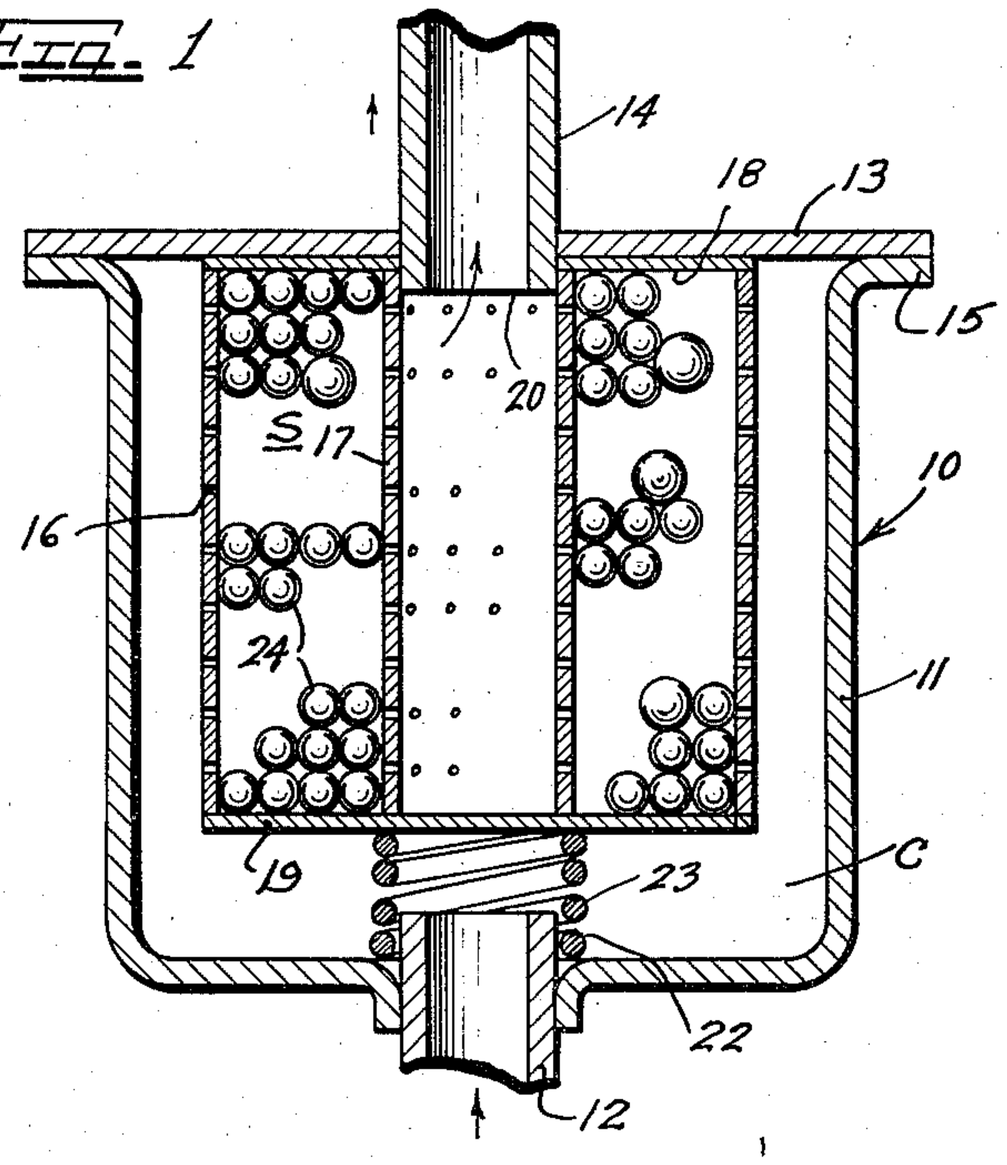

Fig. 2

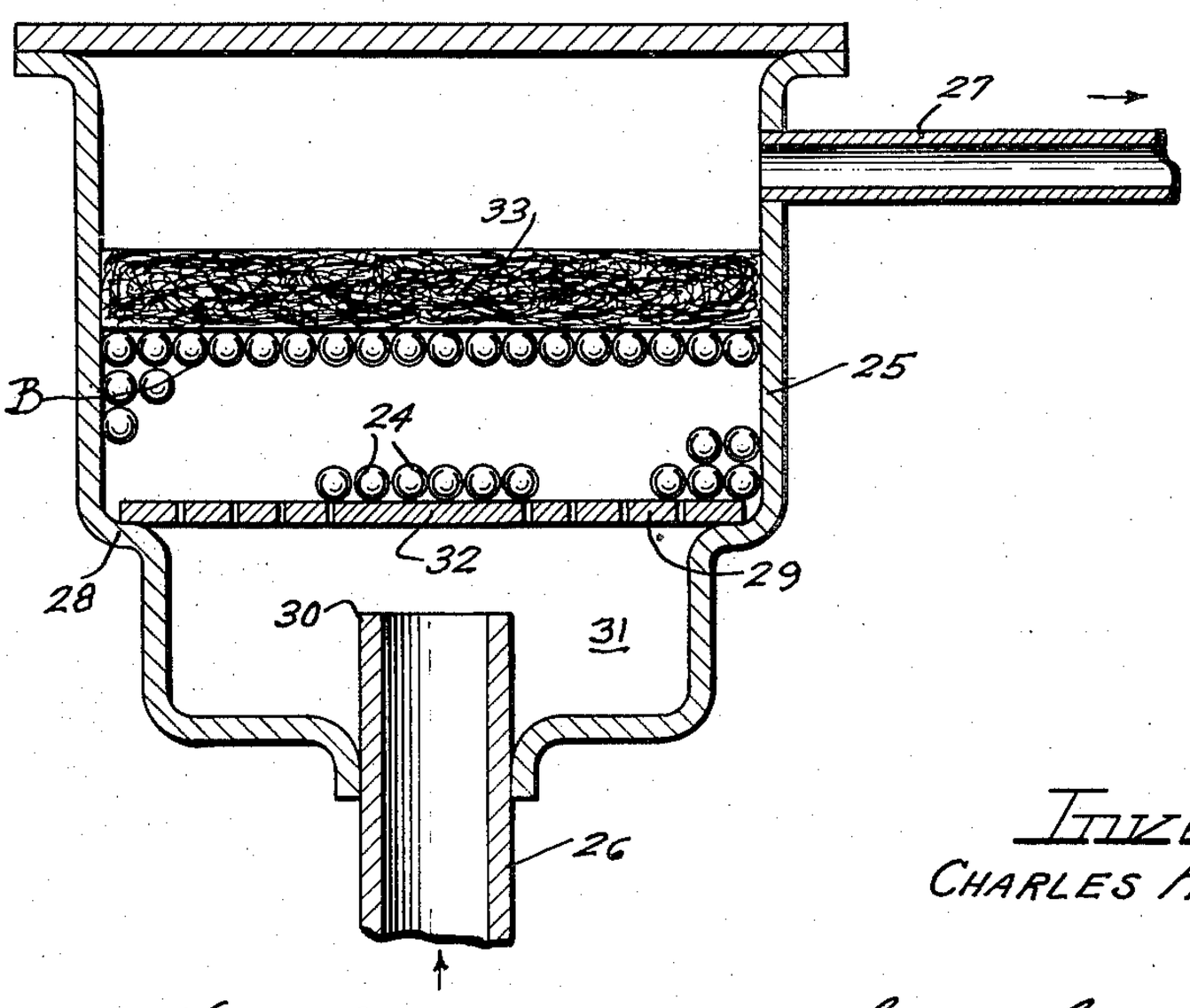

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Fig. 3

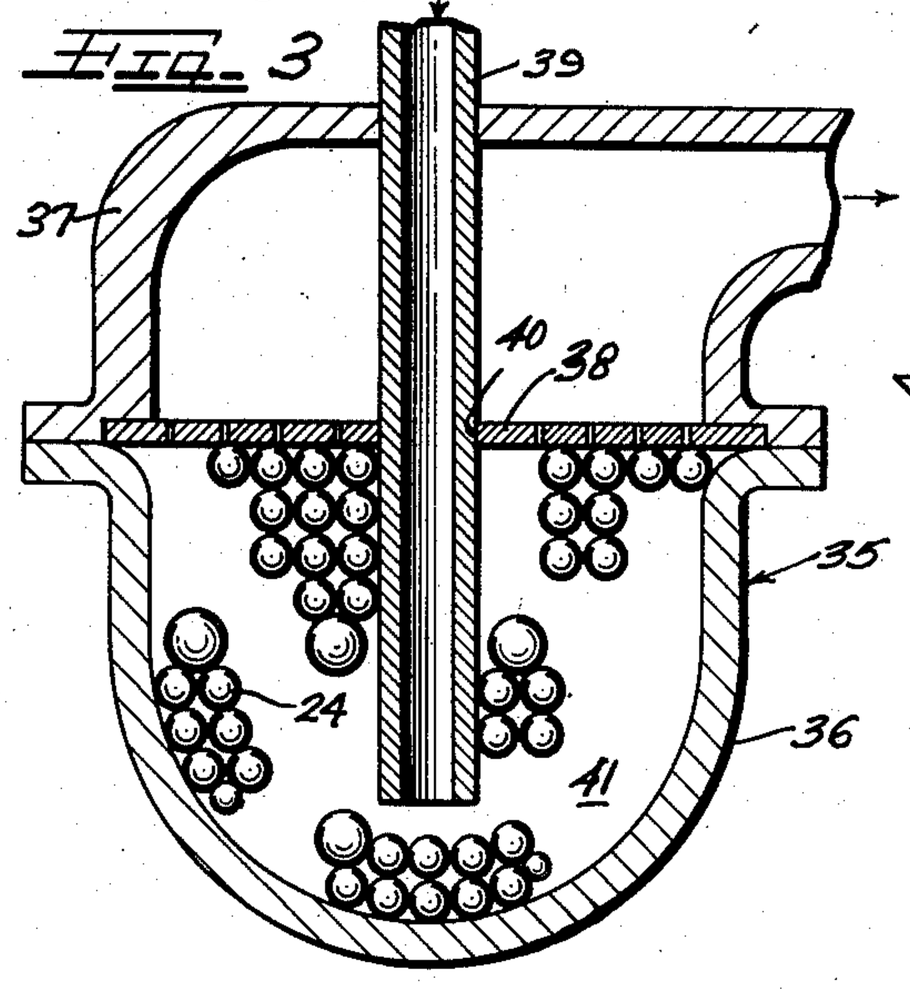


Fig. 4

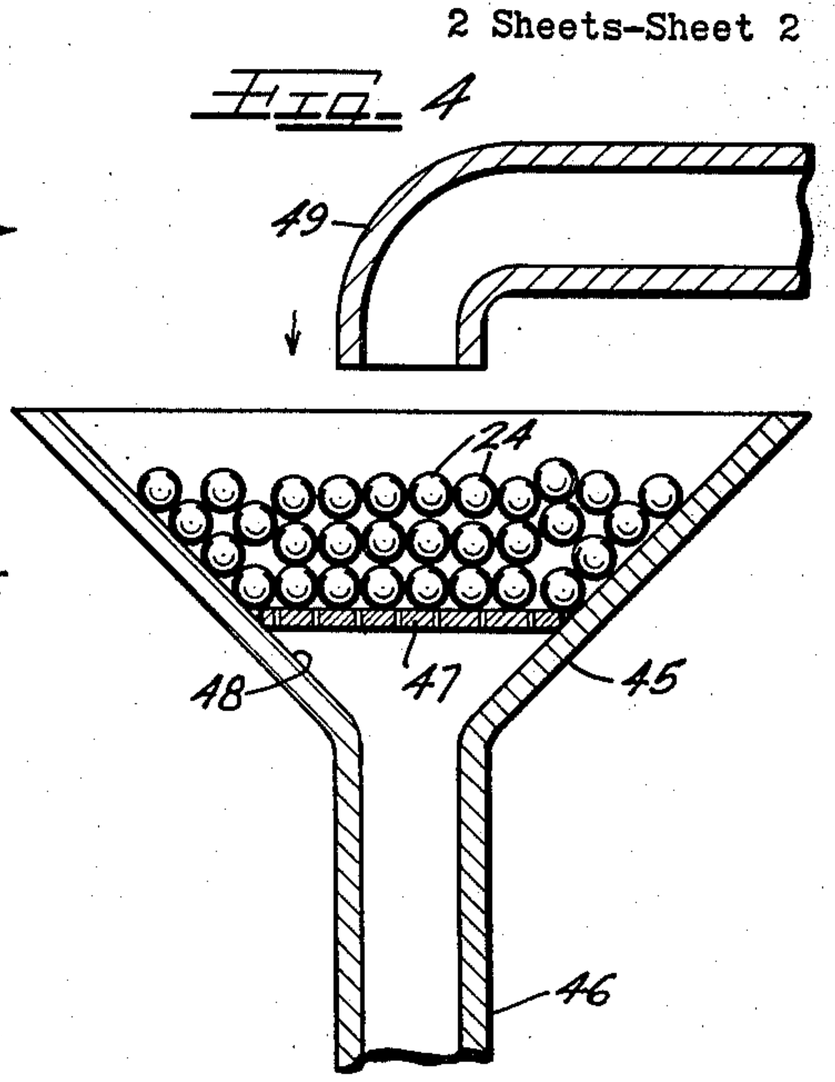


Fig. 5

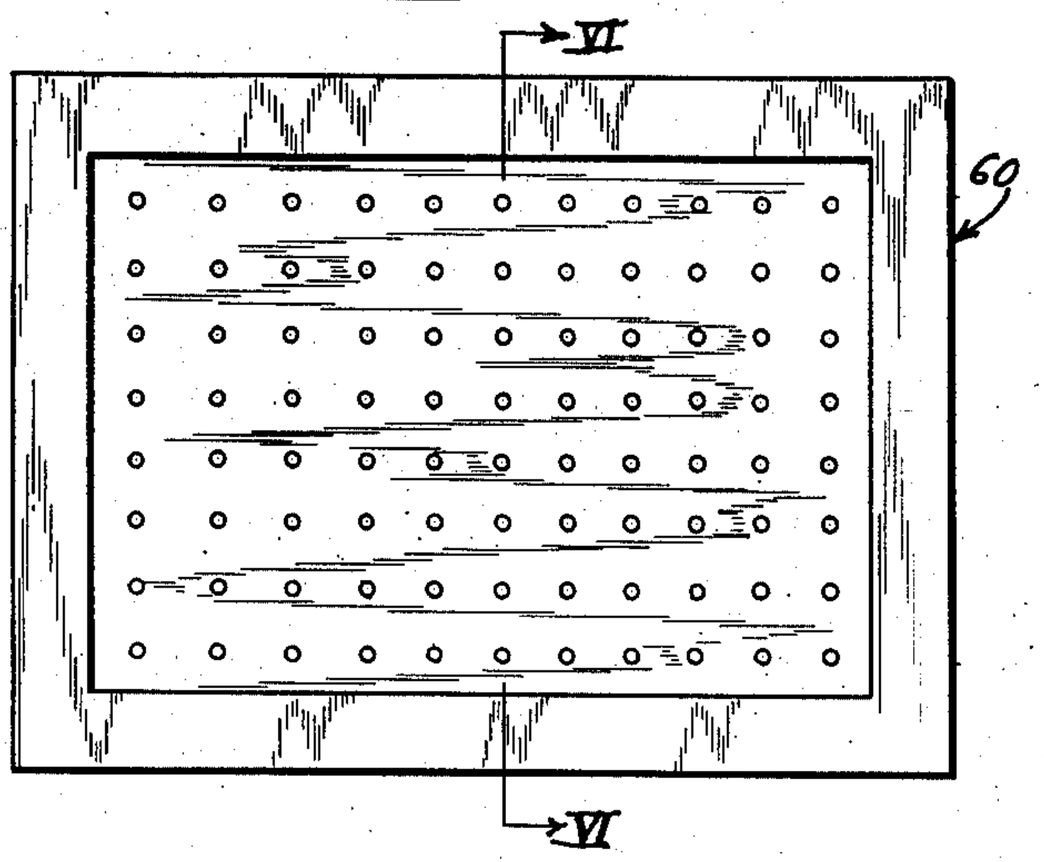
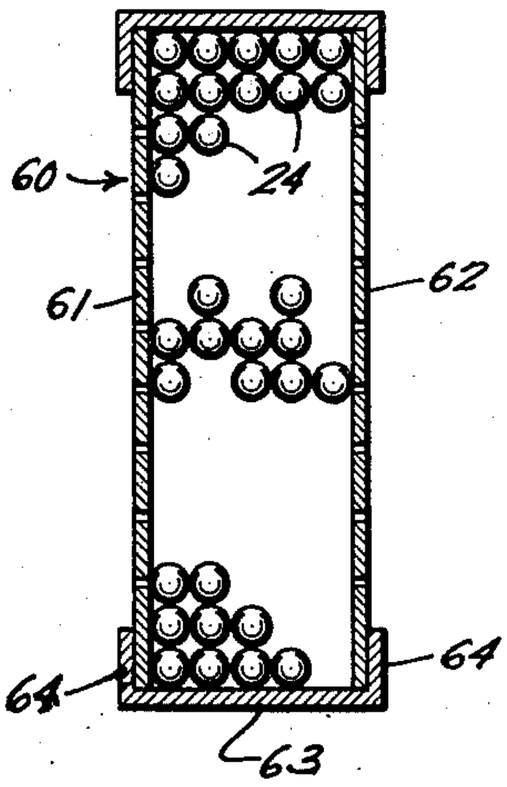


Fig. 6



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United States Patent Office

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MAGNETIC FILTER

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4 Claims. (Cl. 210—223)

This invention relates to a magnetic filter, and more particularly to a filter or separator employing individually pre-magnetized balls of permanent magnet material in the fluid passage zone for separating magnetizable particles and the like from the fluid passing therethrough.

It has heretofore been proposed, as in the Bower Patent No. 2,452,220, to provide a magnetic separator in which balls of a magnetizable material, such as mild steel, are subjected to an externally imposed magnetic flux to magnetize the balls. I have found that more effective separation of magnetizable particles from the fluid flow can be effected, however, if the balls, themselves, are formed of permanent magnet material and are pre-magnetized before being placed in the fluid passage zone. This is for the reason that each of the balls, in accordance with my invention, has a self-contained permanent magnet with its own north and south pole. Consequently, when the pre-magnetized, permanent magnet balls are haphazardly positioned in the fluid flow passage, as, for instance, in a removable perforated basket, or cartridge, of non-magnetic material, the balls do not line up, as would be the case in the prior art arrangement with their north and south poles in contacting alignment, but because haphazardly arranged or oriented, they produce more effective fields of magnetic lines of flux in the spaces between the balls through which the fluid must pass, thereby making possible a more efficient separation of any magnetizable particles contained in or carried by the fluid.

Furthermore, the permanent magnet balls employed in the separator or filter of my invention are preferably formed of permanent magnet material possessing a relatively high coercive force value, such that the balls are capable of setting up independent fields of magnet flux of relatively high density.

Suitable permanent magnet material for this purpose are the polyoxides in which ferric oxide, Fe_2O_3, has been combined in a mixed crystal with a secondary oxide such as barium oxide, strontium oxide, or lead oxide, with or without small amounts of calcium oxide. These materials belong to a class of ferromagnetic hexagonal iron oxide compounds, the prototype of which is $BaFe_{12}O_{19}$. These materials are ceramic and are commercially available under several names including "Indox" and "Ferroxdure," and can be fabricated into magnets by compacting a finely ground mixture of the raw materials followed by sintering, as taught by Went et al. 2,762,777. Materials of this type have extremely high coercive forces, being in the order of 1600 to 2000 oersteds, and are efficiently used when in a substantially spherical shape. While other high coercive force permanent magnet materials can be used in my present invention, these polyoxide materials have been found to be eminently suitable for the purpose.

It is therefore an important object of this invention to provide a magnetic separator, or filter, for the separation of magnetizable particles from fluids, such as hydrocarbon liquids and the like, in which pre-magnetized

balls, or spheres of a high coercive force permanent magnet material are positioned in the fluid flow passage to attract to their surfaces and retain thereon such magnetizable particles as may be contained in or carried by the fluid passing through and around a plurality of such balls.

It is a further important object of this invention to provide a removable and replaceable cartridge, basket, or the like of a fluid permeable, non-magnetic material containing therein a plurality of individually magnetized balls of permanent magnet material for use in magnetic filters, separators and the like, for the extraction from such fluid of magnetizable particles undesirably contained therein.

It is a further important object of this invention to provide a novel, improved magnetic filter having a replaceable perforated container substantially filled with individually magnetized, permanent magnet balls.

Other and further objects of this invention will become apparent from the following description and appended claims.

As shown on the drawings:

Figure 1 is a vertical sectional view of a magnetic separator involving the principles of my invention;

Figure 2 is a vertical sectional view of a modified form of magnetic filter;

Figure 3 is a vertical section view of a further modification of my invention;

Figure 4 is a vertical sectional view of a still further modification of my invention;

Figure 5 is a side elevational view of a removable and replaceable cartridge for use in a magnetic separator or filter.

Figure 6 is a sectional view taken substantially along the line VI—VI of Figure 5.

The various embodiments of my invention illustrated in the drawings may be used to remove impurities of a magnetic nature from a fluid, and more particularly from a liquid such as a lubricating oil, a hydrocarbon fuel, or the like. For instance, certain embodiments of my invention would be useful in filtering gasoline before its introduction into the carburetor of an engine or passage through an engine fuel injection system. In the handling and distribution of gasoline and other liquid fuels, there is the possibility of the liquid taking up or acquiring magnetizable particles due to corrosion, scaling, or the like of the ferrous metal surfaces with which the liquid comes in contact. If such particles are carried with the liquid fuel into the tank of the automotive vehicle and thence into the carburetor or injection system leading into the engine, plugging of the jets and orifices of the system is likely to occur. Other applications of the magnetic filter or separator will occur to those familiar with the art, as, for instance, for the purpose of removing magnetizable particles from lubricating oils, in which such particles may be present due to wear of moving parts.

As illustrated in Figure 1, the reference numeral **10** indicates generally a form of magnetic filter in which a fluid passage zone is provided by a casing **11** of non-magnetic material having a lower inlet **12**, a top, or cover **13**, and an upper outlet **14**. The casing forming the body portion is preferably cylindrical in form and provided with a flanged upper edge **15** to which the top **13** can be secured by suitable means (not shown). A fluid such as a liquid hydrocarbon fuel, oil or the like, is introduced through the inlet **12** to the chamber C defined by the casing **11** and top **13**, for discharge through the axially aligned upper discharge connection **14**.

In accordance with the principles of my present invention, there is provided within the chamber C a perforated

basket, cartridge, or the like, of non-magnetic material, formed with concentric perforated walls **16** and **17** and with upper and lower imperforate walls **18** and **19**. As illustrated, the inner wall **17** is of slightly greater diameter than the outer diameter of the discharge conduit **14** and the upper wall **18** is correspondingly apertured so as to receive the lower end **20** of said conduit **14** and thus position the basket, or cartridge, in axially alignment. The basket is preferably of a height less than the height of the chamber C and a coiled spring **22** is positioned about the upper inner end **23** of the inlet **12** with the upper end of said spring held under compression against the lower imperforate wall **19** of the basket to urge the basket upwardly against the top wall **13** and hold the same in place thereagainst.

Pre-magnetized balls **24** of suitable permanent magnet material and of the same or different size are positioned within the annular space S between the inner and outer perforated walls **17** and **16** of the basket to substantially fill the same. The balls **24** are only incompletely illustrated, and it will be understood that they would normally substantially fill the annular space S and would assume haphazard positions with respect to each other, so far as orientation of their poles is concerned, depending upon the laws of chance rather than an intentional manner of orientation. That is to say, north and south poles of adjacent balls might happen to line up in contact with each other but that would not be generally the case where the balls are introduced into space S by random filling methods as by pouring from a source of supply of the pre-magnetized balls.

The flow of fluid through the device **10** would be that indicated by the arrows, namely into the inlet **12** for lateral and upward flow around the cylindrical apertured wall **16**, through the apertures of such wall into the interior annular space S, and thence through the perforations of the inner cylindrical wall **17** and upwardly into the discharge connection **14**. The balls **24** would cause sufficient breaking up of the flow of the fluid through the annular space S to bring about contact or at least close proximity between the balls and all parts of the liquid mass, thereby insuring the attraction to and the retention by the balls of any magnetizable particles contained in or carried by the fluid.

After a certain period of usage, depending upon the amount of contamination of the fluid by magnetizable particles, the basket or cartridge could be removed from the device **10**, the balls cleaned and replaced, or another fresh lot of pre-magnetized balls substituted for those previously in the basket or cartridge. In this manner, the fluid leaves the device **10** substantially free from any contaminating particles of a magnetizable character.

In the modification illustrated in Figure 2, a generally cylindrical body portion **25**, preferably of non-magnetic material, is provided with a lower axially aligned inlet pipe **26** and an upper laterally extending pipe **27**. The body portion **25** is of reduced diameter to provide an annular shoulder **28** for positioning thereon a perforated plate **29**. The arrangement is such that the upper end **30** of the inlet pipe **26** projects into the space **31** below the perforated plate **29**, and the central portion of the plate **29** is left imperforate, as at **32**, to act as a barrier or baffle for distributing the fluid in its upward flow through the space **31**.

A bed B is formed of a plurality of layers of premagnetized permanent magnet balls **24** resting upon and extending above the perforated plate **29** to any suitable depth. Any conventional filter, or layer of fibrous materials, such as that indicated at **33**, may be positioned above the bed B to filter out particles not trapped by the magnetic filter bed B. In this way the filter material **33** would be effective over a longer period of time than if no magnetic bed were employed. The space **31** below the perforated plate **29** serves for a settling out of such particles as might tend to separate out by gravity and thus lessen the load on the magnetic filter bed B and the conventional filter bed **33**.

In the modification illustrated in Figure 3, the device indicated by the reference numeral **35** is composed of a lower bowl-like casing **36** and an upper casing **37** and with the two casings being suitably flanged and secured together with a perforated plate **38** therebetween. An inlet pipe **39** extended downwardly through the wall of the upper casing and through an aperture **40** provided in the plate **38** for that purpose, and to the lower portion of the chamber **41** provided by the lower casing **36**. The chamber **41** is substantially filled with individually magnetized permanent magnet balls **24**, of varying sizes, or all of the same size, to provide a bed or mass of such balls beneath the perforated plate **38** through which the fluid must pass as it flows upwardly from the lower end of the inlet pipe **39**. In this case, the perforated plate **38** serves merely to prevent upward displacement of the balls **24** under the action of the flow of fluid therethrough. The lower casing **36** may, of course, be readily removable for cleaning or changing the balls.

Figure 4 illustrates a gravity type of filter comprising a funnel shaped receptacle **45**, preferably of non-magnetic material, having a lower axial discharge **46** and provided with a perforated plate **47** supported by the divergent wall of the conical upper portion **48**. The balls **24** are positioned above the perforated plate **47** to rest thereon and to extend thereabove to any desired height depending upon the depth of the filter bed desired. Fluid is introduced above the bed through a fluid intake pipe **49** for gravity flow over and down through the bed of balls **24**.

Figures 5 and 6 illustrate a removable cartridge **60** of non-magnetic material comprising a pair of spaced perforated walls **61** and **62** and a retaining peripheral frame **63**, which may suitably be rectangular in shape and provided with right angle, inturned flanges **64** for securement to the perforated plates **61** and **62**. The interior of the cartridge **60** is substantially filled with balls **24** like those already described. The cartridge thus provides a replaceable unit that may be inserted in a fluid flow passage of suitable configuration to receive the cartridge and position the same so that all of the flow of the fluid must be through the magnetic bed provided by the balls **24**. This type of filter is particularly suited for use as an air or gas filter.

The balls **24** are preferably preformed by pressing, agglomeration or pelletizing, as previously stated, of a powdered polyoxide material, in the nature of a ferrite that is capable of acquiring and exhibiting satisfactory permanent magnet properties. Such preforming may be done in accordance with the teaching of Rodman, U.S. Patent No. 1,239,221. The agglomerated balls are then fired and individually magnetized to provide north and south poles disposed therein and the magnetized sintered balls are randomly filled into casings or cartridges such as has been described above to provide an effective magnetic filter or separating bed. While such magnetic filters or separators are useful in connection with the elimination of magnetizable particles from liquids, it will be appreciated that they could be similarly used with gaseous fluids in which magnetizable particles might be entrained.

While the magnetizable balls have been described herein as being spherical in shape, they need not be truly spherical so long as they approximate a sphere and are capable of assuming random positions in the filter bed or cartridge to provide connecting interstices therebetween for fluid flow. Also, although different sizes of balls may be used, the sizes will ordinarily lie between ⅛ and ½ inch in diameter, with about ½ inch diameter as most satisfactory. Magnetizable foreign particles in the fluid flow being filtered attach themselves to the balls and build up fiber-like agglomerations on the surfaces of the balls that effectively extend the magnetic fields of the balls themselves.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. A magnetic separator comprising a fluid passage chamber having an inlet and discharge, and a plurality of permanently magnetized balls of a ferromagnetic hexagonal iron oxide compound substantially immovably disposed with respect to each other in said chamber in the path of flow of said fluid.

2. In a magnetic filter including a container having spaced inlet and discharge passages connected thereto for fluid flow therethrough, a perforated removable cartridge within said container in the path of fluid flow between said passages, a spring spacing said cartridge from said inlet and holding the same against said discharge passage whereby fluid by-pass flow about said cartridge is precluded at all times, and a plurality of permanently magnetized balls comprising ferromagnetic hexagonal iron oxide compound contained in said cartridge and substantially filling the same, said balls having poles randomly disposed with respect to each other.

3. In a magnetic filter having a fluid flow passage and an inlet thereinto and a discharge therefrom, a plurality of permanently magnetized spheres of a ferromagnetic hexagonal iron oxide compound in direct engagement with each other and substantially filling said passage, said spheres each having a pair of opposite magnetic poles at their peripheries, said spheres being retentively disposed with said poles arranged in a haphazard orientation with respect to the poles of the other spheres for contact with the fluid flowing therethrough.

4. A filter for filtering a fluid comprising in combination, a housing, a non-magnetic mechanical filtering medium in said housing for removing non-magnetic foreign particles from said fluid, and a plurality of permanently magnetized spheres of a ferromagnetic hexagonal iron oxide compound in direct engagement with each other and disposed in said housing in upstream flow relation to said non-magnetic filtering medium for continuously attracting and holding any magnetic impurities in said fluid, said spheres each having a pair of opposite magnetic poles at their peripheries, said spheres being retentively disposed with said poles arranged in a haphazard orientation with respect to the poles of the other spheres for contact with the fluid flowing therethrough.

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