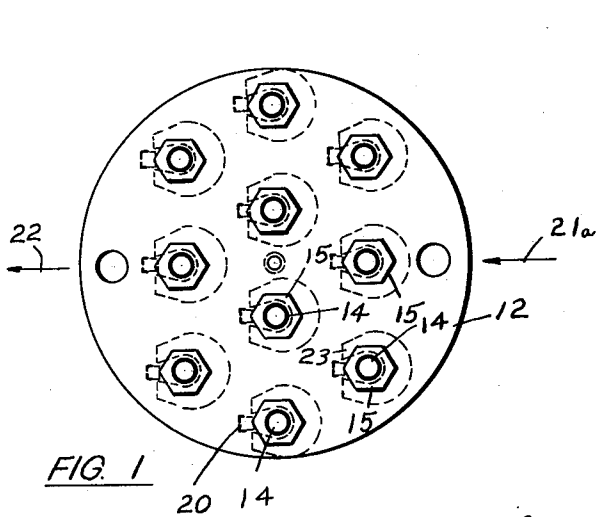
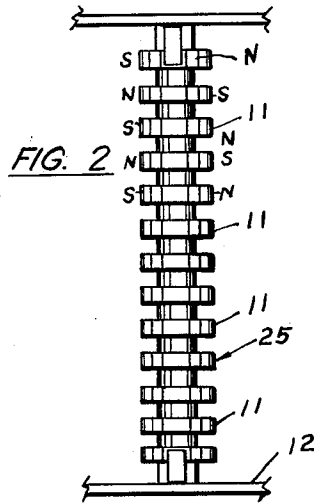
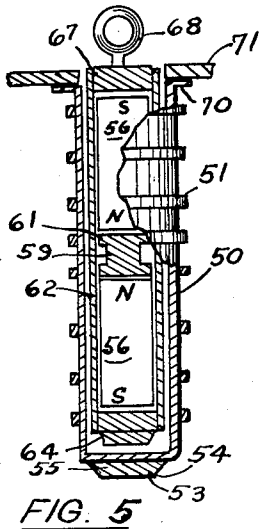
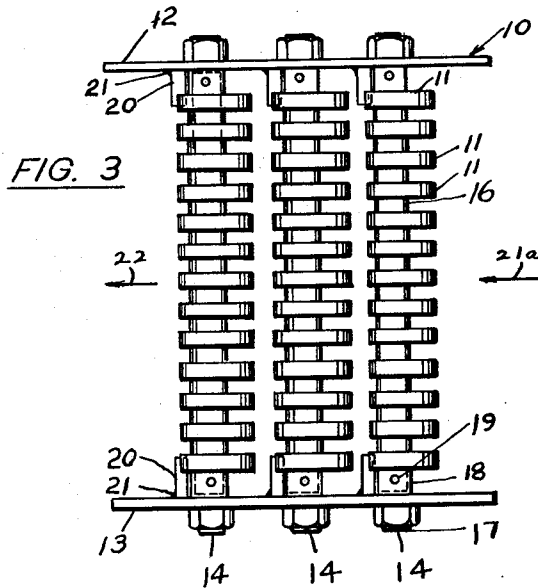
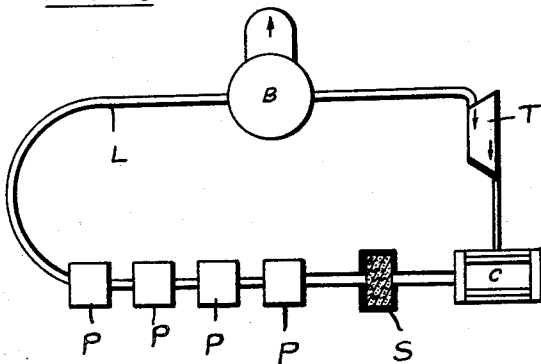


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M. L. CRAMER ETAL
MAGNETIC SEPARATOR FOR REMOVING TRACES
OF MAGNETIC CONTAMINATION FROM FLUIDS
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INVENTORS
MEREDITH L. CRAMER
JAMES FLOROS
BY

Charles L. Lonschke
attorney

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3,139,403 MAGNETIC SEPARATOR FOR REMOVING TRACES OF MAGNETIC CONTAMINATION FROM FLUIDS

Meredith L. Cramer and James Floros, Eric, Pa., assignors
to Eriez Manufacturing Co., Erie, Pa., a corporation of
Pennsylvania

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This invention relates to magnetic separators and, more particularly, to devices for removing fine ferrous and non-ferrous particles from liquids or gases.

In nearly every case where liquids or gases are used for one purpose or another, the removal of fine iron and non-ferrous particles has been a serious and recurring problem. Many methods have been devised to accomplish this removal. The methods have included screens, filter cloths, ceramics, magnets, centrifuges, chemical flocculation, settling beds, etc.; however, all of these methods either have economical or physical limitations so that no one method can solve all of the separation problems.

There is a need for a separator which will effectively remove fine iron and non-magnetic particles from a few microns down to a fraction of a micron in size under operating conditions which prohibit the practical use of any heretofore known separator. The referenced operating conditions usually include high material velocities, large volumes, high temperatures up to 1100° F., and probably most important is the fact that extreme pressure drop caused by the separator cannot be tolerated. Such a separator must be economically practical and its performance efficiency can be measured by the parts per billion remaining in the liquid or gas after separation rather than parts per million which has been a commonly accepted measurement of efficiency.

Specifically, such a separator would be of extreme value in the purification of steam condensate wherever boilers are used and in the purification of petroleum products, gases, printing inks, chemicals, food products, etc.

The present invention consists of a magnetic separator unit which, when installed in an appropriate vessel, effectively removes the desired amount of fine iron particles which, in turn, physically entrap a satisfactory quantity of non-magnetic particles. A unit is currently installed for test purposes on a steam condensate line of a large utility company and is performing very satisfactorily.

The magnetic separator element consists of multiple columns or fingers composed of permanent magnets so arranged that the fluids or gases passing through the trap must enter a magnetic field of such intensity and high magnetic gradient that substantially all of the iron particles, along with a high percentage of non-magnetic inclusions, are attracted and held by the magnets.

The configuration, placement, and polarity arrangement of the multiple permanent magnets are such that if any entrapped particles are forced to move along the magnet surface, they move into an area of greater flux density and higher magnetic gradient. Furthermore, as they approach the downstream or rear of the magnets, the water pressure, because of the velocity, is so much less that there is an actual physical as well as increasing magnetic tendency to hold the accumulated contamination tighter to the magnets, thus preventing its being washed away.

The intensity of the magnetic flux is always greatest and extremely concentrated about a sharp corner or point. This invention takes advantage of this principle by providing a multiplicity of such sharp corners and points.

The polarity arrangement of the permanent magnets in this invention is important in that by placing the magnets one above the other with a non-magnetic space between with alternate north and south polarity, auxiliary air gaps

are created, resulting in strong magnetic fields throughout the entire area through which the liquids and gases must pass.

After a quantity of iron and non-magnetic particles has been accumulated by the magnets, the magnetic element may be removed from the vessel and may be cleaned by any one of several methods. Preferably, it may be blown off by compressed air although a high speed stream of water or steam may be directed against the magnet faces, or downstream side, to accomplish the same purpose.

One purpose of this arrangement is to cause high magnetic induction of the outer magnetic rings, the sharp corners being areas of high magnetic gradient which are most effective in the entrapment of magnetic and weakly magnetic particles. A further and equally important purpose is to provide an easy means of removing accumulated particles from the magnets. In practice, after the magnetic element has accumulated a sufficient amount of particles, it can be removed from the pressure vessel and the inner magnetic elements may be removed from the assembly. Then the outer tubes, having lost their magnetism, can easily be cleaned by shaking, wiping, or tapping gently.

In another embodiment of this invention, a similar arrangement of permanent magnets is placed within non-magnetic tubes. Telescoped on each tube is a secondary non-magnetic tube. This secondary tube has narrow peripheral magnetic rings on its outer diameter placed directly adjacent to the inner magnetic poles with auxiliary rings of magnetic material placed between the first mentioned rings. A removable cartridge containing steel wool or another configuration of an induceable material could serve the same purpose.

It is, accordingly, an object of the present invention to provide an improved magnetic separator.

Another object of the invention is to provide a magnetic separator having a specifically designed magnetic circuit for removing traces of fine iron and non-ferrous magnetic particles from liquids and gases.

A further object of the invention is to provide an improved separating device which has an arrangement of magnetic elements which are simple and easy to clean after use.

Still a further object of the invention is to provide a magnetic separator which is simple in construction, economical to manufacture, and simple and efficient to use.

With the above and other objects in view, the present invention consists of the combination and arrangement of parts hereinafter more fully described, illustrated in the accompanying drawing and more particularly pointed out in the appended claims, it being understood that changes may be made in the form, size, proportions, and minor details of construction without departing from the spirit or sacrificing any of the advantages of the invention.

In the drawing:

FIG. 1 is an end view of a magnetic separator according to the invention;

FIG. 2 is a front view of one magnetic column of the separator;

FIG. 3 is a top view of the magnetic separator;

FIG. 4 is a schematic view of the magnetic separator assembled in a boiler circuit; and

FIG. 5 is a view of another embodiment of the invention.

Now with more specific reference to the drawing, FIGS. 1, 2, and 3 show a magnetic separator 10 having two spaced end plates 12 and 13 held together by means of rods 14 which constitute part of the magnetic columns and are distributed in vertical rows and in staggered horizontal rows as shown in FIG. 1. The rods 14 are preferably made of non-magnetic material such as stainless

steel, for example, and they support the magnetic elements with the spaces therebetween.

The magnetic elements are made up of horseshoe shaped magnets 11 which are supported in spaced aligned relation on the rods 14. The rods 14 are made up of intermediate round cylindrical portions which are attached to stub ends 17 by means of hollow cylindrical sleeves 18 which receive the rods 14 and are held thereto by means of pins 19 which extend through the sleeves 18. The sleeves 18 are made of stainless steel or some other non-magnetic material.

Disposed between the magnetic elements or magnets 11 are hollow, cylindrical, sleeve like spacers 16 which receive the rods 14 and are disposed concentric thereto and rest between the magnetic elements 11 and hold them in spaced relation. The spacers 16 are made of non-magnetic material such as stainless steel as are the rods 14.

The horseshoe shaped magnets 11 are generally circular at the upstream end and the circular portion is smoothly connected to the straight edge. Therefore, there is a considerably greater volume of magnetic material at the upstream ends of the magnets. The downstream end of each magnet is flat as disclosed and the legs of the horseshoes are spaced from each other. The legs of all of the horseshoe magnets point in the direction of the flow of fluid. The polarity of the magnets in each individual row is as shown in FIG. 2; that is, the polarity of the magnets on any single rod is staggered. The polarity of any leg is adjacent a leg of unlike polarity of a magnet in the same row on each side of it. The same polarity arrangement is used for all of the magnetic assemblies such as shown in FIG. 2.

Blade like lock bars 20 are welded at 21 to the insides of the end plates 12 and 13 adjacent the end of each rod 14 and along the side and in spaced relation to the sleeves 18 so that the blade like bars may extend between the legs of the magnet adjacent thereto and hold the magnetic column against rotation. The flow of the fluid through the magnetic separator when it is supported in a circuit is as indicated by arrows 21a and 22 and as the fluid flows over the rear end of the magnet, the particles therefor are attracted by the magnetic flux concentration at sharp edge tip corners 23 of the magnets and thereby subject the traces of foreign matter entrained in the fluid stream to a strong attractive force. The material attracted to the magnets by the strong magnetic field is held between the magnets and, therefore, does not tend to be washed off by the fluid stream.

In FIG. 4, the device is shown inserted in a steam power plant boiler circuit, by way of example of a typical installation, wherein it is suited to remove traces of iron oxide entrained in the boiler feed water. A boiler B is indicated having a turbine T connected thereto which discharges to a cooler receiver C and from thence into a magnetic separator S, which constitutes the subject matter of this invention, where traces of iron oxide are removed. Thereafter, the liquid water flows through preheaters P and through a line L back to the boiler B. This is disclosed as a typical example of installation of the apparatus.

In the embodiment of the invention shown in FIG. 5, a magnetic tube is shown which may be used to remove iron from various materials which may move relative thereto. The device is made up of an outside non-magnetic tube 50 having spaced peripheral bands 51 supported thereon and welded thereto. The bands 51 are made of magnetic material and have sharp corners on each edge thereof which cause a flux concentration and result in areas of high magnetic force. A magnetic member 53 has a peripheral corner 54 which extends around it in annular form with a flat lower end 55 thereof.

Cylindrical permanent magnetic slugs 56 have like poles adjacent each other as shown and have a magnetic spacer 59 therebetween which is in the shape of a spool having spaced flanges 61.

An inner tube 62 is made of non-magnetic material such as stainless steel, brass, or the like and it has a plug 64 disposed in the lower end thereof. The plug 64 is made of magnetic material. A non-magnetic plug 67 is disposed in the other end of the tube 62 and an eye bolt 68 is fixed to the plug 67 for lifting and supporting the assembly.

The non-magnetic tube 50 is flared out at its ends at 70 and may be attached to a supporting member 71. Therefore, when the tube 50 is attached to the supporting member 71, the assembly made of the tube 62, slugs 56, spacer 59, and plugs 64 and 67 may be lifted from the device. Then when the magnet assembly is removed, the bands 51 as well as the member 53 will be de-magnetized. Therefore, any magnetic material adhering thereto will drop away from it.

The foregoing specification sets forth the invention in its preferred practical forms but the structure shown is capable of modification within a range of equivalents without departing from the invention which is to be understood is broadly novel as is commensurate with the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A magnetic separator adapted to be connected in a fluid stream of a flow line for removing magnetic particles from said fluid stream comprising spaced members, a plurality of spaced, parallel columns attached at their ends to said members and adapted to be surrounded by the fluid of said fluid stream, each said column comprising a rod, axially spaced horseshoe shaped magnets on said rods and having one leg of each said horseshoe magnet on opposite sides of a said rod from each other, and spacers on said rods between each two adjacent said magnets, some of said columns being spaced laterally from each other and some of said columns being disposed longitudinally of said fluid stream from each other, the legs of each said horseshoe shaped magnet extending in a downstream direction of said fluid stream with the ends of said magnets terminating downstream with the part of each said horseshoe shaped magnet between the said legs thereof being upstream of said legs.
2. The magnetic separator recited in claim 1 wherein one leg of each said magnet has a north polarity and the other a south polarity and each said leg of each said magnet is disposed adjacent a leg of another said magnet on said column on the same side having an opposite polarity.
3. The magnetic separator recited in claim 1 wherein said horseshoe shaped magnets are flat on the ends thereof and said flat ends join the sides of the side edges of said legs at sharp corners.
4. The magnetic separator recited in claim 3 wherein one leg of each said magnet has a north polarity and the other a south polarity and each said leg of each said magnet is disposed adjacent a leg of another said magnet on said column on the same side having an opposite polarity.

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