Dec. 12, 1967 A. F. ISRAELSON 3,357,559

ENDLESS BELT MAGNETIC SEPARATOR WITH MAGNETIC DOFFER

Filed July 28, 1964 2 Sheets-Sheet 1

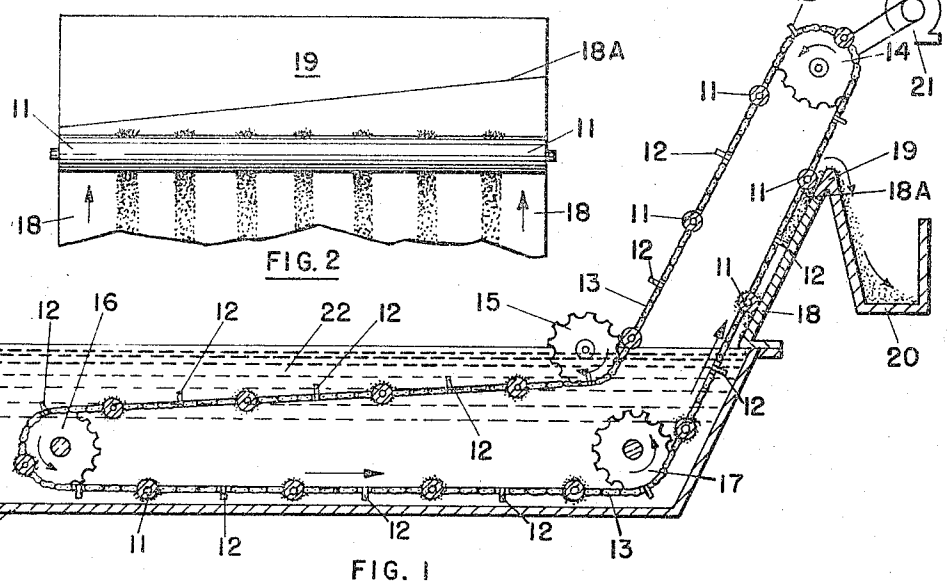

FIG. 1

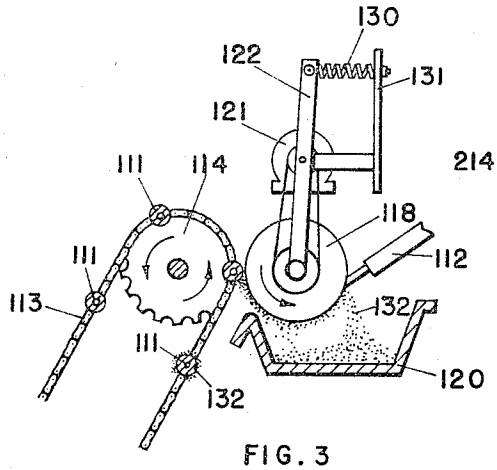

FIG. 3

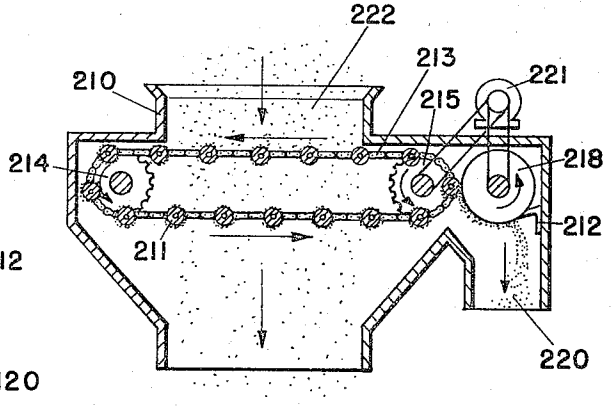

FIG. 4

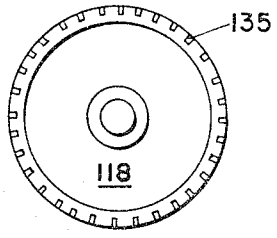

FIG. 5

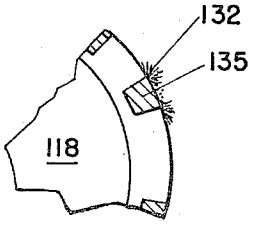

FIG. 6

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ENDLESS BELT MAGNETIC SEPARATOR WITH MAGNETIC DOFFER

Filed July 28, 1964 2 Sheets-Sheet 2

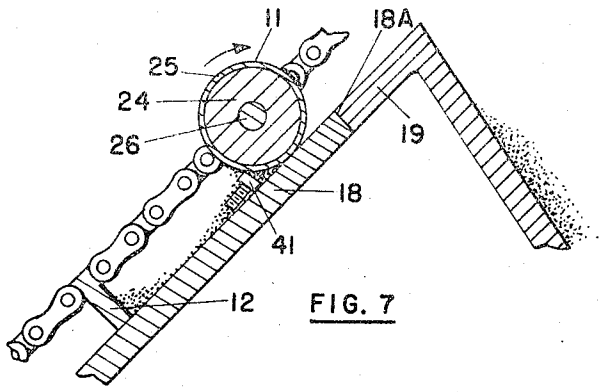

FIG. 7

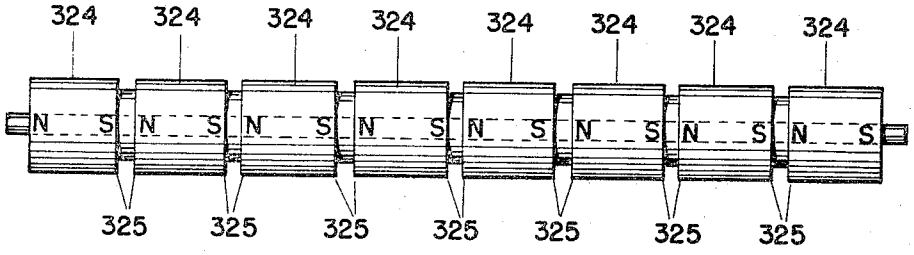

FIG. 8

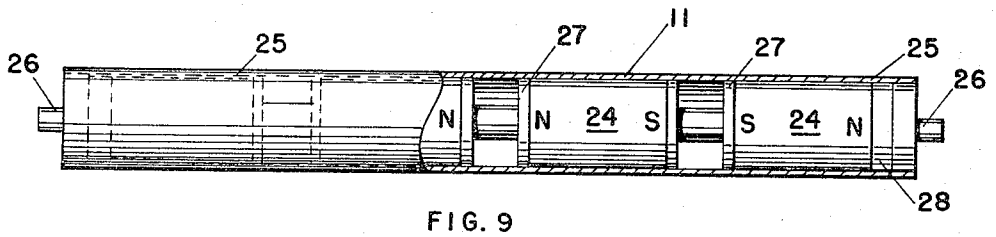

FIG. 9

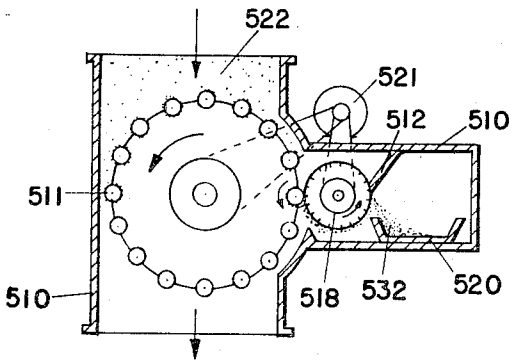

FIG. 10

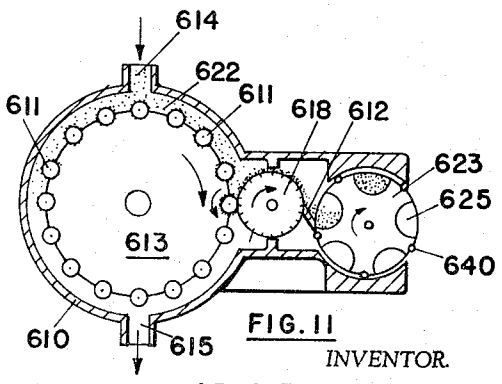

FIG. 11

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ENDLESS BELT MAGNETIC SEPARATOR WITH MAGNETIC DOFFER

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6 Claims. (Cl. 209—218)

This invention relates to an improved magnetic device for efficient removal of iron or steel particles from liquids, gases, or bulk materials, and for removal of the trapped particles from the magnets by an induction principle.

It has been established that magnets of the tube type do efficiently attract and retain ferrous particles when immersed in liquids, gases, or bulk materials. The tube type magnets referred to can be either of the type where cylindrical slugs of permanent magnet materials are enclosed within non-magnetic tubes, or of the type where short ring-type permanent magnets are stacked adjacent to each other with appropriate air gaps separating the rings; the stack forming a magnetic rod, or finger. The disadvantage of using these types of magnetic separators has been the difficulty and expense of manually removing the accumulated ferrous particles from the magnets.

The invention consists of an arrangement where magnetic tubes are mounted between two chains (this could be a single chain only) and conveyed by sprockets through the liquid to be cleaned. Each tube type magnet is supported on each end by bearings so that it is free to rotate. Equally spaced between the magnetic tubes and also attached to the chains are scrapers. As the magnetic tube moves through the liquid it accumulates the ferrous contamination. As the magnetic tubes are conveyed diagonally upward and out of the vessel they contact a steel or iron sheet. Magnetic attraction and friction causes the magnetic tubes to roll on the steel surface. The steel surface becomes magnetically induced with the result that the ferrous particles leave the magnetic tube and remain on the steel sheet. The cleaned tube magnet is then conveyed again through the liquid for another quantity of ferrous particles. Immediately following each magnetic tube is a scraper which scrapes the particles left by the magnet upward on the steel plate onto a non-magnetic surface, which can be a stainless steel plate and past the end where the ferrous particles fall into a container or chute.

Another embodiment involves the same type of tube magnets with bearings except the induction removal is accomplished by means of a driven steel cylinder which rotates and also rotates the magnets by friction and cleans the magnets by the same induction principle. A self cleaning grate magnet is illustrated which can be employed to magnetically clean wet or dry bulk materials.

The matter of rolling the magnetic tubes from a steel or iron surface onto a non-magnetic surface is important because where the sharp corner of the steel occurs, the induced flux density is higher than it is in the flat area and will remove larger pieces of iron from the magnet than would be removed by the flat surface. It then follows that, to take full advantage of this principle with the roll type iron remover, the face of the roll must consist of alternate steel and non-magnetic areas.

It is, accordingly, an object of the present invention to provide an improved magnetic separator and magnet cleaner in combination therewith.

Another object of the invention is to provide an improved structure for removing magnetic particles from permanent magnetic separators.

Still another object of the invention is to provide an improved method of removing trapped particles from magnets.

A further object of the invention is to provide an improved magnetic separator.

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 drawings:

FIG. 1 is a longitudinal cross sectional view of a magnetic separator according to the invention;

FIG. 2 is a top view of a combination magnetic and non-magnetic plate showing the tube type magnet;

FIG. 3 is a longitudinal cross sectional view of another embodiment of the invention;

FIG. 4 is a longitudinal cross sectional view of yet another embodiment of the invention;

FIGS. 5 and 6 are enlarged views of parts of the embodiment shown in FIG. 3;

FIG. 7 is an enlarged partial view of the structure shown in FIG. 1 of a magnetic tube and plate and non-magnetic member according to the invention;

FIGS. 8 and 9 are top views of two embodiments of magnetic tubes; and

FIGS. 10 and 11 are longitudinal cross sectional views of other embodiments of the invention.

Now with more particular reference to the drawings and with particular reference to the embodiment shown in FIG. 1, the magnetic separator is made up of the tank or vessel **10** having the non-magnetic tube members **11** having permanent magnets therein supported on the sprocket chain **13** in spaced relation. The sprocket chain is supported on the sprockets **14**, **15**, **16**, and **17**. These sprockets are fixed to the tank for rotation thereon in a well known manner. The sprocket **14** has a suitable driving means thereon indicated at **21**.

The tank **10** is suitable for containing a liquid **22** from which magnetic particles which are suspended in the liquid are to be removed.

The magnetic particles are attracted to the magnetic tube members **11** and are carried along above the bottom of the tank to the steel plate **18** where the particles are attracted to the plate by magnetism induced in the plate by the magnet tubes as the tubes pass along the plate in a manner hereinafter to be described and the particles are scraped from the plate **18** by the scrapers **12**. As the particles are scraped from the plate **18**, they are carried over the non-magnetic portion **19** of the device into the hopper **20** which may be in the form of a waste container. As indicated in FIG. 7 there will be field concentration at **18A** due to the sharp corner of the plate **18** where it joins the non-magnetic portion **19**. This will hold the particles such as bolt **41** or the like in place as the tubes pass. The magnetic tubes are made in the form shown in FIG. 9. The central part of the tube will be in the form of permanent magnets **24** having a hole therein that receives the axle **26**. An outer shell **25** will be made of non-magnetic material. The plate **18** will be made of magnetic material such as steel or soft iron. The non-magnetic material **25** may be of stainless steel, brass, plastic, or other suitable non-magnetic material. The edge of plate **18** is disposed at an angle to the axis of tube **11** so that the force required to remove the magnet from the plate is gradually reduced as the tube passes the end of plate **18**.

The separator works in the following manner: The magnetic tubes **11** pass through the liquid and gather particles of magnetic material and hold them in contact with the outer surface of the non-magnetic outer shell **25** and thereby carry the particles to the plate **18**. As each roller or tube **11** engages the plate **18**, magnetism will be

induced locally in the plate **18** so that the parts of the plate itself adjacent the non-magnetic material **25** are, in fact, a magnet at the location adjacent the tube. Since the particles on the outer periphery of the tubes **11** are closer to the induced magnet comprising the magnetized part of the plate **18**, they will be attracted from the outer surface of the tubes **11** to the surface of the plate **18** and the particles will be held in place there while the tube **11** moves on up the plate and on away from it. Thus, the magnetic material which previously held against the shell **25** will be attracted and held by the plate **18** until the tube moves on. As the tube continues to advance the scraper **12** on the chain directly behind the particular roll will scrape the magnetic particles from the plate **18** up to the non-magnetic portion **19** and from thence the particles will be carried on over the top of the portion **19** into the waste container **20**.

In the embodiment of the invention shown in FIG. 3, the sprocket **114** is shown by way of example supporting the chain **113** having magnetic tubes **111** attached to it in spaced positions. The tank **120** which is in the form of a waste container is supported below the roll **118** which is supported on axles. The member **118** is rotated by the motor **121** and is flexibly supported on an arm **122** on the axle. The roll **118** is urged against the moving tubes **111** by the tension of springs **130** which are attached to the support **131**. The scraper **112** rests on the outer periphery of the roll **118** and it scrapes the magnetic pieces **132** therefrom.

As the chain **113** is carried by the driven sprocket **114** in the direction shown, the pieces of material **132** will collect on the outside of the magnetic tubes **111**. As these tubes come into close relation with the induced portion of roll **118**, the particles will be attracted to the roll **118** and be removed from the tubes **111** by the magnetic action of the induced magnetism in the induced roll **118**. As the magnetized part of roll **118** moves away from the tubes **111**, the particles move with the roll **118**. The magnetized portion of the periphery of the roll **118** will lose its magnetism as it leaves the position adjacent the tubes **111** and any particles which are inclined to adhere to the outer periphery of the rolls **118** will be scraped therefrom by the scraper **112**. The roll **118** may have spaced axial slots **135** formed in it with non-magnetic material therebetween, as shown in FIGS. 5 and 6. These slots will attract and hold foreign magnetic particles as the roll **118** passes tubes **111**.

In the embodiment of the invention shown in FIG. 4, a chute having a housing **210** is shown through which granular material in the form of fine material and even tramp iron such as bolts indicated at **222** will be dropped. The foreign magnetic material entrained in the material passing through the conveyor chain **213** will be attracted to the tubes **211** and, as the chain continues to rotate into close proximate position to the induced roll **218**, the particles will be removed from the magnetic rolls in the manner set forth above in connection with the other embodiments. The motor **221** is indicated as driving both the induced roll **218** and the sprocket **215** which, in turn, drives chain **213** and sprocket **214** through the belt shown.

The material adhering to the outer periphery of the induced roll **218** will be scraped therefrom by a scraper indicated schematically at **212**.

In the embodiment shown in FIG. 8, the rolls or tubes **11** could be made in the form of spaced permanent magnets **324**. Thus, a field concentration will be formed at the corners **325** so that any minute particles of magnetic material entrained in the liquid will adhere to the magnets at these corners.

In the embodiment of the invention shown in FIG. 10, the magnetic tubes **511** which may be similar to the tubes **11** in FIGS. 1 and 7 are supported on a suitable conveyor to be rotated by the motor **521** as shown. These tubes **511** come in contact with the drum **518** and turn as they are rotated. Thus, they will lose the iron that is attracted

to them to the drum **518** in a manner disclosed in the other embodiments, and this iron will be scraped from the drum by the scraper **512**. The frame **510** may be of any suitable design.

In the embodiment of the invention shown in FIG. 11, the tubes **611** will be supported on a suitable conveyor **613** and will move through material to be processed that flows through the body indicated by **610** from the inlet **614** to the outlet **615**. The tubes **611** will engage the drum **618** in a manner disclosed in connection with the other embodiments of the invention, and the material thereby attracted from the tubes will be scraped from the drum **618** by the scraper **612** and will be trapped in the trap wheel **623** from which it may be discharged in a suitable manner. The trap wheel **623** has the cavity **625** on the outer periphery from which material may be discharged. The seals **640** which may be of conventional design make it possible to utilize a higher pressure inside the body **610** than the outside ambient pressure.

The foreging 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.

What is claimed is:

1. A magnetic separator comprising a tube made of non-magnetic material,

axially spaced permanent magnets in said tube adapted to form a magnetic field through the wall of said tube,

said permanent magnets being disposed with like poles adjacent each other,

a plate made of magnetizable material and having a width greater than the diameter of said tube,

means to move said tube in an endless path from a position spaced from said plate a distance greater than the diameter of said tube through a material containing particles of magnetic material whereby said particles are attracted to said tube,

said means moving said tube into engagement with said plate and along said plate parallel thereto whereby said plate is magnetized by said magnets and said plate is adapted to attract said particles from said tube.

2. The magnetic separator recited in claim **1** wherein said means to move said tube comprises a chain conveyor means having a plurality of spaced tubes like said tube supported thereon,

said chain conveyor means being adapted to move said tubes into engagement with said plate, whereby said fields magnetically induce said plate and said plate attracts said particles of material thereto.

3. The magentic separator recited in claim **2** wherein,

scraper means are supported on said chain conveyor between said tubes and said scraper means are adapted to move said particles of magnetic material along said plate.

4. The magnetic separator recited in claim **3** wherein,

a non-magnetic member is supported at one end of said plate disposed from the path of said magnetic tubes,

and a receptacle to receive said magnetic material is disposed adjacent said non-magnetic member,

said scraper means being adapted to scrape said magnetic particles over said non-magnetic members into said receptacle.

5. A magnetic separator comprising a tank, having two sides, two ends, and a bottom,

spaced sprockets supported in said tank,

a sprocket supported above said tank adjacent one end thereof,

laterally spaced chains supported on said sprockets,

spaced non-magnetic tubes,

permanent magnets in said tubes adapted to provide fields extending through said tubes,

means rotatably supporting said tubes on said chains,
a magnetic plate member supported on said tank adjacent one end thereof,
said magnetic plate having a surface adjacent said chains,
a non-magnetic plate member having a surface disposed generally co-planar with said magnetic member,
means to drive said chain to bring said tubes into rolling engagement with surface of said magnetic plate whereby the part of said plate adjacent said tube is magnetized by said field and said magnetized plate attracts foreign magentic pieces from said tube,
spaced scrapers attached to said chains and spaced between said tubes,
said scrapers being adapted to scrape magnetic pieces along said magnetic plate to said non-magnetic plate.

6. A magnetic separator comprising
a tube made of spaced permanent magnets,
each permanent magnet having its poles adjacent unlike poles of the magnet adjacent therto,
a plate having a width greater than the diameter of said tube made of magnetizable material,
means to move said tube through a material containing pieces of magnetic material whereby pieces are attracted to said tube,
means to move said tube into engagement with said plate whereby said plate is magnetized by said magnets and said plate is adapted to attract said particles from said tube,
said means moving said tube along said plate to the edge thereof and thence away from said plate,
said edge being disposed at an angle to the central axis of said tube whereby to distribute the material over said magnetizable plate preventing erratic and intermittent movement of said moving means.

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