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(54) Low intensity magnetic separator

(57) A magnetic separator apparatus for separating magnetizable particles from a continuously flowing stream of particles in a flowing stream of fluid, including a housing with a tunnel therethrough and a carrier relatively movable reciprocally through the tunnel. The carrier has spaced filter elements containing magnetizable filter media and inlet and outlet streams of particles in a flowing fluid flow into each filter. The separation continues until a filter element becomes filled with particles, at which time the filled filter element is removed from the magnetic field and replaced with a clean element to permit the separation to continue while the filled element is emptied and cleaned to be made ready for subsequent use. The housing is formed by a pair of magnetically permeable spaced plates with magnetic elements therebetween along sides of the tunnel. The elements may be permanent magnets, electromagnets, of superconductive magnets to create a low intensity field.

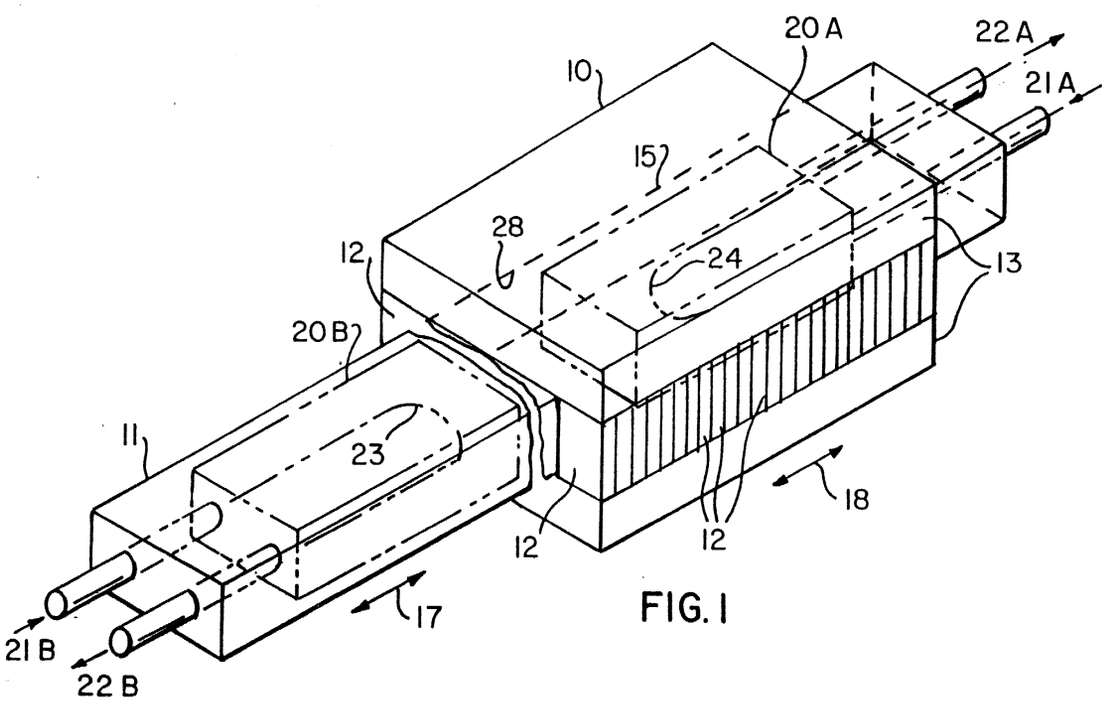

FIG. 1

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Description

[0001] This invention relates to the field of magnetic separation and more particularly, it relates to an apparatus for the separation of magnetizable particles from a mass of ore particles by the use of a low intensity magnetic field.

[0002] Super-conducting magnets are well-known in the prior art, and there is some limited amount of prior art, as indicated in U.S. Patent No. 5,743,410, issued April 28, 1998, that describes the use of such super-conducting magnets in separation techniques.

[0003] This invention provides an apparatus and a method for separating magnetic particles from a liquid or gaseous stream of particles passing through an enclosed housing wherein two opposed magnets, which might be permanent magnets, electromagnets, or super-conducting magnets, which maintain a low intensity magnetic field across the stream of particles. The stream of particles to be separated passes through a series of filter elements as they pass into, through, and out of the magnetic field. At least two of these filter elements are arranged such that one is operational in actively collecting magnetic particles while the other is being cleansed of magnetic particles, as by backwashing, and made ready to be operational again. The housing includes two steel cover plates spaced apart and parallel to each other so as to allow the filter elements to be moved into and out of a tunnel-like space between the plates. Magnetic power is produced across that tunnel space by magnets placed along the tunnel on both sides thereof. The magnetic field strength of this separator is less or equal to 2 Tesla, and as such it is identified as a "low intensity" magnetic separator.

[0004] The novel features believed to be characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a schematic view in perspective of the separation apparatus of this invention which might be employed to separate magnetizable particles from a mass of magnetizable and nonmagnetizable particles;

Fig. 2 is a side elevational vied of a separator of this invention; and

Fig. 3 is a cross-sectional view taken at 3 - 3 of Fig. 2 showing the magnetic fields around the tunnel through the separator housing.

[0005] This invention deals with an apparatus and a method of using the apparatus to separate particles that are capable of being magnetized from a mass of particles in a continuously flowing liquid or gaseous stream. The magnetizable particles in the fluid stream are passed through a magnetic field where these particles are trapped by a filter medium while the nonmagnetized particles pass on through in the stream to an exit for discharge or for further treatment. When the filter medium is full of trapped material and begins to show signs of being clogged and resistant to the flow of the fluid stream there through, the clogged filter is removed from the magnetic field and replaced by a clean filter medium and the separation process is resumed while the clogged filter is cleaned to recover the magnetized particles and to prepare the filter for another operational period when called upon to do so. By appropriate scheduling the magnetic field and the equipment necessary to keep it in operation can produce an almost continuous processing of separating the mass of particles so as to recover the magnetizable portion thereof. This may require more than two filter elements to be serially subjected to the magnetic field, if the turn-around time for cleaning a clogged filter is longer that the time it takes the process to fill and clog a clean filter element. It will become apparent from the following description that a train of filter elements separated from each other by appropriate spacer elements may be arranged so that the time for removing a clogged filter from the line and replacing it with a clean filter element can be reduced to an acceptable minimum to maintain a substantially continuous separation process.

[0006] Fig. 1 of the attached drawings illustrates a typical apparatus for use in accomplishing the separation of this invention. The central housing 10 of this invention includes two parallel plates 13 of magnetizable or magnetically permeable material, such as mild steel. This arrangement form a tunnel 28 through the center to receive filter elemtn carrier 11 movable there through. In order to produce a magnetic excitation of the housing 10 the two side wall spaces immediately adjacent to the central tunnel are filled with magnets 12, i.e. permanent magnets, electromagnets, or super-conducting magnets.

[0007] Filter element carrier 11 in its simplest form is a long rectangular parallelepiped of nonmagnetizable material, e.g. copper, bronze, glass, plastic, or the like, with an internal space to hold two filter elements 20A and 20B, which might be fashioned with baffles and filled with steel wool so as to receive liquid or gaseous streams that will flow through, be dispersed throughout, and the solid magnetizable particles will be filtered therefrom. Each filter element 20A of 20B is connected to its own inlet and outlet liquid or gas streams to be treated for the separation of magnetizable particles from the remainder of the streams. Inlet stream 21B, when filter 20B is located within tunnel 28, brings untreated material into element 20B and it eventually turns around at 23 and flows outwardly at 22B. Similarly, inlet stream 21A brings untreated material into element 20A and it turns around at 24 and flow outwardly at 22A. Thus, the actual filtering operation functions only when respective

element 20A or 20B is in the operative position of housing 10 to apply its full magnetic field on the passing stream, 21A or 21B. That position is shown in Fig. 1 for element 20A. The inoperative position of element 20B in Fig. 1 is for the cleaning operation to be applied to element 20B.

[0008] Fig. 2 shows a side elevational view of the separator of this invention. Separator housing 10 includes a tunnel 28 between cover plates 13 in which filter carrier element 11 moves reciprocally right or left to put a filter element 20A or 20B in the field of the magnets in housing 10 to effect a separation of magnetizable material from nonmagnetizable material. Separating canister 25 separates the filtering operation on element 20A from that of element 20B. Dummy canisters 26A and 26B merely separate filter elements 20A and 20B from any other items that may be in carrier 11 as it is moved to place filter elements 20A or 20B in or out of the magnetic field in housing 10. They also aid the smooth movement of the entire carrier 11. The movement of carrier 11 reciprocally right of left may be controlled by any type of linear actuator 27. Raw material for separation is provided by stream 21A into element 20A while it is in position in the magnetic field in housing 10. The other filter element 20B is outside of the magnetic field and available for cleaning and rejuvenation so as to be available for reuse when needed and when element 20A is ready for cleaning. It is to be understood that linear actuator 27 for moving carrier 11 may be used in the separator illustrated in Fig. 1, and in addition, may alternatively be used to move housing 10 which would be highly unlikely with the separator of U.S. Patent No. 5,743,410.

[0009] Fig. 3 shows a cross-section of the magnetic field in housing 10. Tunnel 28 is the guideway for containing carrier 11 as it relatively moves reciprocally in the direction into and out from the surface of Fig. 3 between cover plates 13 above and below tunnel 28; and also between rows of magnets 12 on either side of tunnel 28.

[0010] When permanent magnets 12 are used in one embodiment of this invention, the magnetic field strength between plates 13 is approximately 0.5 Tesla. When electromagnets of super-conductive magnets are employed between cover-plates 13, in accord with other embodiments of the invention, the magnetic field strength is approximately 2 Tesla. The type of separator disclosed in U.S. patent No. 5,743,410 relates more particularly to separators with field strengths above 5 Tesla and are considered to be high intensity in comparison to the low intensity type to which this invention applies.

[0011] While the invention has been described with respect to certain specific embodiments, it will be appreciated that many modifications and changes may be made by those skilled in the art without departing from the spirit of the invention. It is intended, therefore, by the appended claims to cover all such modifications and changes as fall within the true spirit and scope of the invention.

Claims

1. A magnetic separator for separating magnetizable particles from a continuous stream of particles in a fluid carrier, said separator including a housing having a plurality of magnetic elements producing a magnetic field around a generally horizontal tunnel extending through said housing, a nonmagnetic carrier relatively movable reciprocally through said tunnel and transporting at least two spaced filter containers containing magnetically activated filtration media and operatively connected to said continuous stream of particles, said carrier being alternatively positionable in the magnetic field or operational separation in one container and out of the magnetic field for cleaning while said continuous stream of particles continues to operate with another filter container on said carrier.

2. The magnetic separator of Claim 1 wherein said housing is movable with respect to said carrier.

3. The separator of Claim 1 wherein said carrier is movable with respect to said housing.

4. The separator of Claim 1 wherein said plurality magnetic elements include a side-by-side arrangement as of permanent magnets extending along each side of said tunnel and extending generally the entire length of said tunnel.

5. The separator of Claim 1 wherein said carrier includes a centrally located spacer between said at least two spaced filter elements.

6. The magnetic separator of Claim 1 wherein said magnetic elements include a side-by-side arrangement of electromagnetic coils extending along each side of said tunnel and extending generally the entire length of said tunnel.

7. The magnetic separator of Claim 1 wherein said magnetic elements include a side-by-side arrangement of super-conducting magnets extending along each side of said tunnel and extending generally the entire length of said tunnel.

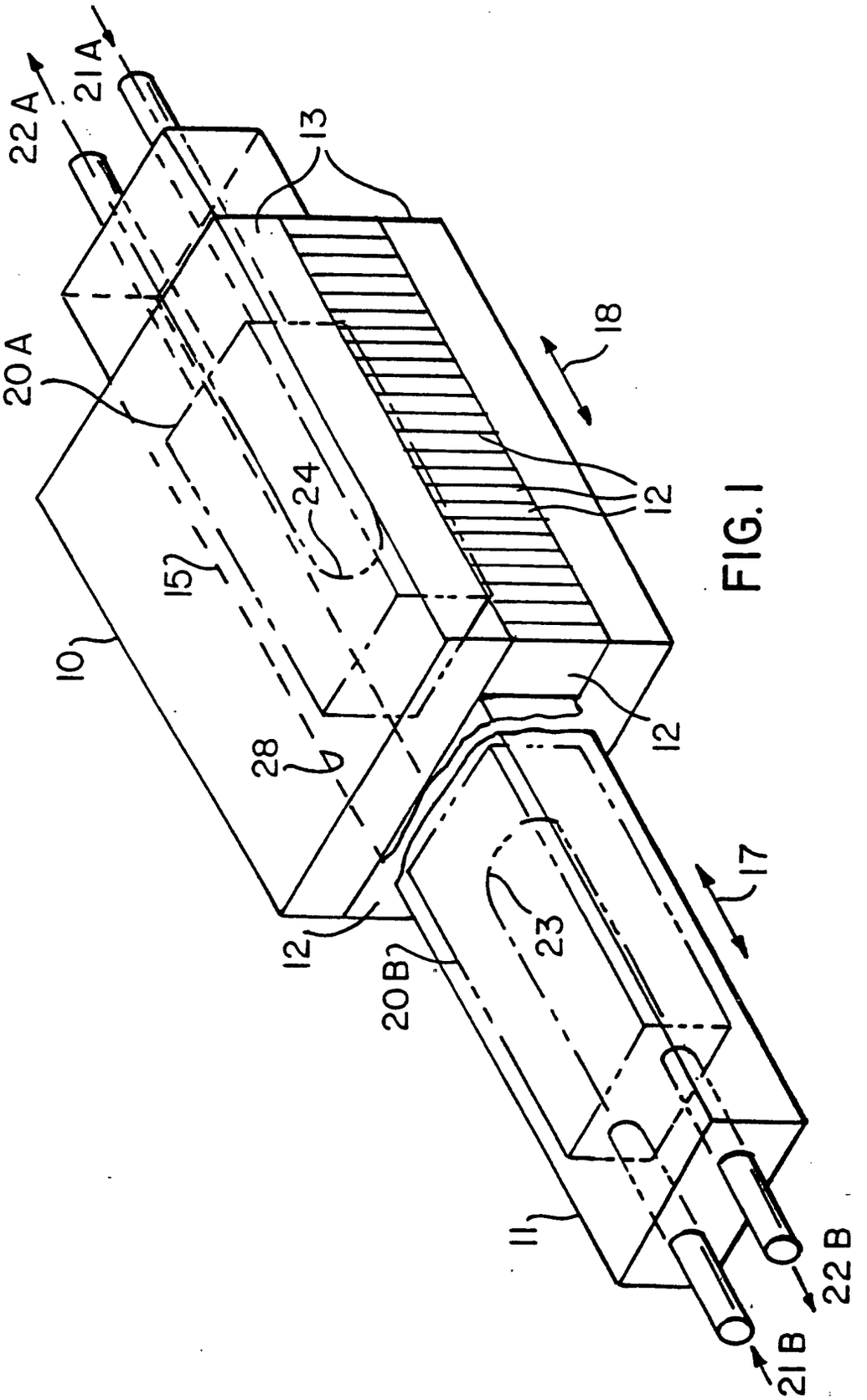

FIG. 1

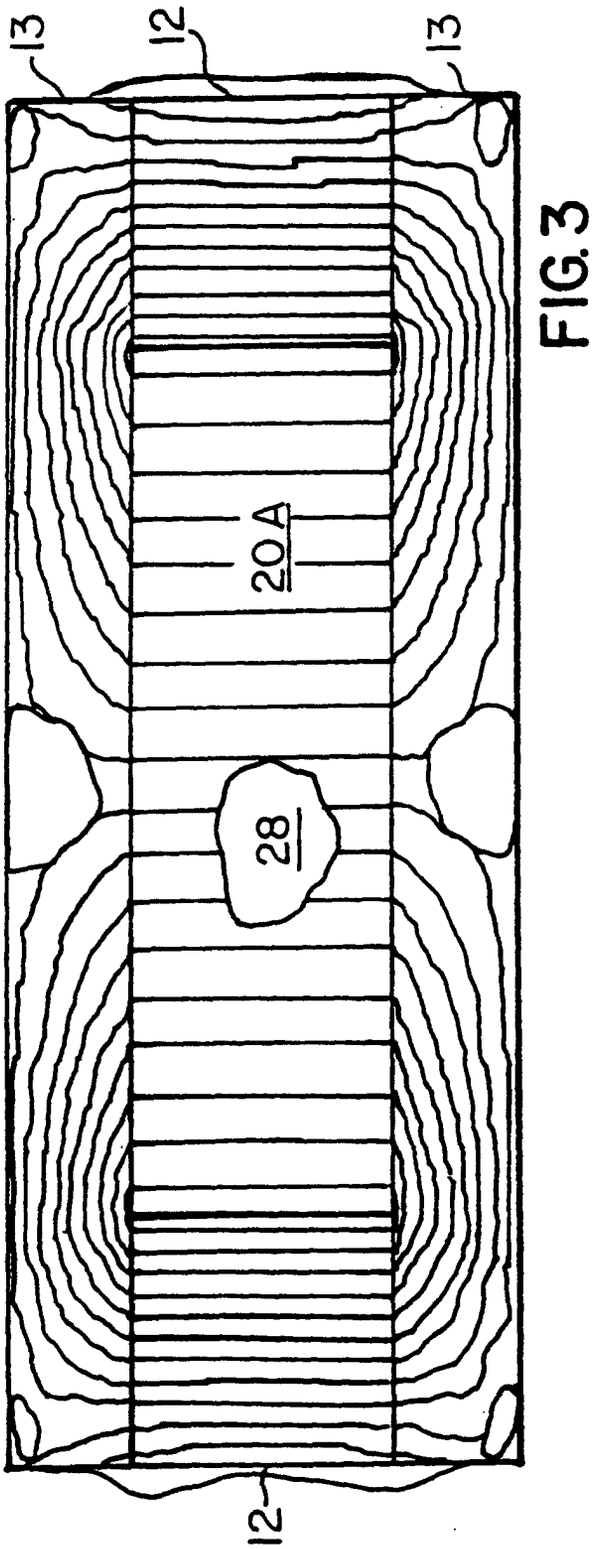
13
12
13
20A
28
12

FIG.3

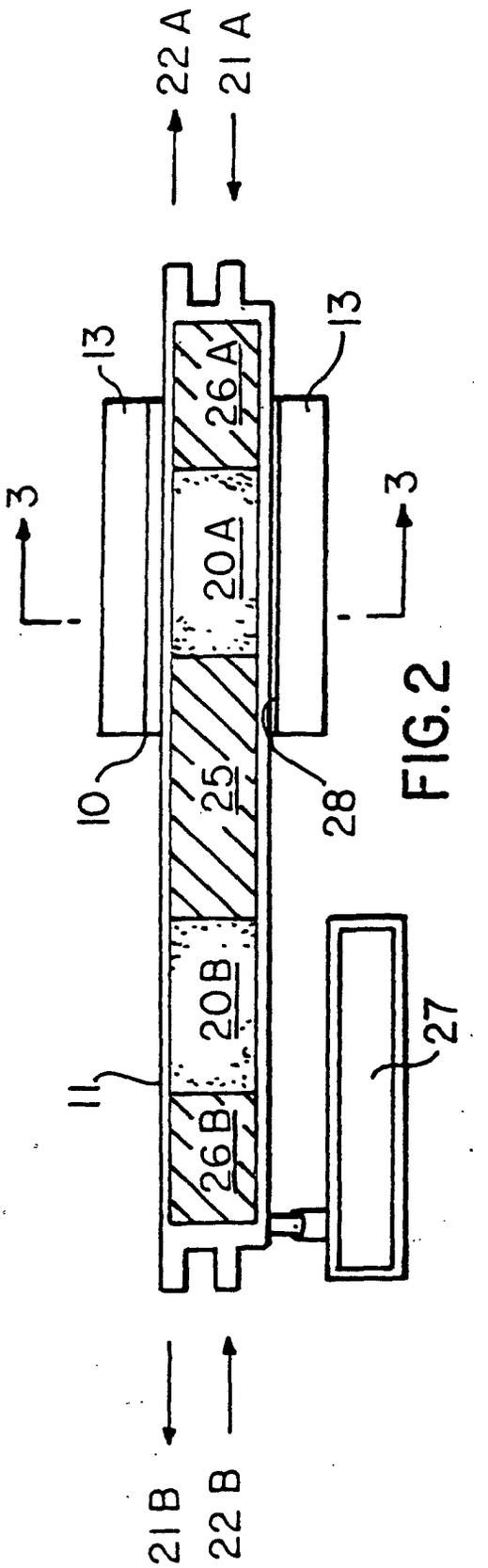
22A
21A
13
13
26A
3
3
20A
10
25
28
20B
11
26B
27
21B
22B

FIG.2