FLOW CONTROL APPARATUS FOR FLUENT MAGNETIC MATERIALS

Original Filed Sept. 24, 1965 2 Sheets-Sheet 1

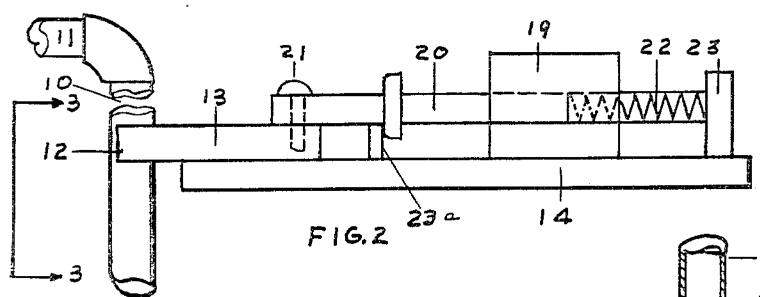

FIG. 2

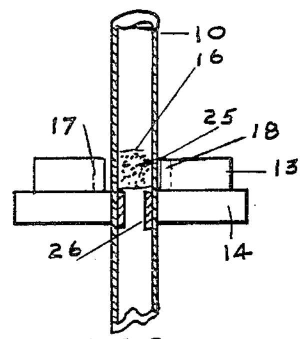

FIG. 3

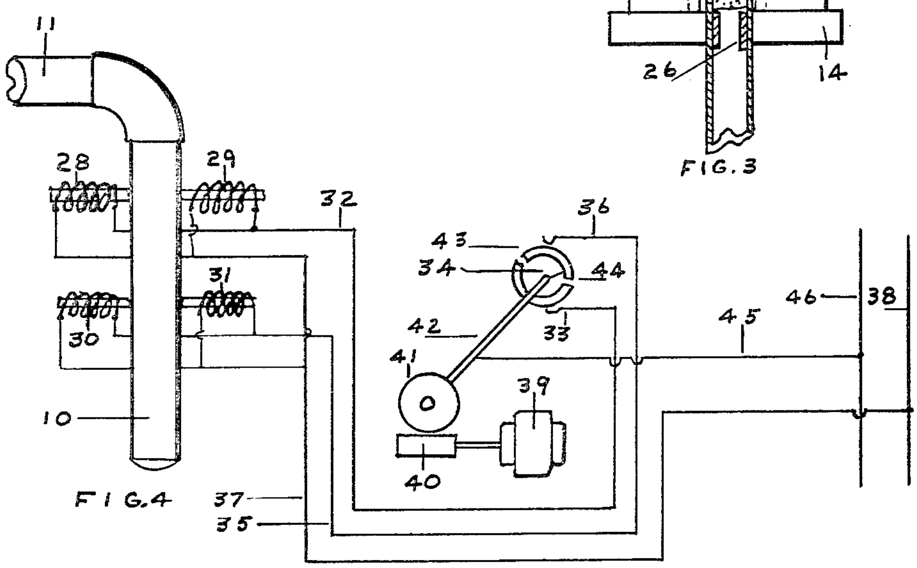

FIG. 4

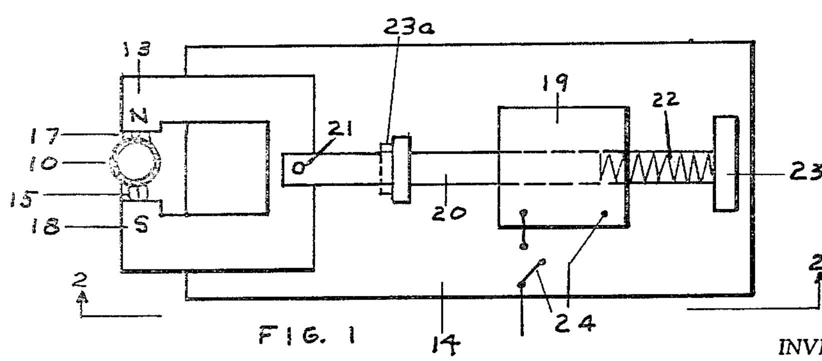

FIG. 1

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FLOW CONTROL APPARATUS FOR FLUENT MAGNETIC MATERIALS

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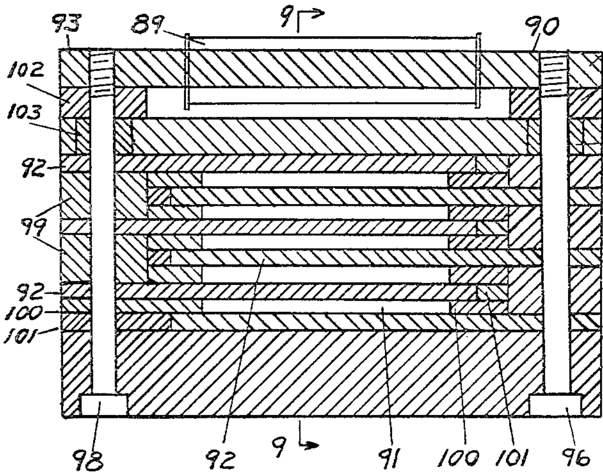

FIG. 8

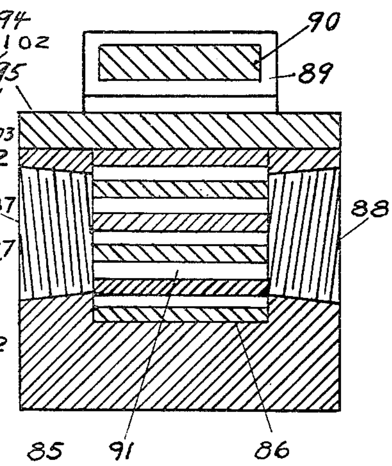

FIG. 9

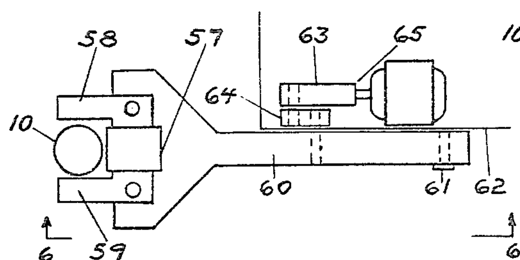

FIG. 5

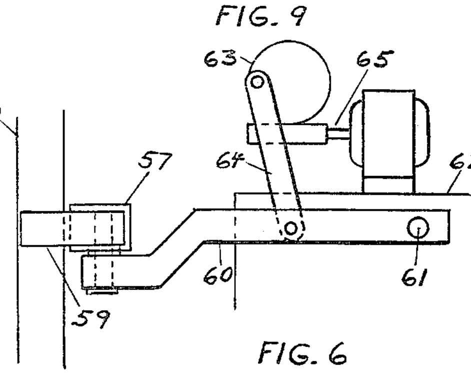

FIG. 6

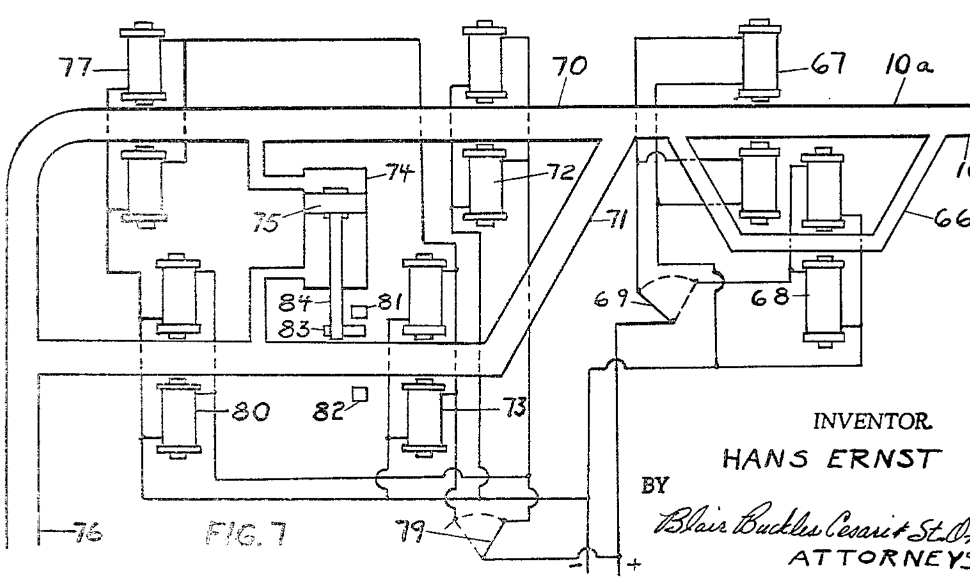

FIG. 7

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FLOW CONTROL APPARATUS FOR FLUENT MAGNETIC MATERIALS

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Original application Sept. 24, 1965, Ser. No. 489,951, now Patent No. 3,417,771, dated Dec. 24, 1968. Divided and this application May 7, 1968, Ser. No. 727,175

Int. Cl. F16k 9/00, 31/06

U.S. Cl. 137—81.5 7 Claims

ABSTRACT OF THE DISCLOSURE

The disclosed apparatus employs the selective introduction of a magnetic field in a channel through which flows a fluid having magnetizable particles dispersed therein in order to control fluid flow. A magnetic control valve disposed in or adjacent the channel includes a permanent or electromagnet for developing a magnetic field through which the fluid flows. The viscosity of the fluid increases with the strength of the magnetic field to restrict or inhibit fluid flow, as desired.

REFERENCE TO RELATED APPLICATION

This is a divisional applicaion of my copending application Ser. No. 489,951 filed Sept. 24, 1965, now U.S. Patent No. 3,417,771, entitled, "Flow Control Apparatus for Fluent Magnetic Materials."

BACKGROUND AND OBJECT OF THE INVENTION

This invention relates to control apparatus for governing the flow or volume translation of a fluent material having magnetic properties.

Fluent materials are those capable of flowing, have no shape, and therefore must be confined in ducts or channels to guide their path of movement during translation from place to place. Such materials may be dry, as metallic dust from tumbling operations, crushed ore and the like; or they may be liquid of any viscosity, containing magnetic particles, such as iron. Thus all these materials have magnetic properties.

In this invention, fluent materials having magnetic properties are contemplated to include those materials which in their natural state contain a large proportion of magnetizable particles and therefore the materials have magnetic properties; and also those materials which in their natural state have no magnetizable particles but to which magnetizable particles have been added to impart magnetic properties to the material. The term magnetic has conflicting definitions, so as used herein, it is intended to mean capable of being magnetized.

The control of volume translation of this class of materials involves several functions such as starting, stopping, volume control, rate control and selection of path of movement. The motivating force which effects the translatory movement may vary from gravity feed pressures to high pressures needed to utilize the material as a power medium. Anyone of the functions recited can be effected by the use of a magnetic control valve which comprises basically a magnet, either electrical or permanent, associated with a channel or passage in a manner that its magnetic field permeates said passage to magnetically intercept the magnetic particles in the approaching material. Thus the particles are interrupted in their course and held.

It should be understood that these particles are relatively small, even minute down to the class of powders and dust. It is contemplated that some may have a magnetic core covered by a non-magnetic coating. By using

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ultra fine particles, they may be adequately suspended in a viscous liquid to make it homogeneous.

One of the objects of this invention is to take advantage of and to utilize the magnetic properties of a fluent material as one of the elements of the combination of means for controlling or modifying its own movement and other characteristics.

Another object of this invention is to eliminate the use of movable mechanical valving or baffles inside a flow channel, as well as the mechanical linkage thereto when the material being conveyed has magnetic properties by contriving a control system that is external of the channel but influential within the channel.

A further object of this invention is to provide a new and novel control apparatus for the purposes described which is simple in construction, effective in use, and lends itself to remote control.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof, and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, wihout departing from or exceeding the spirit of the invention.

Referring to the drawings in which like reference numerals indicate like or similar parts;

FIGURE 1 is a diagrammatic plan view of a reciprocable magnet for stopping and starting flow of a fluent material having magnetic properties.

FIGURE 2 is an elevational view taken on the line 2—2 of FIGURE 1.

FIGURE 3 is an end view partly in section taken on the line 3—3 of FIGURE 2.

FIGURE 4 is a diagrammatic view showing one form of a flow rate control mechanism.

FIGURE 5 is a plan view showing another form of flow rate control mechanism.

FIGURE 6 is an elevational view taken on the line 6—6 of FIGURE 5.

FIGURE 7 is a diagrammatic view of a flow rate and channel selector control mechanism.

FIGURE 8 is a sectional view through a magnetic control valve.

FIGURE 9 is a section on the line 9—9 of FIGURE 8.

DETAILED DESCRIPTION OF THE INVENTION

A simple basic form of the invention is shown in FIGURES 1, 2 and 3. The reference numeral **10** indicates a closed channel, such as a pipe or conduit, to the top of which is connected a suitable source of supply **11** of a fluent material from which the material flows into the channel **10**. At a suitable location along the channel **10** is a control station indicated generally by the reference numeral **12**, at which a magnetic control is mounted to control the function of stopping and starting the flow. In this form of the invention, a bifurcaed permanent magnet **13**, shown in FIGURE 1, is mounted for reciprocation on suitable supporting means **14**, to and from the channel **10**. It will be obvious that when the open end of the magnet **13** embraces the channel **10**, as shown in FIGURE 1, that a magnetic field **15** will be projected into the channel **10** through which is flowing a fluent material having magnetic properties.

The magnetic field **15** functions to intercept, that is, to magnetize, attract, and hold the moving magnetic particles **16** of the material when the magnet is advanced to the position shown in FIGURE 1. This action clogs the channel, which in the process will stop the flow of non-magnetic particles as well, until the build-up stops the flow entirely. It will now be seen that the magnetic properties of the material cooperate with the magnet and its magnetic field to form a combination of means to initiate and stop the flow of material.

The magnet **13**, having opposing north and south pole pieces **17** and **18**, is reciprocated to and from an active position, preferably by power means rather than by manual means, such as solenoid **19**. It has a plunger **20**, connected at one end by a pin **21** to the magnet **13**. A spring **22** working against a fixed abutment **23** holds the plunger in an advanced position against a stop **23***a* to stop the flow. By operation of the switch **24**, the solenoid is energized, and the magnet **13** is retracted against the stop **23***a* to start the flow. Thus, when the power is off, the channel is blocked. This is convenient when the system is shutdown.

The effectiveness of this stopping operation will of course depend for one thing on the proportion of magnetic particles to non-magnetic material. Regardless of the proportions, however, if the magnetic particles are intercepted, that is stopped and held, it impedes the flow. It is also recognized of course, that the size of the cross section of the channel **10** and the strength of the magnetic field **15** of magnet **13** also plays an important part in this action.

Therefore it is obvious that there must be a prescribed relationship between the cross sectional space in the channel and the strength of the magnetic field for the field to adequately and effectively magnetize the particles as they enter the field. Thus the magnetized particles form or build up artificial poles on the inside of the channel. Other magnetic material is constantly being added as long as the flow continues, to build up these poles and bridge the channel, which stops the flow completely.

In any case, this results in the formation of a short section **25** of frozen material in the channel **10**, as shown in FIGURE 3, within the confines of the magnetic field **15** and held together by magnetic forces. Being confined in length by the extent of the magnetic field, this frozen section must also support the weight of the free material above it and beyond the reach of the magnetic field when the flow is stopped.

With fuzzy, light, dry material, probably somewhat aerated, the attraction of the magnetic forces and the friction of the side walls of the tube **10** are sufficient to hold back the material without slippage. With more compact and heavier material, and especially frictionless material, such as oils and the like, these forces may not be sufficient. To aid in this situation, the interior of the tube may be fitted with a short bushing **26**, as shown in FIGURE 3, just below the station **12**, which provides a more positive support against slippage.

Strong electro-magnets may be utilized in place of permanent magnets, and controlled by conventional switches, when it is desired to eliminate movable magnets. It may not be convenient to use a vertical channel with gravity feed, in which case the tube may be set at an angle, or even horizontal, and the source of supply pressurized sufficiently to effect flow. In some cases, suction may be resorted to.

Another function of the control of volume translation is determining the rate of flow of these materials by use of their own magnetic properties. One form of rate control mechanism is diagrammatically shown in FIGURE 4, comprising two independent magnetic control valves mounted in spaced relation along the tube **10**, the first valve comprising a pair of electromagnets **28** and **29**, and the second valve having a pair **30**, **31**. In operation, the second pair **30**, **31** are energized to stop the flow and thereby fill the tube **10** above this point. Then the first pair **28**, **29** are energized to hold back or stop the flow at that point, and the second pair simultaneously de-energized to release the material trapped between the two pairs so that it flows on as by gravity.

The cycle is repeated by again energizing the magnets **30**, **31** and the first pair simultaneously de-energized which again fills the interval of tube **10** between the two pairs of magnets. Thus, by these alternate operations, an intermittent feed is achieved.

An electrical control circuit for governing automatic alternate operation of these valves is shown diagrammatically in FIGURE 4. One end of the windings of the first pair of magnets **28**, **29** is electrically connected in parallel by line **32** to brush **33** of a commutator **34**. One end of the windings of the other pair of magnets **30**, **31** are connected in parallel by line **35** to brush **36**. The remaining ends of all the windings are connected in parallel by line **37** to a power line **38**.

Power rotation of the commutator is obtained by providing a conventional power driven reduction gear drive mechanism comprising a motor **39**, a worm **40** and a worm gear **41** mounted on shaft **42**. The shaft **42** bears the commutator **34** having independent arcuate sections **43** and **44**. The brush **33** is shown riding in contact with the segment **44** which is insulated from the shaft **42**. The brush **36** is shown riding in contact with the segment **43**. This segment is electrically connected to shaft **42**. A line **45** electrically connects shaft **42** to power main **46**. In the position of parts shown in FIGURE 4, current flows from the power line **46** to brush **36** and thus energizes magnets **30** and **31**, which stops the flow in channel **10** at that point. Since brush **33** is insulated, the magnets **28**, **29** are de-energized. Upon rotation of the commutator **34**, the brush **36** eventually engages the insulated segment **44** and the brush **33** engages the power segment **43**. This results in the upper magnets **28** and **29** stopping the flow, and the lower magnets **30**, **31** releasing the material trapped between the two pairs of magnets. Thus by continuous rotation of the commutator, the cycle repeats and an intermittent feed is obtained.

Another form of automatic feed mechanism is diagrammatically shown in FIGURES 5 and 6. In FIGURE 5, an electromagnet **57** having arms **58** and **59** embracing the feed tube **10**, is supported on the end of a swinging lever **60**, pivoted at **61** on a fixed support **62** at a control station. An eccentric **63** is connected by link **64** to the lever **60**. By driving the eccentric with a slow speed mechanism, indicated generally by numeral **65** and of the same type as that shown in FIGURE 4, the arm **60** is slowly raised and lowered longitudinally of the tube **10**. When the magnet coil **57** is energized, it will stop the flow of material in the tube regardless of its position. If this happens in the uppermost position of the lever **60**, then when the lever is lowered, the material in the tube will follow the lever down. But when the lever is reversed, the magnet **57** quickly pulls away and releases a certain amount of material in the lower end of the tube due to the departure of the magnetic field. Thus by regulating the rate of rotation of the eccentric and the throw, the rate of feed may be varied.

When it is desired to have a selection between a fast and a slow rate of flow, the channel **10** as shown in FIGURE 7 may be provided with a narrow by-pass channel **66**. The main branch **10***a* is provided with a magnetic control valve **67** and the by-pass channel **66**, of smaller flow capacity, is provided with a magnetic control valve indicated generally by the reference numeral **68**. These magnets are connected to a selector switch **69** whereby a selection of rate may be made.

In other words, by blocking the flow in the channel **10***a* by magnet **67**, with the switch **69** in the full line position, the material is forced to flow through the narrow channel section **66**, and therefore at a reduced rate. By throwing switch **69** to its dotted line position, the magnet **68** blocks the by-pass **66**, and magnet **67** is released to permit normally faster flow through channel section **10***a*. Thus the same arrangement may be set up for selection of different paths of flow as shown in FIGURE 7. This arrangement is particularly useful when the fluent material having magnetic properties is being pumped through the channel under pressure for use as a power medium. In such a case, the branch channels **70** and **71** are provided with magnetic control valves, indicated generally by numerals 72 and 73 which may be alternately energized by switch 79 to select the path of flow by blocking flow in the other channel. In this case the channels 70 and 71 are connected to opposite ends of a cylinder 74, containing a piston 75. Thus selection of channels determines the direction of movement of the piston.

The channels 70 and 71 are connected together to an exhaust channel 76. When the flow is coming into channel 70, a magnetic control valve 77 is energized by switch 79 in its dotted line position to block the flow from channel 70 to exhaust; and the magnetic control valve 73 is energized to block the incoming flow to channel 71. The exhaust from cylinder 74 is now free to flow to channel 76.

On the other hand, if the flow in channel 71, is to be utilized, the switch 79 is turned to its full line position to energize magnetic control valve 72 and block flow in channel 70, and also energize magnetic control valve 80 to block exhaust flow from cylinder 74, whereby the piston is actuated in the opposite direction. Turning the switch also released magnetic control valves 73 and 77, permitting exhaust from channel 70 and one end of cylinder 74, and permitting flow into the other end of cylinder 74.

Positive stops 81 and 82 are provided for engagement by abutments 83 carried by the piston 84 for positively limiting the movement of the piston in either direction. These stops may be replaced by switches or other mechanical means to effect actuation of switch 79, thereby providing continuous reciprocation of piston 75.

It is to be understood that the cylinder 74 and piston 75 may be replaced by any other form of linear or rotary hydraulic motor, or pressure responsive device.

The magnetic control valves which have been shown diagrammatically in the several views thus far, may be constructed as separate units for insertion in a flow line. FIGURES 8 and 9 show such a magnetic control valve comprising a block housing 85, made of non-magnetic material, having a central chamber 86 and a threaded inlet 87 and an outlet 88 at opposite ends thereof whereby the material may flow through the housing. A magnetizing coil 89 is mounted on top of the housing 85 and supported on an iron core 90. The opposite ends of the core are thus of opposite polarity when the coil is energized.

The chamber is subdivided into sub-chambers 91 by several flat dividers or laminae 92 whereby the incoming flow is caused to divide and flow simultaneously through the sub-chambers 91 and then collected to flow through the outlet 88. The laminae 92 are made of magnetic material, and alternate ones are connected to one pole 93 of the core 90 and the remainder of pole 94.

The path of flow of flux from each pole to the laminae is arranged so as to minimize loss or short circuit. Spacers of magnetic material 102 are placed between the non-magnetic cover 95 and the ends of the core to support the coil and core above the cover. Spacers 103 at the ends of the core 95 are also of magnetic material. The laminae on the right are stacked on the bolt 96 with spacers 97 of magnetic material between them. The laminae on the left are stacked on the bolt 98 with similar spacers 99 between them. It will be noted that the laminae are short enough that they do not extend to the other bolt. Spacers 100 of non-magnetic material are placed between the laminae to isolate them from each other because of their opposite polarity. Non-magnetic filler pieces 101 are placed between the free ends of the laminae to isolate them from the magnetic spacer blocks. The result is a plurality of narrow slots or sub-chambers 91, the opposite sides of which are of opposite polarity. Since the space between a pair of sides is narrow, a very strong magnetic field can be created and due to the relatively large area in addition, almost instantaneous stopping of flow can be obtained.

It will be noted that the bolts 96 and 98 are passed through the block 85 and are threaded in the ends of the core 90 whereby the entire assembly is secured together. It will be seen that the flux flows from the ends of the core 90 through the bolts 96 and 98, the spacers 102, 103, 97 and 99 to the laminae to create the magnetic field.

There has thus been provided a new and improved apparatus for controlling the flow of fluent magnetic materials within a channel. The fluent material may be selected to have characteristics suited to a particular application. For instance graphite, oil, molybdenum disulphide, tetrafluoroethylene, or nylon particles impregnated with magnetic material could be used. The use of impregnated resilient solid materials permits elastic deformation thereof under pressure, thereby aiding in the complete blocking of flow when desired. Furthermore, the fluent medium may be selected to have electrically conductive properties also and this is particularly advantageous to facilitate the pumping action in alternating current energized systems. In this case self induced fields in the fluent medium resulting from the impressed alternating magnetic field are generated.

The apparatus is designed to interact on the magnetic property of the material to effect interception of the flowing magnetic particles in the material and thus stop and hold them. This action progresses to the point that complete stoppage of flow is effected. It is of course contemplated that de-magnetizers can be used when the material is released to start flow again if found necessary for efficient operation. Such a system has many advantages. There are no moving parts and therefore no mechanical linkages to maintain and keep in repair and the system lends itself to remote control and to miniaturization.

I claim:

1. In an apparatus including a channel for conveying a fluent material having magnetic properties and a magnetic control valve comprising, in combination:

(A) at least one first lamina disposed in the channel;
(B) at least one second lamina disposed in the channel in closely spaced parallel relation to said first lamina,
 (1) whereby to define a passageway through which the fluent material conveyed in the channel must pass;
(C) a magnet; and
(D) means associated with said magnet selectively effective to couple magnetic flux from said magnet into said first and second laminae,
 (1) whereby to selectively create a magnetic field across said passageway effective to control fluent material flow therethrough.

2. In an apparatus for conveying a fluent material having magnetic properties, a magnetic control valve comprising, in combination:

(A) a housing having
 (1) an inlet,
 (2) an outlet; and
(B) a magnetic core mounted on said housing;
(C) a magnetizing coil wound around said core;
(D) at least one first magnetic lamina;
(E) a first magnetic insert coupling one end of said first lamina in magnetic circuit with one end of said core;
(F) at least one second magnetic lamina;
(G) a second magnetic insert coupling one end of said second lamina in magnetic circuit with the other end of said core;
(H) said first and second laminae disposed in said housing in closely spaced relation to define opposing sides of a channel communicating with said inlet and outlet,
 (1) whereby upon energization of said magnetizing coil, a magnetic field distributed substantially uniformly over the entire area of the gap between said laminae arrests the flow of fluent material through said channel from said inlet to said outlet.

3. In an apparatus for conveying a fluent material having magnetic properties, a magnetic control valve comprising, in combination:

(A) a housing having
  (1) an inlet,
  (2) an outlet, and
  (3) a chamber communicating with said inlet and outlet;
(B) a magnetic core mounted on said housing;
(C) a magnetizing coil wound around said core;
(D) a series of first magnetic dividers in magnetic circuit with one end of said core,
  (1) said first dividers being spaced apart and disposed to span said chamber;
(E) a series of second magnetic dividers in magnetic circuit with the other end of said core,
  (1) said second dividers disposed to span said chamber in alternating relation with said first dividers;
(F) said alternating first and second dividers defining a plurality of parallel channels, each communicating with said inlet and outlet,
  (1) whereby upon energization of said magnetizing coil, magnetic fields developing between adjacent first and second dividers arrest the flow of the fluent material through said channels from said inlet to said outlet.

4. The magnetic control valve defined in claim 3 wherein

(1) said first and second dividers are of a flat configuration and are arranged parallel to one another,
(2) whereby said channels are of substantially uniform cross-section throughout their lengths.

5. The magnetic control valve defined in claim 3 wherein said housing is formed of a non-magnetic material, and further includes

(G) magnetic inserts
  (1) interposed between said first dividers and said one end of said core for coupling said first dividers in magnetic circuit with said core, and
  (2) interposed between said second dividers and said other end of said core for coupling said second dividers in magnetic circuit with said core.

6. The magnetic control valve defined in claim 5 which further includes

(H) non-magnetic spacers
  (1) interposed between said first dividers and said other end of said core and between second dividers and said one end of said core,
  (2) whereby to confine said magnetic circuit to parallel paths across said channels between adjacent first and second dividers.

7. The magnetic control valve defined in claim 6 which further includes

(H) at least one bolt affixing said core, said first and second dividers, said inserts, and said spacers to said housing.

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U.S. Cl. X.R.

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