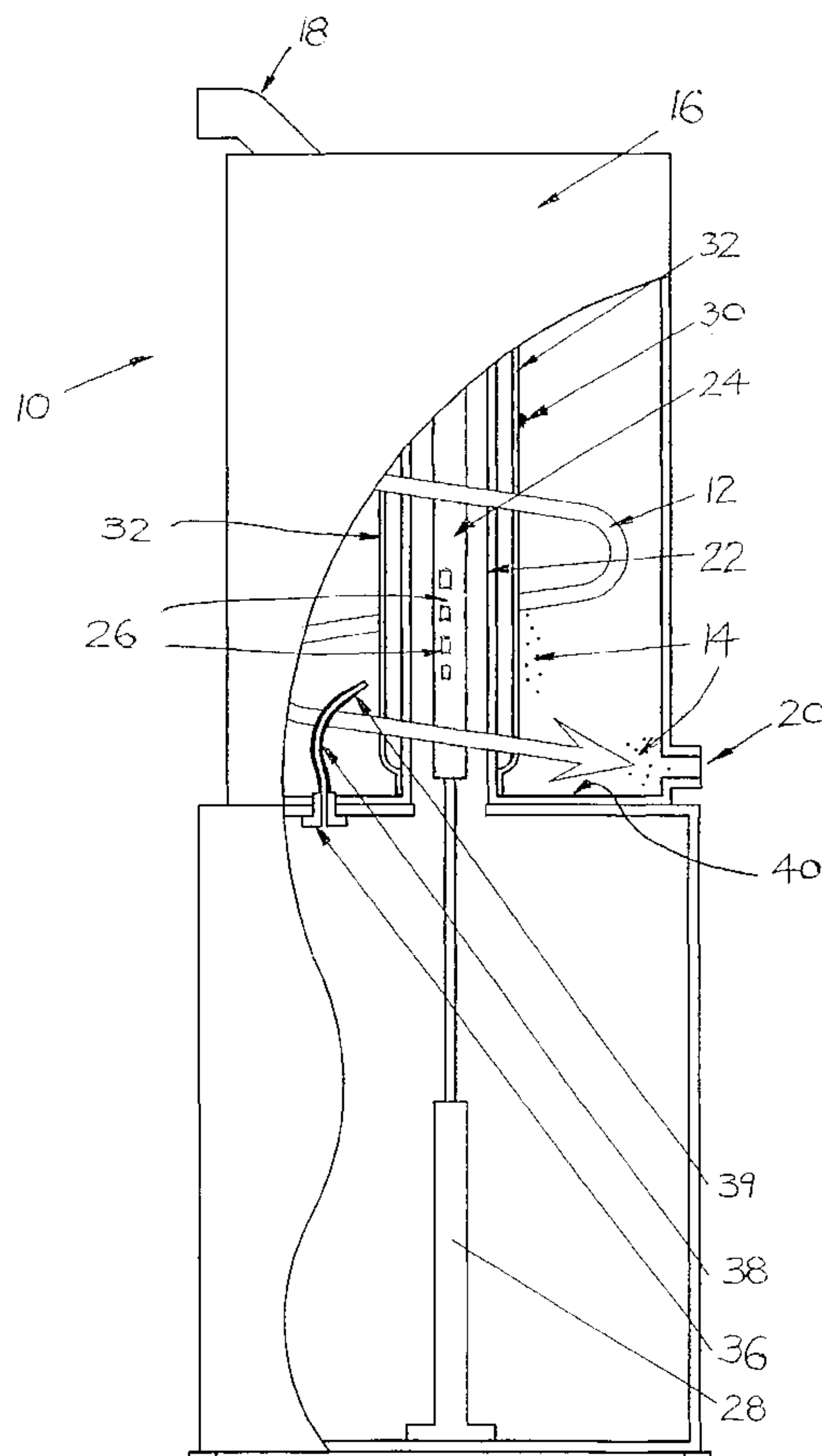




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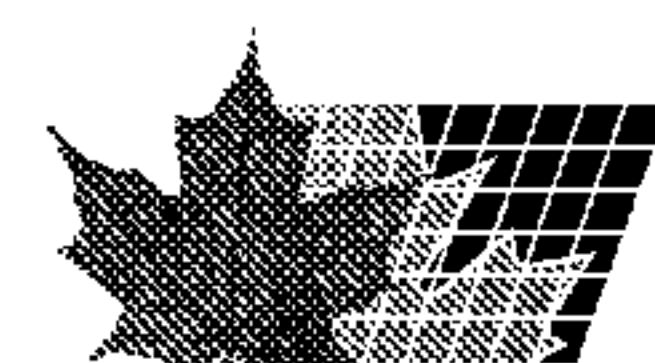
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(54) Titre : APPAREIL ET PROCEDE DESTINES A INDUIRE UN MAGNETISME
(54) Title: AN APPARATUS AND PROCESS FOR INDUCING MAGNETISM



(57) Abrégé/Abstract:

The present invention provides an apparatus for inducing magnetism in a flowstream of an at least partially magnetisable particulate feed material suspended in a liquid, the apparatus including: a treatment chamber having an inlet and an outlet



(57) Abrégé(suite)/Abstract(continued):

through which the flowstream respectively enters and exits the chamber; and a magnetic source able to be selectively activated with respect to the treatment chamber, such that, when activated, the magnetic source induces magnetism in at least some of the particulate feed material located in the chamber. This allows the introduction of a high gradient magnetic field to effectively magnetise both the weakly and strongly magnetic particulates for subsequent removal by setting or other techniques. When the magnetic source is deactivated, the flow stream of feed material dissipates the deposits of magnetised material from around the source to reduce the possibility of any flow restrictions and maintain the effectiveness of magnets.

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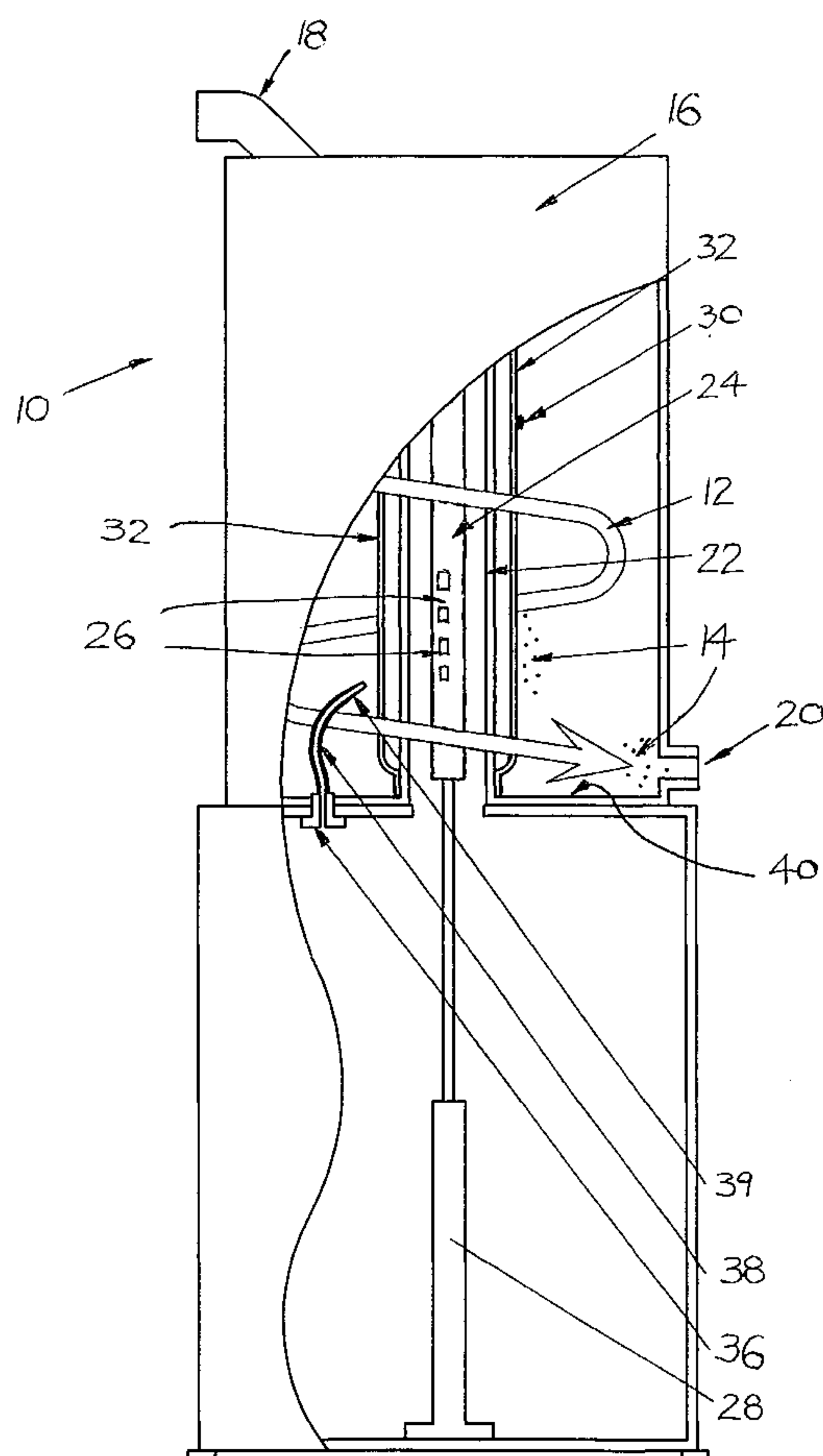
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(54) Title: AN APPARATUS AND PROCESS FOR INDUCING MAGNETISM



(57) Abstract: The present invention provides an apparatus for inducing magnetism in a flowstream of an at least partially magnetisable particulate feed material suspended in a liquid, the apparatus including: a treatment chamber having an inlet and an outlet through which the flowstream respectively enters and exits the chamber; and a magnetic source able to be selectively activated with respect to the treatment chamber, such that, when activated, the magnetic source induces magnetism in at least some of the particulate feed material located in the chamber. This allows the introduction of a high gradient magnetic field to effectively magnetise both the weakly and strongly magnetic particulates for subsequent removal by setting or other techniques. When the magnetic source is deactivated, the flow stream of feed material dissipates the deposits of magnetised material from around the source to reduce the possibility of any flow restrictions and maintain the effectiveness of magnets.

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AN APPARATUS AND PROCESS FOR INDUCING MAGNETISM**Field of the Invention**

The present invention relates to an apparatus and
5 process for magnetising a magnetisable material. In one
form the invention relates to a process for inducing
magnetism into a flow stream of particulate material to
facilitate subsequent separation of some of the magnetised
material and will primarily be described with reference to
10 this context. It should be remembered, however, that the
process of the invention may have broader use in systems
not involving the subsequent separation of any of the
magnetised material, such a general particulate settling
and water clarification process.

15

Background Art

Devices for inducing a magnetic field into a
magnetisable particulate suspension are known in the art
and have been applied to coagulate fine particles. Prior
20 to entering a settling tank for separation, such a
particulate suspension can be passed through a vessel in
which a magnetic field is applied. The magnetisable
particles become magnetised and subsequently self-
attracted. These self-attracted particles may then settle
25 under the influence of gravity to the bottom region of the
tank faster than they would have done as individual
particles, without any need to use chemical coagulant or
flocculation reagents. Such a process is useful for
removing very fine particulates which generally do not
30 separate quickly or easily under the influence of gravity.

The apparatus for such a process commonly makes use
of a low gradient magnetic field having a small rate of
change of magnetic strength. This type of magnetic field

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reduces the tendency of the magnetised particles to move toward the poles of the magnet/s that are used to create the magnetic field.

5

Summary of the Invention

In a first aspect the present invention provides an apparatus for inducing magnetism in a flowstream of an at least partially magnetisable particulate feed material suspended in a liquid, in use to precondition the
10 flowstream for a subsequent separation process in a separate stage, the apparatus including:

- a treatment chamber having an inlet and an outlet through which the flowstream respectively enters and exits the chamber; and
- 15 - a magnetic source able to be selectively activated with respect to the treatment chamber, such that, when activated, the magnetic source induces magnetism in at least some of the particulate feed material in the chamber.

20 Such an apparatus allows the introduction of a high gradient magnetic field to effectively magnetise the both weakly and strongly magnetic particulates for subsequent removal by settling or other techniques. When the magnetic source is activated both the weakly and strongly
25 magnetic particulates are attracted toward that magnetic source and become, at least in part, magnetised. When the magnetic source is deactivated, the flow stream of feed material dissipates the deposits of magnetised material from around the source to reduce the possibility of any
30 flow restrictions.

In the known apparatus if a high gradient magnetic field was used, the magnetic particles would be strongly attracted to the magnetic poles where they will collect

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and thus reduce the effectiveness (ie. the magnetic induction properties) of the magnets, as well as possibly restricting the flow of suspended particulate material in or through the vessel.

5 Additionally a low gradient magnetic field has a reduced ability to magnetise weakly magnetic particulates such as paramagnetic particulates. In a mixture of strongly magnetic particulates (such as ferromagnetic particles) and paramagnetic particulates, a low gradient magnetic
10 field will be likely to only effectively magnetise the strongly magnetic particulates for subsequent removal by settling. Whilst a high gradient magnetic field may be preferable in order to magnetise both weakly and strongly magnetic particulates, the aforementioned problems of a
15 reduction in the effectiveness of the magnets, as well as vessel flow restriction or blockage are likely to arise in the known apparatus and thus limit the use of such a magnetic field for such a purpose.

Preferably activation of the magnetic source involves
20 moving that source into and out of proximity with the chamber.

Preferably the magnetic source is mounted on a motive means which causes the magnetic source to reciprocatingly move into and out of proximity with the treatment chamber.
25 Most preferably the motive means is a piston.

Preferably the treatment chamber is annularly shaped, having an internal elongate recess into which the magnetic source is reciprocatingly receivable.

Preferably an interior face of the treatment chamber,
30 which adjoins the internal elongate recess, has an expandable membrane positioned thereover, the expansion and contraction of which serves to dislodge particulate

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feed material which may adhere at the internal elongate recess.

Preferably the membrane is made of an elastomeric material which is expandable or contractable by the
5 respective introduction into or removal of a fluid from the space between the membrane, and that part of the interior face of the treatment chamber which adjoins the internal elongate recess.

Preferably the treatment chamber has a fluid inlet
10 through which a fluid is able to be introduced into the liquid to aid suspension of particulate feed material in that liquid.

Preferably the fluid inlet is joined to a flexible hose located internally of the treatment chamber the hose able
15 to move flexibly within the chamber as fluid is passed therethrough to facilitate suspension of particulate feed material in the liquid.

Preferably the feed material includes paramagnetic and ferromagnetic particulates. The feed can also include
20 diamagnetic or non-magnetic particulates (e.g. gangue minerals). Preferably the paramagnetic particulates include at least one sulfide mineral containing copper, zinc or another transition metal. Platinum and palladium metal is also paramagnetic and can be present in the feed
25 material. Most preferably the paramagnetic particulates include at least one of the group including sphalerite contaminated with iron, arsenopyrite, cassiterite or chalcopyrite mineral.

In a second aspect the present invention provides an
30 apparatus for magnetising a portion of a feed material, the portion including material fractions having a range of magnetic susceptibilities, the apparatus including a treatment chamber and a magnetic source selectively

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activatable with respect to the treatment chamber to induce magnetism in the portion so as to facilitate the subsequent separation in a separate stage of a more weakly magnetic feed material fraction from a more strongly magnetic feed material fraction. The feed material may also include a diamagnetic or non-magnetic gangue component.

Preferably the more weakly magnetic feed material fraction includes mainly paramagnetic particulates and the more strongly magnetic feed material fraction includes mainly ferromagnetic particulates.

Preferably the apparatus of the second aspect is as defined in the first aspect.

Preferably the portion of the second aspect includes materials as defined in the first aspect.

In a third aspect the present invention provides an apparatus for inducing magnetism in a flowstream of an at least partially magnetisable particulate feed material suspended in a liquid, the apparatus including:

- a treatment chamber having an inlet and an outlet through which the flowstream respectively enters and exits the chamber; and
 - a magnetic source able to be selectively activated with respect to the treatment chamber,
- such that, when activated in use, the magnetic source induces magnetism in at least a portion of the particulate feed material in the chamber whilst maintaining that portion in the flowstream in the treatment chamber.

Preferably the apparatus of the third aspect is as defined in the first aspect.

Preferably the portion of the third aspect includes materials as defined in the first aspect.

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In a fourth aspect the present invention provides an apparatus for inducing magnetism in an at least partially magnetisable particulate feed material suspended in a liquid, the apparatus including:

- 5 - a treatment chamber for retaining the feed material;
 and
- a magnetic source able to be activated with respect
 to the treatment chamber, such that it induces
 magnetism in at least some of the particulate feed
10 material located in the chamber,
 the treatment chamber having an interior face adjacent to
 which the magnetic source can be activated, with an
 expandable membrane positioned at least partly over that
 face, such that expansion and contraction of the membrane
15 causes dislodgement of any particulate feed material
 which is adherent at the interior face as a result of the
 magnetic source. Such a membrane helps to dislodge or
 dissipate the deposits of magnetised material from around
 the source to reduce the possibility of any flow
20 restrictions or blockage in the treatment chamber.

Preferably the magnetic source is selectively activatable with respect to the treatment chamber.

Preferably the membrane is made of an elastomeric material which is expandable or contractable by the
25 respective introduction into or removal of a fluid from
 the space between the membrane and the interior face of
 the treatment chamber.

In a fifth aspect the present invention provides process
for inducing magnetism in a flowstream of an at least
30 partially magnetisable particulate feed material suspended
 in a liquid, in use to precondition the flowstream for a
 subsequent separation process in a separate stage,
 involving the steps of:

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- passing the flowstream through a treatment chamber;
and
- selectively activating a magnetic source with respect
to the treatment chamber,

5 such that, when activated, the magnetic source induces magnetism in at least some of the particulate feed material located in the chamber.

Such a process allows the introduction of a high gradient magnetic field to effectively magnetise the both weakly
10 and strongly magnetic particulates for subsequent removal by settling or other techniques. When the magnetic source is activated both the weakly and strongly magnetic particulates are attracted toward that magnetic source and become, at least in part, magnetised. When the magnetic
15 source is deactivated, the flow stream of feed material dissipates the deposits of magnetised material from around the source to reduce the possibility of any flow restrictions.

Preferably the activation of the magnetic source involves
20 moving that source into and out of proximity with the treatment chamber.

Preferably at least some of the magnetisable feed material is paramagnetic, the induced magnetism causing at least some of the magnetised paramagnetic particles to
25 become aggregated in the liquid flowstream.

In a sixth aspect the present invention provides a process for magnetising a portion of a feed material, the portion including material fractions having a range of magnetic susceptibilities, the process including the steps
30 of passing the feed through a treatment chamber and selectively activating a magnetic source with respect to the treatment chamber to induce magnetism in the portion so as to facilitate the subsequent separation in a

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separate stage of a more weakly magnetic feed material fraction from a more strongly magnetic feed material fraction.

5 Preferably the process also includes the step of subsequently separating the weakly magnetised feed material fraction from the more strongly magnetised feed material fraction by a flotation separation process. Most preferably the flotation separation process recovers the weakly magnetised feed material in a froth phase.

10 Preferably the more weakly magnetic feed material fraction includes mainly paramagnetic particulates and the more strongly magnetic feed material fraction includes mainly ferromagnetic particulates, as well as some diamagnetic or non-magnetic gangue particulates.

15 Preferably at least some of the magnetisable feed material is paramagnetic, the induced magnetism causing at least some of the magnetised paramagnetic particles to become aggregated in the liquid flowstream.

20 In a seventh aspect the present invention provides a process for inducing magnetism in a flowstream of an at least partially magnetisable particulate feed material suspended in a liquid involving the steps of:

- passing the flowstream through a treatment chamber; and
- 25 - selectively activating a magnetic source with respect to the treatment chamber,

such that, when activated in use, the magnetic source induces magnetism in at least a portion of the particulate feed material in the chamber whilst
30 maintaining that portion in the flowstream in the treatment chamber.

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Preferably the activation of the magnetic source involves moving that source into and out of proximity with the treatment chamber.

Preferably at least some of the magnetisable feed
5 material is paramagnetic, the induced magnetism causing at least some of the magnetised paramagnetic particles to become aggregated in the liquid flowstream.

Brief Description of the Drawings

10 Notwithstanding any other forms which may fall within the scope of the present invention, preferred forms of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows a partially-sectioned side view of one
15 embodiment of an apparatus for inducing magnetism in accordance with the invention.

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Modes for Carrying out the Invention

In a preferred embodiment, the present invention provides an apparatus 10 for inducing magnetism in a flow stream 12 of an at least partially magnetisable particulate feed material 14 suspended in a liquid. The feed material typically includes a mixture of paramagnetic and ferromagnetic particulates present with other non-magnetic or diamagnetic gangue minerals in a water slurry. Paramagnetic particulates usually require a high gradient magnetic field in order to become magnetised. Some sulfide minerals containing copper (such as chalcopyrite), zinc (such as sphalerite contaminated with iron) or other transition metals are paramagnetic. Ferromagnetic particulates include iron oxide minerals (such as magnetite) and metallic iron particles (from worn grinding media, for example).

Referring to the drawing, the apparatus 10 includes a treatment chamber in the form of an annularly shaped vessel 16 with an uppermost inlet 18 and a lowermost outlet 20 through which a flow stream of the aforementioned mineral mixture can flow respectively into and out of the vessel 16 with some residence time therein. The apparatus can also be used in 'batch' mode, and does not require a continuous flow stream of the mineral slurry mixture.

The chamber vessel incorporates a central elongate recess 22. A magnetic source is able to be selectively activated to induces magnetism in at least some of the particulate feed material 14 located in the vessel 16 by movement of the magnetic source into and out of proximity with the vessel 16. In one preferred embodiment the magnetic source is at least one permanent magnet mounted on a motive means in the form of a piston which is

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connected to a drive so that the piston can be reciprocatingly moved into and out of the recess 22. In one preferred embodiment the piston 24 is cylindrically shaped, having a diameter of approximately 300 millimetres and is fitted with a number of inset permanent magnets 26 that are square in shape and have a side dimension of 50 millimetres, made of neodymium or other materials. The diameter of the recess 22 in the vessel 16 is 800 millimetres.

10 In further embodiments the permanent magnets can be of any shape, size or material and the piston need not be cylindrical, but can be square or triangular in cross-section for example, and of any overall length. The means by which the piston is moved reciprocatingly with respect to the vessel can include any type of drive including a cam, a spring, an air cylinder (28, as illustrated) or an eccentrically rotatable shaft etc.

In still further embodiments the relative movement of the vessel and the magnetic source need not involve a piston being received into a recess in a vessel. The magnetic source need only be brought into proximity to the vessel, for example by being moved close to one side of a vessel so that a magnetic field can magnetise the particulate materials located in the vessel. In other
25 embodiments the vessel itself may be able to be moved in relation to a stationary magnet. The vessel can be of any particular shape, size and orientation to facilitate the magnetic source coming into proximity to the vessel contents.

30 The apparatus 10 described allows the introduction of a high gradient magnetic field to effectively magnetise both the weakly and strongly magnetic particulates 14 for subsequent removal of all particulates by enhanced gravity

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settling or separation of the weakly magnetic particulates by techniques such as flotation. When the piston 24 carrying the magnets 26 is moved into the recess 22 of the vessel 16, both the weakly and strongly magnetic particulates 14 are attracted and migrate toward the portion of the interior face of the vessel 16 which adjoins the internal elongate recess 22. The particles then become, at least in part, magnetised. When the piston 24 carrying the magnets 26 is moved out of the recess 22, deposits of magnetised particulate material 14 are no longer held to the interior face by magnetic attraction and are mostly dissipated by the flow stream 12 of feed material in the vessel 16. Depending on the location and orientation of the inlet and outlet ports, the vessel contents can develop a swirling fluid motion (illustrated in the drawing by an arrow in the vessel 16). The dissipation of solids can reduce the possibility of any flow restrictions developing in the vessel and improve the efficiency of the magnet/s.

In still further embodiments a magnetic source can be selectively activated to induces magnetism in at least some of the particulate feed material located in the vessel by use of electromagnet/s located proximal to the vessel. The supply current fed to the electromagnet/s can be switched on and off repeatedly to provide the same effect as if a permanent magnet was moved in and out of proximity with the vessel. In still further embodiments the field of a permanent magnet can be shunted or blocked by moving a magnetic field barrier in between the permanent magnet and the vessel containing the magnetisable particulates.

The cycle or frequency of movement of the magnetic source may be initiated by a timing device or by sensors

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that detect the mass of accumulated particles 30. The measurement of this mass may be made by determining the interference to the magnetic field or by measuring the resistance to flow of the particulate slurry as the mass
5 of particles 30 increases.

In the preferred embodiment shown in the drawing, the interior face of the vessel 16 that adjoins the internal elongate recess 22 has a thin, expandable, rubber membrane 32 positioned thereover. This membrane 32 can be expanded
10 and subsequently contracted by the respective introduction into or removal of a gas such as air from the space 34 between the membrane 32 and that part of the interior face of the vessel which adjoins the internal elongate recess 22. The movement of the exterior of the membrane 32
15 serves to assist in the dislodgement of particulate feed material 30 which may be adherent at the internal elongate recess 22 so that these particulates may be dissipated by the flow stream 12 of feed material in the vessel 16. In further embodiments, the membrane need not be positioned
20 over all of the interior face of the treatment chamber that adjoins the internal elongate recess 22, and may only be partly covering that face. In still further embodiments of the invention where the vessel is of a different shape, the flexible membrane can be positioned
25 at any other position on the interior face of the vessel so that it lies between the magnetic source and the contents of the vessel to be magnetised while still being able to be expanded and subsequently contracted by a gas flow into or out of the space between the membrane and the
30 interior face of the vessel.

In still further embodiments the flexible membrane can be stretched or moved by other means such as an injection of a fluid other than a gas into the space

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between the membrane and the interior face of the vessel or a vibratory device, for example. The membrane need not be made of rubber, but can be of any elastomeric material, eg plastics, synthetics.

5 The vessel of the preferred or another embodiment can also be agitated by internal or external mechanical means to facilitate the dissipation of accumulated magnetised material 30. For example motorised mixer blades can be used to stir the contents of the vessel. In the preferred
10 embodiment shown in the drawing, the treatment chamber has a fluid inlet in the form of jet orifice 36 through which a gas such as air or a liquid such as water is able to be introduced into the liquid in the vessel 16 to aid suspension of the particulate feed material 14 in that
15 liquid. An introduced gas can fluidise any settled particulate material. The jet orifice 36 is joined to a length of flexible hose 38 located internally of the vessel. The hose 38 is fitted with an end nozzle 39. The hose 38 is able to move flexibly within the vessel 16 as
20 gas or liquid is passed through it to facilitate fluidisation and suspension of particulate feed material 14 in the liquid in the vessel 16, and functions like a random agitator moving about the internal base 40 of the vessel 16. Such agitation is important to prevent
25 settling when a decrease in the flow velocity of the particulate slurry through the vessel is required in order to increase the exposure time of the slurry particulates 14 to the magnetic field.

 The flexible hose 38 has several advantages over use
30 of a fixed fluid inlet jet orifice alone. Fixed jet orifices are limited in their area of coverage of the vessel base 40 and if mechanically pivotable jet orifices are used, they usually incorporate bearings, seals and

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other wear components that have a limited life in a wet and abrasive environment. The flexible hose 38 in the preferred embodiment sweeps over a large area of the vessel base 40 and uses less introduced gas or liquid than a multiplicity of fixed jets would. The flexible hose 38 provides for a large sweep area over the vessel base 40 using a device that requires no bearings or seals.

In use the apparatus 10 can be used to induce magnetism in a flow stream 12 of an at least partially magnetisable particulate feed material 14 suspended in a liquid. Once the flow stream 12 (which by definition can also include a repeated sequence of batch treatment steps involving filling, treating and emptying of the vessel) of a particulate slurry is passing through the vessel 16, the magnetic source (be it an electromagnet or a mechanically actuated apparatus such as the preferred embodiment) can then be selectively activated to induce magnetism in at least some of the particulate feed material 14 located in the vessel 16. Such a process allows the introduction of a high gradient magnetic field to effectively magnetise the both weakly and strongly magnetic particulates for subsequent removal by settling, or separation by other techniques such as flotation. When the magnetic source is activated, both the weakly magnetic (eg. paramagnetic) and strongly magnetic (eg. ferromagnetic) particulates are attracted toward that magnetic source and become, at least in part, magnetised. When the magnetic source is deactivated, the flow stream 12 of feed material dissipates the majority of the deposits 30 of magnetised material to reduce the possibility of any flow restrictions in the vessel 16.

In the case of the paramagnetic feed material, the inventors have surprisingly discovered that the induced

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magnetism can cause at least some of the magnetised paramagnetic particles to become aggregated in the liquid flow stream. The inventors have observed that the aggregated paramagnetic particles remain aggregated for at least several hours and that the aggregated particles can survive further treatment steps in a mineral separation process such as pumping and agitation. In a feed with particulate materials of a range of magnetic susceptibilities, the preferred apparatus is able to be operated in a manner to facilitate the subsequent separation of the magnetised paramagnetic feed material fraction from the magnetised ferromagnetic feed material fraction. The magnetised paramagnetic feed fraction is also separable from the non-magnetic or diamagnetic gangue minerals.

In the experimental work, a flotation separation process was used on several finely ground mineral ores (typically with 80% of the ore particles of a particle size less than 100 micrometres in diameter) in order to separate the magnetised paramagnetic feed material into a froth phase. The experimental results have demonstrated good increases in sulfide mineral recovery by flotation due to the use of the magnetisation treatment step prior to the flotation step (see forthcoming Example 3 results). The inventors believe that the very fine (eg. <10 micrometre diameter) paramagnetic particles, which ordinarily exhibit poor flotation rates and recoveries, once magnetised, can become aggregated to give an 'effective' (coagulated) particle diameter of greater than 10 micrometres. Such aggregates can exhibit good flotation rate and recovery characteristics due to hydrodynamic reasons such as better attachment to rising air bubbles in a flotation cell.

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The use of sulfide mineral collector reagents such as xanthates or dithiophosphates can ensure that the surfaces of the paramagnetic mineral particles become hydrophobic and more readily attach to the surface of the rising air bubbles in the flotation cell. Typically the ferromagnetic particles in a particulate mixture of paramagnetic and ferromagnetic minerals are rejected in a flotation process (having no affinity for xanthate or dithiophosphate collectors) and report to gangue or tailings. In the experiments conducted, the sulfide mineral collector reagents used were present in the magnetisation treatment vessel 16 prior to any subsequent flotation step. In experiments where no magnetic treatment step was applied prior to the flotation step, the feed to flotation containing sulfide mineral collector was still passed through the vessel 16 prior to being passed to the subsequent flotation apparatus. The flotation apparatus used can comprise any standard type of agitated flotation cell, flotation column or flotation circuit.

As an example of the improvements that this apparatus and process have provided over that known in the prior art, experimental results produced using conventional froth flotation with and without the pretreatment step of the invention are now presented.

The present apparatus can allow the introduction of a very high gradient magnetic field to effectively magnetise the both weakly and strongly magnetic particulates. When the magnetic source is activated both the weakly and strongly magnetic particulates are attracted toward that magnetic source and become, at least in part, magnetised. Previous apparatus and methods have not allowed the use of very high gradient magnetic fields because of the problem

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of deposition of magnetised feed material around the magnetic source and the low degree of magnetisation of the weakly magnetic particulates. A cyclical activation of the magnetic field in a feed slurry flow stream as well as
5 use of the flexible membrane go some way to removing the problem of such deposition.

In Example 1, the influence of changing the magnetic field gradient on flotation recovery (%) and grade (wt%) parameters is demonstrated.

10

EXAMPLE 1. The effect of changing magnetic field strength on subsequent flotation recovery data in comparison to no magnetic pre-treatment

	3000 Gauss	4500 Gauss
Increase in copper flotation Recovery (%) relative to no Magnetic Treatment	0.6 %	0.5 %
Increase in copper flotation Grade relative to no magnetic treatment	0.2 %	4.3 %

15

A measure of the improvement in the flotation separation process is measured by the increase in the recovery and the grade (the purity of the separated mineral concentrate). In the results, while the magnetic
20 field strengths of 3000 Gauss and 4500 Gauss give an effectively identical improvement in the recovery, there is a very large improvement in the purity of the separated copper and clearly 4500 Gauss is better than 3000 Gauss in this regard.

25

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EXAMPLE 2. Effect of residence time in the magnetic field on subsequent copper flotation recovery

Residence time of slurry in magnetic field (minutes)	0	2	4	8
% Copper recovery to flotation concentrate	88.6	90.8	92.3	95.1

5 From the results it appears that longer exposure times of paramagnetic particles to a magnetic field can yield improved mineral flotation recoveries, possibly because of the achievement of a greater degree of magnetisation of the paramagnetic value minerals, and an
10 enhanced ability to self-attract.

EXAMPLE 3. Improvement achieved with magnetic treatment prior to flotation

% Zinc flotation recovery - after magnetic treatment	84.6
% Zinc flotation recovery - before magnetic treatment	82.6

15

These experimental results demonstrate the effect of a magnetisation treatment step yielding a beneficial increase in subsequent sulfide mineral flotation recovery.

20 The vessel and piston can be made of any suitable materials of construction which wear appropriately and that can be shaped, formed and fitted in the manners so described, such as a metal, metal alloy, hard plastics or ceramic. The expandable membrane and hose can be made of

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any suitable flexible materials that can be used in the manner so described.

It is to be understood that, if any prior art information is referred to herein, such reference does not
5 constitute an admission that the information forms a part of the common general knowledge in the art, in Australia or any other country.

Whilst the invention has been described with reference to preferred embodiments it should be
10 appreciated that the invention can be embodied in many other forms.

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CLAIMS

1. An apparatus for inducing magnetism in a flowstream of
5 an at least partially magnetisable particulate feed
material suspended in a liquid, in use to precondition
the flowstream for a subsequent separation process in a
separate stage, the apparatus including:
- a treatment chamber having an inlet and an outlet
10 through which the flowstream respectively enters and
exits the chamber; and
 - a magnetic source able to be selectively activated
with respect to the treatment chamber,
such that, when activated, the magnetic source induces
15 magnetism in at least some of the particulate feed
material in the chamber.
2. An apparatus as claimed in claim 1 wherein activation
of the magnetic source involves moving that source into
20 and out of proximity with the chamber.
3. An apparatus as claimed in claim 2 wherein the magnetic
source is mounted on a motive means which causes the
magnetic source to reciprocatingly move into and out of
25 proximity with the treatment chamber.
4. An apparatus as claimed in claim 3 wherein the motive
means is a piston.
- 30 5. An apparatus as claimed in any one of the preceding
claims wherein the treatment chamber is annularly shaped,
having an internal elongate recess into which the
magnetic source is reciprocatingly receivable.

- 20 -

6. An apparatus as claimed in claim 5 wherein an interior face of the treatment chamber, which adjoins the internal elongate recess, has an expandable membrane positioned thereover, the expansion and contraction of which serves to dislodge particulate feed material which may adhere at the internal elongate recess.
7. An apparatus as claimed in claim 6 wherein the membrane is made of an elastomeric material which is expandable or contractable by the respective introduction into or removal of a fluid from the space between the membrane, and that part of the interior face of the treatment chamber which adjoins the internal elongate recess.
8. An apparatus as claimed in any one of the preceding claims wherein the treatment chamber has a fluid inlet through which a fluid is able to be introduced into the liquid to aid suspension of particulate feed material in that liquid.
9. An apparatus as claimed in claim 8 wherein the fluid inlet is joined to a flexible hose located internally of the treatment chamber the hose able to move flexibly within the chamber as fluid is passed therethrough to facilitate suspension of particulate feed material in the liquid.
10. An apparatus as claimed in any one of the preceding claims wherein the feed material includes paramagnetic and ferromagnetic particulates.

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11. An apparatus as claimed in claim 10 wherein the paramagnetic particulates include at least one sulfide mineral containing copper, zinc or another transition metal.
- 5
12. An apparatus as claimed in claim 10 or claim 11 wherein the paramagnetic particulates include at least one of the group including sphalerite contaminated with iron, arsenopyrite, cassiterite, chalcopyrite, platinum
- 10 metal and palladium metal.
13. An apparatus for magnetising a portion of a feed material, the portion including material fractions having a range of magnetic susceptibilities, the apparatus
- 15 including a treatment chamber and a magnetic source selectively activatable with respect to the treatment chamber to induce magnetism in the portion so as to facilitate the subsequent separation in a separate stage of a more weakly magnetic feed material fraction from a
- 20 more strongly magnetic feed material fraction.
14. An apparatus as claimed in claim 13 wherein the more weakly magnetic feed material fraction includes mainly paramagnetic particulates and the more strongly magnetic
- 25 feed material fraction includes mainly ferromagnetic particulates.
15. An apparatus as claimed in claim 13 or claim 14 wherein the apparatus is as defined in any one of claims
- 30 1 to 9.

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16. An apparatus as claimed in claim 13 or claim 14 wherein the portion includes materials as defined in any one of claims 10 to 12.

5 17. An apparatus for inducing magnetism in a flowstream of an at least partially magnetisable particulate feed material suspended in a liquid, the apparatus including:

- 10 - a treatment chamber having an inlet and an outlet through which the flowstream respectively enters and exits the chamber; and
- a magnetic source able to be selectively activated with respect to the treatment chamber,

such that, when activated in use, the magnetic source induces magnetism in at least a portion of the

15 particulate feed material in the chamber whilst maintaining that portion in the flowstream in the treatment chamber.

18. An apparatus as claimed in claim 17 wherein the

20 apparatus is as defined in any one of claims 2 to 9.

19. An apparatus as claimed in claim 17 wherein the portion includes materials as defined in any one of claims 10 to 12.

25

20. An apparatus for inducing magnetism in an at least partially magnetisable particulate feed material suspended in a liquid, the apparatus including:

- a treatment chamber for retaining the feed material;
- 30 and
- a magnetic source able to be activated with respect to the treatment chamber, such that it induces

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magnetism in at least some of the particulate feed material located in the chamber, the treatment chamber having an interior face adjacent to which the magnetic source can be activated, with an expandable membrane positioned at least partly over that face, such that expansion and contraction of the membrane causes dislodgement of any particulate feed material which is adherent at the interior face as a result of the magnetic source.

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21. An apparatus as claimed in claim 20 wherein the magnetic source is selectively activatable with respect to the treatment chamber.

15 22. An apparatus as claimed in claim 20 or claim 21 wherein the membrane is made of an elastomeric material which is expandable or contractable by the respective introduction into or removal of a fluid from the space between the membrane and the interior face of the treatment chamber.

20

23. A process for inducing magnetism in a flowstream of an at least partially magnetisable particulate feed material suspended in a liquid, in use to precondition the flowstream for a subsequent separation process in a separate stage, involving the steps of:

25

- passing the flowstream through a treatment chamber; and
- selectively activating a magnetic source with respect to the treatment chamber,

30

such that, when activated, the magnetic source induces magnetism in at least some of the particulate feed material located in the chamber.

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24. A process as claimed in claim 23 wherein activation of the magnetic source involves moving that source into and out of proximity with the treatment chamber.

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25. A process as claimed in claim 23 or claim 24 wherein at least some of the magnetisable feed material is paramagnetic, the induced magnetism causing at least some of the magnetised paramagnetic particles to become aggregated in the liquid flowstream.

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26. A process for magnetising a portion of a feed material, the portion including material fractions having a range of magnetic susceptibilities, the process including the steps of passing the feed through a treatment chamber and selectively activating a magnetic source with respect to the treatment chamber to induce magnetism in the portion so as to facilitate the subsequent separation in a separate stage of a more weakly magnetic feed material fraction from a more strongly magnetic feed material fraction.

15

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27. A process as defined in claim 26 also including the step of subsequently separating the weakly magnetised feed material fraction from the more strongly magnetised feed material fraction by a flotation separation process.

25

28. A process as defined in claim 27 wherein the flotation separation process recovers the weakly magnetised feed material in a froth phase.

30

29. A process as claimed in any one of claims 26 to 28 wherein the more weakly magnetic feed material fraction

- 25 -

includes mainly paramagnetic particulates and the more strongly magnetic feed material fraction includes mainly ferromagnetic particulates.

5 30. A process as claimed in any one of claims 26 to 29 wherein at least some of the magnetisable feed material is paramagnetic, the induced magnetism causing at least some of the magnetised paramagnetic particles to become aggregated in the liquid flowstream.

10

31. A process for inducing magnetism in a flowstream of an at least partially magnetisable particulate feed material suspended in a liquid involving the steps of:

- passing the flowstream through a treatment chamber;
- 15 and
- selectively activating a magnetic source with respect to the treatment chamber,

such that, when activated in use, the magnetic source induces magnetism in at least a portion of the particulate feed material in the chamber whilst
20 maintaining that portion in the flowstream in the treatment chamber.

25 32. A process as claimed in claim 31 wherein activation of the magnetic source involves moving that source into and out of proximity with the treatment chamber.

30 33. A process as claimed in claim 31 or claim 32 wherein at least some of the magnetisable feed material is paramagnetic, the induced magnetism causing at least some of the magnetised paramagnetic particles to become aggregated in the liquid flowstream.

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34. An apparatus for inducing a magnetic field substantially as herein described with reference to the accompanying examples and drawing.
- 5 35. An apparatus for magnetising a portion of a feed material substantially as herein described with reference to the accompanying examples and drawing.
- 10 36. A process for inducing a magnetic field substantially as herein described with reference to the accompanying examples and drawing.
- 15 37. A process for magnetising a portion of a feed material substantially as herein described with reference to the accompanying examples and drawing.

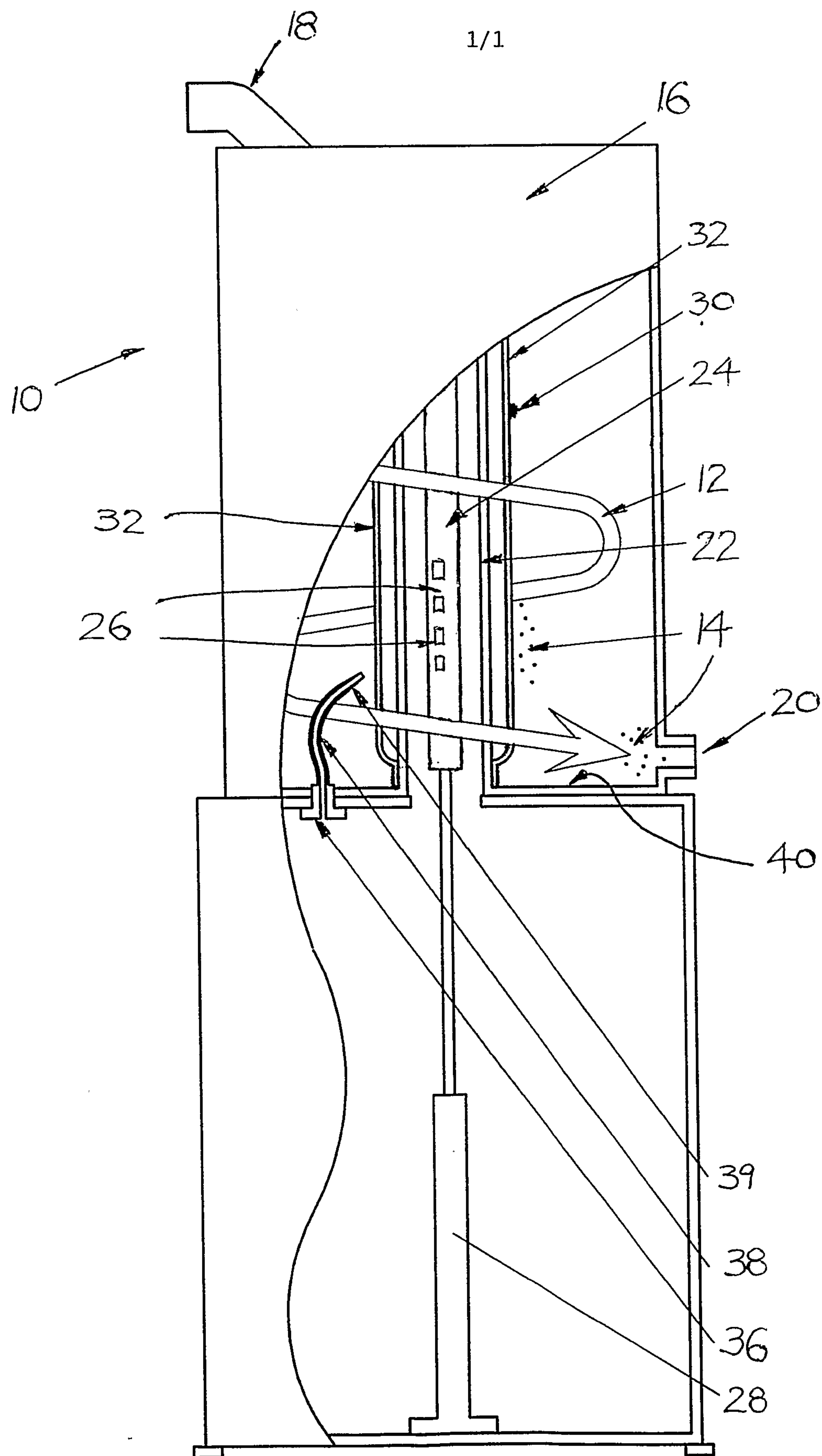


FIG. 1

