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(54) **Titre : APPAREIL ET PROCEDE POUR FACILITER LA SEPARATION D'HYDROCARBURES A PARTIR DE DEBLAIS DE FORAGE CHARGES EN HYDROCARBURES PRODUITS DANS LE FORAGE DE PUIITS DE FORAGE**
(54) **Title: APPARATUS AND METHOD FOR FACILITATING SEPARATION OF HYDROCARBONS FROM HYDROCARBON LADEN DRILL CUTTINGS PRODUCED IN THE DRILLING OF WELLBORES**

(57) **Abrégé/Abstract:**

A method for facilitating separation of hydrocarbons from hydrocarbon laden drill cuttings using a thermal treatment apparatus and a feeder apparatus comprising a metering screw the method comprising the steps of the metering screw receiving and feeding drill cuttings material into the thermal treatment apparatus, the thermal treatment apparatus comprising a reactor, the method further comprising the step of a control system controlling the metering screw, wherein the control system controls the amount of material in the reactor to maintain an airlock at the discharge from the thermal reactor and/or maintain an airlock at the material inlet to the reactor.



ABSTRACT

A method for facilitating separation of hydrocarbons from hydrocarbon laden drill cuttings using a thermal treatment apparatus and a feeder apparatus comprising a metering screw the method comprising the steps of the metering screw receiving and feeding drill cuttings material into the thermal treatment apparatus, the thermal treatment apparatus comprising a reactor, the method further comprising the step of a control system controlling the metering screw, wherein the control system controls the amount of material in the reactor to maintain an airlock at the discharge from the thermal reactor and/or maintain an airlock at the material inlet to the reactor.

5 APPARATUS AND METHOD FOR FACILITATING SEPARATION OF
 HYDROCARBONS FROM HYDROCARBON LADEN DRILL CUTTINGS
 PRODUCED IN THE DRILLING OF WELLBORES

 This is a division of Canadian Patent Application No.
2,731,553 filed August 11, 2009.

10 The present invention relates to an apparatus and
method for facilitating separation of hydrocarbons from
hydrocarbon laden drill cuttings produced in the drilling
of a wellbore.

 In the drilling of a borehole in the construction of
15 an oil or gas well, a drill bit is arranged on the end of
a drill string and is rotated to bore the borehole. A
drilling fluid known as "drilling mud" is pumped through
the drill string to the drill bit to lubricate the drill
bit. The drilling mud is also used to carry the cuttings
20 produced by the drill bit and other solids to the surface
through an annulus formed between the drill string and the
borehole. The drilling mud contains expensive synthetic
oil-based lubricants and it is normal therefore to recover
and re-use the used drilling mud, but this requires the
25 solids to be removed from the drilling mud. This is
achieved by processing the drilling fluid. The first part
of the process is to separate the solids from the solids
laden drilling mud. This is at least partly achieved with
a vibratory separator, such as those shale shakers
30 disclosed in US 5,265,730, WO 96/33792 and WO 98/16328.
Hydrocyclones and centrifuges may also be used to separate
the drill cuttings from the drilling mud.

 The separated solids are contaminated with
hydrocarbons from the drilling mud or from natural oils in
35 the formation being drilled. The solids need to be
processed in order to remove the hydrocarbons therefrom.
The drill cuttings can then be disposed of without harm to
the surrounding environment or, for example, they can be
used as aggregate for building roads or in other

5 construction projects.

The prior art discloses a variety of systems and methods for the thermal treatment of material and thermal treatment of drilled cuttings material. For example, and not by way of limitation, the following U.S. Patents present exemplary material treatment systems: 5,914,027; 10 5,724,751; and 6,165,349.

In accordance with the present invention, there is provided an apparatus for facilitating separation of hydrocarbons from hydrocarbon laden drill cuttings, the 15 apparatus comprising a thermal treatment apparatus and a feeder apparatus, the thermal treatment apparatus comprising a reactor and the feeder apparatus comprising a metering screw for receiving and feeding drill cuttings material into the reactor, the apparatus further 20 comprising a control system for controlling the metering screw. Preferably, the metering screw feeds directly into the reactor.

Preferably, the control system ensures that the metering screw is maintained full or nearly full of 25 material. Preferably, this can be achieved by having a container from which the metering screw draws the hydrocarbon laden drill cuttings and ensuring the container always has a supply of hydrocarbon laden drill cuttings. Advantageously, the control system controls the 30 mass flow rate of hydrocarbon laden drill cuttings into the reactor by adjusting the speed of the metering screw apparatus.

Preferably, the reactor has a material inlet and the metering screw passes therethrough, an airlock maintained 35 between the metering screw and the material inlet. Advantageously, the hydrocarbon laden drill cuttings in the screw feeder maintains the airlock. Preferably, the apparatus further comprises at least one temperature measuring device, the control system providing for

5 control of temperature in the reactor by controlling the
mass flow rate of material into the thermal reactor by
controlling the metering screw that feeds material into
the thermal reactor.

10 Preferably, the thermal treatment apparatus has an
engine rotating friction elements within the reactor and
performance of the engine is optimized by controlling the
metering screw that feeds material into the reactor
vessel, for example, based on sensed speed in rpm's of the
engine.

15 Advantageously, the feeder apparatus further
comprises a container, the metering screw arranged therein
or therebelow. Preferably, the container can store between
three and eighteen cubic metres of hydrocarbon laden drill
cuttings. Advantageously, the container has an open top.
20 Preferably, the container has a lid, which is open and the
interior of the container is maintained at substantially
atmospheric pressure, although may be exposed to a slight
increase in pressure due to the inlet from a positive
pressure pneumatic conveying system introducing
25 hydrocarbon laden drill cuttings into the container.
Advantageously, the container has at least two sides which
converge towards the metering screw. Preferably, the
container comprises a slider mechanism for moving
hydrocarbon laden solids to the metering screw.
30 [Preferably, the metering screw is driven by a hydraulic
double acting piston and cylinder to draw the frame over
an interior surface of the container to move the
hydrocarbon laden drill cuttings to the metering screw.
Advantageously, the container has a flat, substantially
35 bottom section, the slider frame apparatus sliding
hydrocarbon laden drill cuttings on the flat bottom. The
bottom section may be planar and may be horizontal.
Advantageously, the apparatus further comprises at least
one load cell apparatus for weighing the container to give

5 an indication of how much hydrocarbon laden drill cuttings
there is in the container. Preferably, the load cell is
arranged beneath the container to provide information to
indicate an amount of material in the container.

Advantageously, the reactor has a rotor therein, the
10 apparatus further comprising a speed measuring apparatus
to measure the rotational speed of the rotor and sends an
indication of the speed to the control system. Preferably,
if the speed of the rotor slows down, the control system
slows down the metering screw to reduce the amount of
15 hydrocarbon laden drill cuttings entering the reactor.

Preferably, the apparatus further comprises a
drilling mud processing apparatus which comprises a shale
shaker, centrifuge, vortex dryer, hydrocyclone or other
solids control equipment.

20 Advantageously, the apparatus further comprises a
second feeder apparatus feeding the reactor. Preferably,
the apparatus further comprises a third feeder apparatus
feeding the reactor.

Preferably, the metering screw is inclined upwardly
25 towards the reactor. Most preferably, the screw feeder is
inclined at an angle of between three and ten degrees and
preferably about four degrees from horizontal.

Preferably, the apparatus further comprises a load
cell arranged to measure the weight of the reactor to
30 provide information to the control system to control the
discharge rate of drill cuttings from the reactor.

The present invention also provides a method for
facilitating separation of hydrocarbons from hydrocarbon
laden drill cuttings using a thermal treatment apparatus
35 and a feeder apparatus comprising a metering screw the
method comprising the steps of the metering screw
receiving and feeding drill cuttings material into the
thermal treatment apparatus, the thermal treatment
apparatus comprising a reactor, the method further

5 comprising the step of a control system controlling the
metering screw. Preferably, the reactor has a rotor
therein, the apparatus further comprising a speed
measuring apparatus to measure the rotational speed of the
rotor and sends an indication of the speed to the control
10 system. Preferably, if the speed of the rotor slows down,
the control system slows down the metering screw to reduce
the amount of hydrocarbon laden drill cuttings entering
the reactor. Advantageously, the apparatus comprises a
torque measuring device to measure the torque on the rotor
15 and sends an indication of the torque to the control
system. Preferably, if the torque of the rotor increases
above a predetermined threshold, the control system slows
down the metering screw to reduce the amount of
hydrocarbon laden drill cuttings entering the reactor.

20 Advantageously, the method further comprises the step
of measuring the weight of the reactor including the
hydrocarbon laden drill cuttings therein and providing the
measurement to the control system to control the discharge
rate of drill cuttings from the reactor.

25 Preferably, the control system controls the amount of
material in the reactor. Advantageously, the reactor
comprises a rotating drum, amount of material is
controlled by monitoring the speed and/or torque of
rotation of the rotating drum and controlling the speed of
30 the screw feeder in response thereto. Preferably, the
control system controls the amount to maintain an airlock
at the discharge from the thermal reactor. Advantageously,
the control system maintains a desired temperature in the
thermal reactor by adjusting the speed of the screw
35 feeder.

The present invention, in certain aspects, discloses
a thermal treatment system for removing liquid from drill
cuttings material, the thermal treatment system having a
metering screw apparatus for receiving and feeding drill

5 cuttings material to a reactor system, including apparatus
and a control system for controlling the metering screw
apparatus and for insuring that the metering screw
apparatus is maintained full or nearly full of material
and/or for controlling the mass flow rate into a reactor
10 of the thermal treatment system by adjusting the speed of
the metering screw apparatus.

The present invention, in certain aspects, discloses
a thermal treatment system for treating drill cuttings
material in which apparatus and a control system are
15 provided to maintain an airlock at a material inlet to a
thermal reactor of the thermal treatment system by
maintaining a desired amount of material in a container
above a feeder system that feeds material into the thermal
reactor. In one aspect in such a system apparatus and a
20 control system provide for control of temperature in the
thermal reactor by controlling the mass flow rate of
material into the thermal reactor by controlling a
metering screw system that feeds material into the thermal
reactor.

25

5 For a better understanding of the present invention,
reference will now be made, by way of example, to the
accompanying drawings, in which:

Figure 1A is a schematic view of an system in
accordance with the present invention;

10 Figure 1B is a top view of the system shown in Figure
1A;

Figure 1C is a partial side view of part of the
system shown in Figure 1A;

15 Figure 1D is a view in cross-section of a feeder
system of the system shown in Figure 1A;

Figure 1E is a view in cross-section of a feeder
system useful in a system like the system shown in Figure
1A;

20 Figure 1F is a view in cross-section of a container
of a feeder system in accordance with the present
invention;

Figure 2A is a side view partly in cross-section of a
feeder system in accordance with the present invention;

25 Figure 2B is an end view of the feeder system shown
in Figure 2A;

Figure 2C is a top view of the feeder system shown in
Figure 2A;

Figure 2D is a top view of part of the feeder system
shown in Figure 2A;

30 Figure 2E is an end view of a slide of the feeder
system shown in Figure 2A;

Figure 3 is a top view of a system in accordance with
the present invention;

35 Figure 4 is a schematic view of a system in
accordance with the present invention; and

Figure 5 is a schematic view of a system in
accordance with the present invention.

Figures 1A to 1D illustrate a system 10 in accordance
with the present invention which has a thermal reactor

5 section 12 and a feeder system 40 in accordance with the
present invention. Drill cuttings material M is fed from
the feeder system 40 into a reactor vessel 14 (mounted on
supports 18) of the thermal reactor section 12 through an
inlet 13. Treated material exits the vessel 14 through a
10 discharge outlet 15. An engine section 16 has an engine
17 that rotates internal rotors (or friction elements) 8
in the vessel 14. The vessel 14 has, optionally, a
plurality of inlets 7 into which drill cuttings material
for treatment can be fed. Load cell apparatuses 3 in
15 communication with a control system CS indicate the amount
of material in the vessel 14. The reactor vessel may be of
the type disclosed in UK Patent Application Publication
No. 2,337,265.

Figures 1C and 1D illustrate the feeder system 40
20 which has a base 42 with sides 44, 44a, and 44b, and a
bottom 45 within which is mounted a container 46 for
holding drill cuttings material to be fed to the vessel
14. The bottom 45 may be a skid and the sides 44, 44a,
44b may be structural beams making up a frame. It is
25 within the scope of the present invention to have a
container 46 with a substantially horizontal level bottom
with a metering screw system beneath it which is also
substantially horizontal; or, as shown in Figure 1D, the
container 46 has an inclined bottom 48 with a trough 47
30 and a metering screw system 60, which receives material
from the container 46. The inclined bottom 48 may be at an
incline of between one and ten degrees, preferably between
three and five degrees and most preferably about four
degrees from horizontal. The system 60 inclined to
35 correspond to the incline of the bottom 48. Material
falls into a trough 3 at the bottom of the container 46
(in which a screw 62 of the system 60 is located). The
bottom of the container 46 may be any suitable shape to
facilitate the flow and movement of material to the system

5 60; for example as shown in Figure 1F, walls 46w of a
container 46a are inclined above a trough 47a.

Drill cuttings material from a wellbore drilling
operation indicated by an arrow 49 is fed by an auger
apparatus 50 through an inlet 51 into the container 46.
10 The drill cuttings material may come from any suitable
apparatus or equipment, including, but not limited to,
from shale shaker(s), centrifuge(s), tank(s), cuttings
storage apparatus, vortex dryer(s), hydrocyclone(s), or
any solids control equipment that produces a stream or
15 discharge of drill cuttings material.

Optionally drill cuttings material is introduced into
the container 46 through a line 53 from a system 54 (not
directly from drilling operation equipment, like shale
shakers or centrifuges) that transfers and/or transports
20 drill cuttings material (for example, but not limited to,
the known BRANDT FREE FLOW (TRADEMARK) cuttings transfer
and transportation system). Optionally, the material is
fed to a vortex dryer VD for processing and the solids
output of the vortex dryer is fed to the container 46.

25 A valve assembly 56 is used to selectively control
the flow of free flowing material (for example liquids)
from the system 60 into the vessel 14 as described below.
Such liquids are not moved so much by the screw 62 as they
flow freely past the screw 62 to the valve 56 through the
30 system 60.

Optionally, (especially for material that may be
easily compacted) if additional lubricant is needed for
the material to be introduced into the vessel 14, the
lubricant is injected into material in the system 60
35 through injection ports or nozzles 57 from a lubricant
system 58 (for example, but not limited to, a lubricant
that is base oil, an oil component of a drilling fluid).
In one aspect, if a load on a motor 52 which rotates the
screw 62 (for example an hydraulic motor) is increased

5 beyond a pre-selected set point, lubricant is injected through the nozzles 57 to facilitate material flow within the system 60 and lessen the load on the motor 52.

10 Optionally, a pump 70 in fluid communication with the interior of the container 46 pumps free liquid from within the container 46 to reduce the liquid content of the material. This can optimize the performance of the system by insuring that the feed to the vessel 14 has a reduced amount of free liquid. Optionally, as shown in dotted line in Figure 1D, a pump 70a may be located within the
15 container 46 (in one aspect, in the material M).

As shown in Figure 1E, a conveyor apparatus for conveying material to a vessel like the vessel 14 can have a constant pitch screw 62s; or, as shown in Figure 1D, the screw 62 of the system 60 has areas of different pitch,
20 for example areas 62a, 62b, (with the tightest pitch at the end near the motor 52) and 62c which reduce the likelihood of material compaction in the system 60 and facilitates material flow in the system 60. In one particular aspect, the system 60 is about ten inches in
25 diameter; the container 46 has a volume of about eighteen cubic meters; and the bottom 45 is about four meters long. In certain aspects, the container 46 has therein, at any given time, between three to sixteen cubic meters of material and, in one particular aspect, about sixteen
30 cubic meters. The screw may have two, four or more areas of different pitch.

In one aspect, during operation of the system 10, an amount of material is maintained in the container 46 (for example in one aspect, a minimum of about three cubic
35 meters) so that an airlock is maintained at the inlet 13. By insuring, using the control system CS as described below, that a sufficient amount of material is within the vessel 14, an airlock is maintained at the discharge outlet 15 of the system 12.

5 Load cell apparatuses 72 (one, two, or more) indicate
how much material (by weight) is in the container 46.
This correlates with the level of the material so that, as
shown in Figure 1C, a level "a" can be maintained
indicative of the volume of material sufficient to
10 maintain the airlock at the inlet 13 described above. The
load cell(s) is also used with the control system CS to
calculate the rate of metering of material into the vessel
14 and to set and control maximum and minimum levels of
material in the container 46. In one aspect the level "a"
15 is between 50mm and 1000mm and, in one particular aspect,
is 500mm. Optionally, or in addition to the load
sensor(s) 72, a level sensor and indicating apparatus 79
is used to obtain data to determine the amount of material
in the container 46 and its level. In one aspect, the
20 apparatus 79 is an ultrasonic distance measuring apparatus
with an integral or separate display and interface for the
control system CS.

Personnel P can, optionally, remove free liquid from
the top of material in the container 46 (for example from
25 the top thereof) by manually placing an end 75a of a pipe
75 within a conduit 77 connected to the container 46 to
pump free liquid (for example drilling fluid and some
water, inter alia); from the container 46 thereby reducing
the liquid content of material introduced into the vessel
30 14. In one aspect the pipe 75 is connected to the pump
70; or some other pump is used. In one aspect a pump
system is placed within the container 46.

The control system CS controls the various
operational parts and apparatuses of the system 10 as
35 shown schematically in Figures 1A, 1B, and 1D. In
particular aspects, the control system CS receives
information from the load cell(s) 72, and from sensors 2
on the engine 17 (for example torque and/or speed in
rpm's) and from sensor(s) 52a on the motor 52 (for example

5 motor speed in rpm's). The control system CS controls the
operation of the engine 17, the motor 52, the valve 56,
the auger apparatus 50, the system 60, the system 58, the
system 54, the pump 70, and a hydraulic power supply HPP
which supplies power to the motor 52 and any other
10 hydraulically powered item. In one aspect, sensing of the
load on the motor 52 is done using a pressure sensor 52a
(shown schematically). In one aspect, thus monitoring the
pressure of hydraulic fluid applied to the motor 52
provides the information needed to activate the injection
15 of additional lubricant via the nozzles 57. Via sensing
of the temperature within the vessel 14 (using a sensor or
sensors; for example, in one aspect three sensors along
the top of the vessel 14), the control system CS maintains
the flow of material into the vessel 14 by controlling the
20 system 00 at a sufficient rate that the temperature within
the vessel 14 is maintained at a sufficiently high level
(without exceeding a pre-set maximum) to effectively heat
liquid phase(s) in the drill cuttings material to vaporize
the liquid phase(s). The motor 52, engine 17, pump 70
25 and/or other powered items in these systems can be powered
electrically, pneumatically, or hydraulically.

In certain particular aspects, the oil content of
feed into the container 46 is maintained between 15% to
30% by weight and the water content is maintained between
30 8% to 20% by weight.

In other aspects, the solids content of the material
introduced into the container 46 is, preferably, at least
70% solids by weight; and the liquid content of the
material fed into the vessel 14 is 30% or less (liquid
35 includes oil and water). A pump or pumps (for example,
but not limited to, the pump 70) reduces (and, in certain
aspects, minimizes) the amount of free liquid fed to the
vessel 14. If too much liquid is fed into the vessel 14,
undesirable "wash out" may occur, a sufficient amount of

5 solids will not be present, and, therefore, sufficient
friction will not be developed to achieve a desired
temperature within the vessel 14 for effective operation.
In certain aspects, the temperature within the vessel 14
is maintained by the control system between 250 and 400
10 degrees Centigrade.

It is also desirable for efficient operation that the
engine 17 operates at an optimal loading, for example at
95% of its rated capacity. If the control system CS
learns, via a speed sensor 2 on the engine 17 that the
15 RPM's of the engine 17 are dropping off from a known
maximum, this may indicate too much material is being fed
into the vessel 14. The control system CS then reduces
the mass transfer rate into the vessel 14 (by controlling
the system 60). Power generated typically drops off as
20 the RPM's drop off, as can be seen on a typical
performance curve. Insuring that the power generated is
maximized provides the maximum energy available to
generate the heat required within the vessel 14.

Initially at start up, in one aspect, the valve 56 is
25 opened slowly. As free flowing liquid and material flow
into the vessel 14, the temperature is maintained. If
there is no dramatic drop in temperature, this indicates
that the flow of material has an appropriate liquid
content so that a desired operational temperature and
30 effective operation can be achieved. Then the valve 56 is
fully opened as the system 60 is controlled by the control
system CS and full flow commences.

The container 46 may be filled continuously or in
batches.

35 Figure 1E shows a system 10a, like the system 10
described above, and like numerals indicate like parts.
The initial feed of drill cuttings material to the
container 46 is from one or more shale shakers 55 (or
other processing equipment) whose drill cuttings material

5 output (for example off the tops of the shaker screens or
from a centrifuge) is fed to a buffer apparatus BA to
maintain a desired liquid content of the material in the
container 46, and, in one aspect, to minimize this liquid
content. The buffer apparatus BA can be any suitable
10 system or apparatus; for example, but not limited to: a
system in accordance with the present invention (for
example, but not limited to a system as in Figures 1A, 2A,
or 3); a storage system for drill cuttings material; a
skip system; a cuttings containment and transfer system
15 (for example, but not limited to, a known system as
disclosed in U.S. Patent 7,195,084, co-owned with the
present invention); or a transfer/transport system, for
example, but not limited to, the BRANDT FREE FLOW
(TRADEMARK) systems.

20 Figure 2A shows a system 10b like the system 10
described above and like numerals indicate like parts.

The system 10b has a slider system 80 with a slider
frame 82 selectively movable by a piston mechanism 84 with
one part connected to the slider frame 82 and controlled
25 by the control system CS. Power for the piston mechanism
84 is provided by a hydraulic power pack HPP (which also
provides power to the motor 52). The slider frame 82 moves
material on the bottom 48 of the container 46 to
facilitate the flow of material down to the screw 62 of
30 the system 60. A slider frame may be used as shown in
U.S. Patent 7,195,084.

The slider frame 82 has a central beam 86, and,
optionally, bevelled end edges 88. The slide 82 moves
material facilitating its entry into a trough 47 in which
35 is located the screw 62. Optionally, the slider frame 82
is smaller than shown with no central beam 86 and is
movable to and from the trough 47 on both sides thereof.

Figure 3 illustrates a system 10c, like the system
10, and like numerals indicate like parts The reactor

5 section 12c has multiple material inlets 13c into which material is introducible into a vessel 14c. One feeder system may be used at one inlet 13c or multiple feeder systems 40c may be used (three shown in Figure 3).

Figure 4 illustrates improvements to systems of U.S. Patent 5,914,027 and shows a system 200 with a feeder system 210 (like any feeder system disclosed herein in accordance with the present invention) which feeds material into a reactor chamber or vessel 201 with a rotor 202 including friction elements 203, such as flails. The rotor 202 further includes a shaft 204 sealed in the reactor with mechanical seals 205. The friction elements 203 are pivotably mounted in rotor plates 207 (as in U.S. Patent 5,914,027). Each pair of adjacent rotor plates 207 carries a number of friction elements 203. The friction elements 203 are staggered relative to each other. The staggered arrangement may achieve turbulent action in a bed of grained solids in the vessel. The friction elements 203 are pivotably mounted in between adjacent rotor plates 207 by rods extending over the length of the rotor 202 (as in U.S. Patent 5,914,027).

The rotor 202 is driven by a rotating source 209 which can be an electrical motor, a diesel engine, a gas or steam turbine or the like. The material is brought to the reactor from the feeder system 210 via a line 211. Water and/or oil (for example, base oil) can be added to the flow from the pipe 212. Cracked hydrocarbon gases (and, in one aspect, over saturated steam) leaves the reactor via a line 213 and, in one aspect, flows to a cyclone 214 and proceed to a condenser unit 215 which can be a baffle tray condenser, a tubular condenser or a distillation tower. The different fractions of the oil can be separated directly from the recovered hydrocarbon gases. The heat from condensation is removed by an oil cooler 216 cooled either by water or air. The recovered

5 oil is discharged from the condenser by a pipe 217 to a tank 218.

Solids leave the reactor via a rotating valve 219 and a transport device 220 which can be a screw or belt conveyor or an air transportation pipe system to a container 221. The air transportation system may be a positive pressure system moving slugs of solids slowly along the pipe or may use high speed air to transport the solids in suspension. Alternatively, a vacuum system may be used. The solids separated from the cyclone 214 are transported via a rotating valve 222 to the container 221 either by being connected to the transport device 220 or directly to the container 221 by a cyclone transport device 223.

Non condensable gases exit in a pipe 224 and can flow from the pipe 224 to a filter unit or to a flare tower or are accumulated in a pressure tank not shown. The system 200 may be operated in any way described in U.S. Patent 5,914,027. The items downstream of the vessel 201 may be used with any system in accordance with the present invention.

Figure 5 illustrates that the present invention provides improvements to the systems and methods of U.S. Patent 5,724,751 and shows a system 300 in accordance with the present invention with a process chamber with a rotor 302 and blades 303 driven by an engine 304. A mass of material is fed into the process chamber by a feeder system 320 (any feeder system disclosed herein in accordance with the present invention). The mass in the process chamber is whipped by the blades and subjected to energy or vibrations from the said blades and ribs 308, which are sufficiently closely spaced to each other to cause turbulence during the rotation of the blades. Additional energy may be supplied in some form of heated gas from a combustion engine 309. Gases, mist and vapors

5 leave the process chamber 301 via an output opening via a
vent fan 311 and on to either open air or to a condenser.
Dried material is led through an output opening 312 via a
rotating gate 313. The system 300 may be operated in any
way described in U.S. Patent 5,724,751. The items
10 downstream of the process chamber of the system 300 may be
used with any system in accordance with the present
invention.

The present invention, therefore, provides in some,
but not in necessarily all, embodiments a thermal
15 treatment system for removing liquid from drill cuttings
material, the thermal treatment system having a metering
screw apparatus for receiving and feeding drill cuttings
material to a reactor system, including apparatus and a
control system for controlling the metering screw
20 apparatus and for insuring that the metering screw
apparatus is maintained full or nearly full of material
and/or for controlling the mass flow rate into a reactor
of the thermal treatment system by adjusting the speed of
the metering screw apparatus.

25 The present invention, therefore, provides in some,
but not in necessarily all, embodiments a thermal
treatment system for treating drill cuttings material in
which apparatus and a control system are provided to
maintain an airlock at a material inlet to a thermal
30 reactor of the thermal treatment system by maintaining a
desired amount of material in a container above a feeder
system that feeds material into the thermal reactor.

Any system in accordance with the present invention
may include one or some, in any possible combination, of
35 the following: wherein apparatus and a control system
provide for control of temperature in the thermal reactor
by controlling the mass flow rate of material into the
thermal reactor by controlling a metering screw system
that feeds material into the thermal reactor; wherein the

5 thermal treatment system has an engine that rotates
friction elements within a reactor vessel of the thermal
reactor and performance of said engine is optimized by
controlling a metering screw system that feeds material
10 into the reactor vessel (for example, based on sensed
speed in rpm's of said engine); a sensor or sensors or at
least one load cell apparatus or two load cell apparatuses
beneath the container to provide information to indicate
an amount of material in the container; a sensor or
sensors or at least one load cell apparatus or two load
15 cell apparatuses beneath the thermal reactor to provide
information to assist in control of the discharge rate of
solids from the thermal reactor; wherein a control system
controls the amount of material in the thermal reactor;
wherein the control system controls said amount to
20 maintain an airlock at the discharge from the thermal
reactor; apparatus and a control system to maintain a
desired temperature in the thermal reactor; a first feed
of drilling cuttings material into the container; wherein
the first feed is from drilling operations solids control
25 equipment which is at least one of shale shaker,
centrifuge, vortex dryer, and hydrocyclone; wherein the
first feed is from a cuttings conveyance system; a
secondary feed into the container from a cuttings storage
or transfer system; and/or apparatus and a control system
30 for control of temperature in the thermal reactor by
controlling the mass flow rate of material into the
thermal reactor by controlling a metering screw system
that feeds material into the thermal reactor; the thermal
treatment system having an engine that rotates friction
35 elements within a reactor vessel of the thermal reactor
and performance of said engine is optimized by controlling
a metering screw system that feeds material into the
reactor vessel (for example, based on sensed speed in
rpm's of said engine); at least one load cell apparatus or

5 two load cell apparatuses beneath the container to provide information to indicate an amount of material in the container.

WHAT IS CLAIMED IS:

1. A method for facilitating separation of hydrocarbons from hydrocarbon laden drill cuttings using a thermal treatment apparatus and a feeder apparatus comprising a metering screw the method comprising the steps of the metering screw receiving and feeding drill cuttings material into the thermal treatment apparatus, the thermal treatment apparatus comprising a reactor having a material inlet and discharge, the method further comprising the step of a control system controlling the metering screw, wherein the control system controls the amount of material in the reactor to maintain an airlock at the discharge from the thermal reactor.

2. A method for facilitating separation of hydrocarbons from hydrocarbon laden drill cuttings using a thermal treatment apparatus and a feeder apparatus comprising a container and a metering screw the method comprising the steps of the metering screw receiving and feeding drill cuttings material from the container into the thermal treatment apparatus, the thermal treatment apparatus comprising a reactor having a material inlet and discharge, the method comprising the steps of a control system maintaining an airlock at a material inlet to a thermal reactor of the thermal treatment apparatus by maintaining a desired amount of material in the container above the metering screw.

3. The method in accordance with Claims 1 and 2, wherein the control system controls the amount of material in the reactor to maintain an airlock at the discharge from the thermal reactor and an airlock at the material inlet to a thermal reactor.

4. The method in accordance with Claim 1, 2 or 3, wherein the reactor comprises a rotating drum, amount of material is controlled by monitoring the speed of rotation of the rotating drum and controlling the speed of the screw feeder in response thereto.

5. The method in accordance with any one of Claims 1 to 4, wherein the control system maintains a desired temperature in the thermal reactor by adjusting the speed of the screw feeder.

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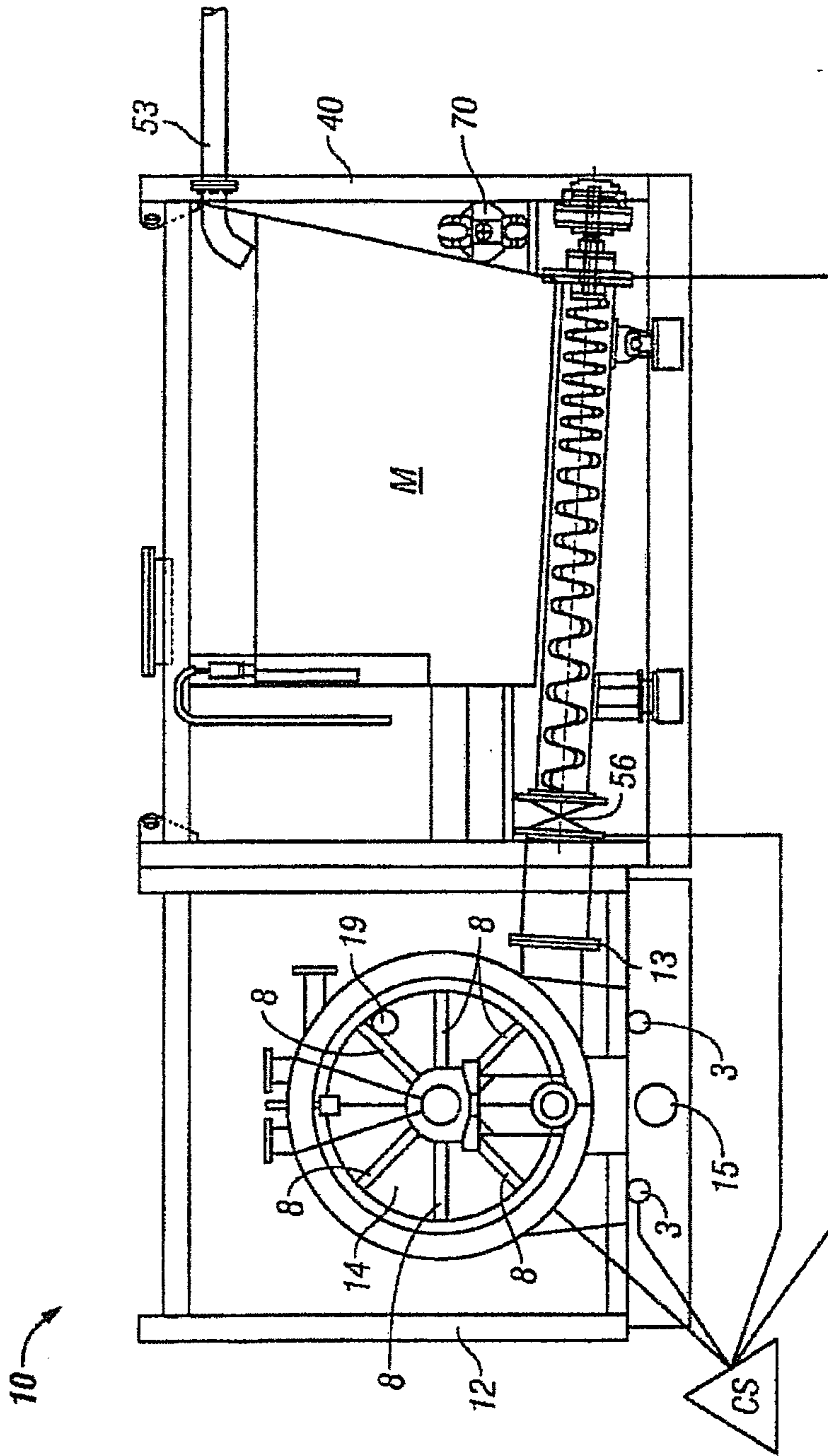


FIG. 1A

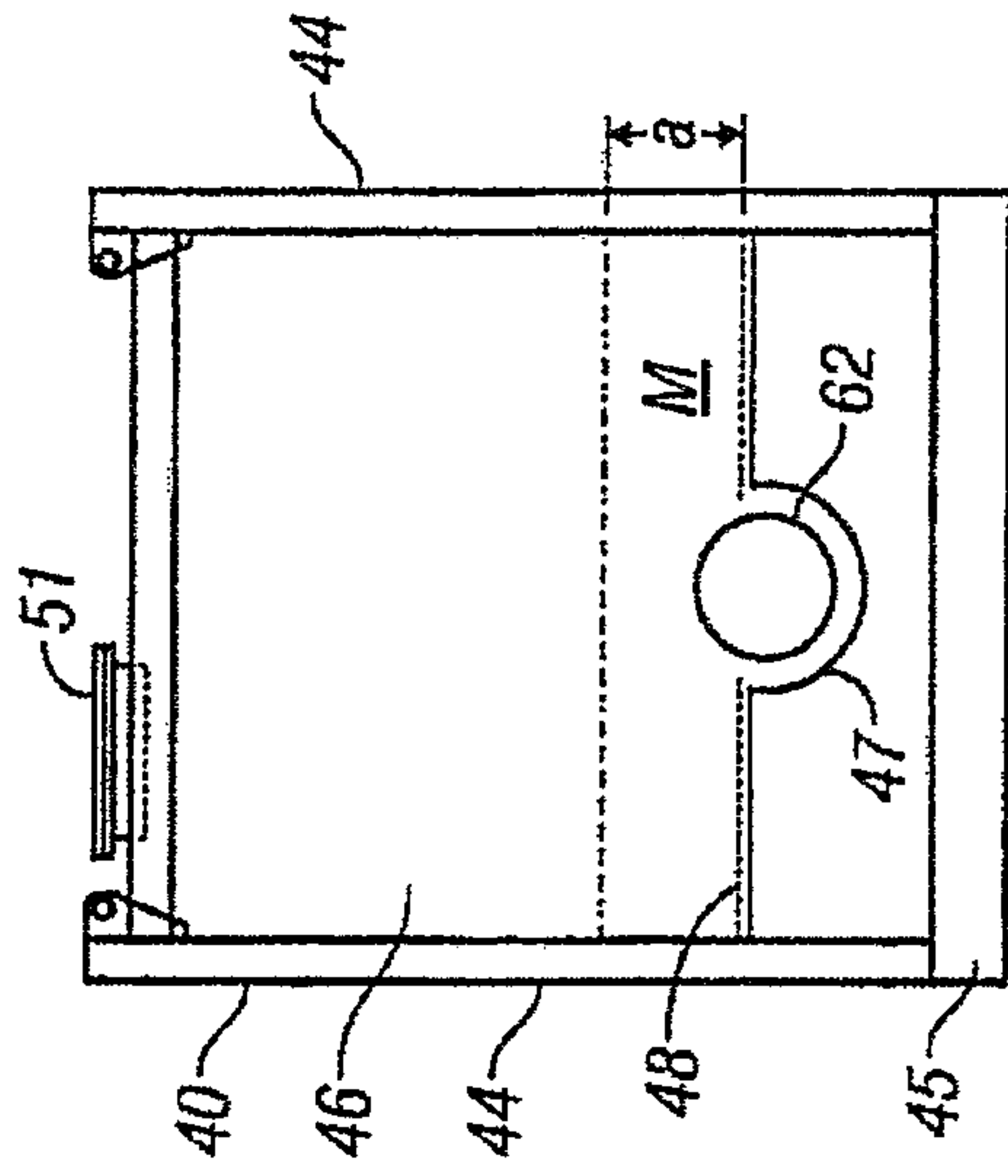


FIG. 1C

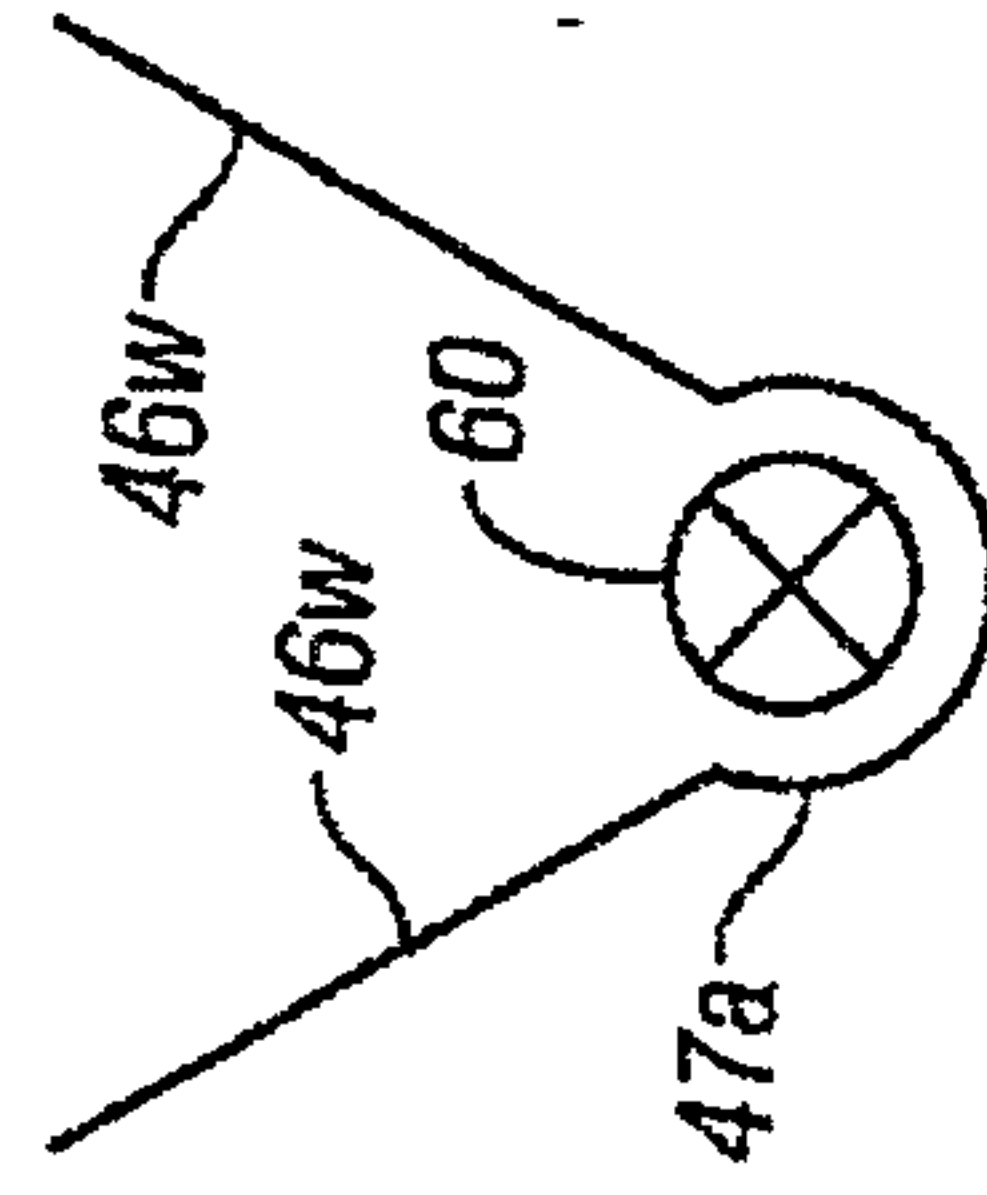


FIG. 1F

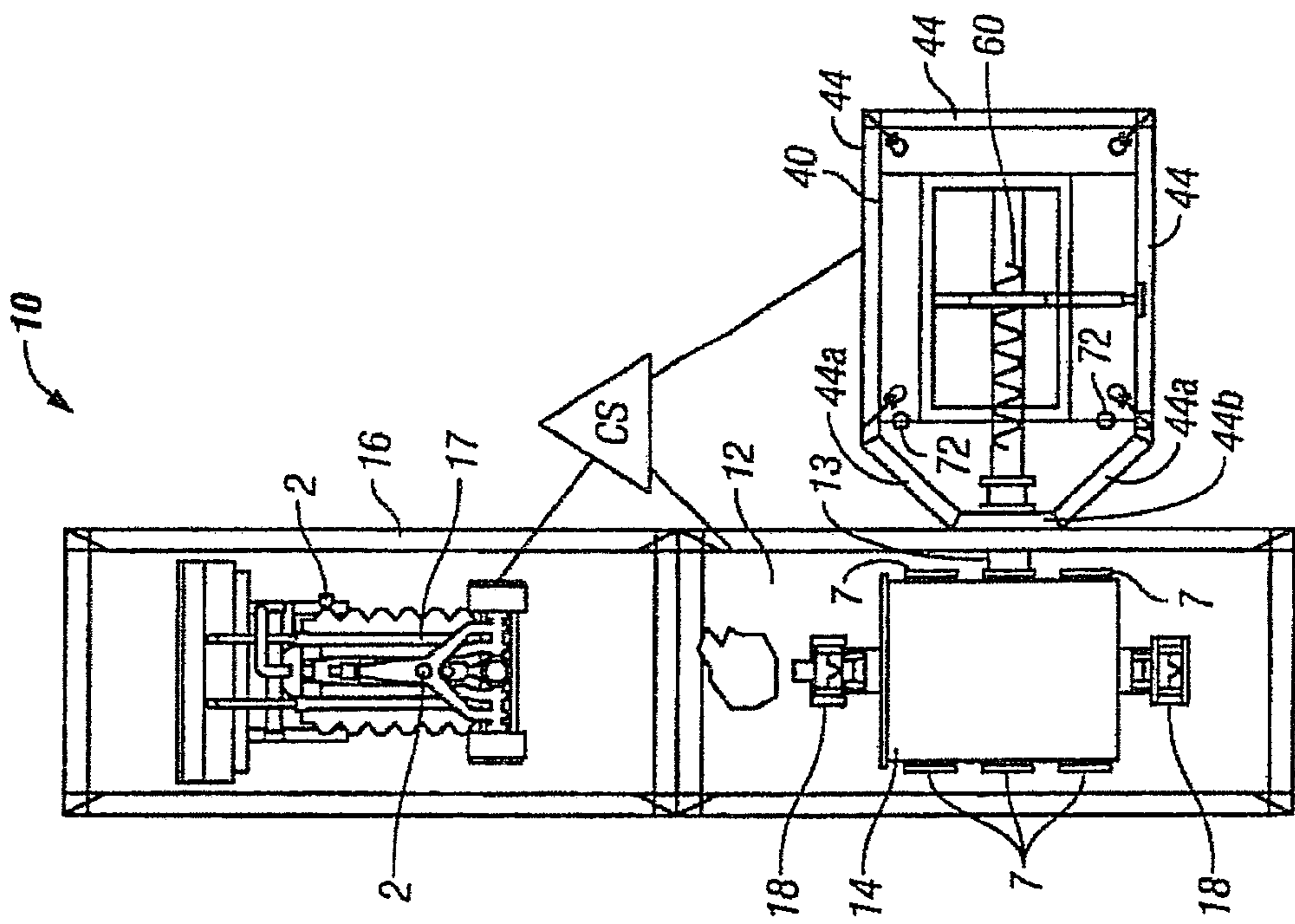


FIG. 1B

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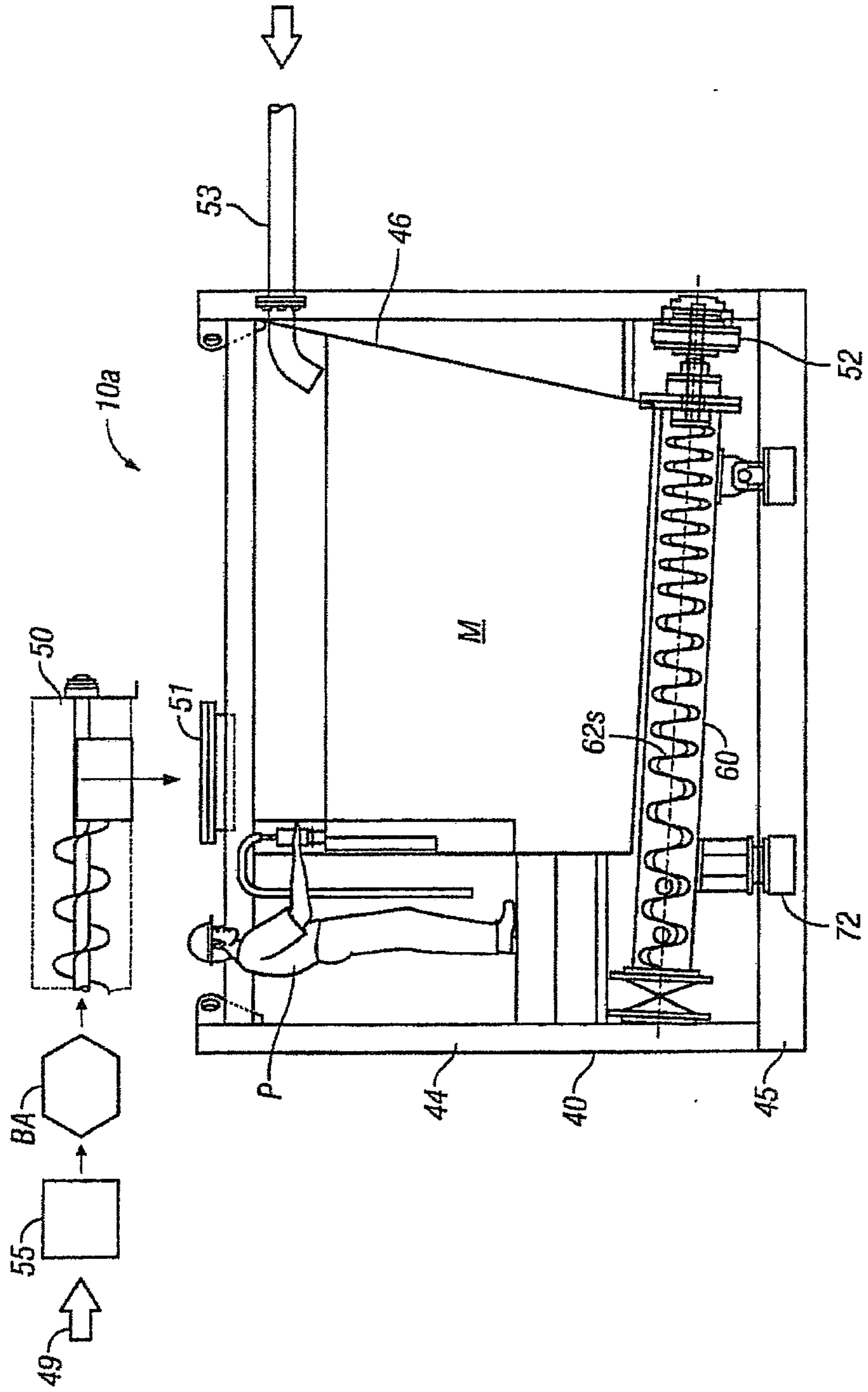


FIG. 1E

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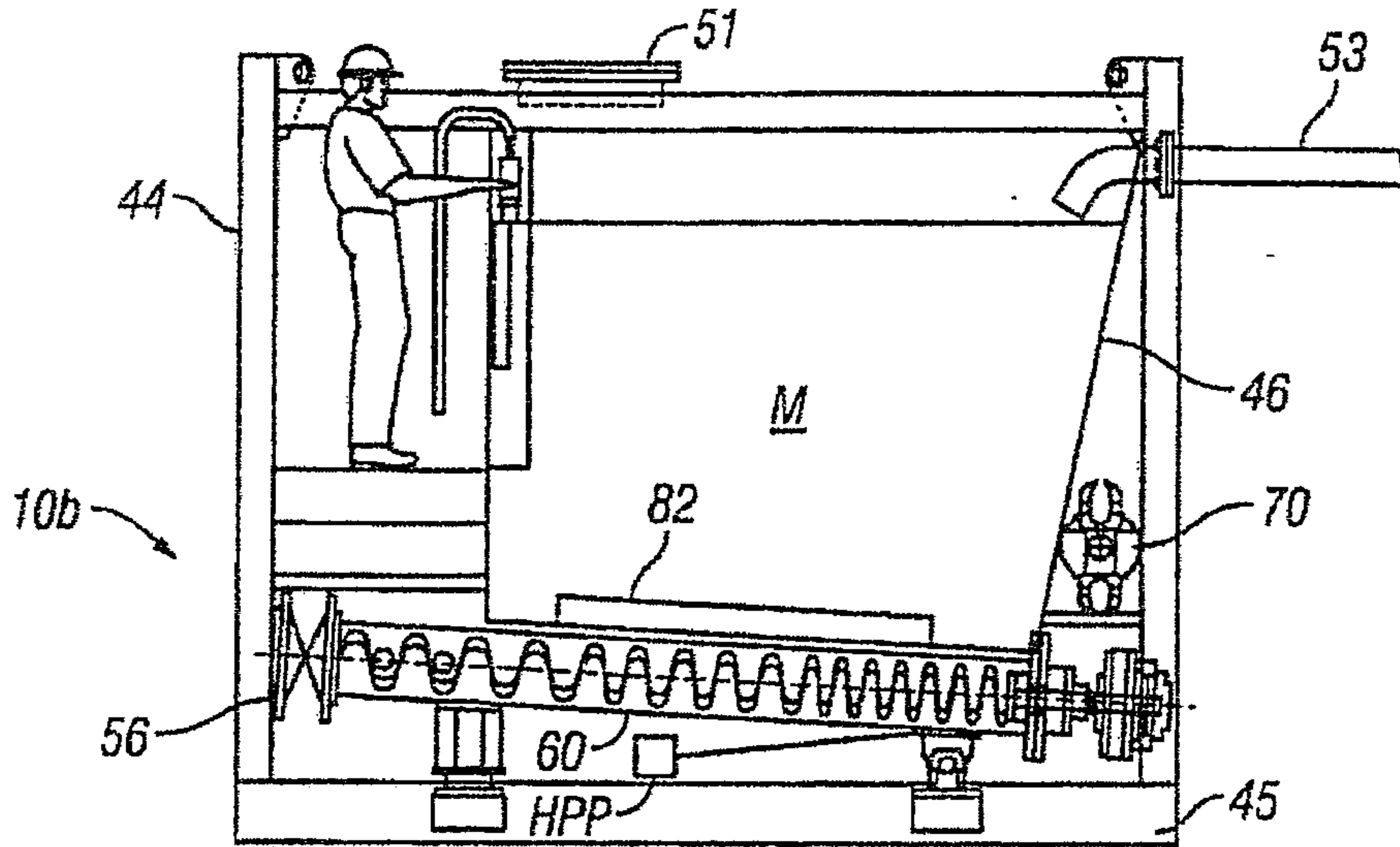


FIG. 2A

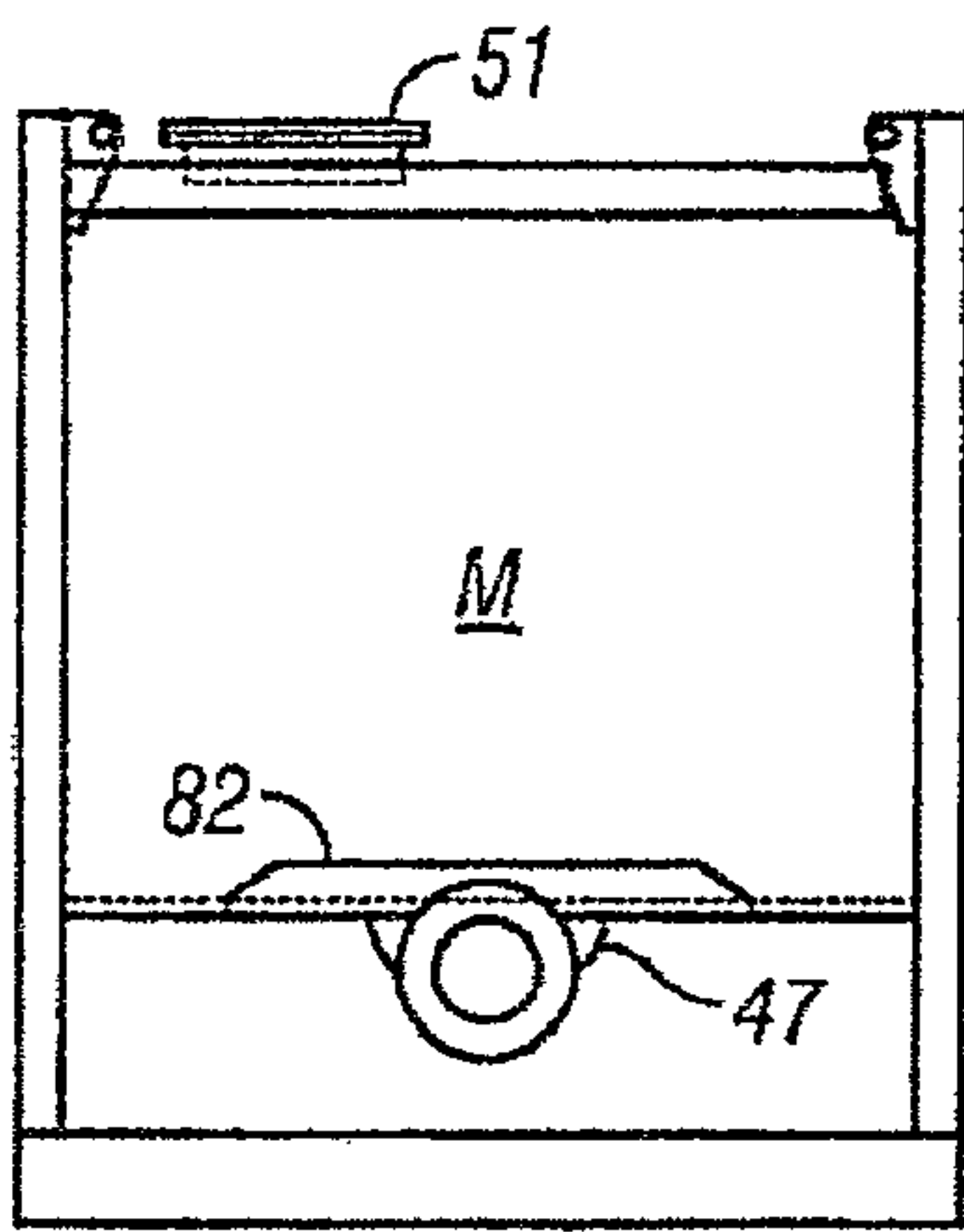


FIG. 2B

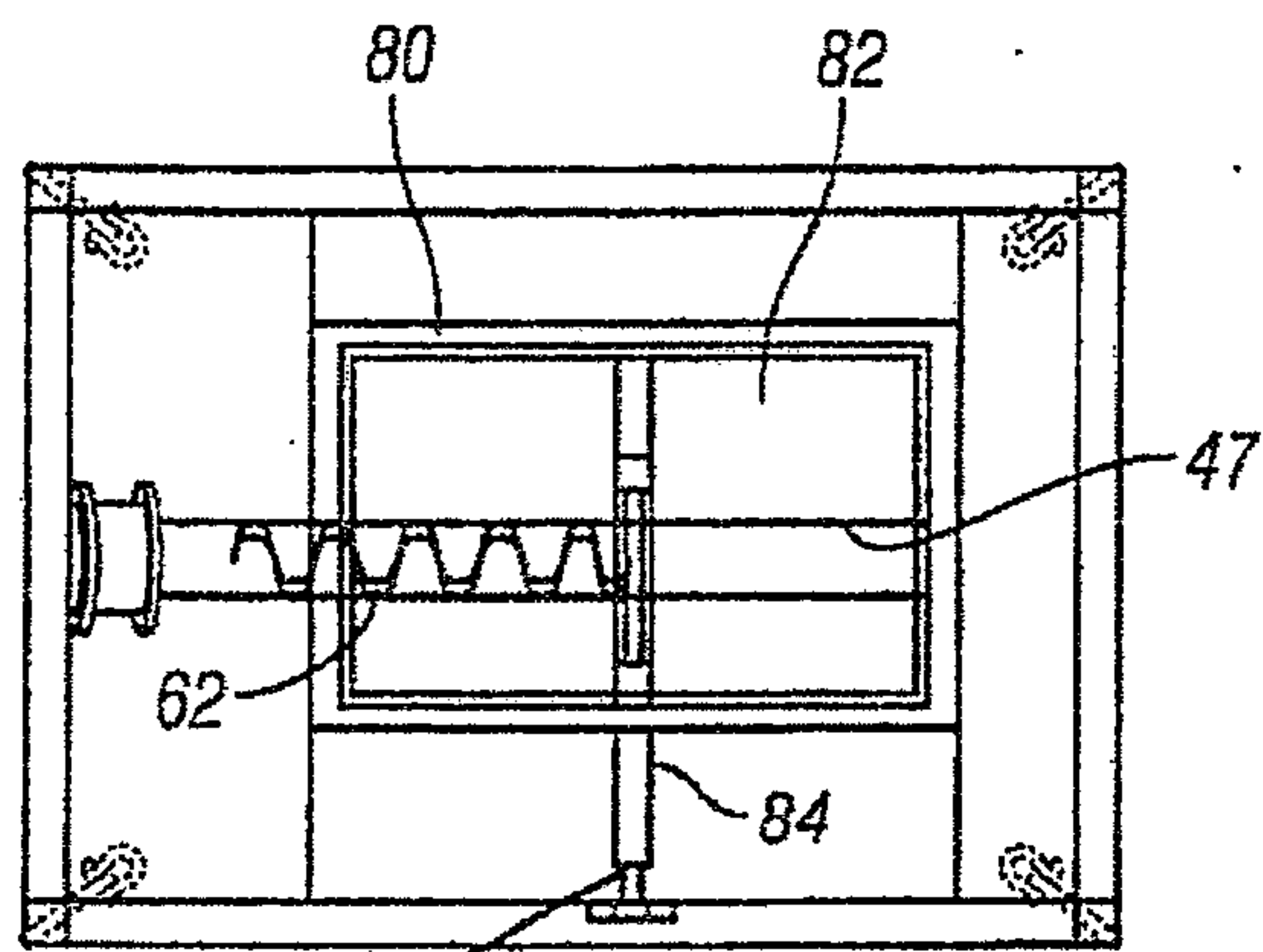


FIG. 2C

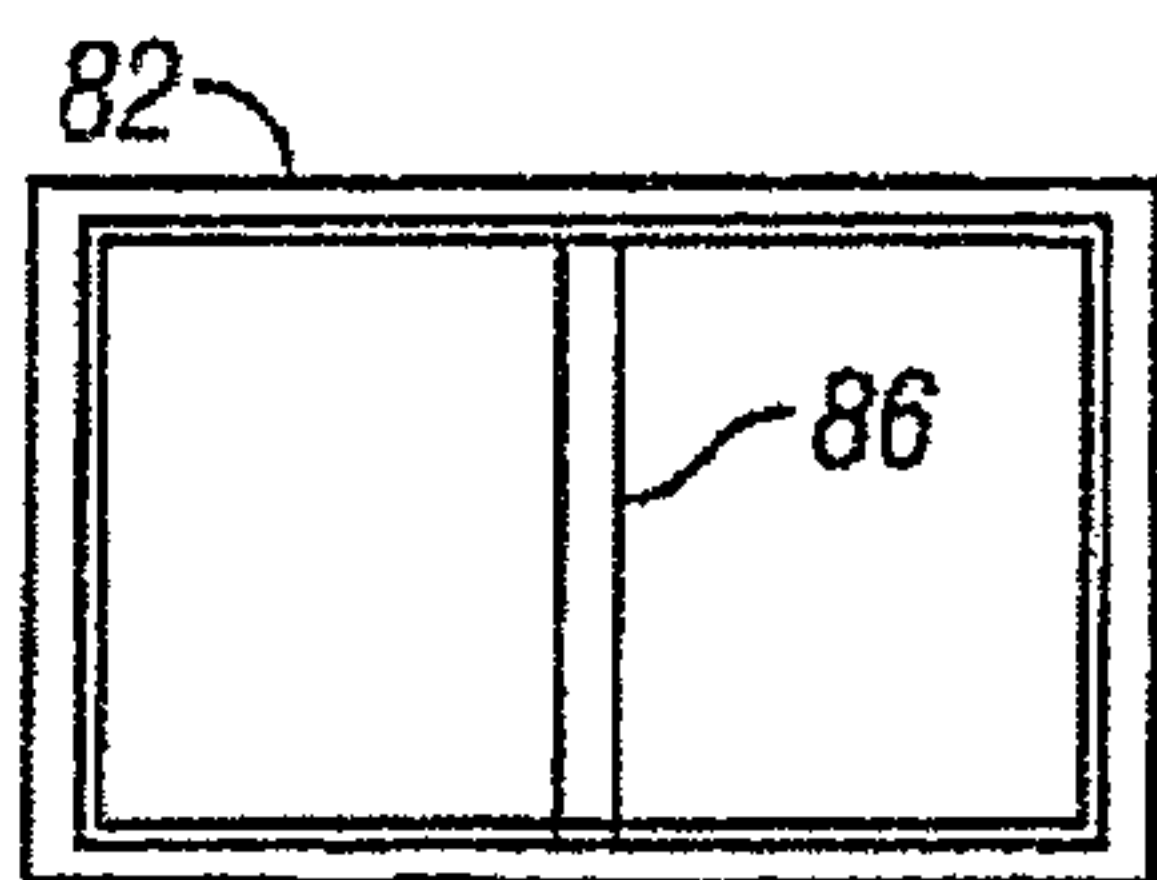


FIG. 2D

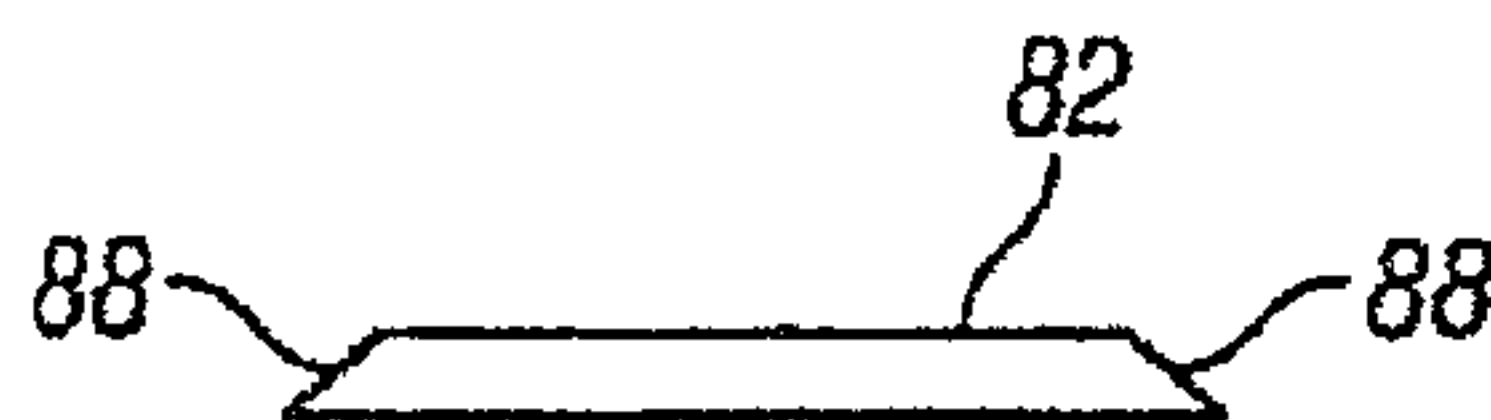
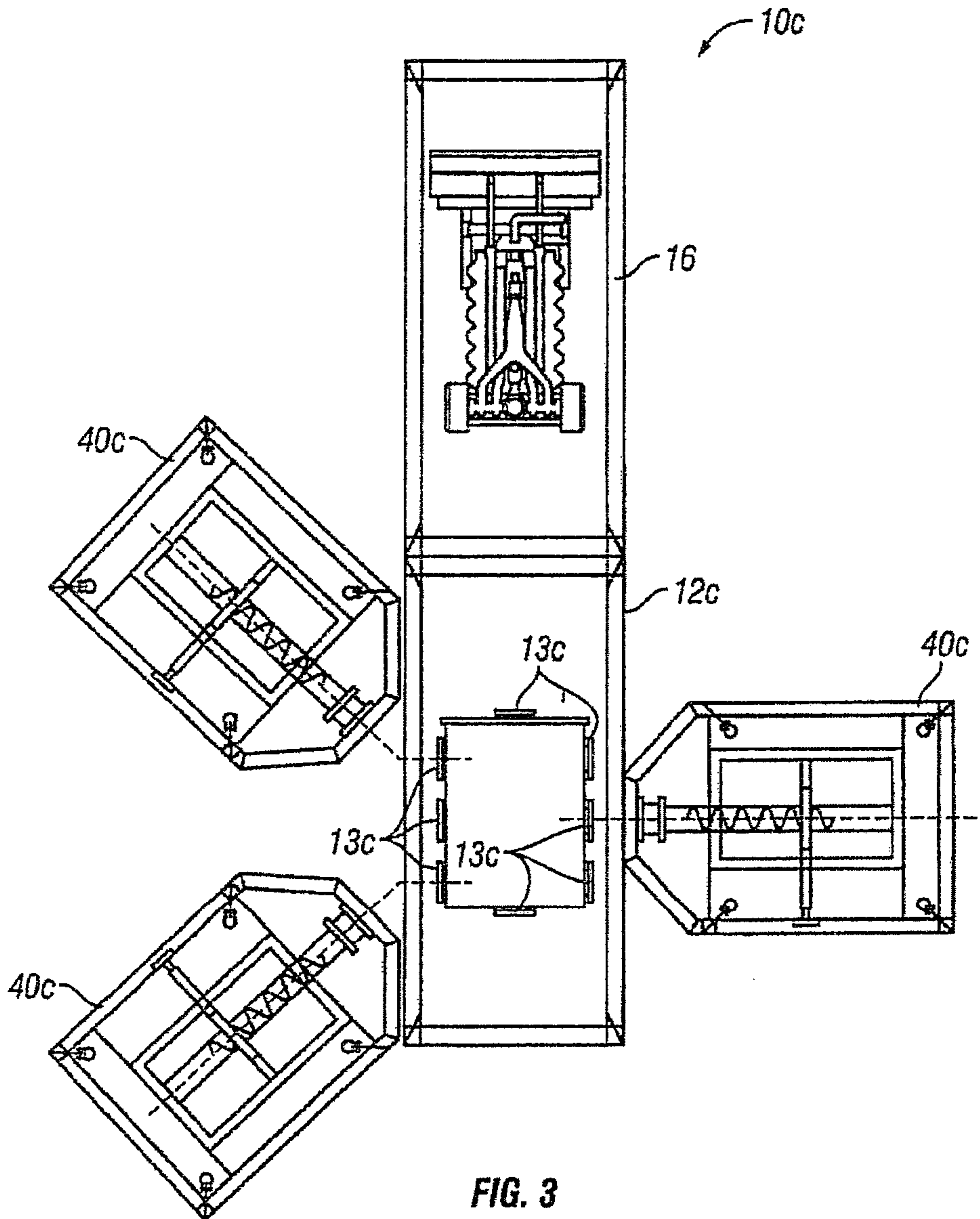


FIG. 2E

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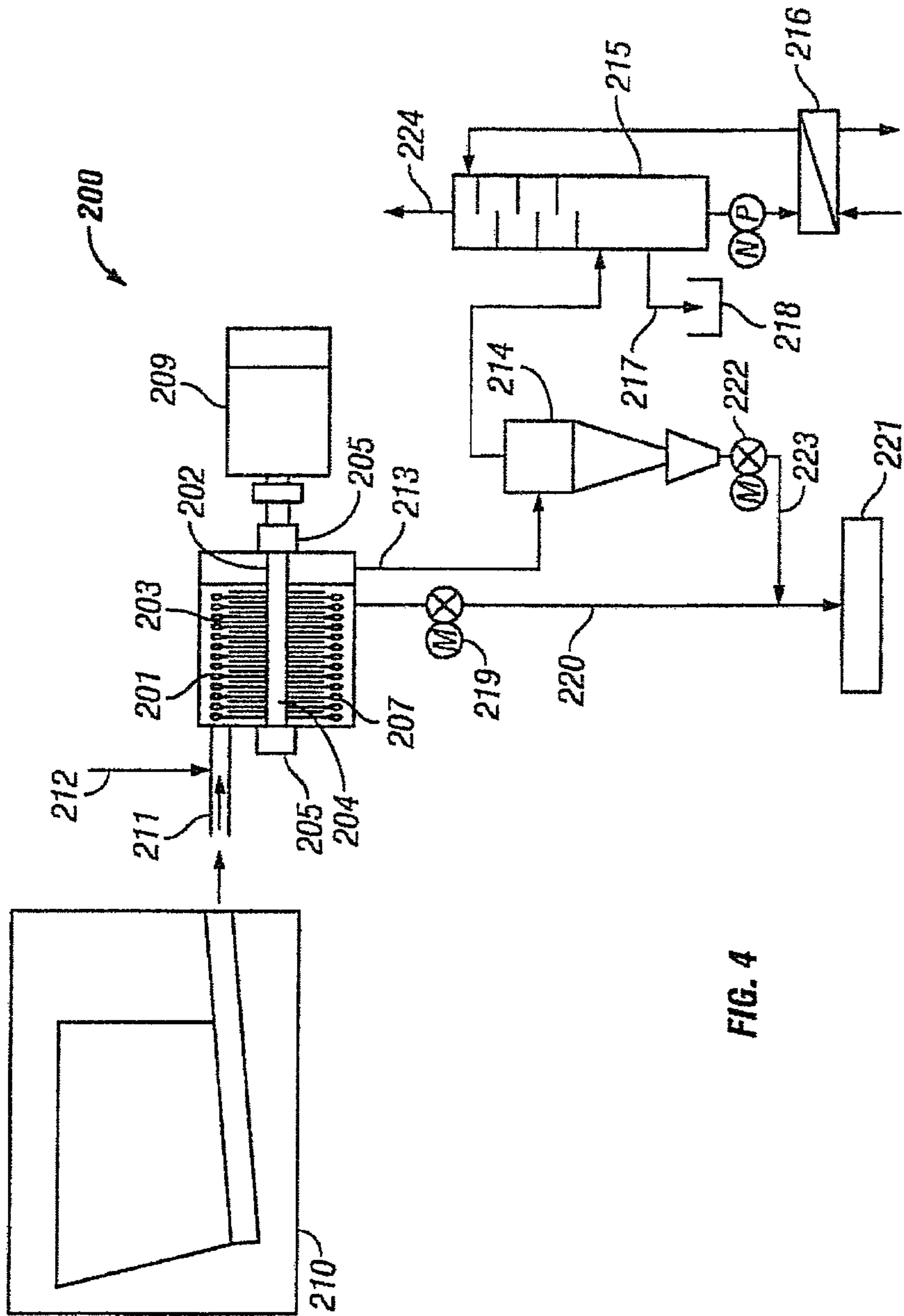


FIG. 4

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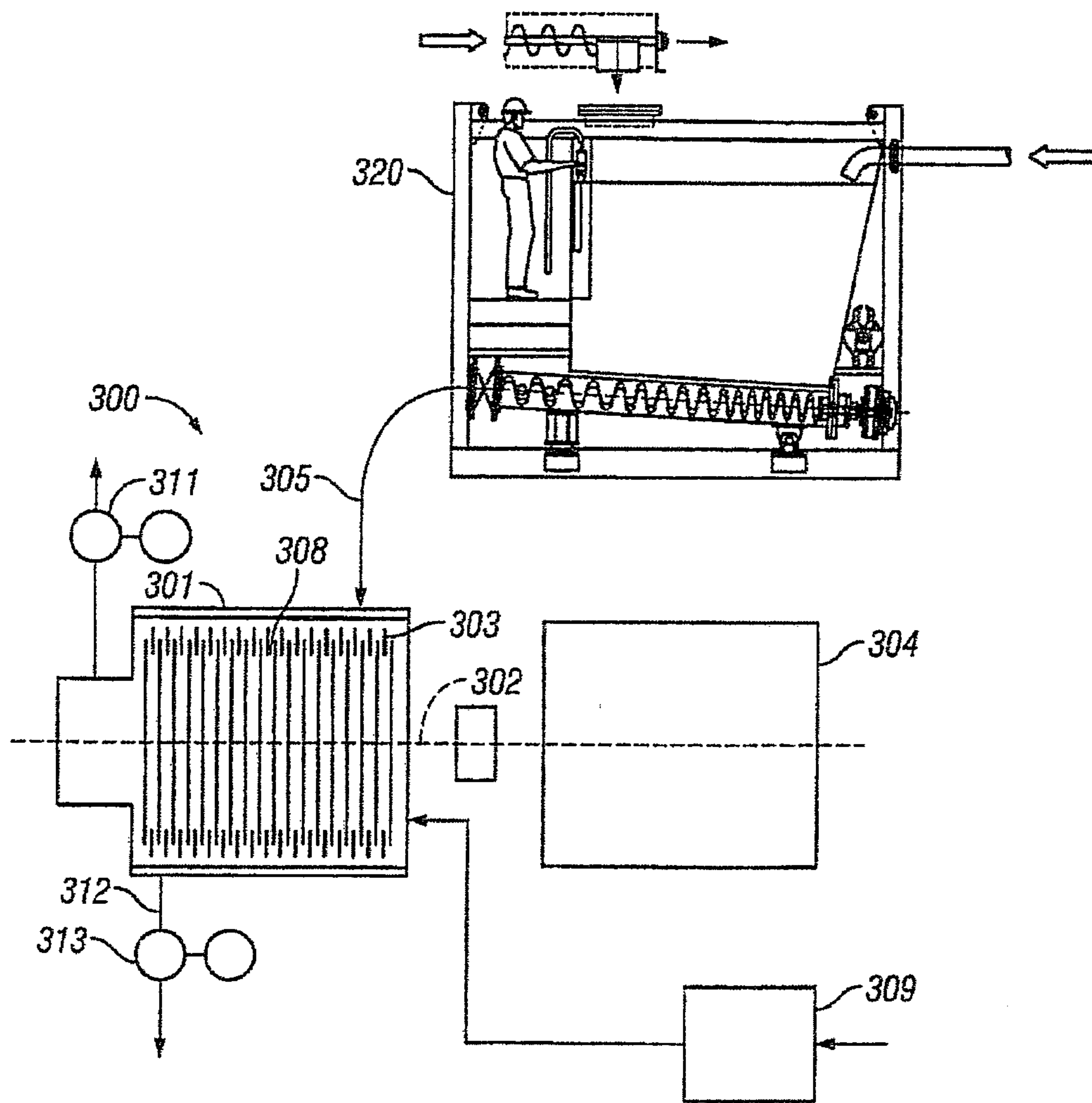


FIG. 5