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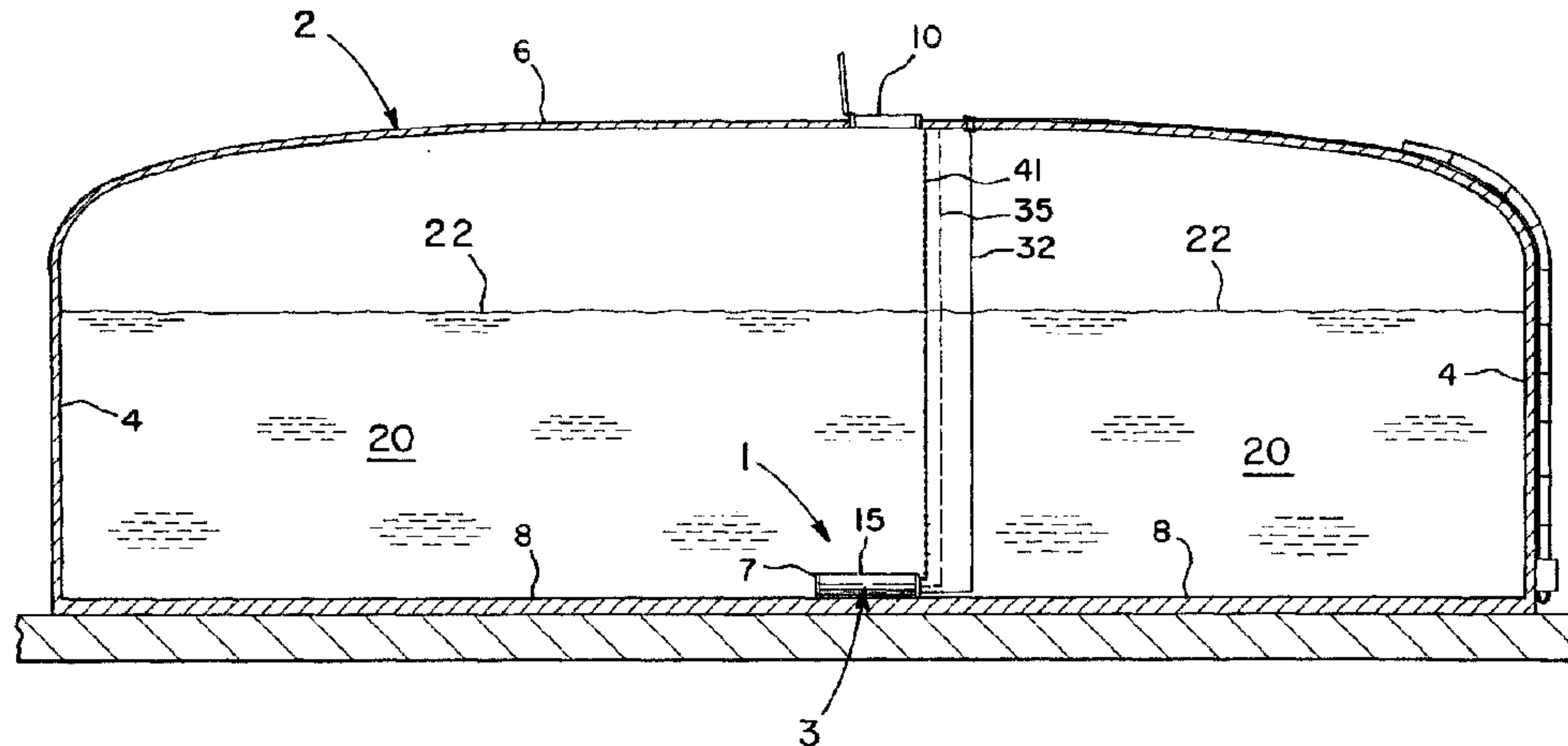
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(54) Titre : SYSTÈME DE CIRCULATION D'EAU SUBMERSIBLE POUR RESERVOIRS ENCLOSES

(54) Title: SUBMERSIBLE WATER CIRCULATION SYSTEM FOR ENCLOSED TANKS



(57) Abrégé/Abstract:

A submersible, water circulation system for enclosed tanks such as used by municipalities, fire districts, and industries. The system includes a driving unit having a shell extending along an axis with a pump supported within the shell. The shell has at least one inlet and at least one outlet and is positionable on the floor of the tank with the outlet facing upwardly. The upwardly facing outlet is preferably a thin, upwardly facing, elongated slot that creates a thin, substantially planar discharge of water therethrough that is directed upwardly toward the surface of the body of water. The substantially planar discharge presents a very large surface area for its volume and induces water adjacent the outside of the shell of the driving unit to move upwardly with it toward the surface of the body of water.

ABSTRACT

A submersible, water circulation system for enclosed tanks such as used by municipalities, fire districts, and industries. The system includes a driving unit having a shell extending along an axis with a pump supported within the shell. The shell has at least one inlet and at least one outlet and is positionable on the floor of the tank with the outlet facing upwardly. The upwardly facing outlet is preferably a thin, upwardly facing, elongated slot that creates a thin, substantially planar discharge of water therethrough that is directed upwardly toward the surface of the body of water. The substantially planar discharge presents a very large surface area for its volume and induces water adjacent the outside of the shell of the driving unit to move upwardly with it toward the surface of the body of water.

SUBMERSIBLE WATER CIRCULATION SYSTEM FOR ENCLOSED TANKS

CROSS REFERENCE TO RELATED APPLICATION

5 The present application is a divisional application of Canadian Patent Application No. 2,765,701 filed on January 31, 2012.

BACKGROUND OF THE INVENTION

10 **1. Field of the Invention.** This invention relates to the field of circulation systems for water tanks and more particularly to the field of circulation systems for enclosed tanks such as used for municipalities, fire protection, and industrial purposes.

15 **2. Discussion of the Background.** Municipalities, fire districts, and industries commonly use enclosed water tanks. Such tanks typically hold about 300,000-500,000 gallons with some larger ones more on the order of 2 to 3 million gallons and are about 50-75 feet wide and 30 or more feet high. The water in these tanks is preferably kept mixed by an internal circulation system to maintain its freshness, particularly in municipal water tanks, and to avoid water quality problems such as bacteria growth and nitrite development.

20 A physical problem with many such tanks is that they normally have only a relatively small access opening (e.g., 18-24 inches wide) which is designed primarily just to permit an individual worker to pass through to inspect or repair the tank. Consequently, many circulation systems if they are going to be used in the tank must be passed through the access opening in nearly completely disassembled or at least partially disassembled condition. One or more workers must then enter the tank to
25 assemble the system. This often requires special, elaborate, and costly training and following strict regulatory and other safety procedures. Special equipment must also often be used such as winches to lower the workers, tethered tools, safety lines, air monitors, inflatable rafts, and even diving gear as well as rescue personnel standing by. Additionally, it can require that the tank be taken off line or out of service and
30 even drained. Alternate sources must often then be arranged to temporarily supply

water to customers and for fire protection. Any unexpected or prolonged delays in bringing the tank back on line can thereafter be quite costly and in some cases present safety concerns to the community. The same problems are presented if the circulation system placed in the tank subsequently breaks down and workers must enter the tank to repair it.

With these and other concerns in mind, the present invention was developed. In it, a submersible circulation system is provided that can easily fit through the relatively small access opening of the tank in a completely assembled condition. Additionally, the circulation system is designed to be lowered to the tank floor to automatically assume the desired operating orientation without the need for any workers to enter the tank. The system can also be raised out of the tank through the access opening without the necessity of any workers having to enter the tank.

SUMMARY OF THE INVENTION

This invention involves a submersible, water circulation system for enclosed tanks such as used by municipalities, fire districts, and industries. The system includes a driving unit having a shell extending along an axis with a pump supported within the shell. The shell has at least one inlet and at least one outlet and is positionable on the floor of the tank with the outlet facing upwardly.

In operation, the pump continuously draws an incoming flow of water from outside of the driving unit adjacent the tank floor through the inlet of the driving unit. In the preferred embodiment, all of the continuously incoming flow is then driven by the pump out of the driving unit through the upwardly facing outlet. The upwardly facing outlet is preferably a thin, elongated slot extending along the shell of the driving unit and creates a thin, substantially planar discharge of water therethrough that is directed upwardly toward the surface of the body of water. The substantially planar discharge induces water adjacent the outside of the shell of the driving unit to move upwardly with it toward the surface of the body of water.

The substantially planar discharge presents a very large surface area for its volume to the adjacent water and induces a very large volume of tank water to flow

with it. The discharge from the submerged driving unit is substantially laminar and travels upwardly to the surface of the water and substantially radially outwardly to the sides of the tank. It then flows downwardly to the tank floor and substantially radially inwardly along the tank floor to the submerged driving unit. In doing so, this primary
5 circulation pattern in turn induces secondary flow patterns within the body of water to thereby thoroughly mix the water in the entire tank and to do so in a substantially laminar manner. .

The driving unit of the circulation system is additionally designed to be received through the relatively small access opening of the tank in a completely assembled
10 conditioned. It can thereafter be lowered to the tank floor by a flexible line to automatically assume the desired operating orientation without the need for any workers to enter the tank. The driving unit can also be raised out of the tank through the access opening without the necessity of any workers having to enter the tank.

BRIEF DESCRIPTION OF THE DRAWINGS

15 Figure 1 illustrates the circulation system of the present invention in its operating position within a water tank.

Figure 2 is a view similar to Figure 1 showing the substantially laminar flow created by the circulation system in the entire tank to thoroughly and completely mix
20 the water.

Figure 3 is a view similar to Figure 2 but taken at a right angle to it.

Figure 4 is a top plan view taken along lines 4-4 of Figures 2 and 3 showing the nearly radial, surface spreading of the water as created by the circulation system

Figure 5 is a perspective view of the driving unit of the circulation system.

25 Figure 6 is a top plan view of the driving unit.

Figure 7 is an end view of the driving unit.

Figure 8 is a partial cross-sectional view of the driving unit showing its interior components.

Figure 9 is a perspective view of the baffle plate positioned inside the driving
30 unit.

Figure 10 is a schematic representation of the manner in which the upwardly directed flow from the driving unit is believed to change from an initial, substantially planar flow to an oval one and then to a final, substantially cylindrical flow as it moves upwardly toward the surface of the tank water.

Figures 11-13 illustrate views of the driving unit of the circulation system in terms of the location of its center of gravity that permits the lowering technique and positioning of Figure 13 to be accomplished.

Figure 14 illustrates a second embodiment of the outlet configuration of the discharge from the driving unit.

Figures 15a-15c illustrate further discharge arrangements from the driving unit that could be used with the lowering technique of Figure 13.

DETAILED DESCRIPTION OF THE INVENTION

As shown in Figures 1-3, the circulation system 1 of the present invention is primarily intended for use to circulate water (Figures 2-3) in an enclosed water tank 2. Such tanks 2 are commonly used to contain water for municipalities, fire prevention, and industrial purposes. The tanks 2 (Figure 1) typically have side and top walls 4,6 and a floor 8. The tank size can vary but typically holds about 300,000-500,000 gallons with some larger ones more on the order of 2 to 3 million gallons and are about 50-75 feet wide and 30 or more feet high. The tanks 2 also usually have a fairly small access opening at 10 (e.g., 18-24 inches wide) in the top wall 6 that is primarily designed to permit a single worker to pass through to inspect or repair the interior of the tank 2. In some cases, the access opening 10 may have safety bars or other restrictions and its width may be only 12 inches or less and not even permit any entry by a worker. The present circulation system 1 of Figures 1-3 in this last regard as explained in more detail below has been specifically designed to fit through such small access openings 10 in a completely assembled condition. Additionally, the circulation system 1 as also explained in more detail below has been designed so it can be lowered to the tank floor 8 to automatically assume the desired operating orientation of Figures 1-3 without the need for any workers to enter the tank

2. Conversely, the circulation system 1 of the present invention can be removed from the tank 2 through the access opening 10 without the necessity of any workers having to enter the tank 2.

Referring again to Figures 1-3, the circulation system 1 has a submersible driving unit 3 (Figure 1) positionable on the floor 8 of the tank 2. The driving unit 1 as illustrated in Figures 2-3 creates an upwardly directed flow 12,12',12" immediately above the drive unit 3 that establishes an overall circulation pattern 14,16,18 in the body of water 20 in the tank 2. In this regard, the overall circulation pattern extends upwardly at 12,12',12" from the submerged driving unit 3 to the surface 22 of the body of water 20 at 22'. The pattern then flows substantially radially outwardly at 14 (see Figures 2 and 4) along the surface 22 of the body of water 20 to the side walls 4 of the tank 2 (see again Figure 2), downwardly at 16 along the tank walls 4, and substantially radially horizontally inwardly at 18 along the tank floor 8 toward the driving unit 3. Aiding the set up of this overall circulation pattern and in particular its radial surface spreading of Figure 4 is that the upwardly directed flow 12,12',12" from the drive unit 3 preferably does not break or at least does not significantly break the surface 22. Rather, the upward flow creates a small mounding or crowning effect at 22' in Figures 2-3 (e.g., less than an inch and preferably a relatively small fraction such as 1/4 to 1/2 of an inch). This mounding or crowning at 22' cyclically rises and collapses creating the substantially uniform, radial surface spreading of Figure 4. Additionally, the overall circulation pattern of 12,12',12" and 14,16,18 in the tank 2 in turn induces secondary flow patterns within the body of water 20 such as at 24 in Figure 2 to then thoroughly mix the water in the entire tank 2.

The driving unit 3 itself as shown in Figures 5-7 has an outer shell 7 that extends along an axis 9 between first and second end portions 11,11'. The shell 7 has at least one inlet at 13 and at least a first outlet at 15. The shell 7 is positionable on the floor 8 of the tank 2 (Figure 1) with the outlet 15 facing upwardly (see also Figures 5-7). The upwardly facing outlet 15 in the preferred embodiment of Figure 5 is a very thin, elongated slot (e.g., 1/4 inch or less wide and 36 inches or so long) that extends substantially along the axis 9 of the shell 7 substantially the entire distance

between the end portions 11,11' of the shell 7. The width of the discharge 12 is then less than 5% of its length and preferably more on the order of less than 1%-2% of its length.

Supported within the shell 7 of the driving unit 3 is a pump 21 (see Figure 8).

5 The pump 21 has first and second end portions 23,23' with the second end portion 23' of pump 21 being preferably spaced from the second end portion 11' of the outer shell 7 in this embodiment. A baffle plate 25 is preferably positioned as illustrated in Figure 8 to extend within the shell 7 from just above the second end portion 23' of the pump 21 to the second end portion 11' of the shell 7. A small volume of water 26
10 (e.g., 16 ounces) is then defined between the end portions 23',11' of the pump 21 and shell 7. The baffle plate 25 as shown in Figure 9 has holes or cutouts 25' to permit water to flow by it to the areas 28,28' in Figure 8 just below the slot of the outlet 15. The baffle plate 25 in this embodiment has been found to help to evenly distribute the pressurized water (e.g., 5-10 psi above ambient) along the entire length of the
15 slot of outlet 15 in the areas 28,28' between the end portions 11,11' of the shell 7.

In operation, the pump 21 continuously draws an incoming flow of water 30 (see Figure 2) from outside the driving unit 3 adjacent the tank floor 8. The incoming water 30 flows axially through the inlet 13 (see also Figure 8) of the shell 7 at its first end portion 11. The water is drawn passed the outside of the pump casing 21' in
20 Figure 8 between the pump casing 21' and an outer tube 27 into the pump inlets 29 just short of the closed wall 31. The drawn water cools the pump 21 on its path to the inlets 29 and then passes through the pump impeller 33 out into the volume of water at 26 under the baffle plate 25. In this manner, the pump 21 draws and then drives the continuously incoming flow 30 through the shell 7 of the driving unit 3 and
25 out of the driving unit 3 (Figure 2) through the slot of the upwardly facing outlet 15 in the shell 7 (see also Figure 5). The slot of the outlet 15 as indicated above is very thin (e.g., ¼ inch or less) and elongated (e.g., 36 inches or more) and creates a very thin (see Figure 3 at 12), substantially planar (see Figures 2-3 in conjunction with each other at 12) discharge of water through the slot of the outlet 15. The thin,
30 substantially planar discharge 12 as shown in Figures 2-3 is directed upwardly toward

the surface 22 of the body of water 20. As indicated above, the upwardly directed discharge at 12 in turn induces water at 18' in Figure 3 adjacent the longitudinal or axial outside of the shell 7 of the driving unit 3 to move upwardly with it toward the surface 22 of the body of water 20. The pump 21 is relatively light weight (e.g., 70-80 pounds) and is preferably a relatively small, electric one (e.g., 48 VAC and 500 watts). The pump 21 as shown in Figures 1 and 8 has a power line such as 32 dropping down to it from the tank top 6 (Figure 1) that is adjacent the disinfectant line 35 and lowering chain 41 discussed below.

For its volume, the thin, substantially planar discharge at 12 (Figure 3) presents a very large surface area along its longitudinal sides to the adjacent water and induces a large amount of adjacent water to travel upwardly with it. In doing so, it is believed that as the initial discharge 12 travels upwardly in Figure 3, the discharge 12 due to the surrounding water it induces as schematically shown in Figure 10 begins to narrow or close in from its edges and increase in volume from essentially a plane to more of a substantially oval shape at 12' (Figure 10). Thereafter, it is believed that the upwardly flow 12' continues to narrow or close in from its edges, increase in volume, and thicken more into a substantially cylindrical shape at 12'' before reaching the surface 22 of the body of water 20 and crowning at 22' in Figures 2-3.

It has been empirically measured that the thin, substantially planar initial discharge 12 (e.g., at 150-200 gallons per minute) will induce an overall flow or movement of water in the tank 2 on the order of 10:1 (e.g., 1500-2000 gallons per minute). This is in comparison to a single nozzle at the same discharge rate and volume inducing or moving flow in the tank 2 at more of a 5:1 ratio. Again, it is believed that the greatly increased surface area of the thin, substantially planar discharge 12 (versus for example the external surface area of a single nozzle creating a substantially cylindrical discharge) contacts and induces the significant difference in overall flow or movement of water in the tank 2. Further, this is accomplished as illustrated in Figures 2-3 without sacrificing the desired surface mounding or crowning at 22' and resulting, radial surface spreading of the water as illustrated in Figure 4.

The essentially non-turbulent discharge 12,12',12" and surface crowning at 22' in Figures 2-3 additionally ensures that the overall circulation pattern with 14,16,18 and induced secondary patterns such as 24 in Figures 2-3 are all desirably created in a nearly laminar manner for thorough and uniform mixing of all of the water in the entire tank 2. Further and because of the thoroughness of the mixing, it is possible to inject disinfectant (e.g., chlorine) as needed at the driving unit 3 via a line such as 35 in Figures 1 and 8 and have the disinfectant be uniformly, reliably, and relatively quickly (e.g., a matter of a few hours) spread throughout all of the water in the tank 2. The disinfectant line 35 in this regard preferably discharges the concentrated disinfectant into the outflow from the pump impeller 33 as shown in Figure 8 in order to avoid having the concentrated disinfectant pass through the pump 21 itself. Because of the thorough and complete mixing of the water by the circulation system of Figures 1-3, the disinfectant is equally mixed throughout the entire tank 2 not only to uniformly disinfect the water but also to contact and disinfect virtually all of the surfaces of the tank 2 below the water line 22. An additional advantage of the uniform mixing of the water is that any sampling of the tank water to monitor the need to add disinfectant or to draw a sample for testing that sufficient disinfectant is present can be reliably done at virtually any location in the tank 2.

As mentioned above, the driving unit 3 of the present invention has been specifically designed to fit through the access opening 10 of the tank 2 (Figures 11-13) even when the opening 10 is on the order of 12 inches or less. In this regard and even though the driving unit 3 preferably has an overall length L in Figure 11 on the order of 36 inches or more to create the desired, elongated, discharge slot at the outlet 15, the height H and width W (Figure 12) of the driving unit 3 are more on the order of 9.5 and 9.0 inches respectively. As also mentioned above, the driving unit 3 with the attached chain or other flexible line 41 in Figures 11-13 has been specially designed so the driving unit 3 can be lowered through the access opening 10 to the tank floor 8 (Figure 13) to automatically assume the desired operating orientation or position with the slot of the outlet 15 facing upwardly. The lowering can be done manually as the driving unit 3 preferably weighs on the order of only 70-80 pounds or

a winch can be used if desired. Regardless, the driving unit 3 will drop down to the tank floor 8 with the leading legs or edge portions 43' (Figure 13) of the second end portion 11' striking the tank floor 8 first. The driving unit 3 will then pivot substantially about the legs or edge portions 43' to assume the predetermined and desired operating orientation with the slot of the outlet 15 facing upwardly.

This last feature is accomplished by securing the lowering chain or other line 41 to the driving unit 3 (e.g., at the first end portion 11 of the shell 7 in Figure 11) above the center of gravity 45 of the driving unit 3 with the driving unit 3 in its operating position of Figure 11 with the axis 9 of the shell 7 extending substantially horizontally.

The chain or other line 41 is also spaced as shown in Figure 11 laterally to the side of a vertical plane 47 passing through the center of gravity 45 and extending substantially perpendicular to the shell axis 9. The chain 41 is also preferably attached in a second vertical plane substantially perpendicular to the plane 47 and containing the center of gravity 45. Consequently, when the driving unit 3 is lowered as in Figure 13 with the second end portion 11' of the driving unit 3 preceding the first end portion 11 through the access opening 10, the driving unit 3 will tilt or swing slightly clockwise in Figure 13 to vertically align the projected axis 41' of the chain 41 and center of gravity 45. In doing so, it will actually move or swing the legs or edge portions 43' of the driving unit 3 slightly to the left in Figure 13 of the projected axis 41' of the vertically extending chain 41. The legs or edge portions 43' as illustrated in Figure 13 will then lead the driving unit 3 downwardly to strike the tank floor 8 first. Thereafter, the center of gravity 45 as positioned to the right of the landing legs or edge portions 43' in Figure 13 will cause the driving unit 3 to pivot substantially about the legs or edge portions 43' (i.e., to the right or clockwise in Figure 13) to assume the desired operating orientation or position on the tank floor 8 in Figure 13. It is noted that the legs or edges portions 43' could be a single member if desired. Further, the preferred legs or edge portions 43' are shown as providing relatively sharp edges for the pivoting action but they could be more rounded (e.g., a rounded surface) and could be a single edge portion as discussed above as long as an axially extending

edge portion (e.g., sharp or rounded) was preferably provided to facilitate the pivoting action.

It is also noted that the pump 21 and shell 7 of the embodiment of Figures 5-8 are set forth as different parts. However, their designs could be combined or integrated with common end portions and a common inlet 13 and/or outlet 15 as long as the slot of the discharge outlet 15 remained thin and elongated. The word shell in this regard is used to refer to the outer element and could be hollow or substantially solid. The single, elongated slot of the outlet 15 of the preferred embodiment of Figures 1-13 could also be a series or plurality of immediately adjacent, thin, elongated slots at outlets 15, 15', 15" as in Figure 14. As shown, the slots of the outlets 15, 15', 15" of Figure 14 extend along the shell axis 9 and would preferably have the same relative dimensions as that of the outlet 15 in the embodiment of Figures 1-13 (i.e., width to length of less than 5% and preferably less than 1%-2%). The combined lengths of the slots of outlets 15, 15', 15" would also extend substantially the same distance as the shell 7 does between its end portions 11, 11'. Although a single, elongated slot is preferred as in the embodiment of Figures 1-13, the closely adjacent and substantially collinear ones of 15, 15', 15" in Figure 14 will essentially merge just outside of the shell 7 into a single, planar discharge like 12 of the embodiment of Figures 1-13.

The outer, tubular shell 7 whether separate from or integral with the pump 21 is also preferably substantially cylindrical along and about the axis 9 as illustrated. This is preferred to provide the maximum, cross-sectional area for its volume so the shell 7 can be as compact as possible and fit through the smaller access openings 10. Additionally, the circulation system of the present invention has been described and illustrated in use in an enclosed, elevated tank but it is equally applicable for use in tanks for ground or underground storage and with other contained bodies of water such as in reservoirs.

It is further noted that although the discharge arrangements such as the plurality of spaced nozzles 51 of Figure 15a and the single nozzles 51' of Figures 15b and 15c are less preferred than the elongated slots of Figures 1-14, these less

preferred arrangements can still be used in the lowering technique of Figure 13. In such cases, the driving unit 3 will still automatically assume the desired operating orientation or position with the discharge nozzles facing upwardly. As in the preferred embodiment of Figures 1-13, the tank water is still preferably drawn in axially along the axis 9 of the shell 7 and discharged radially outwardly of the axis 9. The center of gravity 45 in the embodiment of Figures 1-13 is positioned as shown in Figures 11-13 due primarily to the heaviest component (i.e., the pump 21) being located as illustrated in Figure 8. However, this location of the center of gravity 45 could be accomplished by simply weighting the shell 7 (whether it is a separate component from the pump 21 or integrated with it) in any fashion to position the center of gravity 45 as illustrated in Figures 11-13. The desired lowering technique of Figure 13 can still be accomplished.

In this last regard, the chain or other flexible line 41 in Figures 11-13 could be attached to the shell 7 adjacent to or at the opposite end portion 11' or other locations spaced above the center of gravity 45 (Figure 11) and from the vertical plane 47 but is preferably attached as shown to the end portion 11. With such an attachment, a large moment arm is created tending to more forcefully pivot the landed driving unit 3 of Figure 13 about the legs or edge portions 43' to the final, substantially horizontal operating position. The legs or edge portions 43' as discussed above could also be a single member as long as at least one pivoting edge or surface is created.

The above disclosure sets forth a number of embodiments of the present invention described in detail with respect to the accompanying drawings. Those skilled in this art will appreciate that various changes, modifications, other structural arrangements, and other embodiments could be practiced under the teachings of the present invention without departing from the scope of this invention as set forth in the following claims. In particular, it is noted that the word substantially is utilized herein to represent the inherent degree of uncertainty that may be attributed to any quantitative comparison, value, measurement or other representation. This term is also utilized herein to represent the degree by which a quantitative representation

may vary from a stated reference without resulting in a change in the basic function of the subject matter involved.

CLAIMS:

1. A submersible, circulation system for a body of water having a surface and contained in a water tank having side walls and a floor, said circulation system
5 including:

a driving unit having a shell extending along an axis and including a pump supported within the shell, said shell having at least one inlet and at least a first outlet and being positionable on the floor of the tank with the first outlet facing vertically upwardly perpendicular to a horizontal plane wherein the pump continuously draws
10 an incoming flow of water from outside of the driving unit adjacent the floor of the tank through the inlet of the driving unit with at least a portion of the continuously incoming flow being driven by said pump out of said driving unit through the vertically upwardly facing first outlet, said vertically upwardly facing first outlet being a thin, vertically upwardly facing, elongated slot positioned below the surface of the body of water and
15 extending along the axis of the shell of the driving unit and creating a vertically upwardly directed, thin, planar discharge of water therethrough below the surface of the body of water directed vertically upwardly perpendicular to said horizontal plane toward the surface of the body of water and inducing water adjacent the outside of the shell of the driving unit along the axis thereof to move vertically upwardly
20 perpendicular to said horizontal plane with the planar discharge of the first outlet directed vertically upwardly perpendicular to said horizontal plane toward the surface of the body of water to establish a recurring overall water circulation pattern within the tank up from adjacent the floor and driving unit toward the surface of the body of water, outwardly therefrom toward the side walls, downwardly adjacent the side walls,
25 and back inwardly adjacent the floor toward the driving unit, said circulation system further including at least a second outlet in said shell of the driving unit facing vertically upwardly perpendicular to said horizontal plane, said second outlet being a second, thin, vertically upwardly facing, elongated slot extending along said axis adjacent the thin, vertically upwardly facing, elongated slot of said first outlet wherein the
30 respective slots of said first and second outlets create thin, vertically upwardly

directed, planar discharges of water therethrough, said discharges from said first and second outlets merging immediately adjacent the outside of the shell of the driving unit to form a combined planar discharge of water from the driving unit directed vertically upwardly perpendicular to said horizontal plane toward the surface of the body of water and inducing water adjacent the outside of the shell of the driving unit along the axis thereof to move vertically upwardly with said combined planar discharge directed vertically upwardly perpendicular to said horizontal plane toward the surface of the body of water.

2. The circulation system of claim 1 wherein at least one of the thin, vertically upwardly facing, elongated slots of the first and second outlets has a width less than five percent and greater than zero percent of the length thereof.

3. The circulation system of claim 1 wherein at least one of the thin, vertically upwardly facing, elongated slots of the first and second outlets has a width less than two percent and greater than zero percent of the length thereof.

4. The circulation system of claim 1 wherein at least one of the thin, vertically upwardly facing, elongated slots of the first and second outlets has a width less than one percent and greater than zero percent of the length thereof.

5. The circulation system of claim 1 wherein said slots of said first and second outlets extend collinearly with each other.

6. The circulation system of claim 1 wherein the thin, vertically upwardly facing, elongated slots of said first and second outlets extend respective first lengths along said axis and have respective widths and the respective widths are less than five percent and greater than zero percent of the respective lengths.

7. The circulation system of claim 1 wherein the widths of the thin, elongated slots are in the range of about $\frac{1}{4}$ to about one inch and greater than zero.

8. The circulation system of claim 1 wherein the widths of the thin, elongated slots are less than $\frac{3}{4}$ of an inch and greater than zero.

9. The circulation system of claim 1 wherein the widths of the thin, elongated slots are less than $\frac{1}{2}$ of an inch and greater than zero.

10. The circulation system of claim 1 wherein the widths of the thin, elongated slots are less than $\frac{1}{4}$ of an inch and greater than zero.

11. The circulation system of claim 1 wherein all of the continuously incoming flow is driven by said pump out of the driving unit through the thin, vertically upwardly facing, elongated slots of the first and second outlets.

12. The circulation system of claim 1 wherein the water tank has a ceiling and the surface of the body of water in the tank is spaced from said ceiling to create an air gap.

13. A submersible, circulation system for a body of water having a surface and contained in a water tank having side walls and a floor, said circulation system including:

a driving unit having a shell extending along an axis and including a pump supported within the shell, said shell having at least one inlet and at least a first outlet and being positionable on the floor of the tank with the first outlet facing vertically upwardly perpendicular to a horizontal plane wherein the pump continuously draws an incoming flow of water from outside of the driving unit adjacent the floor of the tank through the inlet of the driving unit with at least a portion of the continuously incoming flow being driven by said pump out of said driving unit through the vertically upwardly

facing first outlet, said vertically upwardly facing first outlet being a thin, vertically upwardly facing, elongated slot positioned below the surface of the body of water and extending along the axis of the shell of the driving unit and creating a vertically upwardly directed, thin, planar discharge of water therethrough below the surface of the body of water directed vertically upwardly perpendicular to said horizontal plane toward the surface of the body of water and inducing water adjacent the outside of the shell of the driving unit along the axis thereof to move vertically upwardly perpendicular to said horizontal plane with the planar discharge of the first outlet directed vertically upwardly perpendicular to said horizontal plane toward the surface of the body of water to establish a recurring overall water circulation pattern within the tank up from adjacent the floor and driving unit toward the surface of the body of water, outwardly therefrom toward the side walls, downwardly adjacent the side walls, and back inwardly adjacent the floor toward the driving unit wherein said shell has an exterior wall with an outer surface with at least a portion of said outer surface extending along said axis and said at least one, vertically upwardly facing, elongated slot extends through said exterior wall and terminates at and flush with the outer surface of the portion of the shell.

14. The circulation system of claim 13 wherein said portion of said outer surface extends along said axis uniformly.

15. The circulation system of claim 13 wherein the water tank has a ceiling and the surface of the body of water in the tank is spaced from said ceiling to create an air gap.

25

16. A submersible, circulation system for a body of water having a surface and contained in a water tank having side walls and a floor, said circulation system including:

a driving unit having a shell extending along an axis and including a pump supported within the shell, said shell having at least one inlet and at least a first outlet

and being positionable on the floor of the tank with the first outlet facing vertically upwardly perpendicular to a horizontal plane wherein the pump continuously draws an incoming flow of water from outside of the driving unit adjacent the floor of the tank through the inlet of the driving unit with at least a portion of the continuously incoming flow being driven by said pump out of said driving unit through the vertically upwardly facing first outlet, said vertically upwardly facing first outlet being a thin, vertically upwardly facing, elongated slot positioned below the surface of the body of water and extending along the axis of the shell of the driving unit and creating a vertically upwardly directed, thin, planar discharge of water therethrough below the surface of the body of water directed vertically upwardly perpendicular to said horizontal plane toward the surface of the body of water and inducing water adjacent the outside of the shell of the driving unit along the axis thereof to move vertically upwardly perpendicular to said horizontal plane with the planar discharge of the first outlet directed vertically upwardly perpendicular to said horizontal plane toward the surface of the body of water to establish a recurring overall water circulation pattern within the tank up from adjacent the floor and driving unit toward the surface of the body of water, outwardly therefrom toward the side walls, downwardly adjacent the side walls, and back inwardly adjacent the floor toward the driving unit.

17. The circulation system of claim 16, wherein the width of the thin, vertically upwardly facing, elongated slot is in the range of about $\frac{1}{4}$ to about one inch.

18. The circulation system of claim 16, wherein the width of the thin, vertically upwardly facing, elongated slot is less than $\frac{3}{4}$ of an inch and greater than zero.

19. The circulation system of claim 16, wherein the width of the thin, vertically upwardly facing, elongated slot is less than $\frac{1}{2}$ of an inch and greater than zero.

20. The circulation system of claim 16, wherein the width of thin, vertically upwardly facing, elongated slot is less than $\frac{1}{4}$ of an inch and greater than zero.

21. The circulation system of claim 16, wherein all of the continuously incoming flow is driven by said pump out of the driving unit through the thin, vertically upwardly facing, elongated slot of the first outlet.

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22. The circulation system of claim 17, wherein the thin, vertically upwardly facing, elongated slot of the first outlet has a width less than five percent and greater than zero percent of the length thereof.

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23. The circulation system of claim 17, wherein the thin, vertically upwardly facing, elongated slot of the first outlet has a width less than two percent and greater than zero percent of the length thereof.

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24. The circulation system of claim 17, wherein the thin, vertically upwardly facing, elongated slot of the first outlet has a width less than one percent and greater than zero percent of the length thereof.

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25. The circulation system of claim 16, wherein the water tank has a ceiling and the surface of the body of water in the tank is spaced from said ceiling to create an air gap.

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26. The circulation system of claim 16, wherein said shell has outwardly facing sides opposite one another relative to the elongated outlet slot and extending along said axis and the vertically upwardly directed, thin, planar discharge of water from the first outlet directed vertically upwardly perpendicular to said horizontal plane toward the surface of the body of water induces water adjacent each of the respective outwardly facing, opposite sides to move vertically upwardly perpendicular to said horizontal plane with the planar discharge of the first outlet on each respective side of the planar discharge.

Fig. 1

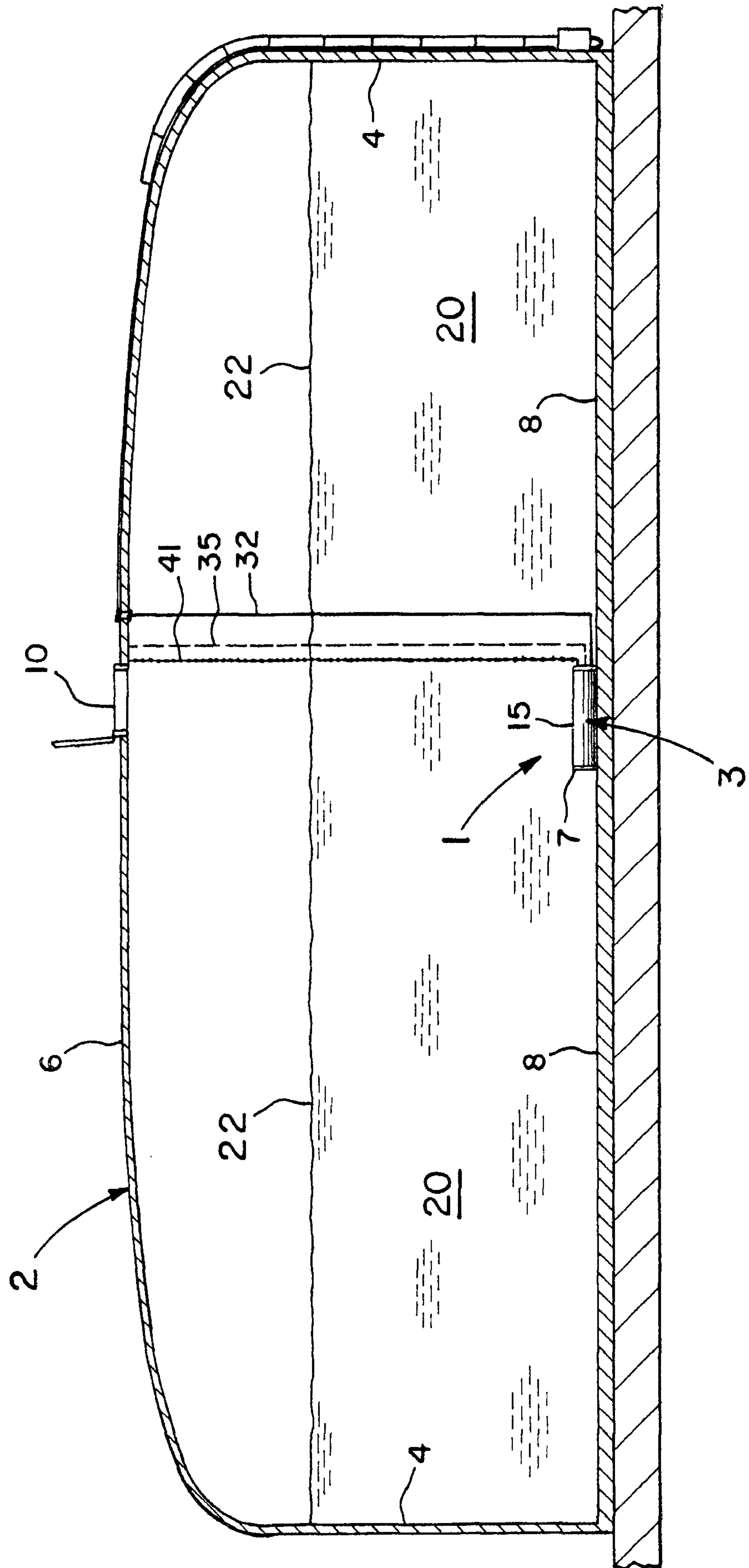


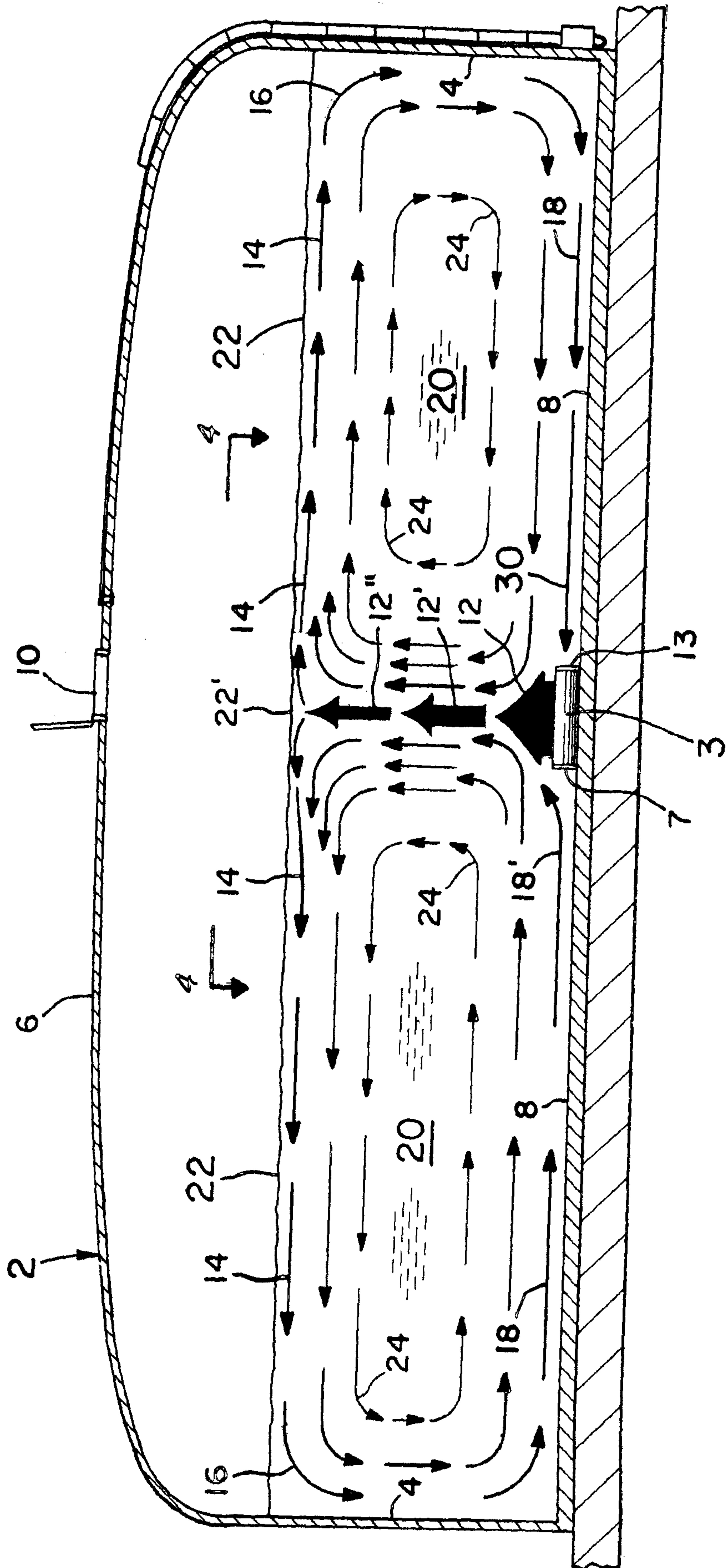
Fig. 2

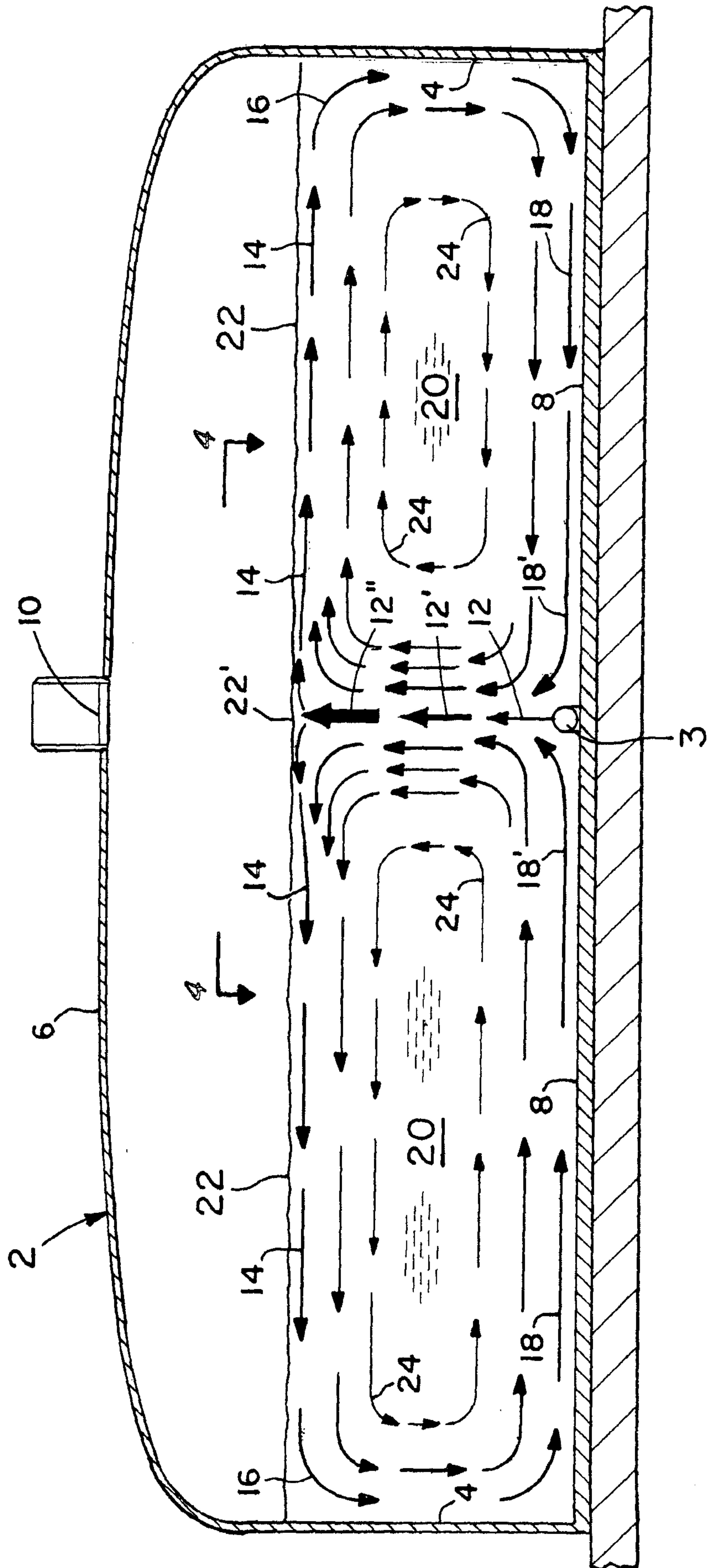
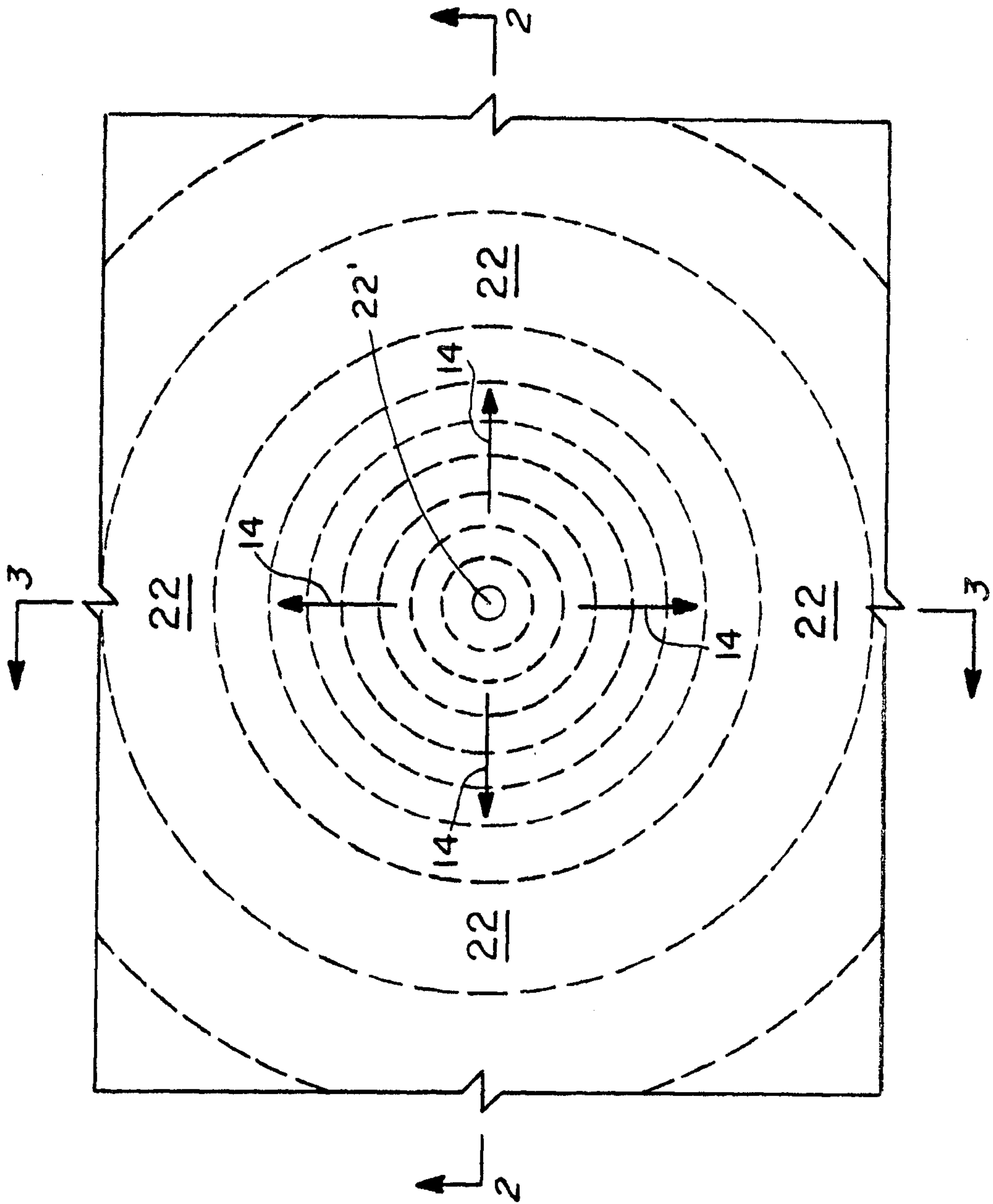
Fig. 3

Fig. 4

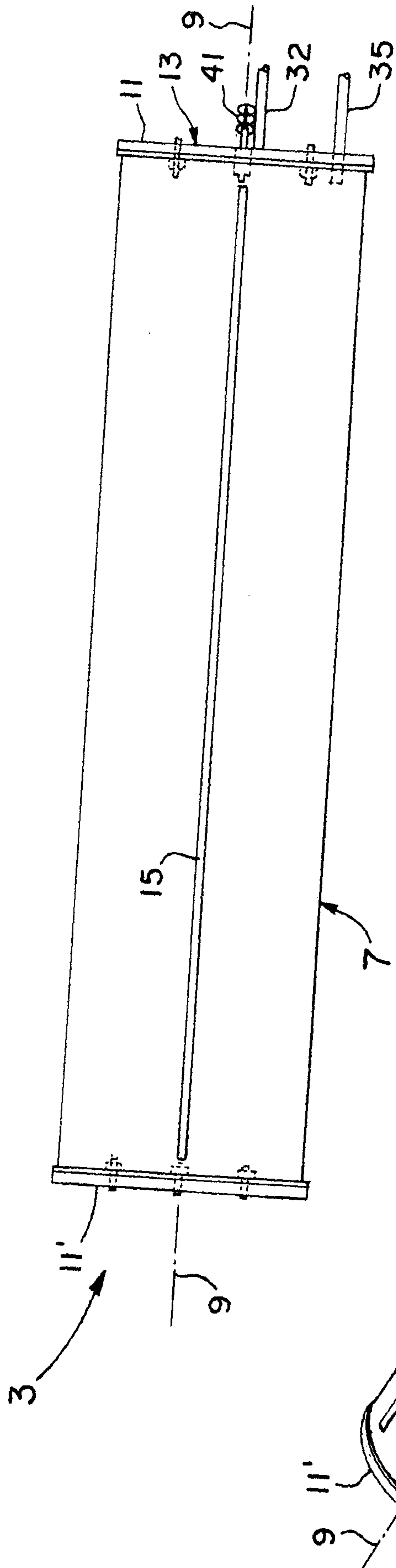


Fig. 5

Fig. 6

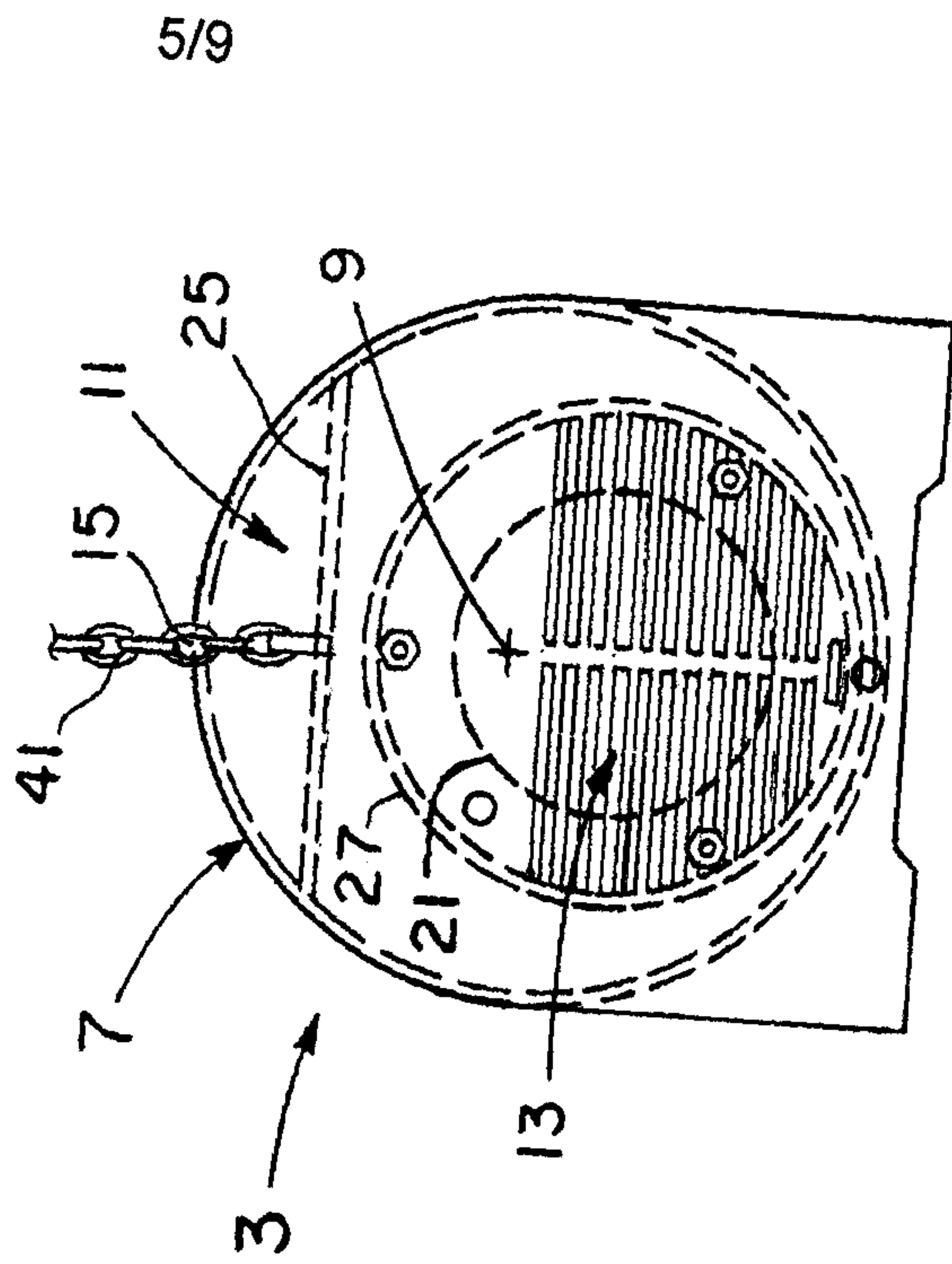


Fig. 7

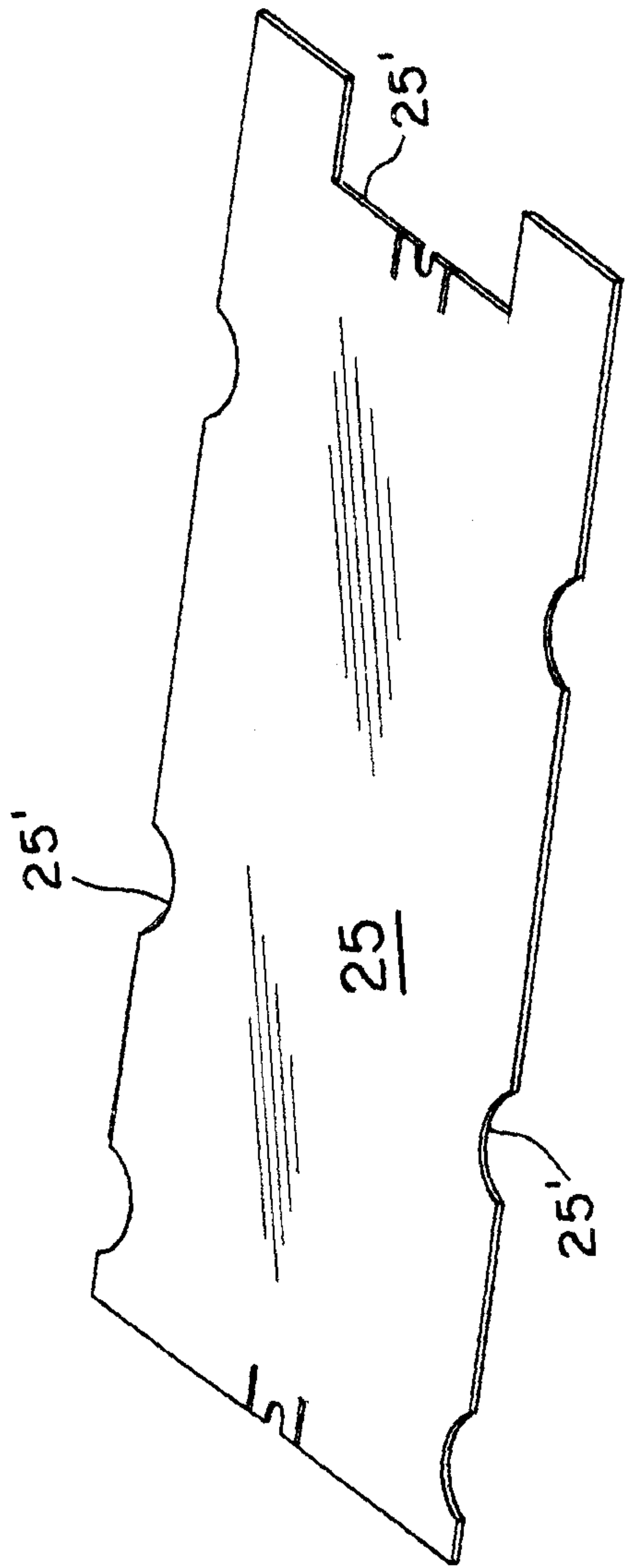


Fig. 9

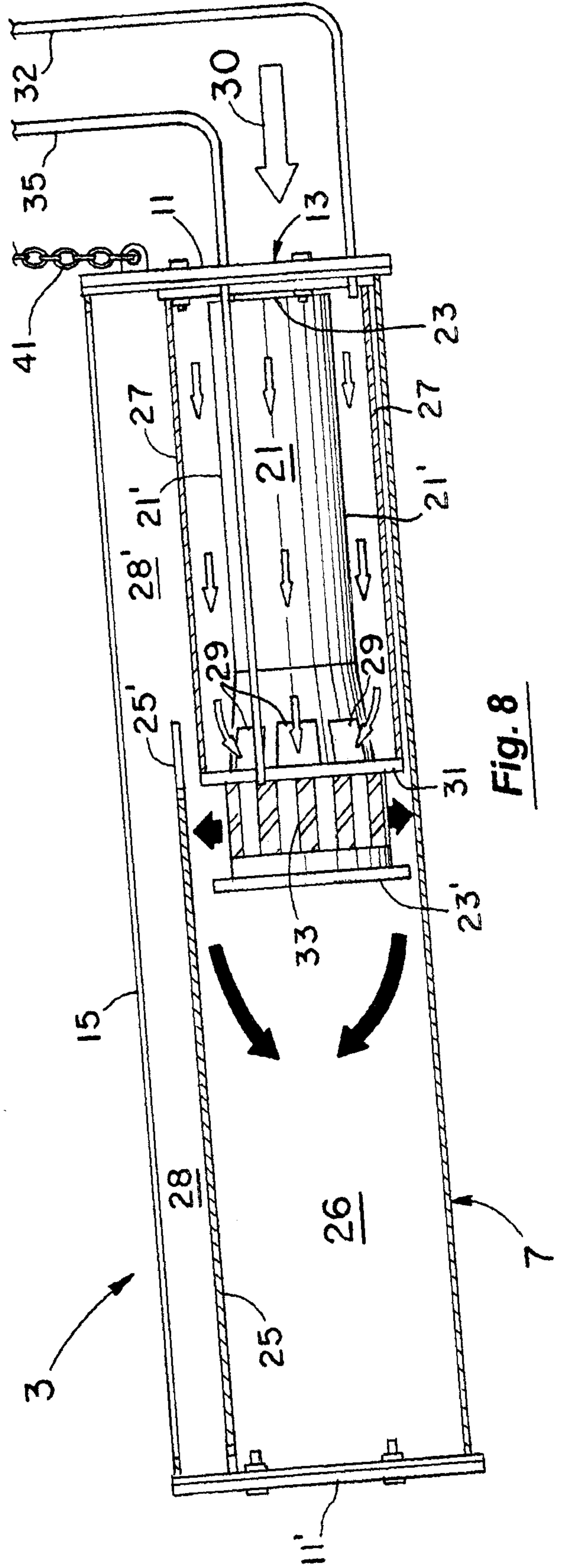
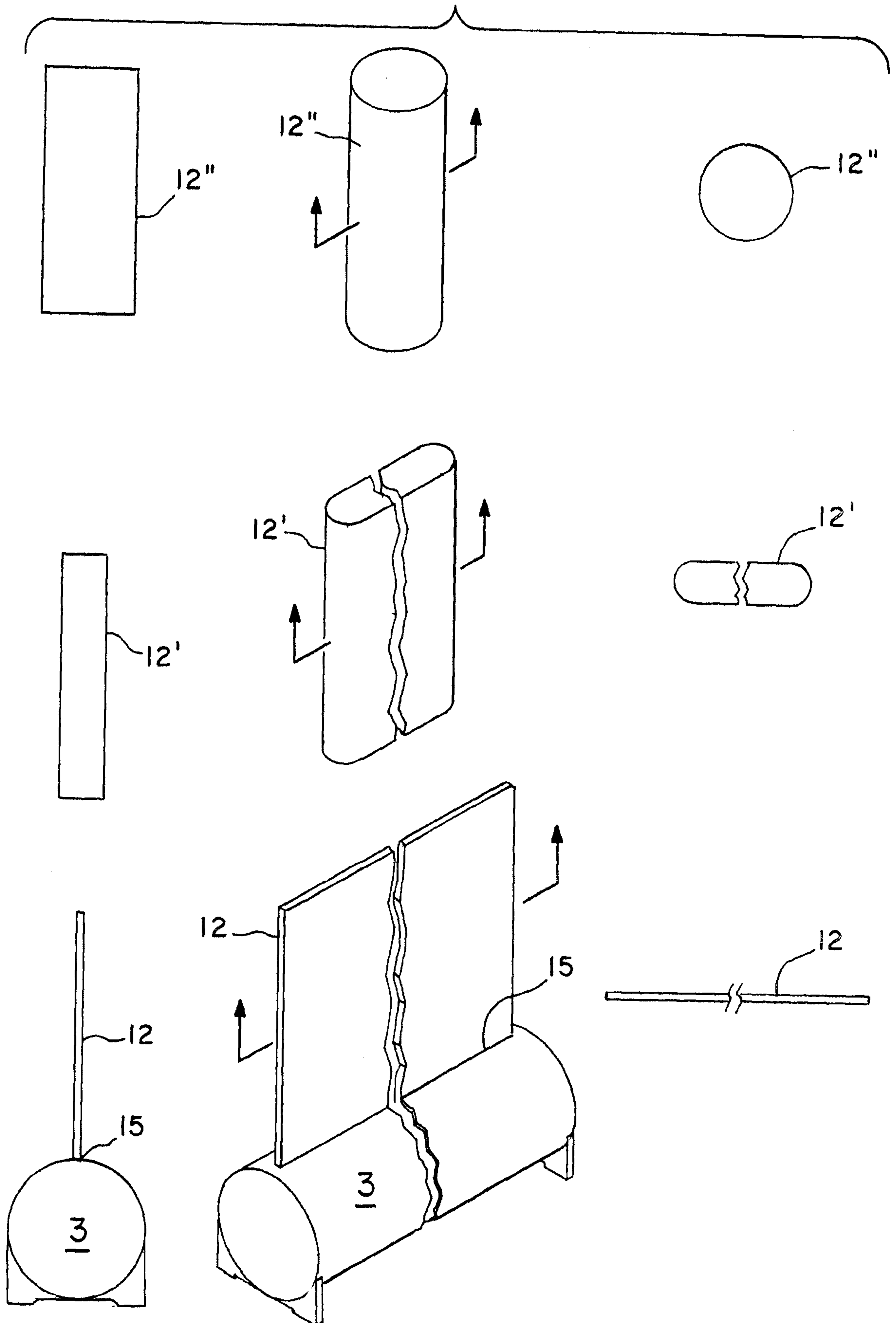
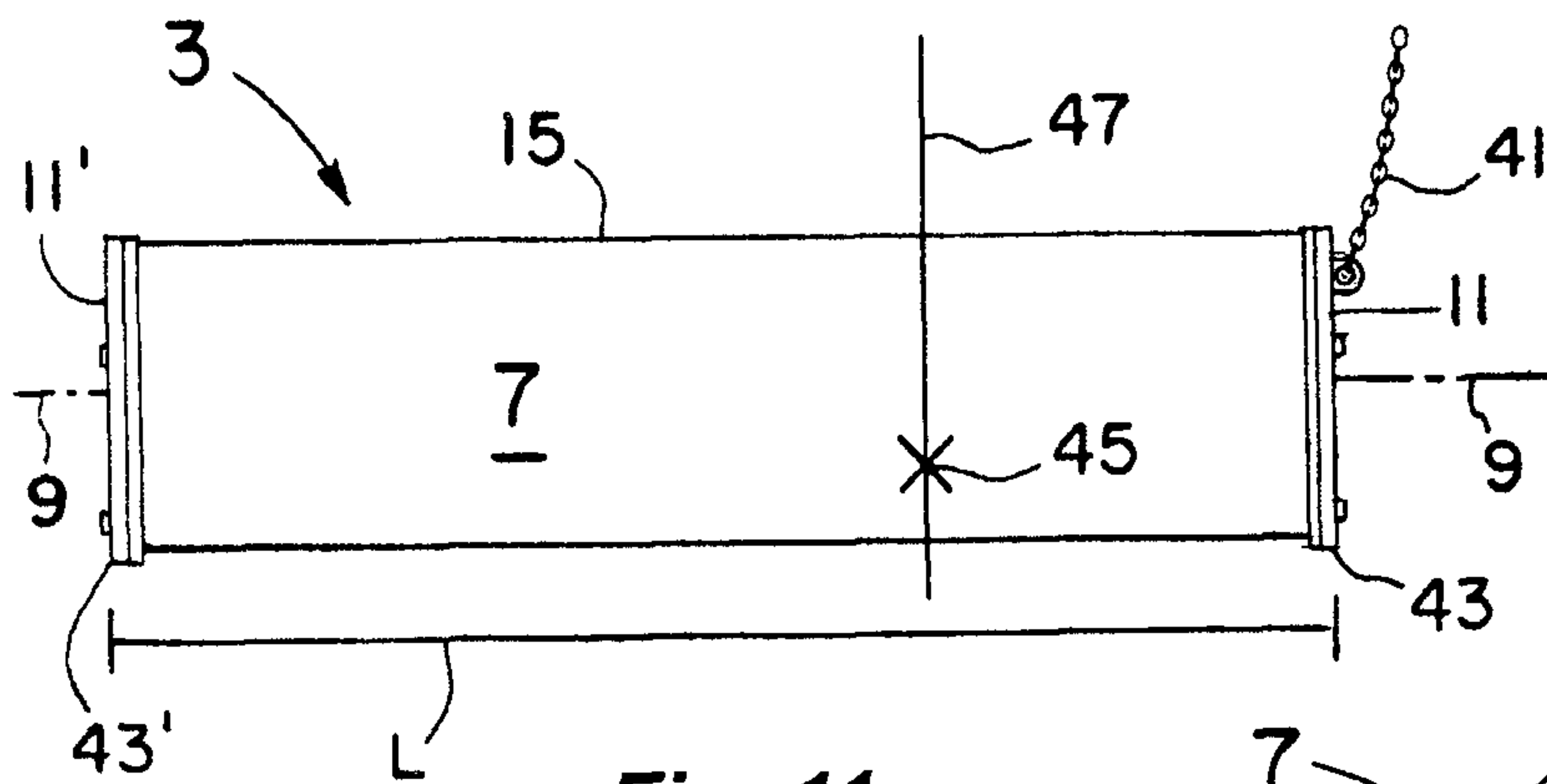
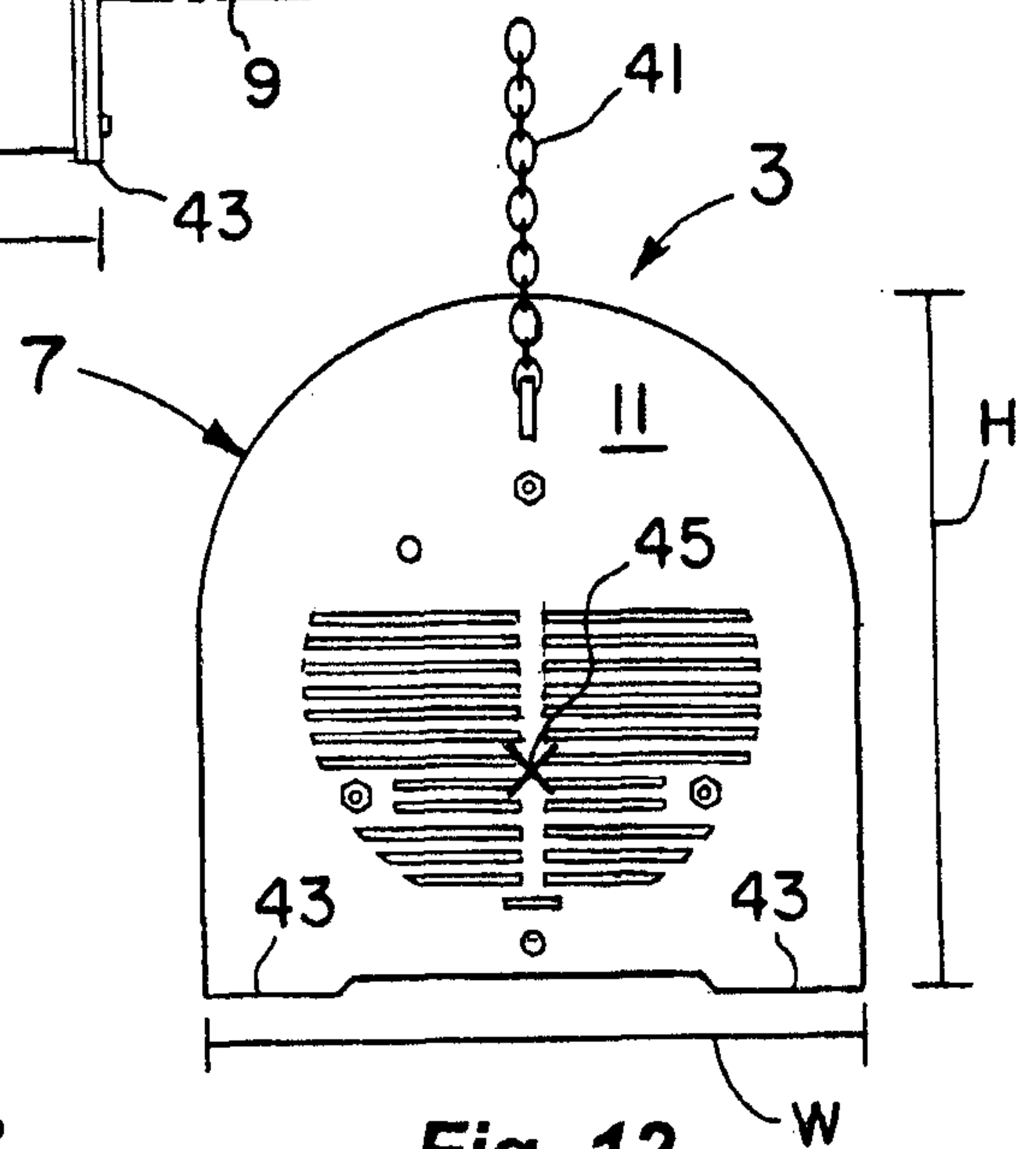
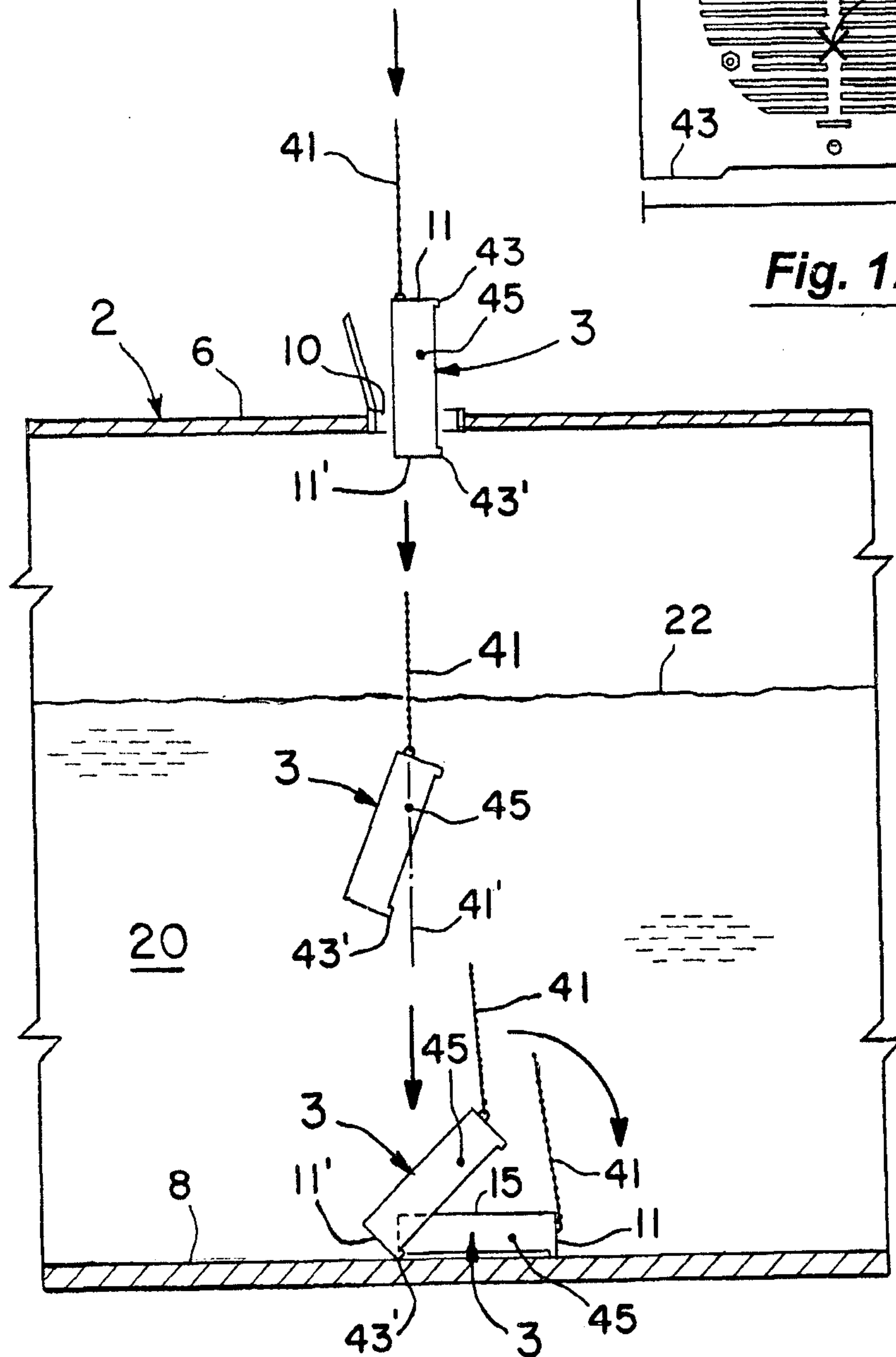


Fig. 8

Fig. 10

**Fig. 11****Fig. 12****Fig. 13**

