United States Patent

Maclin

[15] **3,684,408**

[45] **Aug. 15, 1972**

[54] **PERISTALTIC METERING AND DISPENSING PUMP**

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[73] Assignee: **Electro-Nucleonics, Inc.,** Essex County, N.J.

[22] Filed: **July 29, 1970**

[21] Appl. No.: **59,276**

[52] **U.S. Cl.**....................................**417/477,** 222/214
[51] **Int. Cl.**...**F04b 43/12**
[58] **Field of Search**......222/192, 206, 207, 212, 213, 222/214, 215, 255, 420, 1; 417/474–477; 23/259, 292; 401/146

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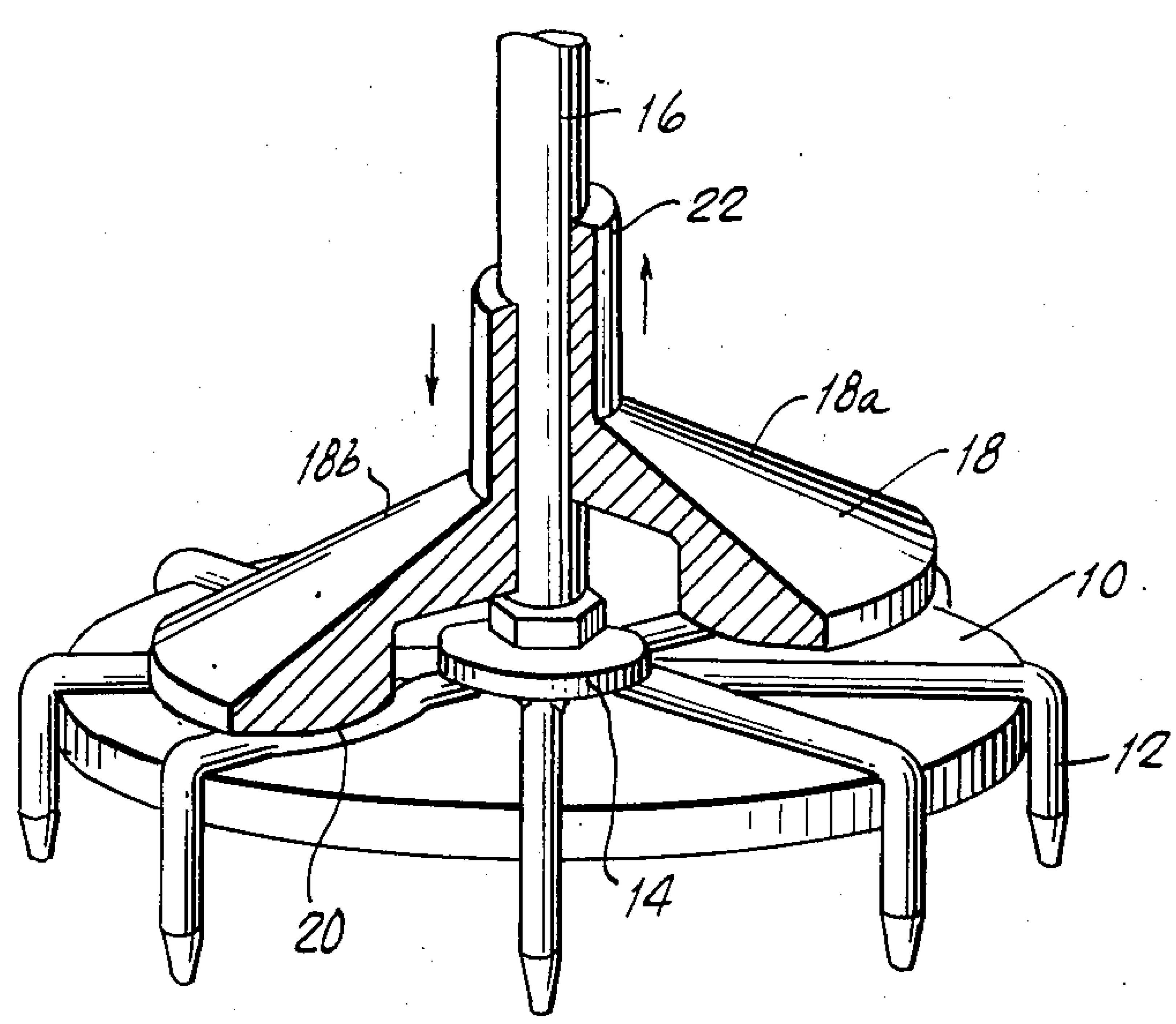
[57] **ABSTRACT**

A peristaltic fluid metering and dispensing pump consists of a rigid base for supporting elastic tubing. Elastic tubes are supported on the base. One end of each tube is blocked on the base while the other end extends beyond the base for submersion in a liquid to be dispensed. Tube compressing means operating upon at least two tubes simultaneously is provided to alternately compress the tubing against the base and then release the tubing. Air is first expelled from the tubing and liquid is then drawn through the free end of the tubing when the latter is released; liquid is expelled from the same end of the tubing when it is again compressed.

6 Claims, 12 Drawing Figures



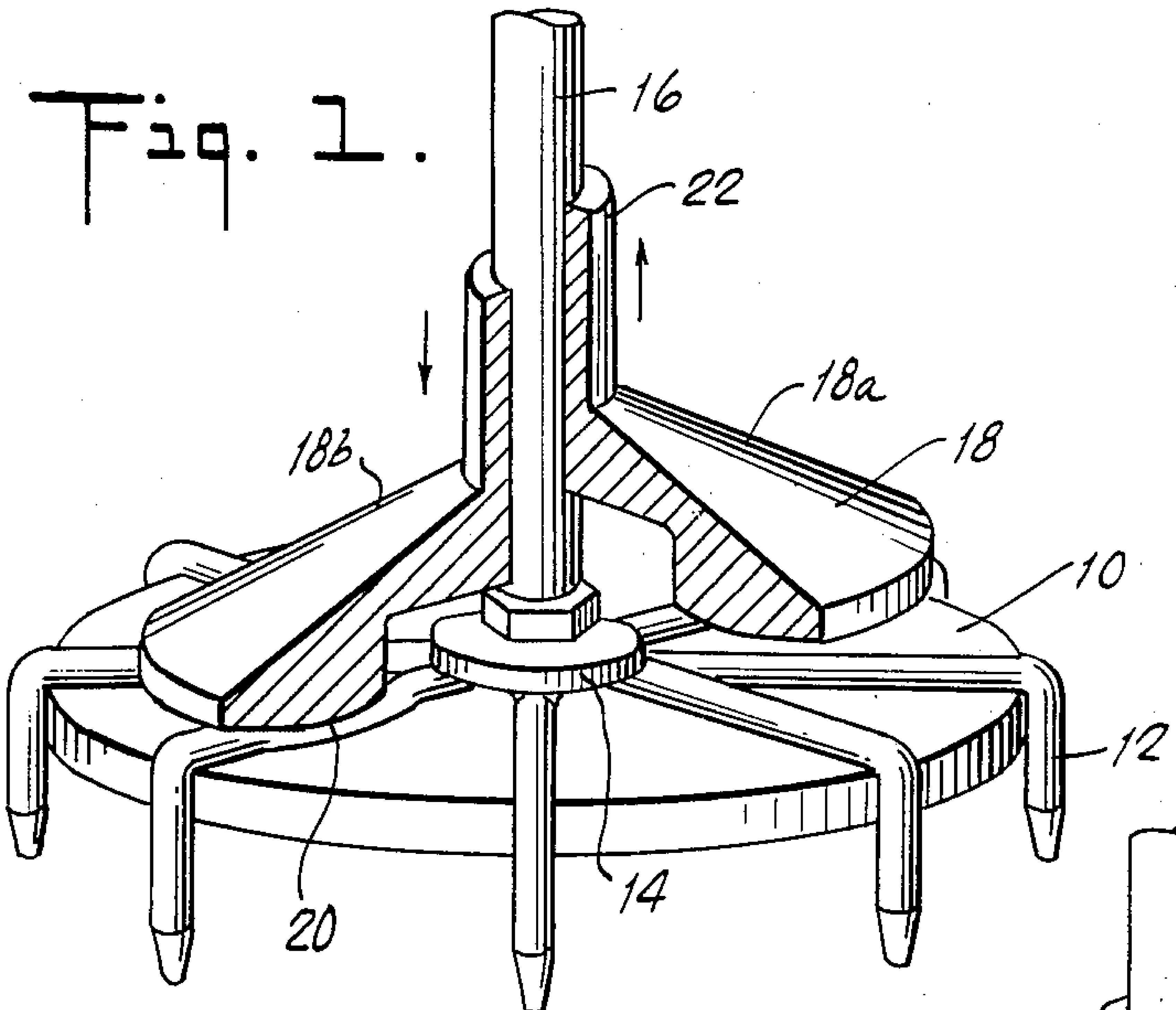


Fig. 1.

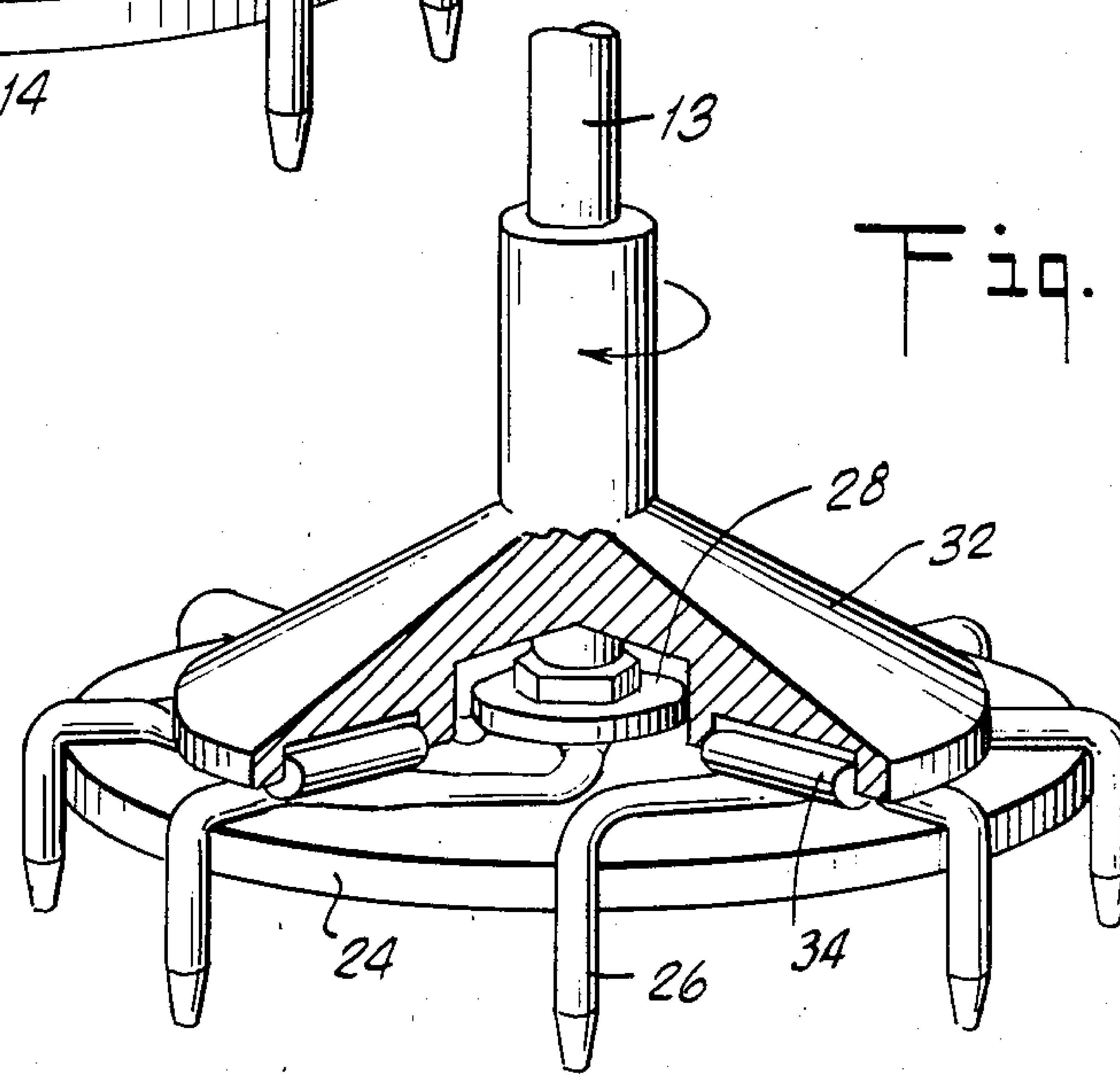


Fig. 2.

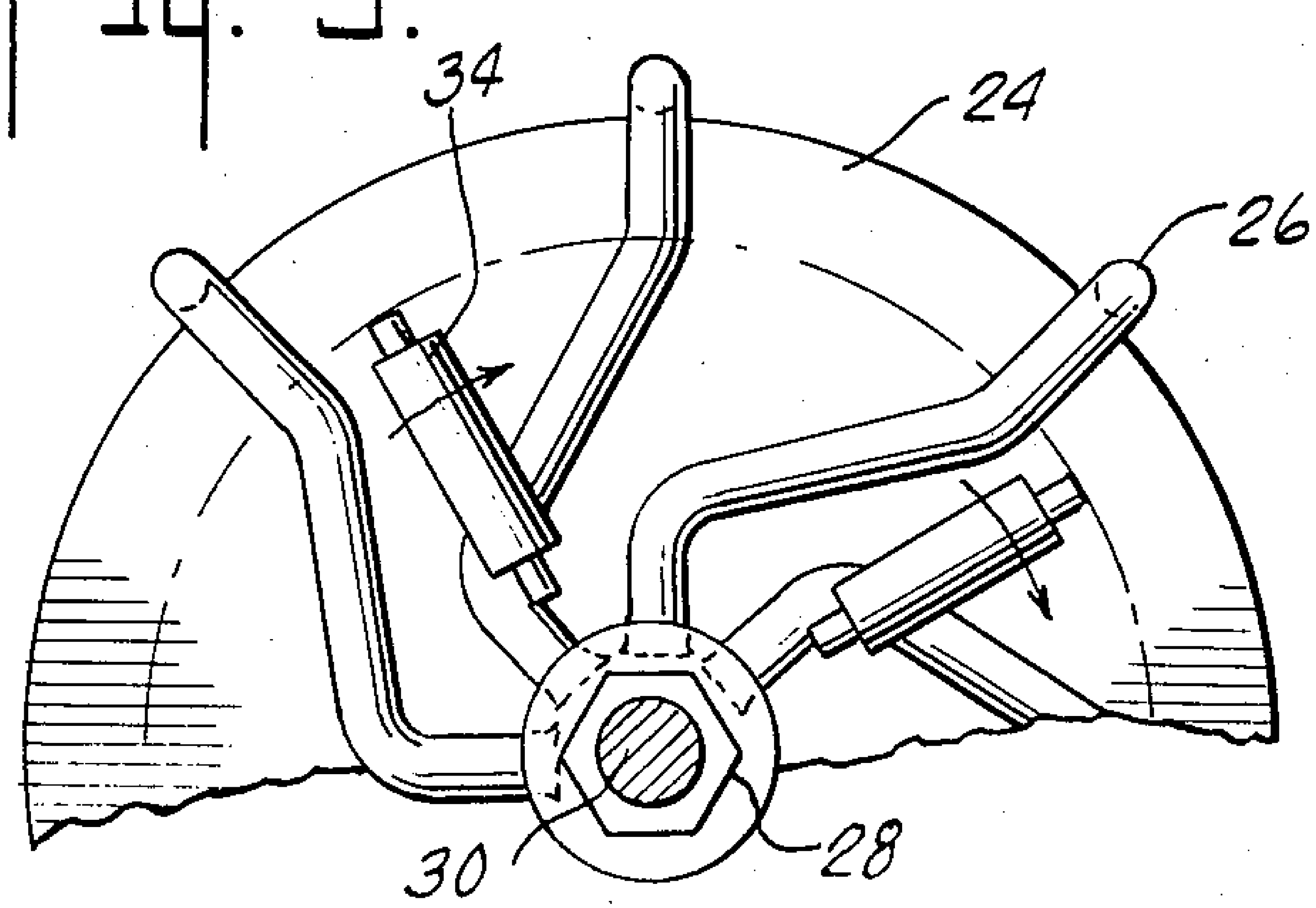


Fig. 3.

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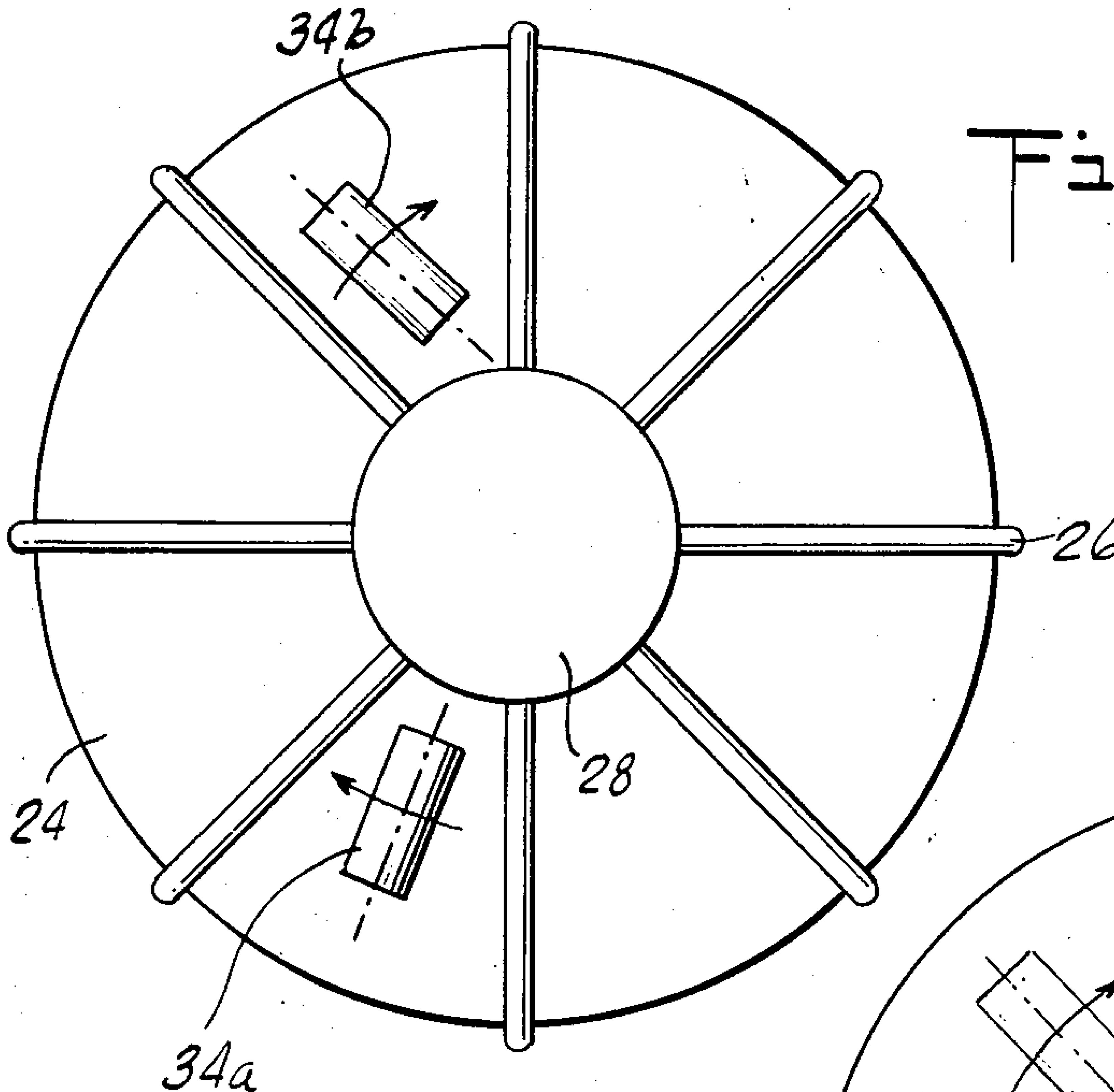

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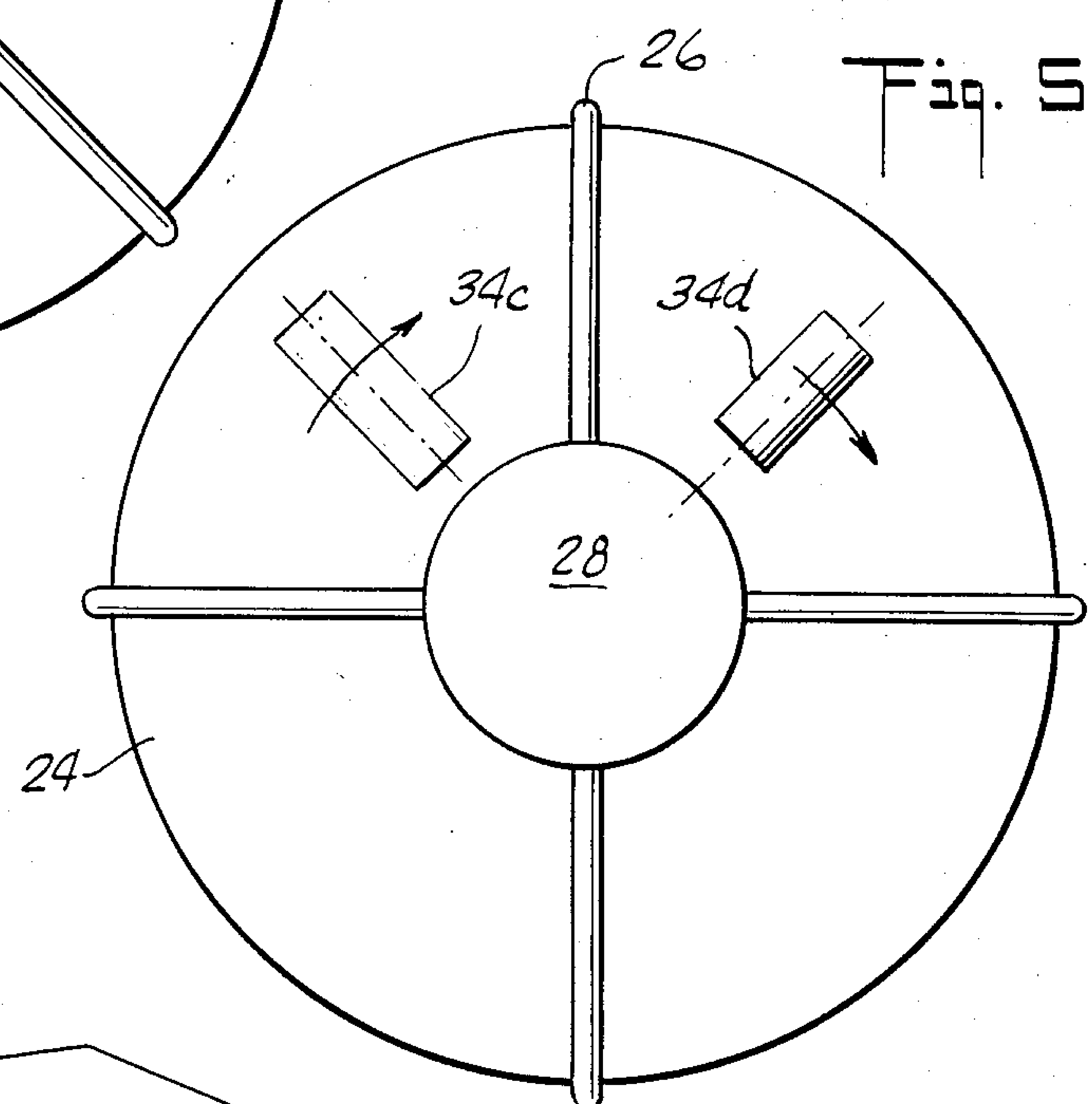

Fig. 5.

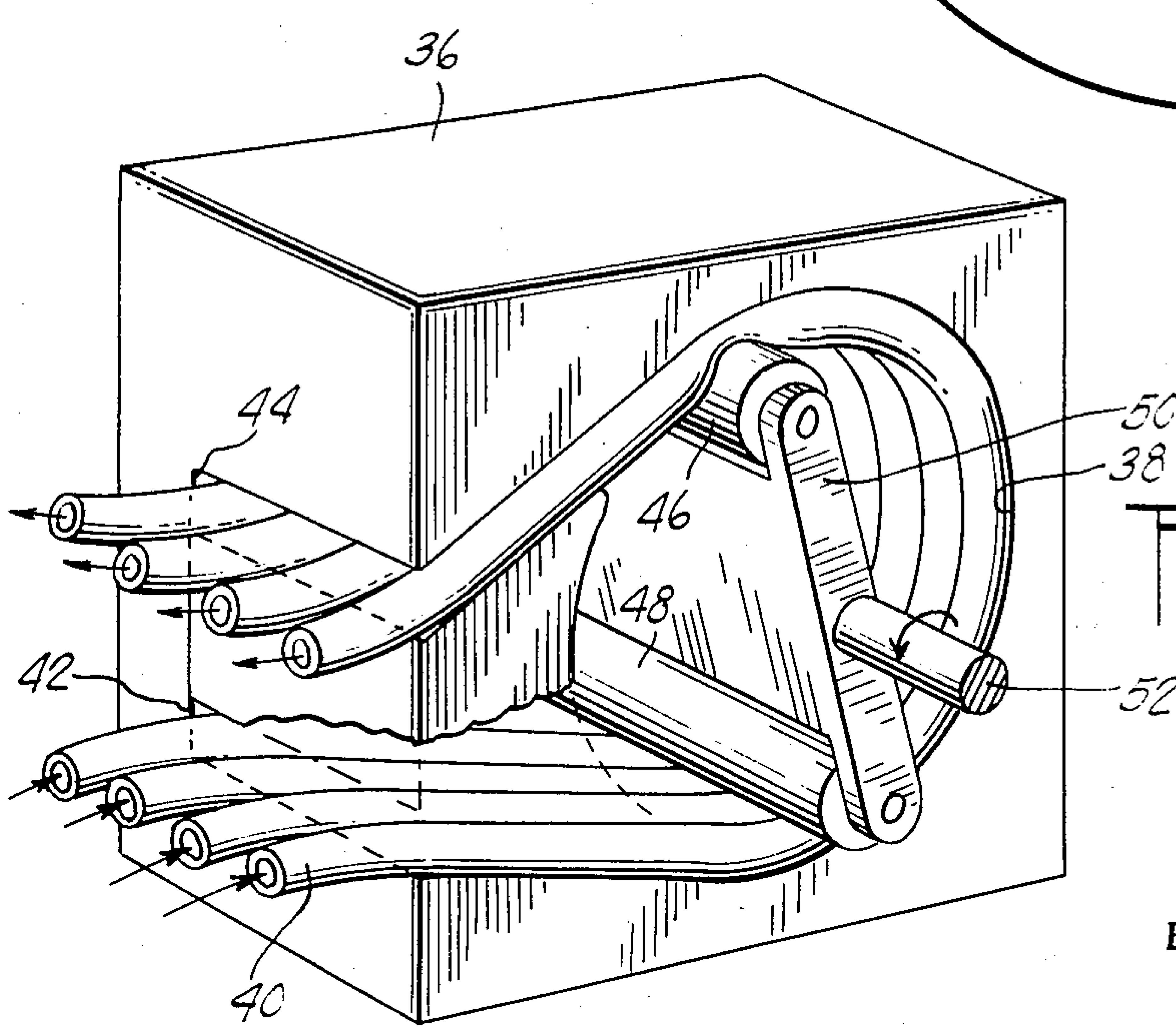

Fig. 6.

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Fig. 7.

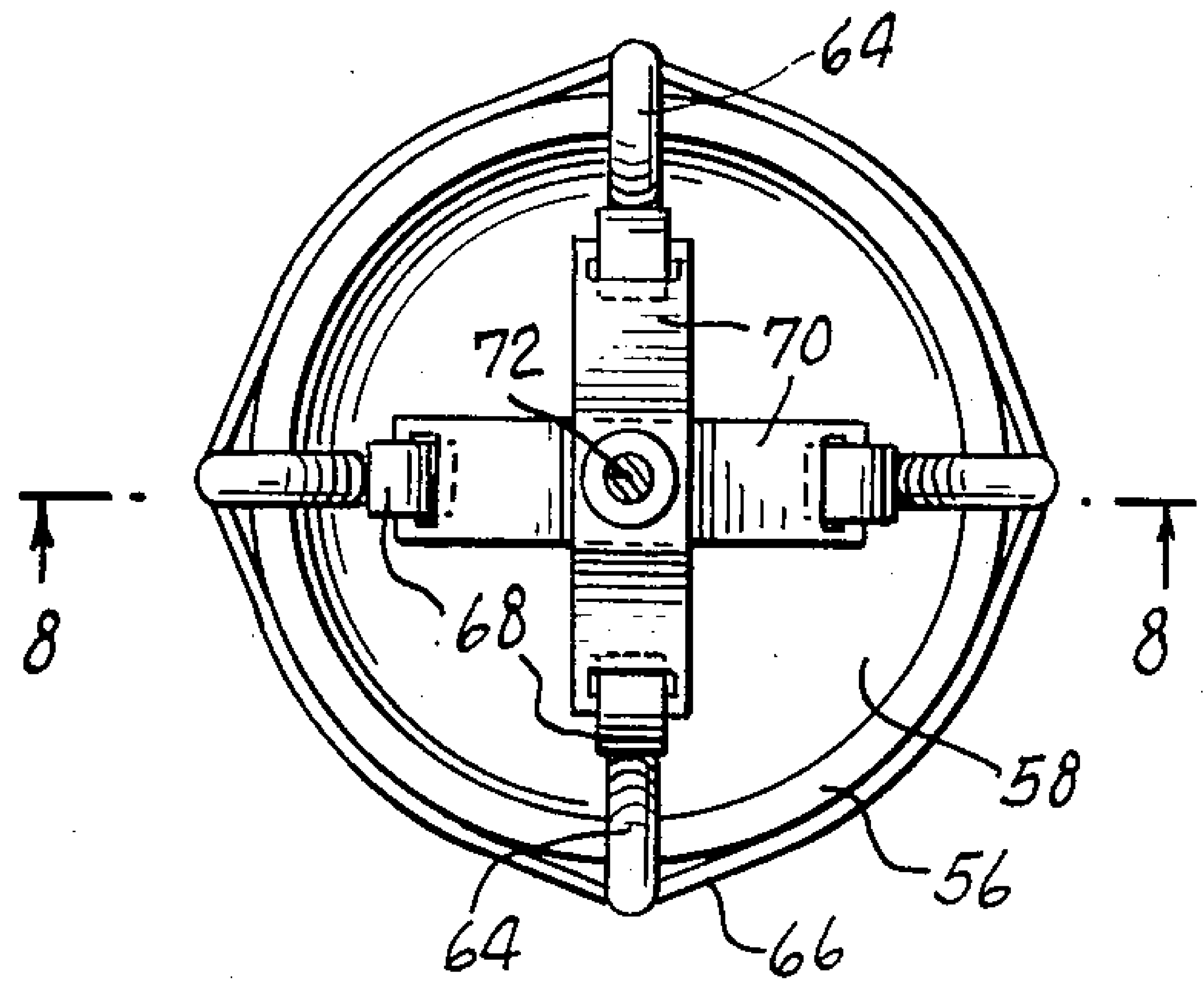
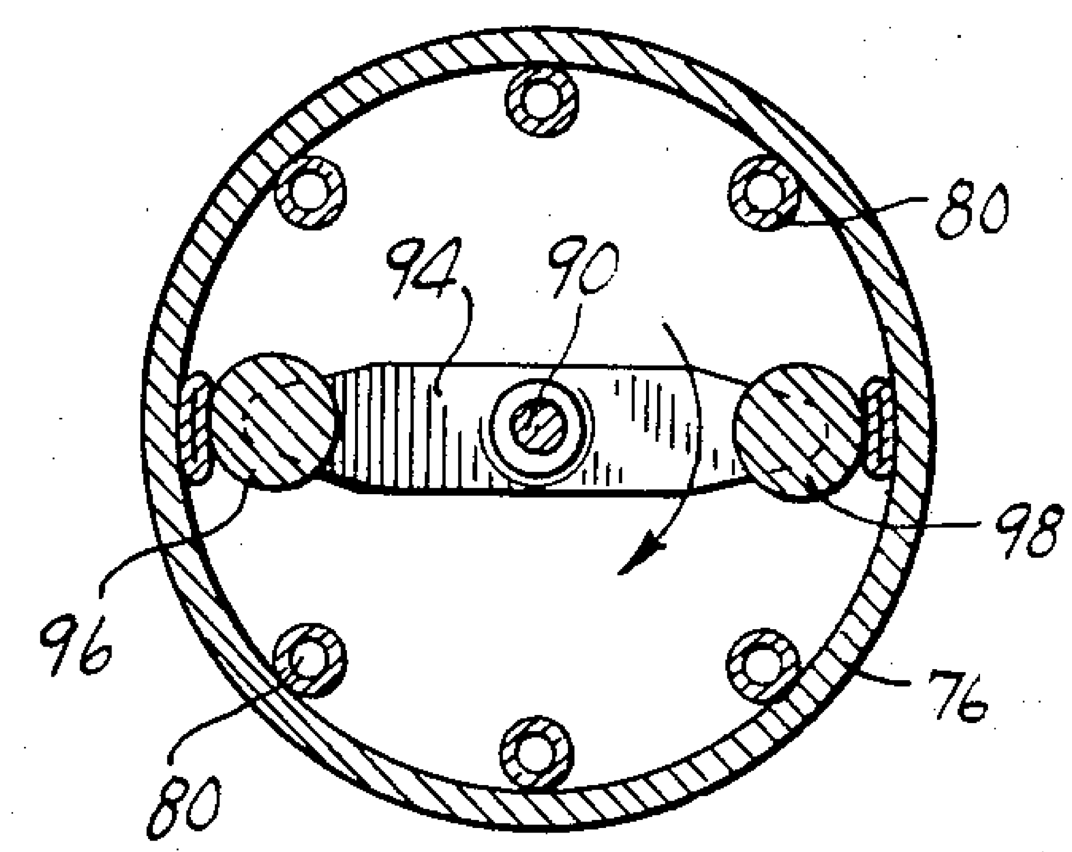


Fig. 9.



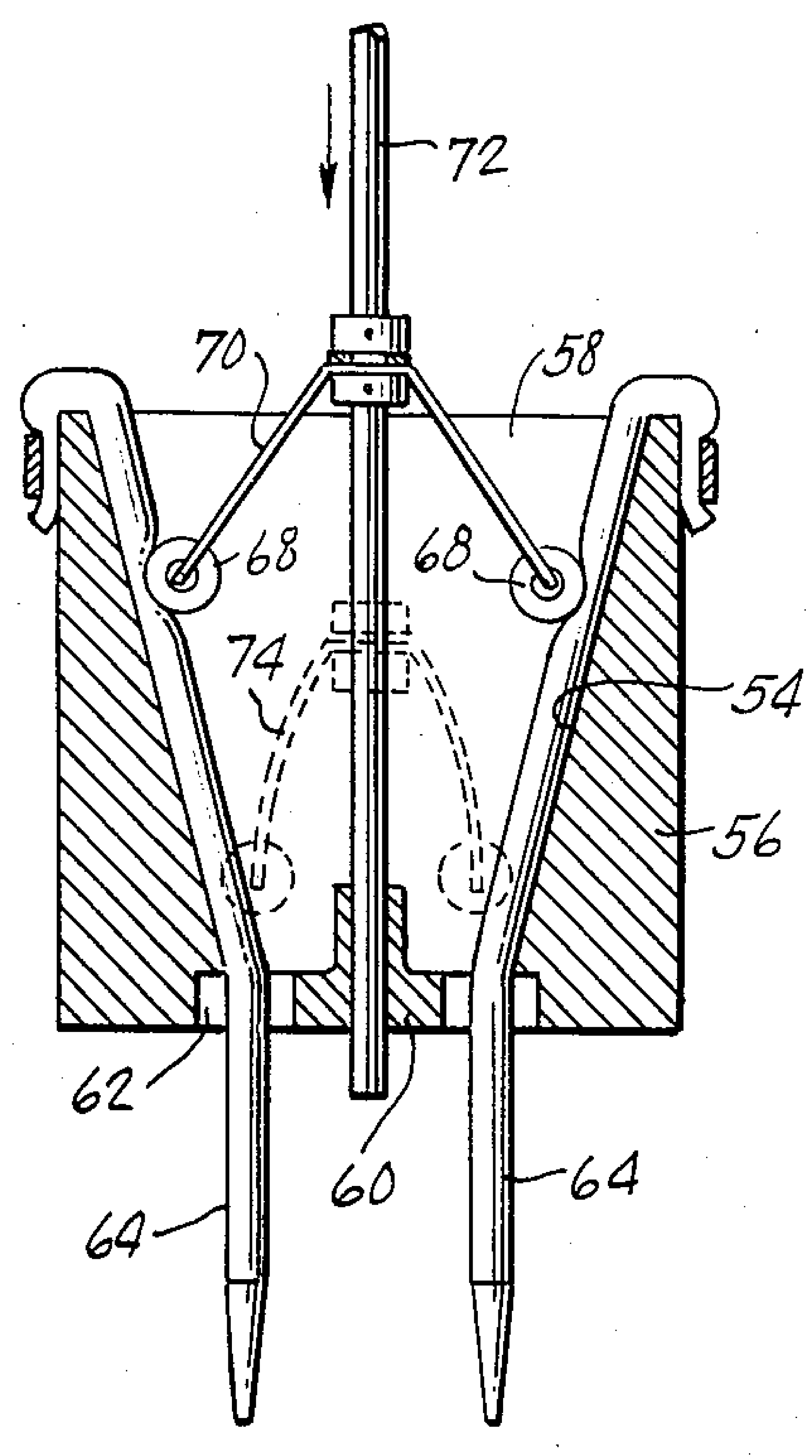


Fig. 8.

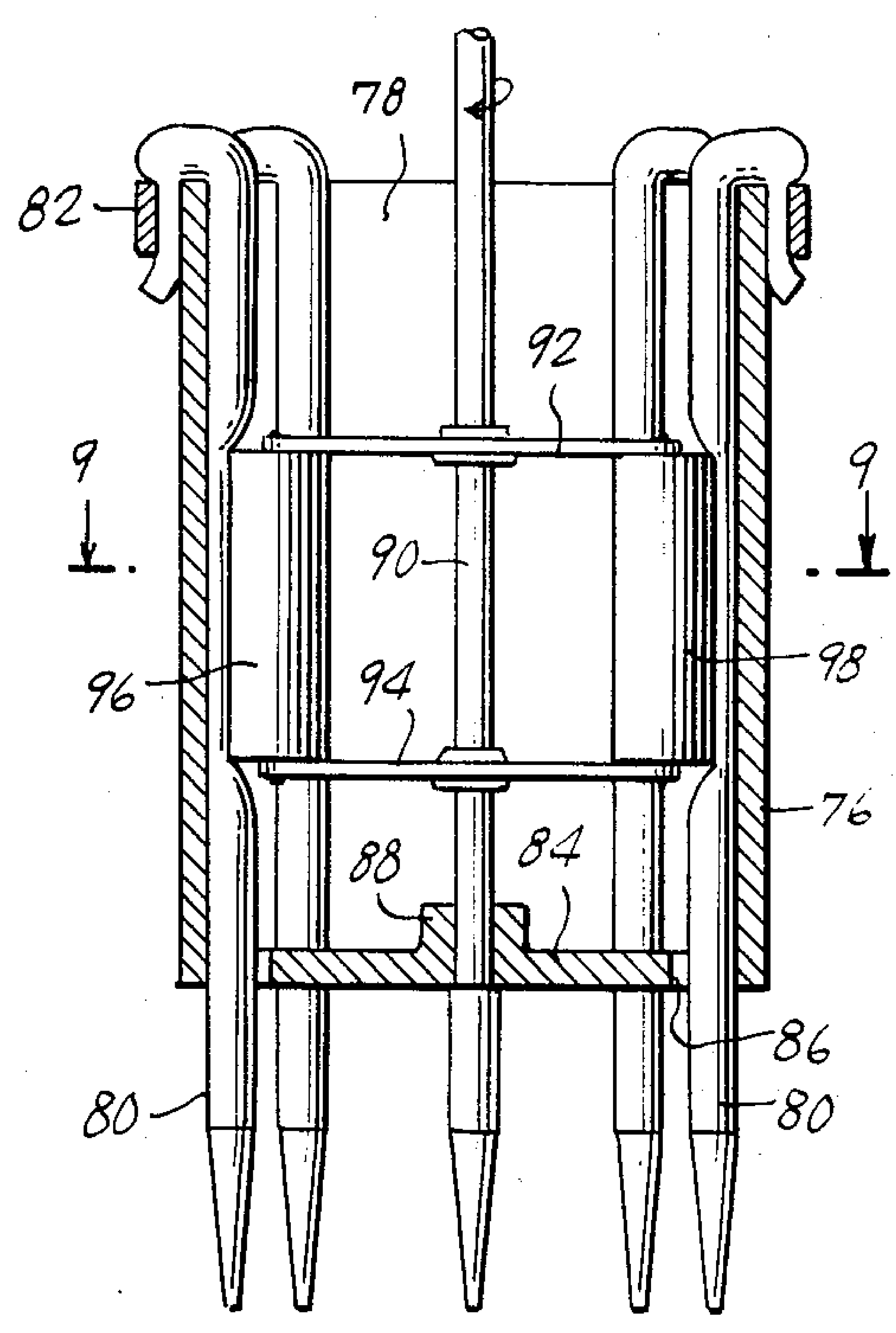


Fig. 10.

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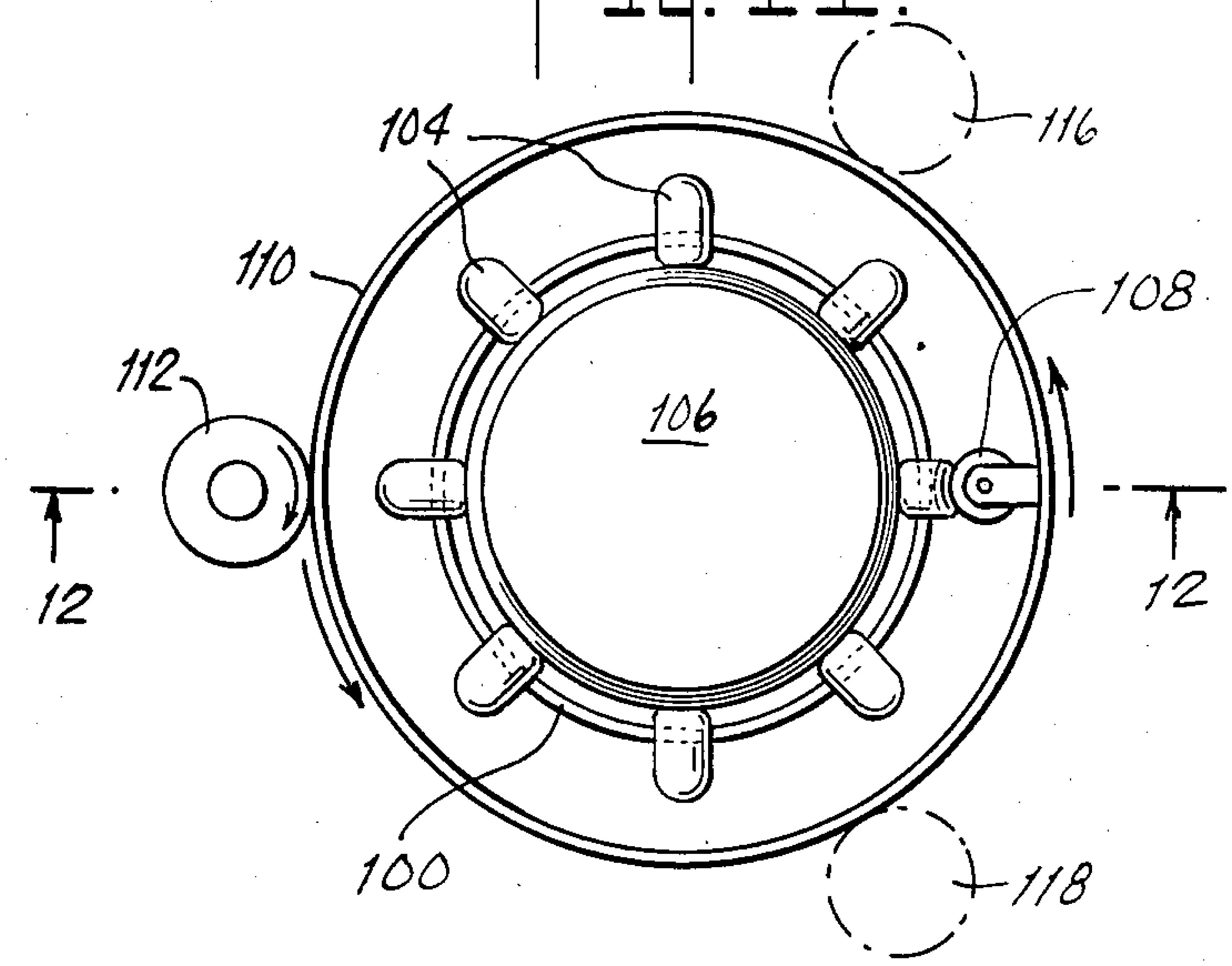
Fig. 11.



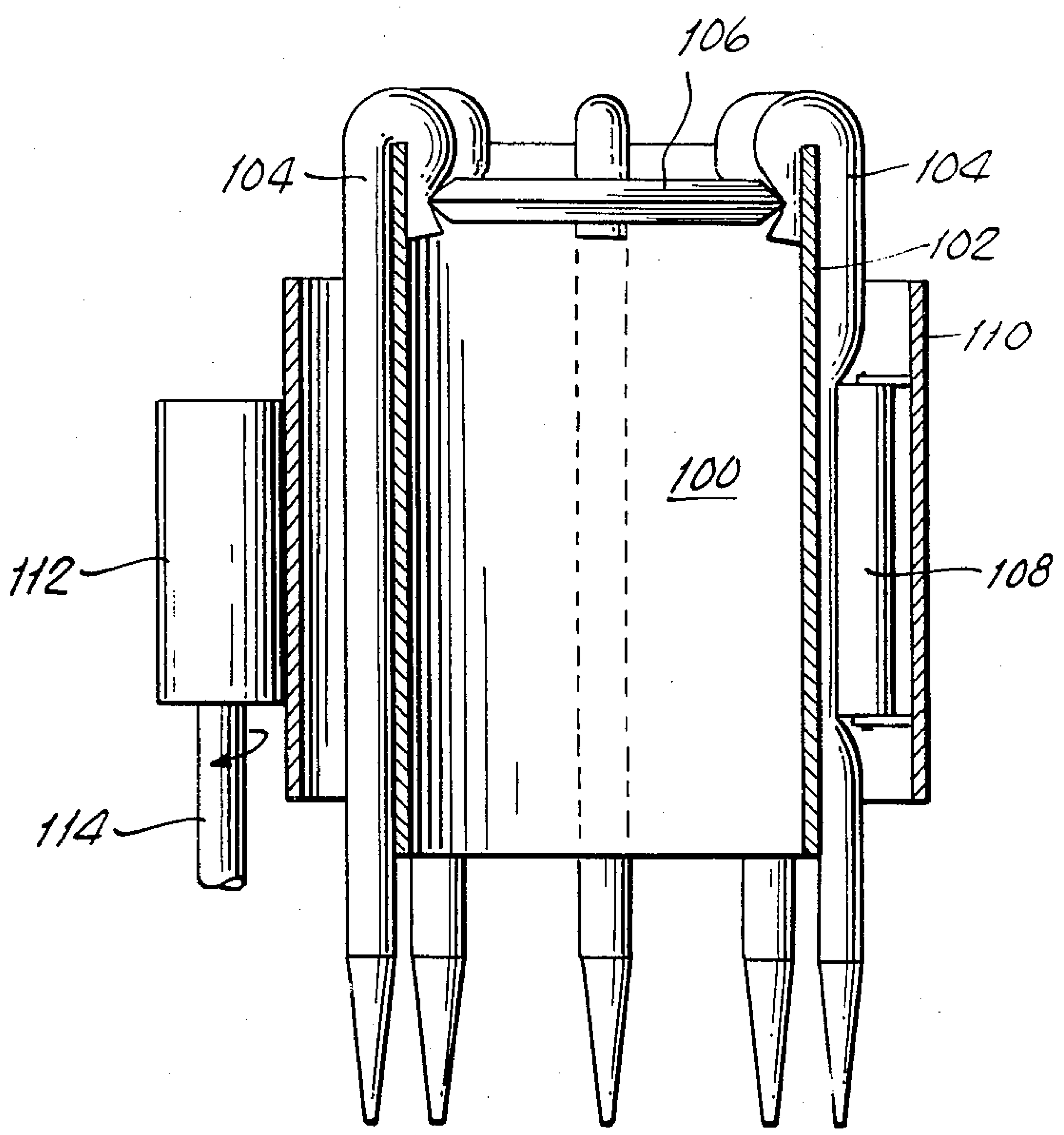


Fig. 12.

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PERISTALTIC METERING AND DISPENSING PUMP

BACKGROUND AND BRIEF DESCRIPTION OF THE INVENTION

Many peristaltic pumping systems have been revised to continuously deform flexible tubing to acquire and subsequently dispense a continuous stream of a fluid, the fluid being acquired at one end of the tube and dispensed from the other end of the tube.

Some of these prior pumps employ a multiplicity of tubes to dispense a plurality of streams continuously. The tubes are deformed in parallel by rollers passing over the tubes so that fluid is drawn up and then dispensed in a continuous stream. These prior pumps were not adapted to meter and dispense metered aliquots of liquid at the same point.

It is therefore the object of this invention to provide a peristaltic pump capable of obtaining and dispensing from the same end of flexible tubing aliquots of liquids simultaneously, the amount so metered and dispensed depending on the effective diameter of the tubing and the length of the roller or other occluding device which may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a preferred form of the peristaltic pump, partly in section to show underlying structure.

FIG. **2** is a modified form of the pump, partly in section to show underlying structure.

FIG. **3** is a fragmentary plan view of the pump of FIG. **2** showing a tube supporting plate and occluding rollers in diagrammatic form.

FIG. **4** is a more or less diagrammatic plan view of a pump base plate suggesting both radial and tangential occlusion roller arrangements.

FIG. **5** is another diagrammatic plan view of a base plate suggesting variations in the length of the occluding rollers.

FIG. **6** is a perspective view of a pump casing having an internal tube supporting surface.

FIG. **7** is a plan view of a pump having an internal conical tube supporting surface.

FIG. **8** is a sectional view on line **8—8** or FIG. **7**.

FIG. **9** is a section view on line **9—9** of FIG. **10**.

FIG. **10** is a vertical sectional view of a modified form of pump having an internal tube supporting surface.

FIG. **11** is a plan view of still a further modification of the pump.

FIG. **12** is a sectional view on line **12—12** of FIG. **11** showing the pump to be tubular in form and having an external tube supporting surface.

DETAILED DESCRIPTION

In FIG. **1** the pump is shown as having a rigid base plate **10** adapted to support flexible tubing **12**. FIG. **1** shows a plurality of flexible tubes **12** arranged on the base plate **10** in radial array. The inner ends of these tubes are clamped against the base plate by a clamp plate **14**, which serves the dual purpose of holding the elastic tubing on the base plate and completely blocking the ends of the tubes so held.

Extending upwardly from the clamping plate **14** is a shaft **16**. The shaft supports a reciprocating head **18** which is adapted to occlude all of the tubes coincidentally. It should be noted that the occluding surface **20** of the head **18** is preferably curved whereby its point of contact with the tubes travels outward radially as the head is forced down against the tubes lying on the base plate. This action insures a complete occlusion of the tubes.

The pump of FIG. **1** is employed by immersing the free ends of the tubes **12** in a liquid to be metered and dispensed. In this connection it will be noted that the tubes **12** are sufficiently long to extend beyond the rigid base plate **10** such that they may be readily immersed in a liquid. In the drawing the length of tube extending beyond base plate has been minimized in order to conserve space. When the free ends of the tubes are immersed in the liquid to be metered and dispensed, the reciprocating head **18** is raised as suggested by its section **18***a*. This will permit the liquid to be drawn up into the tubes. The free ends of the tubes are now inserted into vials or other receiving receptacle and the head **18** is lowered as shown by the head section **18***b*. This will serve to expel the liquid held in the tubes and results in measured aliquots of the liquid to be delivered.

It may be noted in passing that the reciprocating head has a bearing sleeve **22** which is sufficiently long to impart the required stability to the head as it is raised and lowered along the shaft **16**.

The pump of FIG. **2** provides a base plate **24**. This plate like the plate **10** is also rigid and is adapted to support the flexible tubes **26**. The inner ends of the tubes are held and closed by a clamping plate **28** from which extends a shaft **13**. The shaft **13** supports a rotating occluding head **32**. The inner face of the occluding head carries a series of occluding rollers **34**. These rollers are mounted in the inner face of the head such that a part of their diameter will extend beyond the plane of the head. The rollers may correspond in number to the tubes that are supported by the base plate **24**, in which event the pump will occlude all the tubes simultaneously. On the other hand, these rollers may in number be fewer than the tubes employed such as shown in FIG. **3** which suggests that the rollers may be mounted to contact alternate tubes as the occluding head **32** is rotated. The flexible tubes **26** are shown in FIGS. **2** and **3** as being arranged on the base plate in a generally tangential array. This arrangement makes it possible to increase the amount of liquid that can be metered and dispensed at each operation because of the increase in length of tube with which the occluding rollers are in contact during a rotation of the occluding head.

The selection and arrangement of the rollers **34** in the rotating occluding head is subject to wide choice. For example FIG. **4** suggests the radial mounting of a roller **34***a* as well as the tangential mounting of a roller **34***b*. FIG. **5** suggests a choice in selecting the length of the rollers wherein the roller **34***c* is a long roller, while the roller **34***d* is a short roller. Variations in the mounting position and the length of the rollers may be very advantageous and desirable. For example a roller mounted tangentially as the roller **34***b* in FIG. **4** will have a point of contact with the flexible tubes that moves linearly along the tubes and thereby produces an occluding action which differs from that if the roller is mounted radially such as the roller **34***a* which traverses the tubes in a wholly lateral direction. By selecting the length of the roller as suggested in FIG. 5, the amount of liquid dispensed at each operation can be easily selected. It is obvious of course that a long roller like the roller **34***c* will pump a greater amount of liquid that the shorter roller **34***d*.

While the pump of FIG. **6** also relies on the successive compression and release of flexible tubes for its operation, its form is substantially different from that of the pumps heretofore described. In FIG. **6** a pump casing **36** in the form of a cube has a generally circular internal tube supporting surface **38** upon which flexible tubes **40** are arranged in parallel. These tubes enter the pump casing through a slot **42** which communicates with the interior of the casing through the bottom of its front face. The tubes exit from the casing through a similar slot **44** formed in the face of the casing above the tube entry slot **42**. A pair of occlusion rollers **46** and **48** are adapted to contact and compress the tubes **40** as they are rotated in contact therewith. The rollers **46** and **48** are mounted at their opposite ends on a pair of supporting bars **50** (only one shown) which are driven in rotation by applying power to a drive shaft **52**.

The pump of FIG. **6** is designed for the continuous delivery of liquid. Since there is a continuous intake of liquid into and a continuous occlusion of liquid from the tubes, as the rollers **46** and **48** are driven in rotation. As shown, the tubes in the pump of FIG. **6** do not have one end thereof effectively blocked, and hence the precise form of pump shown is not covered by the claims herein.

The principles of the pumping action involved herein is shown embodied in still another form in FIGS. **7** and **8**. Herein there is also an internal tube supporting surface **54** in a pump casing **56**. The tube supporting surface **54** is conically formed with an open base **58** at the top of the casing and its truncated point **60** at the partially closed base of the casing. The base of the casing has formed therein an appropriate number of through passages **62** through which the free end of the tubes **64** are adapted to extend. The other end of the tubes are closed and held in position by a tube clamp **66** which encircles the pump casing at its upper end to clamp the tubes between the tube clamp and the exterior wall of the casing.

The tubes **64** are filled and occluded by occlusion rollers **68**, which are provided in number corresponding to the number of tubes that are employed. The pump of FIGS. **7** and **8** is shown as having four tubes and consequently there are four occlusion rollers **68**. The occlusion rollers are mounted on flexible roller straps **70**, which in turn are mounted on a reciprocating plunger **72**. The roller straps **70** mount the occlusion rollers **68** at their free ends and the length thereof is so chosen as to project the roller **68** into contact with the tubes when the plunger **72** is at the upper limit of its stroke. As the plunger is lowered, the roller straps **70** will flex inwardly toward the plunger and exert increasing pressure on the tubes as the plunger reaches the lower limit of its stroke. This condition is indicated by the dotted line position **74**.

In using the pump of FIGS. **7** and **8**, the open end of the tubes **64** will be immersed in the liquid to be metered and dispensed, the reciprocating plunger **72** is lowered, thereby exhausting any air and residual liquid remaining in the tubes, and it is then elevated to draw liquid into the tubes. Upon depression of the plunger once again, the liquid now in the tubes will be ejected. The amount of liquid so handled can be varied either by variation in the effective tube diameter or in the length of the plunger stroke.

FIGS. **9** and **10** disclose still another application of the metering and dispensing principle. In these figures the pump casing **76** is shown as having a cylindrical internal tube supporting surface **78** on which the tubes **80** are arrayed in parallel order. The upper ends of the tubes are closed and clamped in place by a tube clamp **82** which encircles the upper open end of the casing **76** and clamps the ends of the tubes between it and the outer face of the pump casing. The bottom closure web **84** of the pump casing has formed therein passages **86** through which the free end of the tubes extend.

The web **84** has a bearing hub **88** in which is seated a rotary spindle **90**. The spindle **90** has fixed thereto a pair of spaced plates **92** and **94** such that when the spindle **90** is rotated the plates **92** and **94** will rotate with it. At the end of the plates are mounted occlusion rollers **96** and **98** which are adapted to operate in occluding contact with the tubes when the spindle **90** is driven in rotation.

In using the pump of FIGS. **9** and **10**, the free end of the tubes **80** are immersed in the liquid to be metered and dispensed, the spindle is then rotated. As the rollers **96** and **98** come into compressional contact with the tubes, air and residual liquid will be expelled from the tubes so contacted. When the rollers lose their contact with the tubes liquid is drawn into the tubes in measured amount depending on the effective diameter of the tubes and the length of the rollers. As a roller passes over a loaded tube, the contents of the tube is now occluded. It will be noted that by reason of the two rollers operating in conjunction with a greater number of parallel circumferentially spaced tubes that the discharge from adjacent tubes will be in successive order rather then simultaneously, although two opposite tubes are compressed simultaneously by the rollers **96** and **98**.

The pump of FIGS. **11** and **12** is quite similar to that of FIGS. **9** and **10** in that its casing is cylindrical. The structure of FIGS. **11** and **12** includes a tubular pump casing **100** whose tube supporting surface **102** is the outer face of the cylindrical casing. A plurality of tubes **104** are held in parallel arrangement on the outer surface of the casing by a tube clamp disk **106**, which clamps the inturned upper ends of the tubes between its peripheral edge and the inner face of the pump casing. The tubes **104** extend beyond the open bottom of the pump casing for immersion in a liquid to be metered and dispensed.

The metering and dispensing operation is performed by an occlusion roller **108** mounted to be rotated externally of the pump casing and in filling and occluding contact with the tubes. The rollers **108** (only one shown in FIGS. **11** and **12**) are mounted in a cylindrical shell **110**, which surrounds the pump casing **100**. The shell **110** naturally is of greater diameter than the pump casing itself and it is preferably shorter than the casing. The shell **110** is driven by a drive roller **112** with which the shell makes driving contact. The roller **112** is mounted on a rotary shaft **114** to which driving power may be applied. A plurality of such drive rollers indicated at **116** and **118** in dot dash lines may be employed.

As the cylindrical shell **110** is driven by the drive roller **112**, its roller **108** comes into successive contact with the several tubes **104** on the exterior of the pump casing. As the roller **108** compresses a tube, the air and residual liquid in such tube will be expelled. Upon release of a compressed tube, it will take up liquid and hold it until the roller **108** again crosses its path, whereupon liquid within the tube will be expelled. It may be noted that with a single roller **108** the tubes are first filled in serial order on the first complete rotation of the cylindrical shell **110** and that the liquid will be expelled from the tubes upon the second complete revolution of the cylindrical shell. It is noted of course that this sequence of filling and occluding tubes may be completely altered by selection of the number of occluding rollers that are employed, and that a plurality of rollers are required to compress at least two of the tubes simultaneously as required by the claims. Moreover, the amount of liquid drawn into and expelled from the tubes can be controlled by selecting the effective tube diameter and/or the length of the occlusion roller **108**. In all cases the amount of liquid metered and dispensed can be accurately selected by choosing an appropriated effective tube diameter and/or the length of tube that is affected by the occluding device.

Although preferred embodiments of this invention are illustrated, it is to be understood that various modifications and rearrangements of parts may be resorted to without departing from the scope of the invention as defined in the following claims. Further, in the appended claims the disposition of tubes is defined as "circularly arranged;" such terminology is generic to the radial tubing arrangements of FIGS. **1–5** and the arrangements of FIGS. **6–12** involving positioning of a plurality of tubes upon a cylindrical support.

I claim:

1. A peristaltic fluid metering and dispensing pump comprising elastic tubing having one end thereof secured by means effectively blocking said one end thereof, a support body for a length of said tubing, the free end of said tubing extending beyond said support body for immersion in a fluid, and tube occluding means cooperating with said support body adapted to periodically compress said tubing to fill and occlude the same, in which a plurality of tubes are circularly arranged and held on said support body, and said tube occluding means compresses at least two of said tubes simultaneously.

2. The arrangement of claim **1** in which said tube occluding means comprises a plurality of rollers mounted for contact with said tubes.

3. The arrangement of claim **1** wherein said last named means comprises reciprocating means mounted to move toward and away from said body and compress said tubing between said reciprocating means and said support body.

4. The arrangement of claim **1** wherein a plurality of tubes are arranged radially upon said support body.

5. The arrangement of claim **1**, in which said tubes are supported upon a cylindrical surface.

6. The arrangement of claim **1**, in which alternate ones of said tubes are compressed simultaneously.

* * * * *