

Oct. 1, 1963

M. R. SCHOENFELD

3,105,490

INFUSION MONITORING DEVICE

Filed Feb. 25, 1960

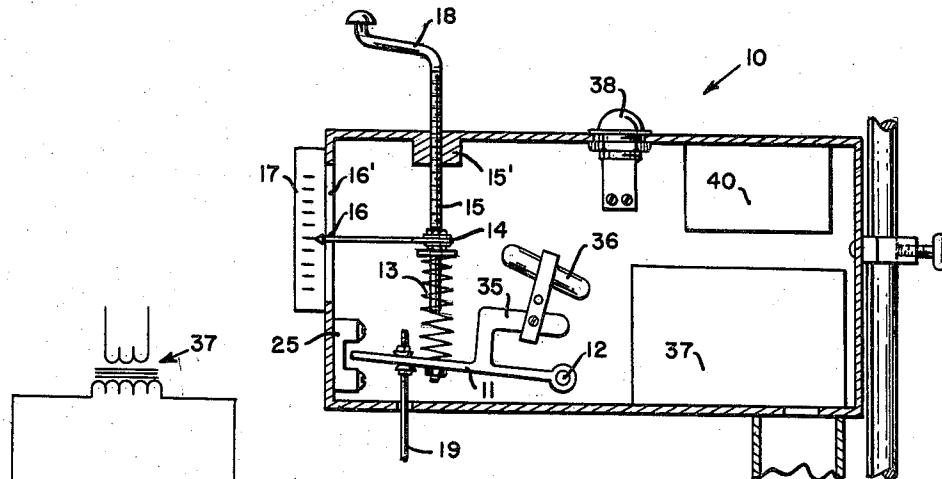


FIG. 1

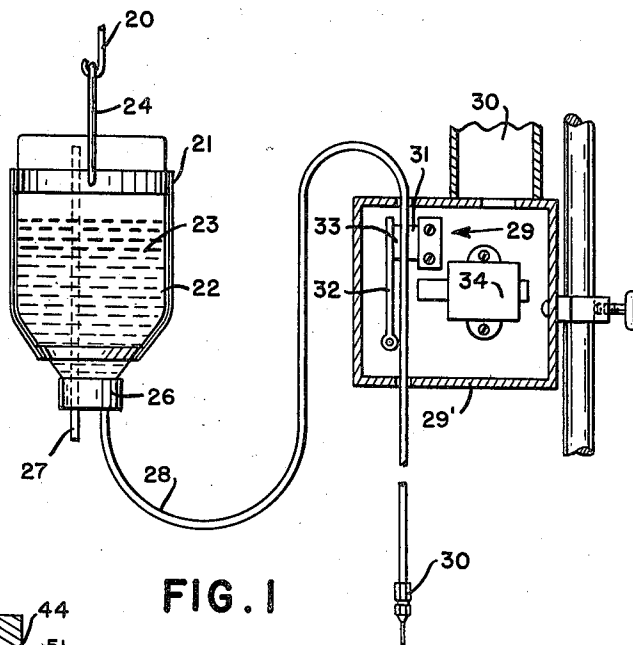


FIG. 2

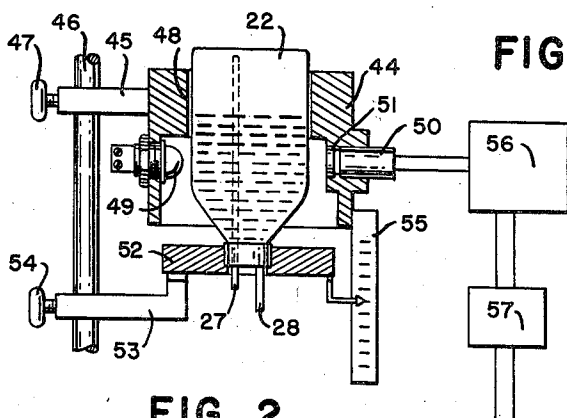


FIG. 3

INVENTOR.
MYRON R. SCHOENFELD

BY
Robertson & Smythe
Attys.

1

3,105,490

INFUSION MONITORING DEVICE

Myron R. Schoenfeld, 277 Bronx River Road,
Yonkers, N.Y.

Filed Feb. 25, 1960, Ser. No. 10,947

5 Claims. (Cl. 128-214)

The present invention relates to the art of intravenous infusion, and particularly to a new and improved apparatus for monitoring and controlling the amount of an intravenous infusion.

One of the greatest triumphs of modern medicine has been the mastery of intravenous feeding. Today it is the exceptional hospital patient who, during his stay on a medical or surgical service, does not receive at least one type of infusion. Blood, plasma, saline, glucose, fructose, and other agents are all regularly given intravenously by slow drip in volumes of 500-3000 cc. or more when indicated, and innumerable lives have been saved by these agents. Despite the general safety and ease of administration of these fluids, there are problems associated with their use. Among these problems is the controlling of the amount of the infusion over a given time interval and avoiding a complete emptying of the infusion container.

While an unnoticed slowing of the infusion rate has sometimes caused great difficulty, an unnoticed acceleration of the rate is a more frequently encountered problem. Excessive rate of infusion may be due to a flow rate actually faster than intended by the physician, or a rate which proceeds to emptying of the infusion bottle without the knowledge of the medical staff.

During cardiac or renal failure, there is retention of abnormal amounts of fluid in the body and an expanded blood volume. The latter places an extra load on the heart, thus creating a vicious cycle. If one loads the circulatory system too rapidly with intravenous fluids (particularly saline), further cardiac decompensation and full-blown pulmonary edema may ensue. This danger is a frequently encountered problem in the older age groups in patients with compromised cardiac reserves due to arteriosclerotic and/or hypertensive heart disease. Nevertheless, in hospital practice one must often administer parenteral fluids to these patients, frequently on a around-the-clock basis. The rate of infusion set by the physician may be inadvertently accelerated by the patient moving his arm and thereby changing the position of the needle tip in relation to the vein wall. Should this occur at night when medical supervision is at a minimum, rapid infusion may continue for a long enough period of time to endanger life.

While performing cardiac catheterization, a slow constant drip of 5% glucose in water under an air pressure in excess of the systemic blood pressure is run through the catheter to prevent clotting within the catheter lumen. During left-sided catheterization, maintenance of such a pressure is always necessary to counterbalance the systemic blood pressure and thus prevent backflow of blood into the catheter. During right-sided procedures, the infusion pressure is generally maintained at this high level prophylactically because of the possibility of meeting high right atrial or right ventricular pressures such as may be encountered in left to right shunts. Particularly in difficult cases, the attending medical personnel may be so busy with the technicalities of the procedure that, occasionally, the infusion bottle runs dry, and air, under a head of pressure of 150 to 200 mm. Hg or more, is injected intravenously or intra-arterially. The empty infusion bottle may go undetected until the patient develops neurologic signs, abdominal pain, other evidence of air embolism, or sudden death. Particular care is essential in right-sided procedures, not only because they are more

2

frequently performed, but also because the air pressure in the infusion bottle is almost unopposed by the very low central venous pressure.

In some patients—children, patients in shock, etc.—veins accessible for intravenous infusion are at a premium. Should the infusion bottle inadvertently run dry, backflow of blood into the needle usually occurs, with clotting and hence occlusion of the needle. The needle must then be removed and another vein sought. If one cannot be found, recourse must be taken to a "cut-down," which is a time-consuming, somewhat mutilating procedure.

Whole blood and some of its derivatives are quite viscous, and flow through an ordinary sized needle (#20-22) very slowly. To expedite the speed of transfusion (e.g. in cases of hemorrhagic shock), air is sometimes pumped into the bottle. The danger of air embolism inherent in such cases is more than a potential problem.

In each of the aforementioned conditions, the common denominator is too rapid an emptying of the infusion bottle without the awareness of supervisory medical personnel.

An important object of this invention is to provide an infusion monitoring device capable of overcoming the above and other difficulties.

Another object of this invention is to provide such a monitoring device of simple and reliable construction.

Another object of the invention is to provide such an infusion monitoring device in which a predetermined desired amount of intravenous infusion will not be exceeded.

Still another object of the invention is to provide such an infusion monitoring device in which alarm signals become effective to warn physicians and attendants of imminent danger.

Another object of the invention is to provide such an infusion monitoring device capable of preventing infusion in quantities greater than those intended by the physician.

Still another object of this invention is to provide such an infusion monitoring device capable of preventing the complete emptying of the bottle of fluid being infused without supervisory personnel being warned.

Another object of the invention is to provide such an infusion monitoring device which will cut off the flow of infusion liquid when the contents of the bottle have reached a predetermined level.

In one aspect of the invention, an inverted bottle of infusion liquid, to which may be connected the usual flexible tube and injection needle, may be supported from a pivoted lever. Adjustable means may act upon the pivoted lever, tending to counterbalance the weight of the infusion bottle. The construction and arrangement of the parts may be such that upon a predetermined decrease in the weight of the bottle of infusion liquid, due to intravenous infusion, the lever is caused to move about its pivot.

In another aspect of the invention, an electrical circuit may be energized by the pivoting of the lever to render effective certain signals to alert the supervisory personnel to the condition of the infusion device.

In still another aspect of the invention, a positive acting device may be provided for interrupting the flow of the infusion liquid through the flexible tube leading from the infusion bottle to the hypodermic needle when the alerting signals are rendered effective.

In still another aspect of the invention, a light-sensitive means may be employed to energize the alerting signals and cut-off means. The light-sensitive means and a source of light may be mounted for simultaneous elevational adjustment, so that predetermined amounts of infusion liquid may be injected.

The above, other objects and advantages of the im-

proved infusion monitoring device will become apparent from the following specification and accompanying drawing which is merely exemplary.

In the drawing:

FIG. 1 is an elevational view of apparatus to which the principles of the invention have been applied;

FIG. 2 is an elevational view of apparatus to which a modified form of the invention has been applied; and

FIG. 3 is a schematic wiring diagram of an electrical circuit for the apparatus shown in FIGS. 1 and 2.

Referring to the drawing, and particularly to FIG. 1, the principles of the invention are shown as applied to a housing 10 in which may be mounted a lever 11 for oscillatable movement about a pivot point 12. The lever 11 may be supported by a spring 13 that has its one end fixed to the lever and its other end fixed to a non-rotatable member 14 that is journaled on, and axially movable with, a rotatable screw 15. The member 14 is provided with a pointer 16 that extends outwardly through a slot 16' within the one side wall of housing 10 and cooperates with a scale 17. The screw 15 may threadingly extend through a boss 15' fixed to the top wall of housing 10 and may have a crank 18 connected to the end extending outside of the housing 10. Accordingly, rotation of crank 18 will raise or lower the member 14, imparting to lever 11 a greater or lesser resilient force tending to raise it. A link 19 may be fixed to the lever 11, and it may extend downwardly through the bottom of housing 10 and may include a hook 20. A cage 21, adapted to support an inverted bottle 22 of infusion liquid 23, may include a handle 24 adapted to be supported from the hook 20. From the foregoing it is evident that the bottle 22 is supported by the spring 13, and the actual limits of movement of the lever 11 are determined by a stop 25. Furthermore, the spring 13 may have such a spring constant that when a 1000 cc. bottle 22 is filled with infusion liquid and supported as shown in FIG. 1, lever 11 will be in a horizontal position. The scale 17 may be calibrated, for example, in increments of 100 cc. Thus, if the pointer 16 is in the position shown, the lever 11 will remain against the lower surface of stop 25 until the liquid within the bottle 22 has been reduced to 500 cc., when lever 11 will rise.

The bottle 22 may include a top 26 through which a tube 27 may extend to prevent the bottle 22 from becoming air-locked. A flexible tube 28 may also lead from top 26 and it may pass through a cut-off device 29 and have the usual hypodermic needle 30 mounted on its free end. The cut-off device 29 may be located within a housing 29' supported from the main housing 10 by a tubular connector 30 through which conductors may pass as will be described later. The cut-off device may include a rigidly mounted anvil 31 and a pivotally mounted lever 32 of magnetic material. A shoe 33 may be fixed to the lever 32 for cooperation with the anvil 31, and the flexible tube 28 may pass between the shoe 33 and the anvil 31. An electromagnetic device 34 may be fixed within housing 29' in position to draw the arm 32 toward it when the device 34 is energized, thus clamping the tube 28 between shoe 33 and anvil 31 to thereby cut off the flow of infusion liquid through the tube 28.

Referring to FIGS. 1 and 3, the lever 11 may be provided with an arm 35 to which is attached a position sensitive switch 36 which in the embodiment disclosed is shown as a mercury switch. The mercury switch may be in open circuit condition when the lever 11 is horizontal, but in closed circuit condition when lever 11 is in the position shown in FIG. 1.

A transformer 37 may be provided if it is desired to operate the device on low voltage to prevent the patient or attendants being inadvertently shocked. Closing of the switch 36 by the raising of lever 11 due to the consumption of the infusion liquid causes the magnet 34 to be energized, thus stopping the flow of infusion liquid through the tube 28. Warning lights 38 and 39 may be in parallel

with the magnet 34 and become illuminated. One of these lights may be located at the device to warn the attending physician, while the other may be located at the nurses' station outside of the room. A bedside buzzer 40 may be provided for also warning the attending physician during daytime intravenous infusion. Switches 41, 42, 43 and 43' may be provided, respectively, in the circuits for lamps 38, 39, the buzzer 40 and the electromagnet 34, so that flexibility of operation is insured.

Referring to FIG. 2, the principles of the invention are shown as applied to a modified form of apparatus including a housing 44 that is connected to an arm 45 adapted adjustably to be locked to a supporting standard 46 by a wing nut 47. The housing 44 may be open at its bottom and may be provided with an elongated cylindrical surface 48 for guiding an inverted bottle of infusion liquid. A light source 49 may be located within one of the side walls of housing 44 near the open end thereof. A photo-electric cell 50 may be located in a side wall of housing 44 diametrically opposite the light source 49. A filter 51 may be mounted between said photo-electric cell 50 and the bottle 22.

A counterbored plate 52 may be fixed to an arm 53 that is adjustably secured to the standard 46 by a wing nut 54. The lower end of the inverted bottle 22 is adapted to register with the counterbore of plate 52 and to be guided by the cylindrical surface 48.

From the foregoing it is evident that with either housing 44 or plate 52 fixed, adjustment of the other will vary the elevational position of the light source 49 and photo-electric cell 50 relative to the bottle 22, thereby providing a means for monitoring the flow of infusion liquid through the flexible hose 28. A stationary scale 55 may be provided for indicating the location of the light source 49 and photo-electric cell 50 relative to the contents of the bottle 22. The photo-electric cell 50 may be connected in a known manner to an amplifier 56, which in turn may be connected to a sensitive relay 57 that is adapted to operate the switch 36 of FIG. 3.

The infusion liquid may be mixed with a harmless coloring agent such as Borrocca-C which is a mixture of vitamins B and C. It is often added to infusion solutions to provide parenteral vitamin therapy and is quite safe. Adding 2 to 4 cc. of Borrocca-C to a liter of clear infusion liquid (e.g., 5% glucose in water) produces a strong yellowish color. Light transmitted through this solution emerges mainly as yellow. The complement of yellow is indigo blue, and an indigo blue filter glass 51 will transmit all colors except yellow. Accordingly, the cell 50 will not respond to yellow light. As long as the light from the source 49 passes through the yellow infusion liquid, the cell 50 is not activated. When, however, the meniscus falls below the level of the light source and photo-electric cell, the emitted light passes through the air-filled bottle. The filter fails to pass the yellow wavelengths, but the remaining light that is transmitted is sufficient to activate the photo-electric cell 50. The weak signal generated by the cell 50 is amplified in the amplifier 56, and the amplified signal activates the sensitive relay 57 which in turn actuates switch 36 of the warning and cut-off circuit of FIG. 3.

From the foregoing it is evident that an infusion monitoring device has been provided that is capable of monitoring the flow of intravenous or intra-arterial infusions and which is capable of avoiding, or even preventing a greater amount being infused than intended by the physician. Likewise, the monitoring device is capable of preventing the bottle from becoming empty without the awareness of the supervisory staff. In special embodiments, the flow of the infusion liquid is automatically cut off before the bottle becomes empty, thereby avoiding the hazards mentioned above and providing a "fail-safe" infusion system.

Although the various features of the monitoring device have been shown and described in detail to fully disclose

5

two embodiments of the invention, it will be evident that changes may be made in such details and certain features may be used without others without departing from the principles of the invention.

What is claimed is:

1. In an infusion monitoring device for controlling intravenous infusion, the combination comprising a container adapted to contain infusion liquid; means resiliently supporting said container in an inverted position; means for adjusting said resilient means; positive cut-off means for stopping the liquid flow from the container; and means responsive to a preset condition of said adjusting means for actuating said cut-off means when the liquid within said container is at a predetermined level.

2. In an infusion monitoring device for controlling intravenous infusion, the combination comprising a container adapted to contain infusion liquid; means resiliently supporting said container in an inverted position; means for adjusting said resilient means; signal means; positive cut-off means for stopping the liquid flow from the container; and means responsive to a preset condition of said adjusting means for simultaneously actuating said signal means and said cut-off means when the liquid within said container is at a predetermined level.

3. In an infusion monitoring device for controlling intravenous infusion, the combination comprising a pivotally mounted lever; a container of infusion liquid suspended from said lever in an inverted position; a spring having its one end connected to said lever and its other end connected to an element adjustably movable along the line of force of said spring to move said lever in response to the presence of a variable but predetermined desired quantity of liquid in said container; circuit making and breaking means responsive to the movement of said lever; and signal means and a positive cut-off device for cutting off the flow of liquid from said container adapted to be actuated by the making of said circuit means.

6

4. In an infusion monitoring device for controlling intravenous infusion, the combination comprising a pivotally mounted lever; a container of infusion liquid suspended from said lever in an inverted position; a spring having its one end connected to said lever and its other end connected to an element adjustably movable along the line of force of said spring; circuit making and breaking means responsive to the movement of said lever; and electromagnetic positive cut-off means adapted to be actuated by the making of said circuit means to stop the flow of liquid from said container.

5. In an infusion monitoring device for controlling intravenous infusion, the combination comprising a pivotally mounted lever; a container of infusion liquid suspended from said lever in an inverted position; a spring having its one end connected to said lever and its other end connected to an element adjustably movable along the line of force of said spring; circuit making and breaking means responsive to the movement of said lever; signal means; electromagnetic positive cut-off means; and means responsive to the making of said circuit means for simultaneously actuating said signal means and said cut-off means to stop the flow of liquid from said container.

References Cited in the file of this patent

UNITED STATES PATENTS

1,455,795	Logan	May 22, 1923
1,604,492	Smith	Oct. 26, 1926
2,490,627	Hofberg	Dec. 6, 1949
2,705,493	Malmros	Apr. 5, 1955
2,706,755	Krasno	Apr. 19, 1955
2,784,932	Poitras	Mar. 12, 1957
2,835,252	Mauchel	May 20, 1958
2,927,582	Berkman et al.	Mar. 8, 1960
3,014,481	Rumble et al.	Dec. 26, 1961