Jan. 27, 1953

W. S. MOORE

2,626,446

EMBALMING APPARATUS

Filed Sept. 10, 1949

3 Sheets-Sheet 1

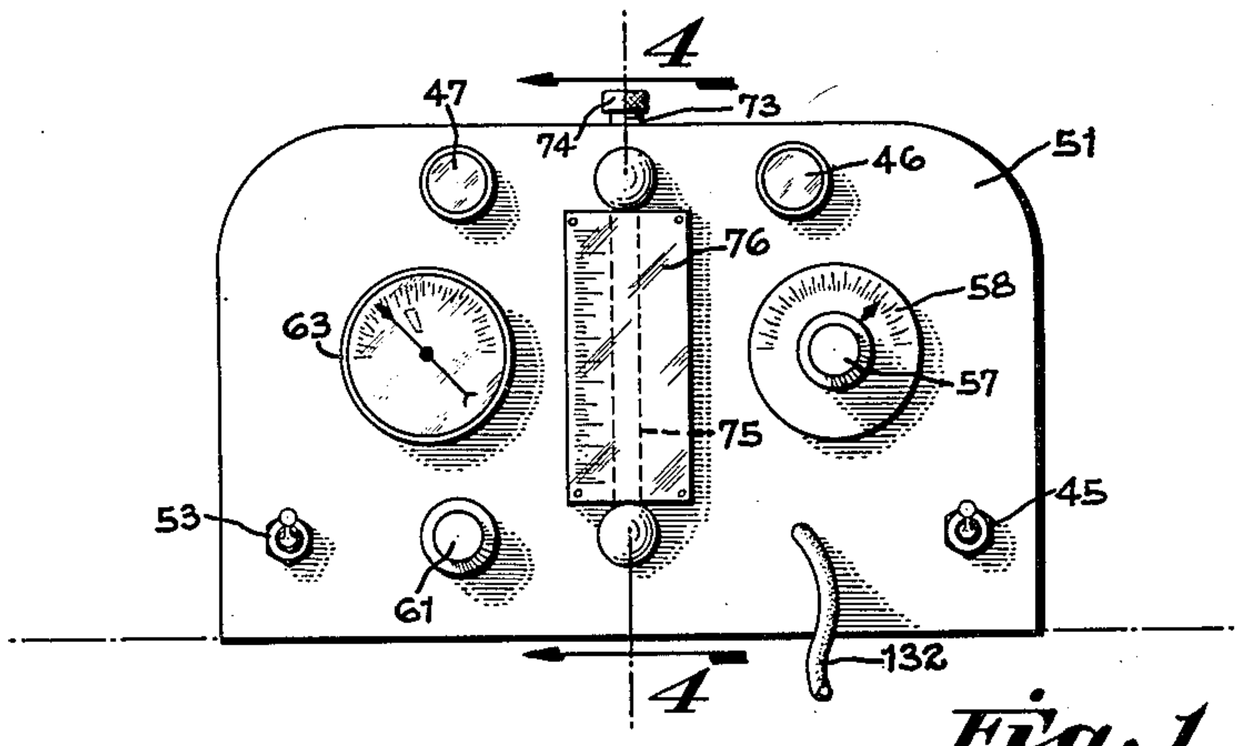

Fig. 1

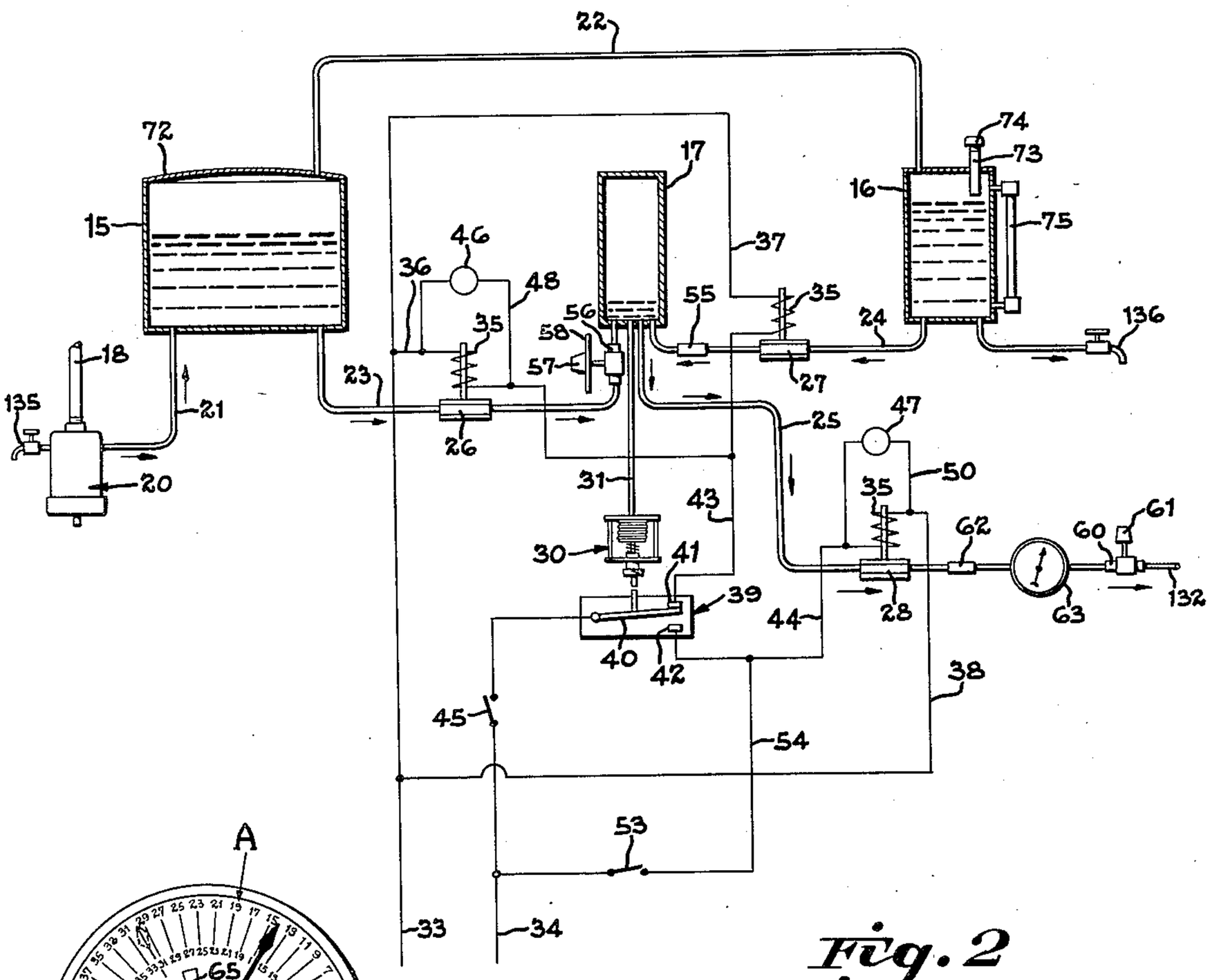

Fig. 2

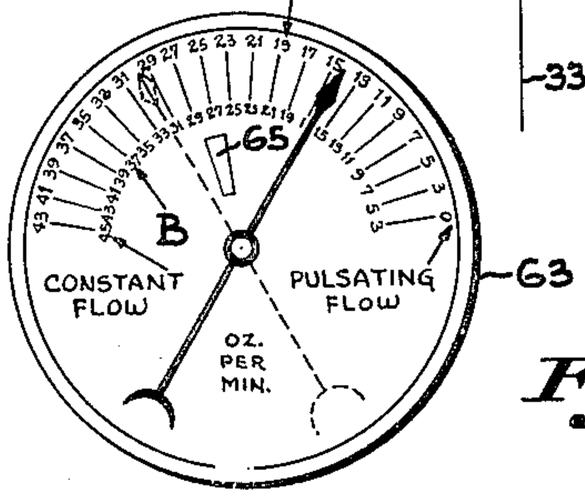

Fig. 3

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EMBALMING APPARATUS

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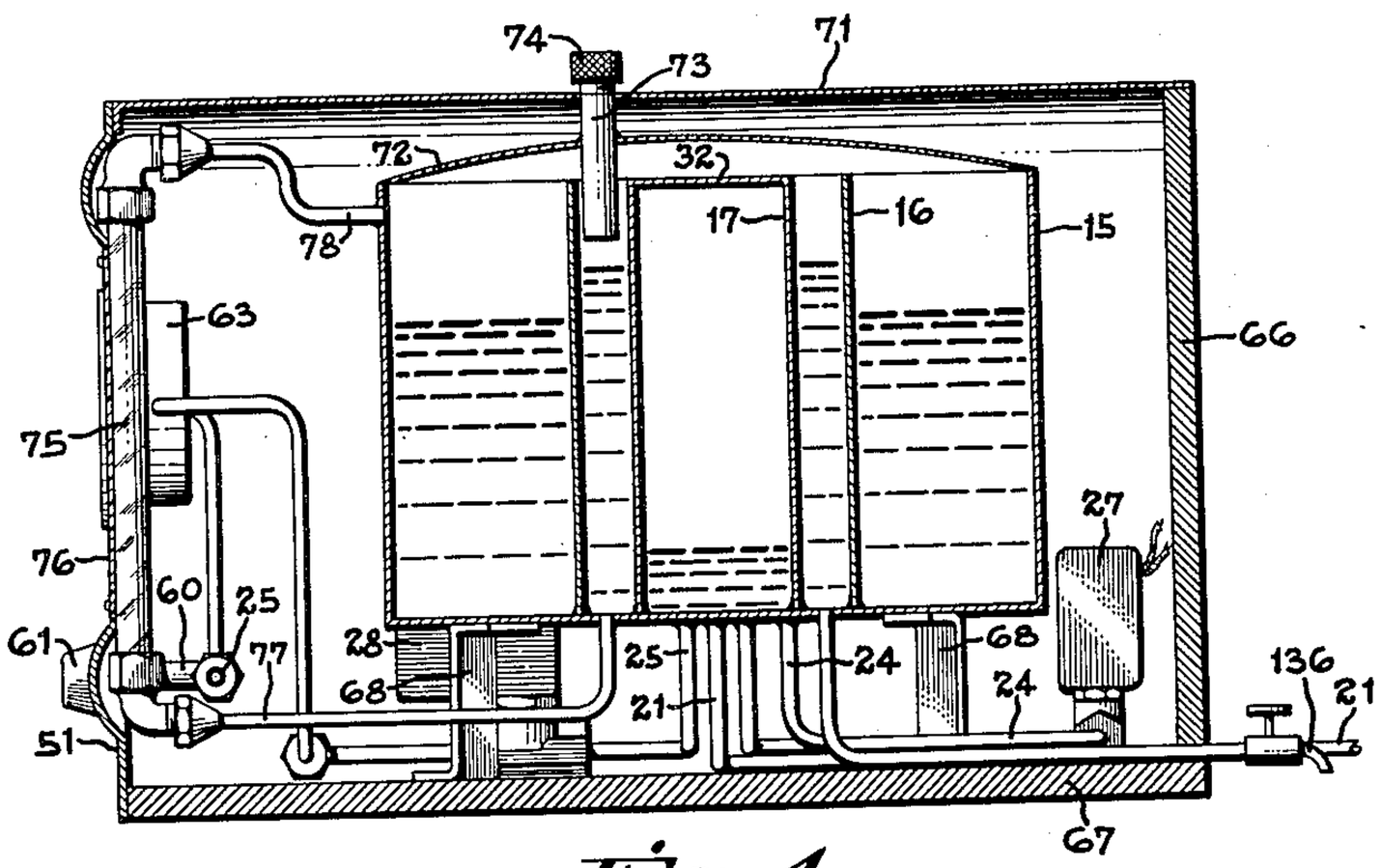

Fig. 4

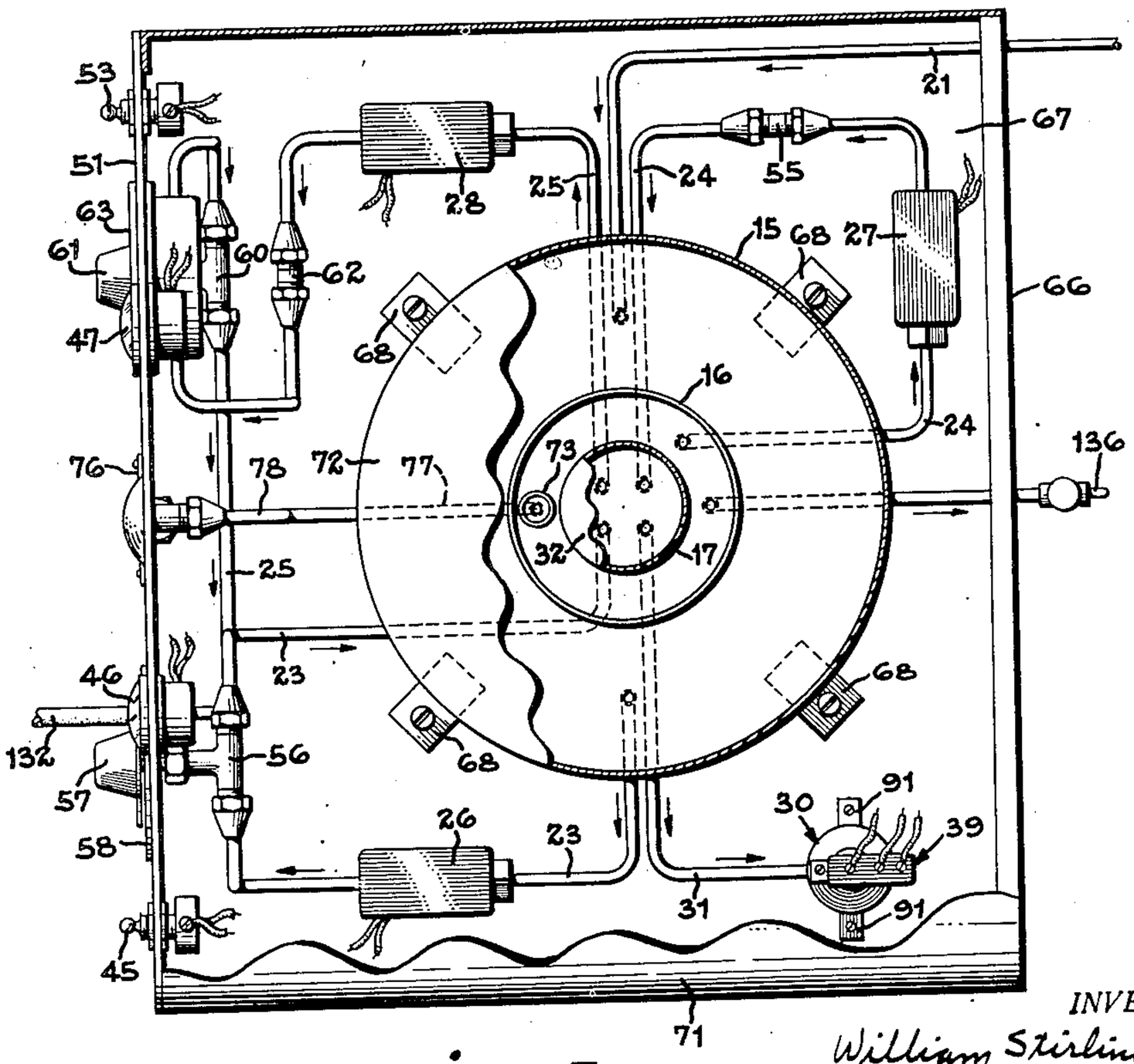

Fig. 5

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3 Sheets-Sheet 3

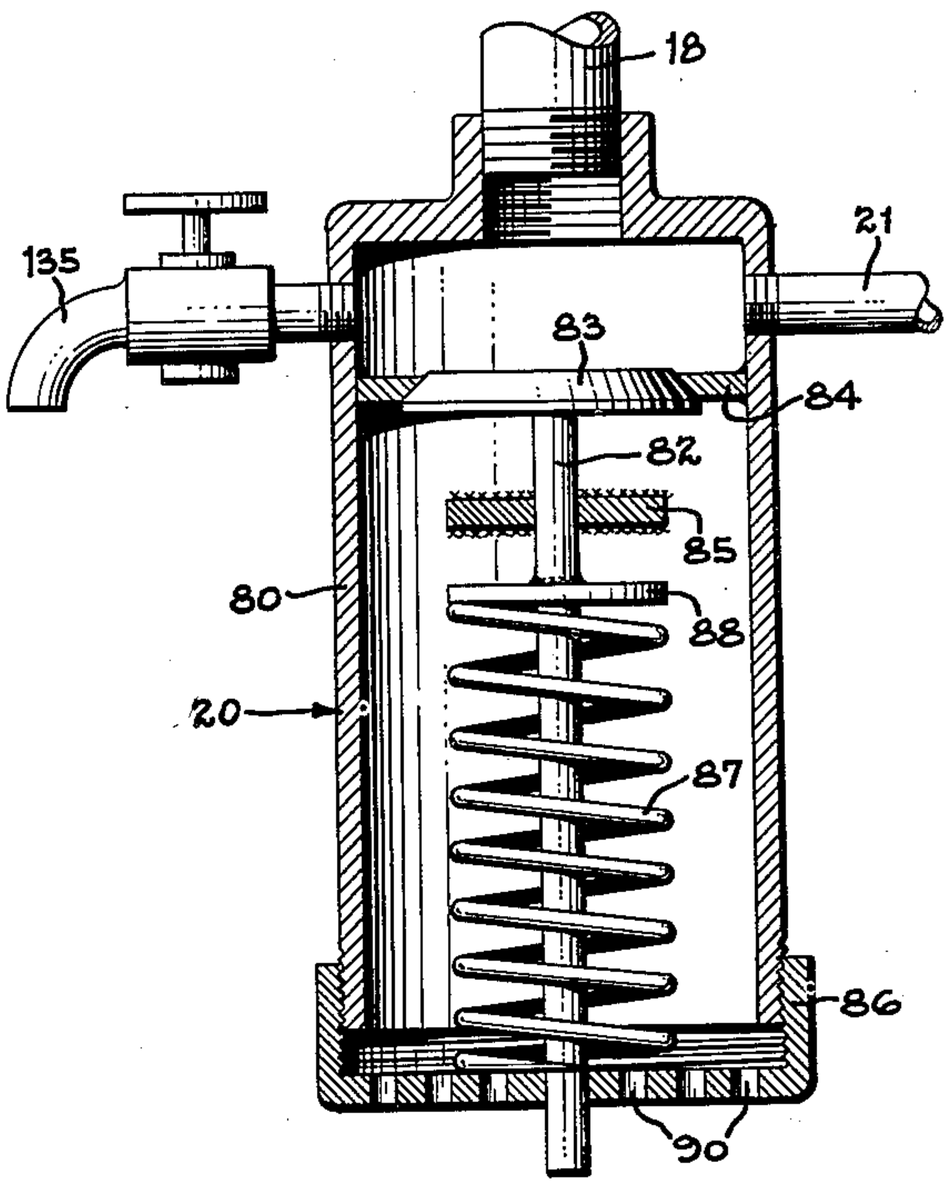

Fig. 6

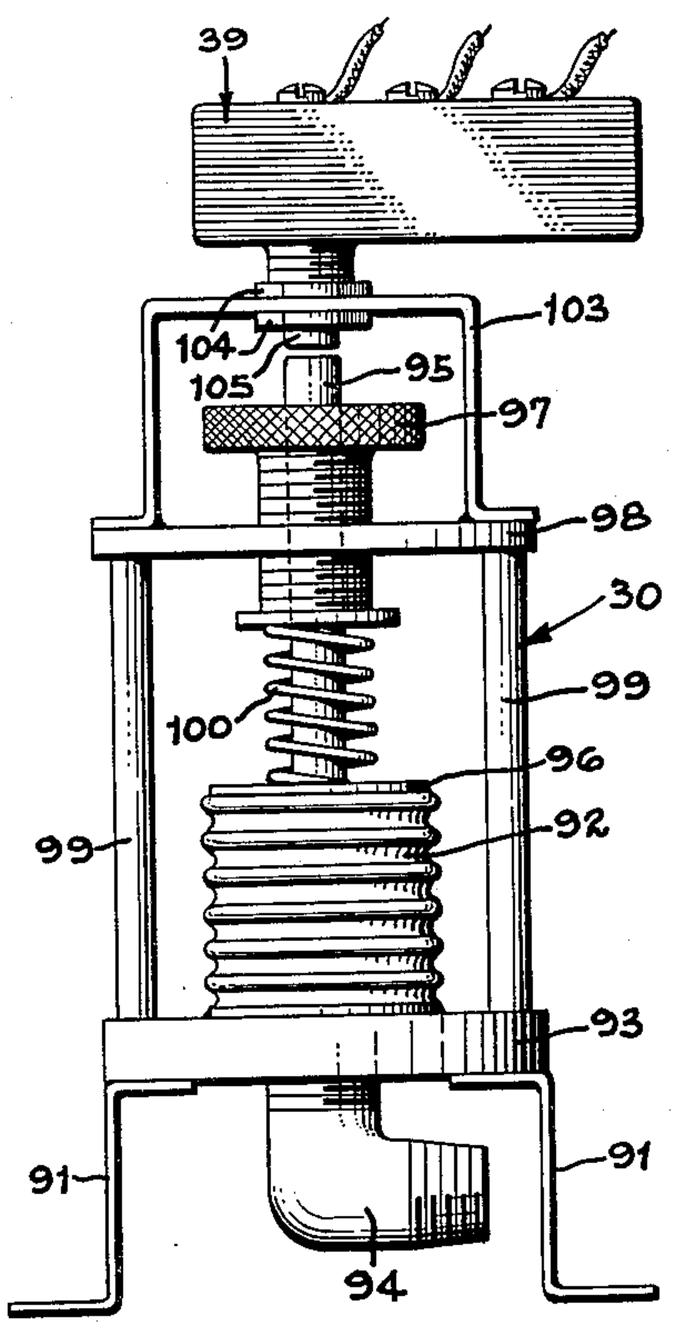

Fig. 7

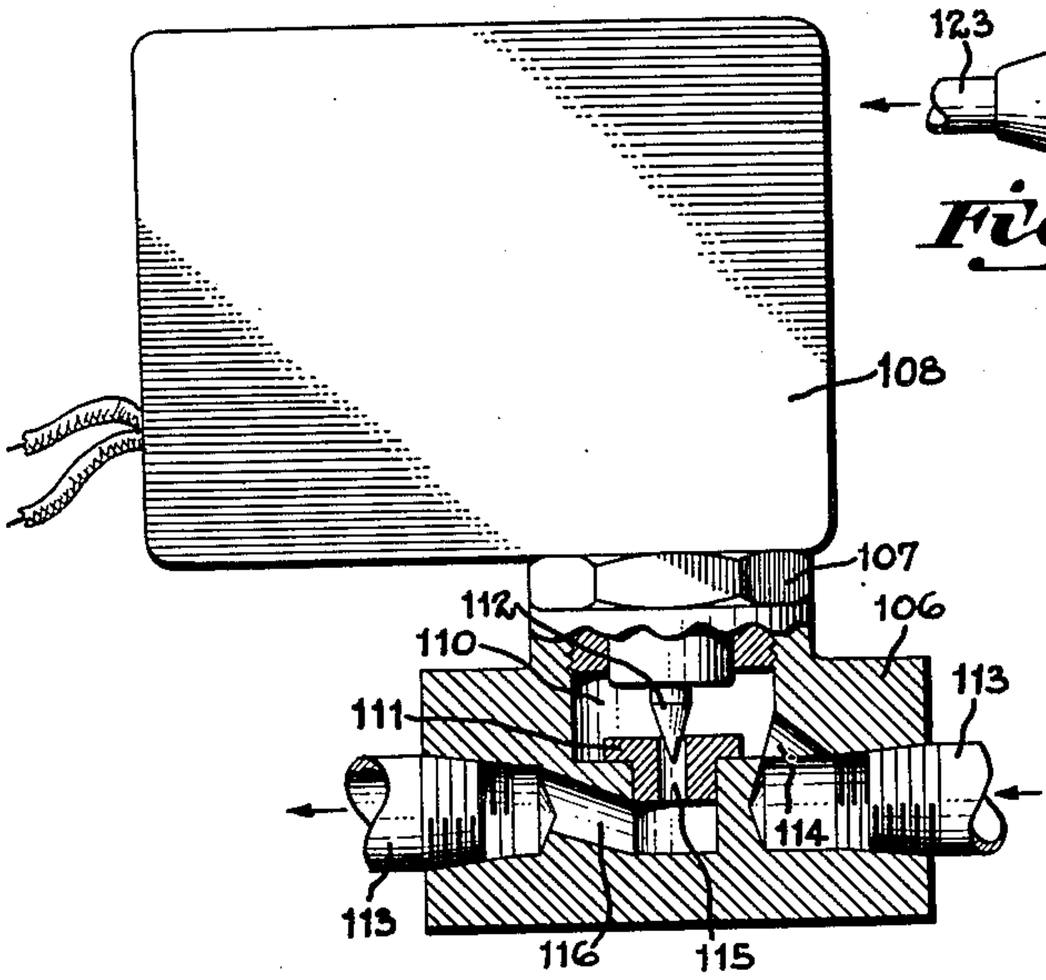

Fig. 8

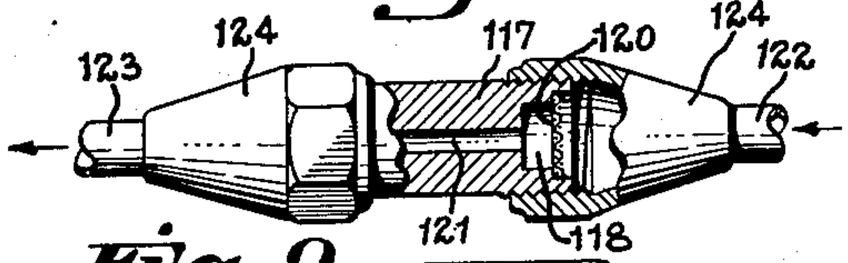

Fig. 9

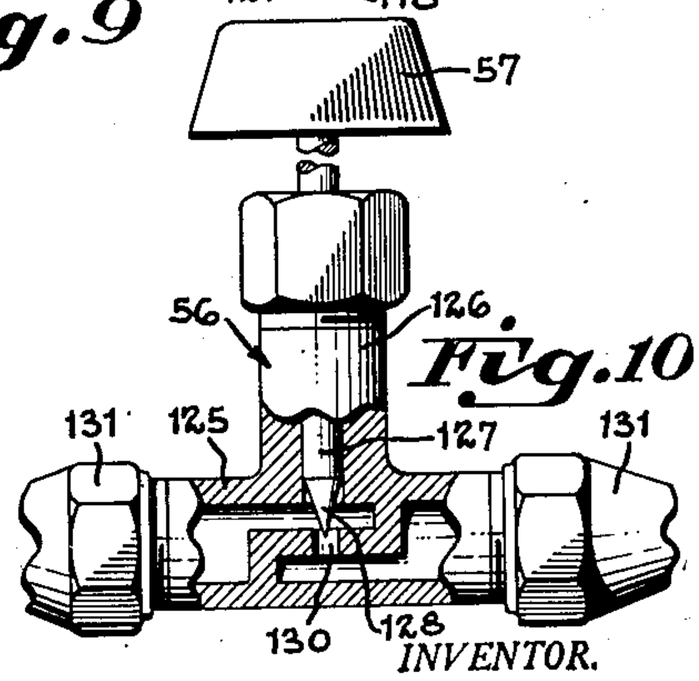

Fig. 10

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UNITED STATES PATENT OFFICE

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EMBALMING APPARATUS

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Application September 10, 1949, Serial No. 115,020

12 Claims. (Cl. 27—24)

1

This invention relates to the art of embalming and has particular reference to an apparatus for mixing and delivering under automatic control a solution of embalming fluid for injection into the body. The apparatus is intended to utilize a standard embalming liquid which is mixed with water in predetermined proportion and injected rhythmically into the circulatory system by way of the arteries.

The technique of embalming by arterial injection has been practiced for a great many years and consists essentially of injecting under pressure a solution of embalming fluid into the larger arteries, for example, the axillary or carotid, for distribution through the circulatory system. Drainage is accomplished through the venous system and, if the operation is performed under proper conditions, the treating fluid reaches substantially all parts of the body. In the past, one practice has been to inject the solution by gravity pressure by feeding the embalming fluid from an elevated vessel, the pressure of injection corresponding to the amount of elevation of the vessel. This arrangement provides constant pressure and extreme care must be exercised throughout the operation because distension or swelling can occur very rapidly in areas where there is present some obstruction in the circulatory system. The formation of swellings is a serious mishap because the chemical action of the fluid causes them very quickly to become fixed, making it very difficult to reduce or conceal them. In order to gain closer control of injection pressure, another procedure has been to inject the fluid by using a hand operated syringe. Approximately the same amount of pressure can be developed but the operation is slow and tedious. A more recent technique involves the use of mechanical injectors, such as pumps, which perform their function with greater efficiency and speed than the hand and gravity systems but they still tend to cause distension due to constant injection pressure and lack of precise regulation. Thus, while the injecting machine provides faster and more efficient treatment, it, nevertheless, is subject to the same disadvantages inherent in the gravity systems and requires very careful supervision.

It has been determined by experiment that, while a given injection pressure may cause distension when applied constantly; the same or greater pressure, if developed intermittently, may be applied without injurious effects. This phenomenon apparently is due to temporary dilation of the blood vessels, permitting the injection

2

pressure to be dissipated gradually before the next impulse reestablishes pressure. In other words, the solution must pass through the smaller capillaries which set up considerable flow resistance, but by rhythmic application of pressure, the liquid is given opportunity to pass through, instead of building up excessive back pressure. By operation in this manner, it has been found that the solution can be injected safely at considerably greater pressure and rate of flow than was possible by the apparatus available in the past and, consequently, a more thorough operation can be performed in a shorter period of time. Furthermore, much better blood drainage is obtained due to the pulsating action which allows the use of higher injecting pressure. It has been determined that an injection rate of 60 to 90 pulsations a minute, which approximates normal heart-beat frequency, with a potential output pressure in the neighborhood of 10 lbs. per square inch, will produce most efficient results in the average case.

A primary object of the invention, therefore, has been to provide a simple reliable apparatus which is arranged to mix and deliver a solution rhythmically at a controlled rate of flow, with provisions for varying conveniently the rate of flow and solution strength to adapt the apparatus to various operating conditions. The advantages to the operator are that he handles no water and concentrate, the operation need not be halted for mixing and recharging the machine since mixing is done automatically, and the solution strength can be varied at will almost instantly during the operation.

A further advantage lies in the fact that the amount of mixed concentrate and water in the apparatus at any given time is limited approximately to 8 ounces so that little or no concentrate need be wasted at the finish of the operation. Briefly, the invention is based upon the concept of providing a water reservoir and a concentrate reservoir, both of which are maintained under a common head pressure, in conjunction with an automatic valving system which feeds metered streams of liquid from the respective reservoirs to a closed mixing tank, the valving system being responsive to the mixing tank pressure simultaneously to block the supply lines and open a discharge line leading from the mixing tank to the injecting instrument. Thus, the mixing tank is alternately charged and discharged so long as water and concentrate are supplied, resulting in a pulsating discharge. By supplying a constant flow of water to the water

reservoir at controlled pressure, a constant head pressure is maintained by air trapped in the reservoir and this pressure is transmitted to the concentrate reservoir. By metering the flow from the respective reservoirs to the mixing tank, a predetermined proportion of concentrate and liquid are forced into the mixing tank upon each impulse.

The pulsating discharge is accomplished in a very simple manner by the use of electrically controlled valves which regulate simultaneously the flow of liquid from the water and concentrate reservoirs to the mixing tank, in conjunction with a third valve interconnected in the circuit to discharge the mixture from the mixing tank at injection pressure when the mixture attains a predetermined pressure by compression of air trapped in the tank. The supply valves operate alternately with respect to the discharge valve by means of a pressure responsive switch which communicates with the mixing tank, the switch being electrically interconnected with the valves in a manner to open the supply valves when pressure in the mixing tank is at minimum, and alternately to close the supply valves and open the discharge valve when pressure is at maximum. Pressure for operating the apparatus is developed and maintained constantly in a simple and reliable manner by air trapped in the water reservoir, which in turn, is regulated by a pressure regulating supply valve placed in a line leading from the water service line to the reservoir. This valve preferably is regulated and set permanently at the factory to introduce water at constant pressure into the reservoir to replenish the supply in accordance with the rate of delivery.

In the use of the injecting equipment available in the past, the usual practice has been to mix together the embalming concentrate and water before placing it in the injecting equipment. However, the strength of the solution must or should be varied according to a great number of factors, some cases requiring a stronger solution than others; also, in certain cases, the embalming operation must be started with a weak solution, followed by one or more stronger solutions. Obviously, this procedure involves a great deal of extra work and time if the equipment must be shut down for the change over. By the provisions of the improved system, a supply of concentrate is placed in the apparatus and mixed in uniform percentage with fresh water to provide the desired solution of concentrate, and by a variable metering arrangement the solution strength can be varied conveniently while the apparatus is in operation so as to meet the particular requirements of a case with efficiency and precision. The proportion of concentrate and water is controlled very simply by a variable metering valve placed in the supply line from the water reservoir to the mixing tank, operable to vary the volume of water which may pass during one pulsation, the valve operating in conjunction with a fixed orifice placed in the line leading in the concentrate tank to the mixing tank so that the quantity of water and concentrate are correlated. Since, as above noted, the water and concentrate are maintained in storage at the same pressure, a fixed quantity of each will be introduced into the mixing tank at each pulsation. The rate of flow is regulated by a second variable metering valve placed in the discharge line which leads from the mixing tank to the injection instrument, whereby the flow may be

restricted in accordance with the requirements of each particular case.

In a preferred structural embodiment of the invention, the respective tanks or reservoirs are cylindrical and are placed one within the other concentrically for compactness. Thus, the largest or exterior tank which includes a top, constitutes a water reservoir, a second tank concentrically nested within the water tank constitutes a concentrate reservoir, while the mixing tank, which is the smallest of the three, is nested concentrically within the concentrate tank. In order to provide a common head pressure for both the water and concentrate, the top of the concentrate tank is open so that the concentrate and water are exposed to the air which is trapped therein. The mixing tank, however, is required to develop its own pressure as the concentrate and water are fed into it, consequently, its upper end is provided with a closure so that it is not exposed to the head pressure within the water tank. The tanks form a compact unit housed within a cabinet, the front of which is provided with a control panel for mounting the various control and indicating devices for convenient observation and regulation. The water supply for the apparatus is pressure regulated by the previously noted by-pass valve which, for convenience, is remote from the control cabinet, preferably being placed in or above the sink or bowl usually associated with the water service valves so that the water by-passed by the valve in its pressure regulating capacity is drained away in a convenient manner.

By virtue of operation by water pressure, the apparatus, with the exception of the valves, has no moving parts which are subject to wear. Its operation is found to be extremely quiet and reliable and by reason of the lightweight compact construction of the unit, it may readily be transported and installed in a convenient manner. Further advantages of the invention are disclosed in greater detail in the specification with reference to the drawings illustrating a preferred embodiment so that those skilled in the art will comprehend readily the various modifications to which the invention is subject.

In the drawings:

Figure 1 is a front view of the cabinet which houses the apparatus, illustrating generally the arrangement of the control and indicating devices with respect to the panel which forms the front of the cabinet.

Figure 2 is a diagrammatic view illustrating the complete liquid system and control circuit constituting the apparatus.

Figure 3 is a diagrammatic view illustrating the arrangement and operation of the flow meter which is incorporated in the system.

Figure 4 is a sectional view taken on line 4—4, Figure 1, illustrating a preferred structural arrangement of parts within the cabinet.

Figure 5 is a top plan view of the cabinet unit illustrated in Figure 4 with the respective tops of the cabinet and tanks removed to facilitate illustration.

Figure 6 is a vertical cross section illustrating a preferred form of pressure regulating valve utilized in conjunction with the fresh water supply to regulate input pressure.

Figure 7 is an enlarged side elevation of the pressure responsive switch which is used in conjunction with the mixing tank.

Figure 8 is a side elevation partially in section

illustrating one of the solenoid operated valves which are utilized in the apparatus.

Figure 9 is a view partially in section of one of of the fixed orifices which are used in the apparatus to meter liquid flow.

Figure 10 is a view partially in section illustrating an adjustable metering valve which is employed to vary the strength of the embalming solution.

General structure and operation

The operation of the apparatus is most clearly disclosed with reference to Figure 2 which illustrates diagrammatically the complete liquid distribution system in conjunction with the electric control circuit. In general, the apparatus constitutes a water reservoir **15**, a concentrate reservoir **16** and a mixing tank **17**. Fresh water is supplied constantly to the reservoir from the service line **18** which supplies water at normal service pressure, which may be in the neighborhood of 60 to 100 lbs. per sq. in. Pressure is reduced by the fixed or set variable pressure regulator **20** (Figure 6), the water supply passing from line **18** into regulator **20**, water at reduced pressure being introduced into the water reservoir by way of line **21**. Regulator **20** in general constitutes an adjustable valve which by-passes the high pressure water supply but maintains a fixed back pressure, for example, 18 to 20 lbs. per sq. in. for passage to the reservoir **15**.

As shown diagrammatically, water reservoir **15** is a closed vessel so that air is trapped in its upper portion to form a cushion providing a flexible head pressure which remains practically constant, whereby passage of water from the reservoir can be metered accurately. The concentrate tank **16**, which contains the concentrated embalming fluid, is maintained under the same pressure as the water reservoir. In practice, head pressure is developed by the same cushion of air which is trapped in the water reservoir so that pressure is uniform in both tanks, making it possible to provide a metered flow from the concentrate reservoir, correlated with the metered flow from the water reservoir. Thus, the flow of liquid from each tank can be metered precisely in proportion to provide the desired solution strength. Upon reference to Figure 4, it will be observed that the concentrate tank is disposed within the water reservoir, the top of the tank being open so that the air pressure trapped in the reservoir acts also upon the concentrate; however, for illustrative purposes, in Figure 2, a conduit **22** is shown in connection with both tanks to illustrate the pressure communication between the tanks. If desired, the tanks can be arranged separately as shown in Figure 2, although for compactness, it is preferred to nest them one within another in the manner illustrated in Figures 4 and 5.

As shown, there is provided a supply line **23** leading from the water reservoir to the mixing tank **17** and a supply line **24** leading from the concentrate reservoir **16** to the mixing tank **17**. From the bottom of the mixing tank, there is extended a discharge line **25** for conducting the mixed solution from the mixing tank to the injecting instrument. The flow of liquid from the water and concentrate reservoirs is controlled by solenoid valves **26** and **27** placed in the respective lines **23** and **24**, and a third solenoid valve **28** is placed in the line **25** to control the discharge of liquid from the mixing tank to the injecting instrument. These valves are energized intermittently by a pressure responsive switch unit indicated generally at **30** which is in communication with the mixing tank by the conduit **31**. The solenoid operated valves **26**, **27** and **28** may be identical in construction as illustrated in Figure 8 and the pressure responsive switch assembly is illustrated structurally in Figure 7.

It will be noted that mixing tank **17** constitutes a closed vessel which preferably is placed concentrically within the concentrate tank, as shown in Figure 4, the tank including a top cover plate **32** to isolate it from the air pressure trapped above the liquid level in the concentrate and water reservoirs. In the position shown, the pressure responsive switch holds the solenoid valves **26** and **27** in open position to cause water and concentrate to be conducted to the mixing tank **17** at a metered rate, and as the liquid level in the mixing tank rises, it compresses by displacement the air which is contained in the tank. Upon attaining a sufficient head pressure, as determined by the setting of the pressure responsive switch, the switch is actuated to close the supply valves **26** and **27** and simultaneously to open the discharge valve **28**, causing the mixed solution to be discharged from the mixing tank through line **25** to the injecting instrument, under pressure exerted by the air trapped in the mixing tank. When mixing tank pressure drops to minimum, the pressure responsive switch reacts to open the supply valve **26** and **27** and close the discharge valve **28** to repeat the cycle.

An electric circuit interconnects the supply and discharge valves with the pressure responsive switch to perform automatically this operation. As shown in Figure 2, the circuit is energized by a pair of power lines **33** and **34**, line **33** being connected in common to the coils **35** of the three solenoid valves by means of branch lines **36**, **37** and **38**. The circuit is completed to the opposite ends of the coils **35** through the pressure responsive switch **39**, which includes a pole **40** which is connected to the supply line **34**. As shown, switch **39** is a single pole, double throw unit having contacts **41** and **42**. A line **43** is connected to contact **41**, branching respectively to the coils **35** of valves **26** and **27** so as to complete the circuit through both coils simultaneously when the switch pole is in the position illustrated. Upon being energized, these coils open the respective solenoid valves **26** and **27** to supply concentrate and water to the mixing tank. When a predetermined mixing tank pressure is reached, the position of pole **40** is reversed to close valves **26** and **27** and to establish a circuit from pole **40** to contact **42** to open the discharge valve **28**. The circuit to valve **28** is completed from line **34** through switch pole **40**, line **44**, through the coil of valve **28**, line **38**, to line **33**. It will be observed, therefore, that the mixing tank will be charged and discharged alternately under control of the pressure responsive switch so long as the electric circuit is energized, and concentrate and water supply is maintained.

The operation of the apparatus is controlled by a main power switch **45** which is interposed in the power line **34**, the switch preferably being of the toggle type mounted upon the control panel, as shown in Figure 1. The circuit further is provided with indicating lamps **46** and **47**, the lamp **46** being connected by line **48** in shunt with the coil of supply valve **26** and thus is illuminated each time the solenoid valve is en-

ergized. The lamp 47 is shunted by the line 50 across the coil of discharge valve 28 in the same manner as lamp 46 and indicates the intermittent operation of discharge valve 28. The lamps are mounted behind the control panel 51 and are visible through windows mounted in the panel for this purpose. The windows are identified in Figure 1 by the numerals 46 and 47 to show the location of the respective supply and discharge lamps.

In normal pulsating operation, lamps 46 and 47 will flash alternately as the supply and discharge valves open and close. In performing certain other techniques, the apparatus may be operated at constant delivery instead of pulsating. For this purpose, there is provided a second control switch indicated at 53, interposed in a line 54 which is connected in shunt with respect to the pressure responsive switch. When switch 53 is closed, the circuit to the discharge valve 28 is by-passed from line 34 to line 44 around the pressure responsive switch, thus completing a circuit from line 34 through the coil of valve 28 to line 33 so that the valve is maintained in open position. When the circuit is thus conditioned, the supply valves 26 and 27 will operate as explained before to maintain normal injecting pressure in mixing tank 17 and metered flow of liquid from the water and concentrate reservoirs to the mixing tank. Thus, the supply and mixing apparatus operates under control of the pressure responsive switch because the discharge flow is less than the flow of water and concentrate but since the discharge valve is held open, the mixture is discharged continuously to the injecting instrument.

Flow control apparatus

As above indicated, the concentrate and water reservoirs are maintained at uniform constant pressure in the neighborhood of 18 to 20 lbs. per sq. in. The pressure responsive switch for the mixing tank may be regulated for various pressures and in the present structure, the system has been found to perform best at a setting of approximately 10 lbs. per sq. in. In other words, the pressure responsive switch will maintain the supply valves 26 and 27 in open position until a pressure of 10 lbs. per square inch is developed in the mixing tank before the switch trips to block the supply valves and open the discharge valve 28. Thus, disregarding flow resistance, there is a pressure differential of approximately 10 lbs. between the supply tanks and the mixing tank at the start of each charging operation. Since the water and concentrate reservoirs are under the same pressure, the flow from the respective tanks to the mixing tank can be metered precisely by interposing metering orifices in the supply lines.

In the present structure, a fitting 55, having a fixed metering orifice is interposed in the concentrate supply line 24, and a variable metering or mixing valve 56 is interposed in the line 23 leading from the water reservoir. The fixed orifice in line 24, therefore, permits a fixed quantity of concentrate to pass in a given time period while the adjustable valve 56 permits a fixed quantity of water to pass during the same interval, bearing in mind the fact that both reservoirs are under the same pressure and that both lines are opened simultaneously for the same time period by operation of valves 26 and 27. Thus, the adjustable valve 56 may be regulated so as to supply a fixed quantity of water in proportion to the quantity of concentrate metered by fitting 55.

As an example, in using a commercial embalming concentrate, the mixture may be a weak solution in the proportion of 1 part concentrate to 64 parts water, while a solution of maximum strength may be in the proportion of 16 to 64, depending upon various factors encountered in the operation. By way of example but not of limitation, the fixed orifice in line 24 may meter the concentrate at a flow rate of 1 ounce per minute, while the adjustable metering valve may be regulated to meter the water at a flow rate of 4 to 64 ounces per minute. Thus, the proportion of water to concentrate may be indicated directly with reference to the adjustment dial of the mixing valve by means of calibrations. It will be observed at this point that the adjustable metering valve 56 is placed in the water supply line 23 to provide maximum precision, since the flow of water is far greater than the flow of concentrate. In other words, by fixing the minor flow rate (concentrate) and varying the major flow rate (water) the control of solution is made far more precise than if the concentrate flow were variably metered.

In its preferred form, as illustrated in Figure 10, the variable metering valve is of the needle valve variety, having a control knob 57 operating in conjunction with graduations 58 (Figure 1) which indicate the percentage of solution so that the operator may conveniently vary the solution. The detailed construction of the needle valve, as illustrated in Figure 10, and the fixed orifice fitting, illustrated in Figure 9, are further described in an appropriate section of the specification.

The rate of flow of the solution to the injecting instrument may be varied by a variable metering valve 60 which may be identical in construction to the valve 56, above noted. This valve is regulated by a knob 61 mounted on the face of control panel 51 for convenient manipulation by the operator. In order to provide accuracy of control, the flow valve 60 operates in conjunction with a fitting 62 having a fixed orifice similar to the fitting 55 previously described. The rate of flow is indicated in ounces per minute by a flow gauge indicated at 63 which is interposed between the fixed orifice fitting 62 and variable discharge valve 60.

In general, the flow gauge 63 consists of a conventional pressure indicating gauge which, in conjunction with the flow valve 60, indicates the amount of flow in terms of back pressure. In other words, the solution flows at a fixed rate through the fixed orifice 62, in the present instance, at the rate of 45 ounces per minute when flow valve 60 is wide open; thus, when the flow valve is wide open, back pressure theoretically is at zero, disregarding flow resistance and back pressure beyond the gauge. The graduations of gauge 63 decrease gradually as back pressure increases so that when valve 60 is completely closed with pressure at maximum, the flow gauge will indicate zero. As indicated diagrammatically in Figure 3, the flow gauge is provided with two sets of numerals, the numerals designated at A indicating the flow in ounces per minute when the apparatus is pulsating, the second set B, indicating the flow in ounces per minute under continuous discharge. This arrangement is necessary because there is obviously a greater displacement of solution under con-

tinuous discharge at a given pressure than at intermittent discharge. The dial further includes a mark 65 which indicates dangerous back pressure under certain conditions as described later in detail.

Structure and arrangement of parts

As shown in Figures 4 and 5, the respective tanks 15, 16 and 17 preferably are nested one within the other and enclosed by a cabinet 66, the front of which is provided with the aforesaid control panel 51. The cabinet includes a base plate 67 upon which the tank assembly is mounted in an elevated position by the angle brackets 68 which are secured to the bottom of tank 15, preferably by soldering or brazing. The lower ends of the brackets are secured to the base plate 67 and thus support the tank in an elevated position so that the various conduits may enter directly into the bottom of the tanks, as illustrated. The top of the cabinet includes a cover plate 71 and the water reservoir includes a cover plate 72. In order to replenish the concentrate reservoir, a filler tube 73 passes in sealed relationship through the tank top 72 and extends through the cabinet top 71 for convenience in adding the concentrate to the apparatus. The upper end of the filler pipe includes a screw-threaded cap 74 which provides a seal to prevent loss of air pressure.

A liquid level gauge 75 (Figures 1, 2 and 4) indicates the liquid level of the concentrate within the reservoir, the gauge being visible through an opening formed in the control panel and having a transparent graduation plate 76 (Figure 1) secured to the control panel to indicate the level. The bottom of the liquid reservoir is connected to the concentrate tank by a tube 77 which extends through the tank bottom and into connection with the lower end of the gauge while the upper end of the gauge is connected to a tube 78 which communicates with the water reservoir. The various control and indicating components of the apparatus are appropriately mounted upon the rear surface of the control panel 51 in the manner shown in Figure 5. The tubes and components bear the same reference numerals as indicated on the diagram of Figure 2 and may be identified readily.

The various components detailed in Figures 6 to 10 are intended to represent preferred structures only, since the units may take other forms, in some instances commercially available units being usable. Figure 6 illustrates the water pressure regulating and supply valve which is indicated generally at 20 in the diagram. In the form illustrated, the unit consists of a chamber 80 having the water supply conduit 18 screwthreaded into its upper end, and the previously noted supply conduit 21 screwthreaded laterally into the upper portion of the chamber. Within chamber 80, there is mounted, a valve consistituting a slidable stem 82 having a bead 83 at its upper end cooperating with a valve seat formed in a partition 84 which is welded within the inside diameter of the chamber near its upper end. The upper end of the valve stem is slidably guided by a cross strap 85 extending crosswise of the chamber, and the lower end of the stem is guided by a cap 86 which is adjustably screwthreaded upon the lower end of the chamber. A spring 87 is maintained in compression between cap 86 and a disk 88 secured to the valve stem so as to maintain the valve under spring pressure in its closed position, as shown. Cap 86 includes drainage holes 90 to permit the water which is by-passed by the valve to drain freely and output pressure is increased or decreased by adjusting the cap 86 to increase or decerase the pressure of spring 87.

Water at service pressure is introduced into the upper end of the chamber through the conduit 18 and flows through tube 21 until the desired back pressure of 18 to 20 lbs. is developed in the water reservoir. When this pressure is reached, it is sufficient to actuate valve 83 to by-pass the supply through the holes 90, the unit preferably being located above a sink or drainage receptacle. It will be apparent that as water is withdrawn from reservoir 15, back pressure will be reduced whereupon the valve will replenish the reservoir. It has been found in operation that this arrangement is capable of maintaining the pressure within very close limits so as to render the operation of the injecting machine uniform and reliable.

The pressure responsive switch 30, as illustrated in Figure 7, is mounted within cabinet 66 by means of angle brackets 91 which are secured to a base plate 67. The switch is actuated by a conventional pressure operated metal bellows 92, having a lower end plate 93 which is secured upon the brackets 91. A fitting 94 extends through the mounting plate and is connected to the mixing tank 17 by the conduit 31 previously noted. The bellows is provided with a vertical actuating stem 95 which is mounted upon a disk 96 secured upon the upper end of the bellows. This stem passes slidably through a knurled adjustment screw 97 which is screwthreaded through a plate 98 mounted upon spacers 99 rising from the mounting plate 93. A compression spring 100 is interposed between disk 96 and the end of screw 97 to regulate the pressure required to actuate the microswitch 39. As shown, the microswitch is mounted above the stem 95 upon a U-shaped bracket 103, the switch being clamped in position by nuts 104—104 and having its actuating stem 105 closely adjacent the upper end of stem 95. The position shown in Figure 7 corresponds to that shown diagrammatically in Figure 2; and it will be apparent that when fluid pressure is applied to the bellows, it will expand causing its stem 95 to depress plunger 105 of the switch to reverse the switch position. After experimentally setting the adjustment screw 97, the assembly may be left undisturbed, the routine adjustments being made by the control knobs 57 and 61 which are mounted upon panel 51.

A typical solenoid operated valve which represents valves 26, 27 and 28, is illustrated in Figure 8. This valve constitutes a valve body 106 having a fitting 107 upon which is clamped a solenoid unit 108. The valve is conventionally designed and for this reason the mechanism of the solenoid is not detailed. Fitting 106 is bored to provide a chamber 110 in which is located a valve seat 111 cooperating with a vertically slidable needle valve 112. When the solenoid is energized, the needle valve is lifted from its seat to permit liquid to flow from the conduit 113 which represents the conduits 23, 24 or 25 indicated in the diagram. The liquid flows in the direction indicated by the arrow through a lateral passageway 114 to chamber 110, passing through aperture 115 to valve seat 111 to a passageway 116 communicating with the outlet end of the valve.

The fixed orifice fittings **55** and **62** of the diagram, which may be identical, are detailed in Figure 9. The fitting constitutes a body member **117** having a large bore **118** at its receiving end which provides a shoulder for fitting a sediment screen **120** which is secured preferably by applying solder to the periphery of the screen. The restricted orifice is indicated at **121** and is formed by drilling a small hole through the body of the valve. The liquid flows through the fitting in the direction indicated by the arrows, passing first through screen **120**, then through the fixed orifice **121** to the opposite end of the housing. The tube sections **122** and **123** represent either the liquid conduits **24** or **25**, in practice the tubes being connected to the valve body by standard tube couplings **124**—**124** which are screwthreaded on the opposite ends of the fitting.

The variable flow metering or mixing valve **56** is detailed in Figure 10 and, in general, consists of a valve body **125** having a boss **126** in which is screwthreaded a valve stem **127**. For accuracy of control, the valve is of conventional needle valve construction, the lower end of stem **127** being tapered as at **128** to meter the flow of liquid through the valve orifice **130**. The valve is controlled by the knob **57** previously noted which includes an indicator finger which operates in conjunction with the graduated dial plate **58** to indicate to the operator the proportion of water and concentrate being mixed. The valve is located in the water supply line **23** and, as shown, the conduit **23** is connected to the opposite ends of the valve body by the tube couplings **131**—**131**.

Operation

In summary, the apparatus is conditioned for operation by filling the concentrate tank **16** and opening the main water service control valve (not shown) to admit fresh water by way of pipe **18**, through regulating valve **20** to water reservoir **15**. With the control circuit deenergized, the supply valves **26** and **27** and discharge valve **28** are in closed position; therefore, as reservoir **15** fills, the air trapped in the tank is compressed. When operating pressure, as determined by the setting of regulator **20**, is reached, the water delivered by conduit **18** will by-pass through the valve. The apparatus is now ready for operation.

With the injecting instrument in position and connected to the discharge tube **132** which extends from instrument panel **51** (Figure 1) pulsating injection operation may be started by closing the main control switch **45** to energize the operating circuit. The control knob **57** of mixing valve **56** is adjusted to the desired mixture and the flow control valve **60** is adjusted by the knob **61** to the desired flow rate, as indicated by flow gauge **63**. It is to be noted at this point that the flow gauge will indicate maximum flow before the apparatus is placed in operation since, as previously noted, the gauge operates by indicating back pressure as developed by valve **60**; therefore, in order to obtain the desired flow rate, it is advisable to adjust the rate while the apparatus is in operation.

Gauge **63** performs a dual function since, in addition to indicating the rate of flow, it is responsive to changes in back pressure which may develop in the circulatory system during the injection. During pulsating operation, the needle oscillates in accordance with the rise and fall of pressure and in time with the flashing of the indicator lights **46** and **47**. Normally the needle should swing within a range defined by the rate

of flow as determined by the adjustment of flow valve **60**. By way of example, should the valve be set for 15 ounces per minute, as illustrated diagrammatically in Figure 3, the needle should indicate this rate intermittently at each flash of the discharge indicating lamp **47**, at which moment discharge valve **28** is open and fluid is being injected. During the charging cycle when supply valves **26** and **27** are open, indicating lamp **46** will flash and at this moment pressure should decrease to a minimum value and thus cause the indicating needle to swing to an apparently higher rate of flow, as indicated in broken lines, by reason of the drop in pressure. Disregarding back pressure and assuming that pressure in line **132** drops to zero, at this moment, the flow gauge needle would indicate an apparent maximum rate of 45 ounces per minute although there is no flow. Practically, however, there is present a certain amount of back pressure due to flow resistance in the circulatory system and other factors, which will prevent the needle from reaching its maximum flow indication. By way of example, back pressure in the circulatory system sufficient to hold the indicating needle at the position shown in broken lines in the diagram may be considered safe. However, should the needle fail to pass over the danger mark **65** between injection surges, it may be assumed that an abnormal condition exists and that excessive back pressure is being generated which may lead to dilation or distension of the blood vessels and swelling of parts of the body. In this case, the operator should immediately take steps to remedy the situation, either by shutting down the apparatus or by reducing the rate of flow to a safe factor.

In performing the operation, some cases require that the solution be varied in accordance with conditions encountered as the chemical change progresses in the tissues. For example, if discoloration is present, it may be advisable to begin the operation with a relatively weak solution so that the capillaries may be washed out, after which the solution strength is increased until proper preservation is attained. By placing under accurate control both the rate of flow and the proportion of mixture, the variable factors can be accommodated very conveniently and quickly in accordance with changing conditions.

If conditions so require, the pulse regulation switch **53** may be closed to provide a constant discharge. When the circuit is so conditioned, the discharge valve **28** is held open constantly and the concentrate and water flow turned on and off, as previously explained.

If the machine is not to be reused immediately after the embalming operation is completed, the residue of concentrate and water is drained from the respective reservoirs **15** and **16** by opening the drain cocks **135** and **136** (Figure 2). It will be noted in Figure 4, that the various conduits pass into the bottom of the tanks to facilitate drainage and that the stop cocks **135** and **136** are located below the level of the apparatus so that all of the liquid is withdrawn from the system by siphon action. After drainage, it is recommended that the system be flushed with fresh water which may be introduced into the concentrate tank through the filler pipe **73**. The apparatus then is placed in operation as before, preferably with the switch **53** in closed position to permit the water to flow freely through discharge line **25** to remove all residue from the

system. After a flushing period, the remaining water may be drained from tanks 15 and 16 as before, leaving the switch 53 closed to hold the discharge valve open to insure drainage of the entire system after which the main switch 45 is opened to deenergize the circuit.

Having described my invention, I claim:

1. An embalming apparatus or the like comprising; a water reservoir, a concentrate reservoir, a mixing unit, delivery means for introducing water and concentrate from the respective reservoirs into the mixing unit, means for applying a uniform air pressure in common upon the respective water and concentrate reservoirs to force the water and concentrate at substantially equal pressures into the delivery means, respective metering devices in said delivery means operable in conjunction with the air pressure means to meter the flow of water and concentrate to the mixing unit, a conduit for delivering the solution from the mixing tank to an injecting instrument, a pressure responsive device connected to the mixing unit, a discharge valve in said conduit adapted to control the delivery of solution from the mixing unit, and connecting means between said pressure responsive device and said discharge valve adapted to open said valve when a predetermined pressure is developed within the mixing unit.

2. An embalming apparatus comprising; a water reservoir, a concentrate reservoir, a closed mixing tank, a respective delivery system connecting the water and concentrate reservoirs to the mixing tank, respective metering devices in said delivery systems operable to provide a metered flow of water and concentrate from the respective reservoirs to the mixing tank, a water supply system in communication with the water reservoir operable to supply water to the reservoir in accordance with the quantity of water drawn from the reservoir, means for transmitting the pressure developed in the water reservoir to the concentrate reservoir, a discharge conduit connected to the mixing tank, a discharge valve in said conduit, a pressure responsive device connected to the mixing tank, means connecting the discharge valve to the pressure responsive device operable to open the discharge valve when a predetermined pressure is developed in the mixing tank and to close the valve when the pressure drops below said predetermined pressure, a variable flow metering valve in the discharge conduit operable to regulate the rate of flow through the conduit, and a pressure responsive gauge in the discharge conduit operable in conjunction with the variable flow metering valve to indicate the rate of flow in accordance with the back pressure developed by the valve.

3. An embalming apparatus comprising; a water reservoir, a concentrate reservoir, a closed mixing tank, a respective delivery system connecting the water and concentrate reservoirs to the mixing tank, a fixed metering device in the concentrate delivery system, a variable metering device in the water delivery system operable in conjunction with the fixed metering device to provide a proportioned flow of water and concentrate from the respective reservoirs to the mixing tank, a water supply system in communication with the water reservoir operable to supply water to the reservoir in accordance with the quantity of water drawn from the reservoir, means for transmitting the pressure developed in the water reservoir to the concentrate reservoir, a discharge conduit connected to the mixing tank,

a discharge valve in said conduit, a pressure responsive device connected to the mixing tank, means connecting the discharge valve to the pressure responsive device operable to open the discharge valve when a predetermined pressure is developed in the mixing tank and to close the valve when the pressure drops below said predetermined pressure, and a variable metering valve in the discharge conduit operable to regulate the rate of flow through the conduit to an injecting instrument.

4. An embalming apparatus or the like comprising; a water reservoir, a concentrate reservoir, a closed mixing tank, delivery means for introducing water and concentrate from the respective reservoirs into the mixing unit, means for applying a uniform delivery pressure upon the respective water and concentrate reservoirs, respective metering devices in said delivery means operable in conjunction with the delivery pressure means to meter the flow of water and concentrate to the mixing tank, a pressure responsive device connected to the mixing tank, an electrical switch connected to the pressure responsive device and adapted to be actuated in response to a predetermined pressure in the mixing tank, a conduit for delivering the solution from the mixing tank to an injecting instrument, an electrically operated valve in said conduit in electrical connection with the electrical switch and arranged to provide a pulsating discharge of solution from the apparatus in response to the changes in pressure within the mixing tank, a variable discharge valve in the delivery conduit operable to control the rate of solution discharge, and a pressure responsive gauge in the solution delivery conduit operable in conjunction with the variable discharge valve to indicate the rate of discharge flow in accordance with back pressure developed by the variable discharge valve, the pressure responsive gauge being operable between discharge pulsations to indicate back pressure at the injecting instrument.

5. An embalming apparatus or the like comprising; a pressurized water reservoir, a concentrate reservoir, a mixing tank, a respective delivery system connecting the water and concentrate reservoirs to the mixing tank, respective flow control devices in said delivery systems operable to provide a metered flow of water and concentrate from the respective water and concentrate reservoirs to the mixing tank, means for transmitting the pressure of the water reservoir to the concentrate reservoir whereby the water and concentrate are delivered to the mixing tank in proportions determined by the said flow control devices, a discharge system connected to the mixing tank, an electrically operated valve interposed in said discharge system, a pressure responsive device connected to the mixing tank, an electrical switch operatively connected to the pressure responsive device, said switch being electrically connected to the electrically operated valve and being operable to open said valve when the pressure in the mixing tank reaches a maximum value to discharge the mixture and operable to close the valve when the pressure reaches a minimum value to provide a pulsating discharge of mixed solution from the mixing tank.

6. An embalming apparatus or the like comprising; a water reservoir, a concentrate reservoir, a mixing tank, a respective supply system for conducting water and concentrate from the respective reservoirs to the mixing tank, re-

spective supply valves in the supply systems operable to regulate the flow of water and concentrate to the mixing tank, a pressure responsive device connected with the mixing tank and operated in accordance with the quantity of water and concentrate introduced into the mixing tank, an electrical valve control switch connected to the pressure responsive device and arranged to be actuated by the pressure responsive device, a discharge system communicating with the mixing tank, a discharge valve interposed in the discharge system, the respective supply and discharge valves being interconnected electrically with the valve control switch to open the supply valves and close the discharge valve when the quantity of solution in the mixing tank is at minimum and to open the discharge valve and close the supply valves when the quantity of solution in the mixing tank is at maximum.

7. An embalming apparatus or the like comprising; a water reservoir, a concentrate reservoir, a closed mixing tank, a respective supply system for conducting water and concentrate under controlled pressure from the respective reservoirs to the mixing tank, respective electrically operated supply valves in the supply systems operable to regulate the flow of water and concentrate to the mixing tank, a pressure responsive device connected with the mixing tank and operable in response to the pressure developed by the quantity of water and concentrate introduced into the mixing tank, an electrical switch connected to the pressure responsive device and arranged to be actuated by said device, a discharge system communicating with the mixing tank, an electrically operated discharge valve interposed in the discharge system, the respective supply and discharge valves being interconnected electrically with said electrical switch to open the supply valves and close the discharge valve when the pressure of solution in the mixing tank is at minimum and to close the supply valves and open the discharge valve when the pressure of solution in the mixing tank is at maximum.

8. An embalming apparatus or the like comprising; a water reservoir, a concentrate reservoir, a closed mixing tank, a respective supply system for conducting water and concentrate under controlled pressure from the respective reservoirs to the mixing tank, respective flow control devices in said supply systems arranged to regulate the volume of water and concentrate introduced into the mixing tank, respective electrically operated supply valves in the supply systems operable to time the flow of water and concentrate to the mixing tank, a pressure responsive device associated with the mixing tank and operated in accordance with pressure developed by the quantity of water and concentrate introduced into the mixing tank, an electrical switch connected to the pressure responsive device and arranged to be actuated by said device, a discharge system communicating with the mixing tank, an electrically operated discharge valve interposed in the discharge system, the respective supply and discharge valves being interconnected electrically with the said electrical switch to open the supply valves and close the discharge valve when the pressure of solution in the mixing tank is at minimum and to close the supply valves and open the discharge valve when the pressure of solution in the mixing tank is at maximum.

9. A machine for mixing and delivering a solution of water and embalming concentrate comprising; a closed vessel constituting a water reservoir adapted to maintain the water under pressure by air trapped therein, means for supplying water to the reservoir at predetermined pressure, a concentrate reservoir nested within the water reservoir, the concentrate reservoir being open to the air trapped within the water reservoir to maintain the concentrate under the same pressure as the water, a mixing tank constituting a closed vessel nested within the concentrate reservoir, respective supply conduits extending from the water and concentrate reservoirs to the mixing tank including means for metering at differential rates the supply of water and concentrate to the mixing tank, an electrically operated supply valve in each of said supply conduits, a delivery conduit connected with the mixing tank operable to deliver the mixed solution to an injecting instrument, an electrically operated discharge valve in the discharge conduit, a pressure responsive device connected to the mixing tank, said device including a two-position switch electrically connected to the supply and discharge valves and thereby to charge and discharge the mixing tank intermittently to provide a pulsating discharge of solution.

10. An embalming apparatus or the like comprising; a water reservoir, a concentrate reservoir, a closed mixing tank, a respective supply system for conducting water and concentrate at predetermined pressure and rates of flow from the respective reservoirs to the mixing tank, respective electrically operated supply valves in the supply systems operable to regulate the flow of water and concentrate to the mixing tank, a pressure responsive device associated with the mixing tank including an automatic switch adapted to be operated in accordance with the quantity of water and concentrate introduced into the mixing tank, a discharge system communicating with the mixing tank, an electrically operated discharge valve interposed in the discharge system, the respective supply and discharge valves being interconnected electrically with the automatic switch to open the supply valves and close the discharge valve when the quantity of solution in the mixing tank is at minimum and to open the discharge valve and close the supply valves when the quantity of solution in the mixing tank is at maximum to provide a pulsating discharge, and a two-position manually operated control switch interconnected with the discharge valve, the said switch in one position providing an open circuit to allow said pulsating discharge by operation of the automatic switch and in a second position being operable to maintain the discharge valve in open position to provide a continuous discharge from the mixing tank.

11. An embalming apparatus for intermittently discharging a uniform solution of water and concentrate comprising; a water reservoir, a concentrate reservoir having a changing liquid level, a closed mixing tank, a supply conduit connecting the water reservoir to the mixing tank, a second supply conduit connecting the concentrate reservoir to the mixing tank, a respective metering device in each of said supply conduits operable to provide a metered flow of water and concentrate from the respective reservoirs to the mixing tank, a water supply system including a pressure regulating device connected to the water reservoir operable to supply water

constantly at a predetermined charging pressure to the water reservoir, the water reservoir being adapted to trap and compress a volume of air above the water contained therein to maintain a constant charging pressure, means for conducting the air pressure of the water reservoir to the concentrate reservoir whereby the water and concentrate are delivered through both of said supply conduits to the mixing tank at uniform charging pressure, a discharge conduit connected to the mixing tank, a pressure responsive device connected to the mixing tank, a discharge valve in said discharge conduit adapted to control the discharge of water and concentrate solution from the mixing tank, means connecting said pressure responsive device to the discharge valve, the pressure responsive device being operable to open said discharge valve when a predetermined discharge pressure is developed within the mixing tank and to close the valve when the discharge pressure drops to a predetermined limit, the pressure responsive device being constructed and arranged to operate the discharge valve within discharge limits substantially less than the charging pressure maintained within the water reservoir to provide metering of concentrate and water at a pressure which is sufficiently high to overcome the hydrostatic effect of the concentrate liquid level, whereby a uniform mixture is provided as the concentrate liquid level decreases.

12. An embalming apparatus for intermittently discharging a uniform solution of water and concentrate comprising; a water reservoir, a concentrate reservoir having a changing liquid level, a closed mixing tank, a supply conduit connecting the water reservoir to the mixing tank, a second supply conduit connecting the concentrate reservoir to the mixing tank, a respective metering device in each of said supply conduits operable to provide a metered flow of water and concentrate from the respective reservoirs to the mixing tank, a water supply system including a pressure regulating device connected to the water reservoir operable to supply water constantly at a predetermined charging pressure to the water reservoir, the water reservoir being adapted to trap and compress a volume of air above the water contained therein at the predetermined charging pressure, means for conducting the air pressure of the water reservoir to the concentrate reservoir whereby the water and concentrate are delivered through both of said supply conduits to the mixing tank at the uniform charging pressure and at a flow rate determined by said metering devices, a discharge conduit connected to the mixing tank, a pressure responsive device connected to the mixing tank, a discharge valve in said discharge conduit adapted to control the discharge of solution from the mixing tank, a respective supply valve in each of said water and concentrate supply conduits, means connecting said pressure responsive device to the said supply and discharge valves, the pressure responsive device being operable to open said discharge valve and to close said supply valves when a predetermined discharge pressure is developed within the mixing tank and to close the discharge valve and open the delivery valves when the discharge pressure drops to a predetermined limit, the pressure responsive device being constructed and arranged to operate the supply and discharge valves within discharge pressure limits substantially less than the charging pressure maintained in the water reservoir to provide metering of concentrate and water at a pressure which is sufficiently high to overcome the hydrostatic effect of the liquid level in the concentrate reservoir, whereby a uniform mixture is provided as the concentrate liquid level decreases.

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