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2,959,151

APPARATUS FOR MULTIPLE LIQUID TREATMENTS OF MATERIALS

Filed April 8, 1954

3 Sheets-Sheet 1

Fig. 1.

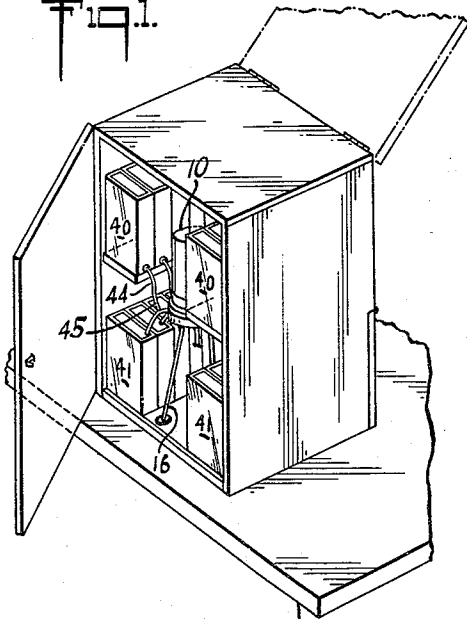


Fig. 2.

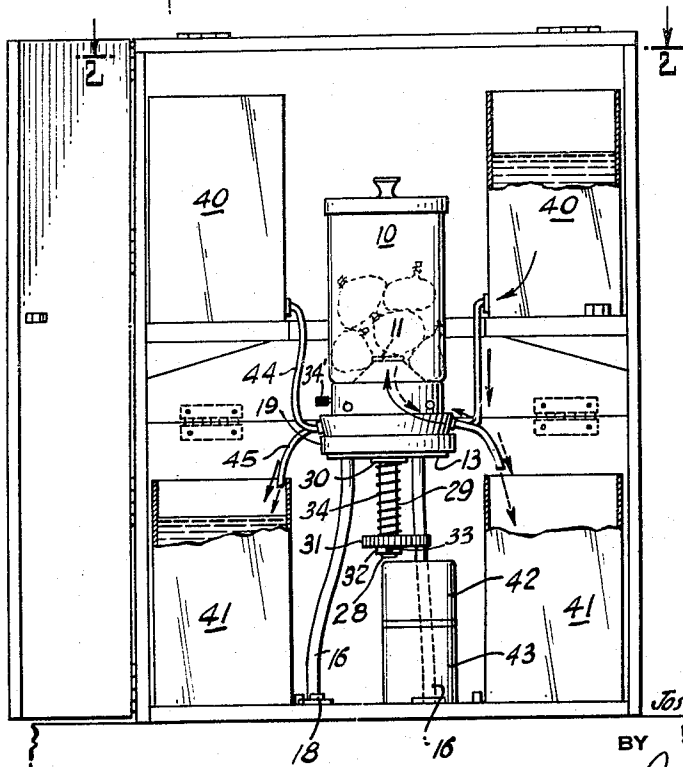
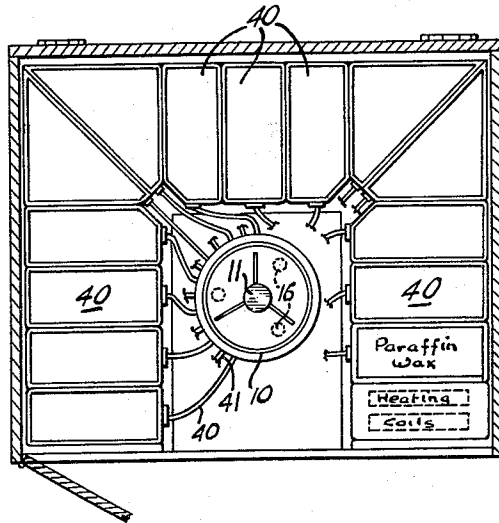


Fig. 3.

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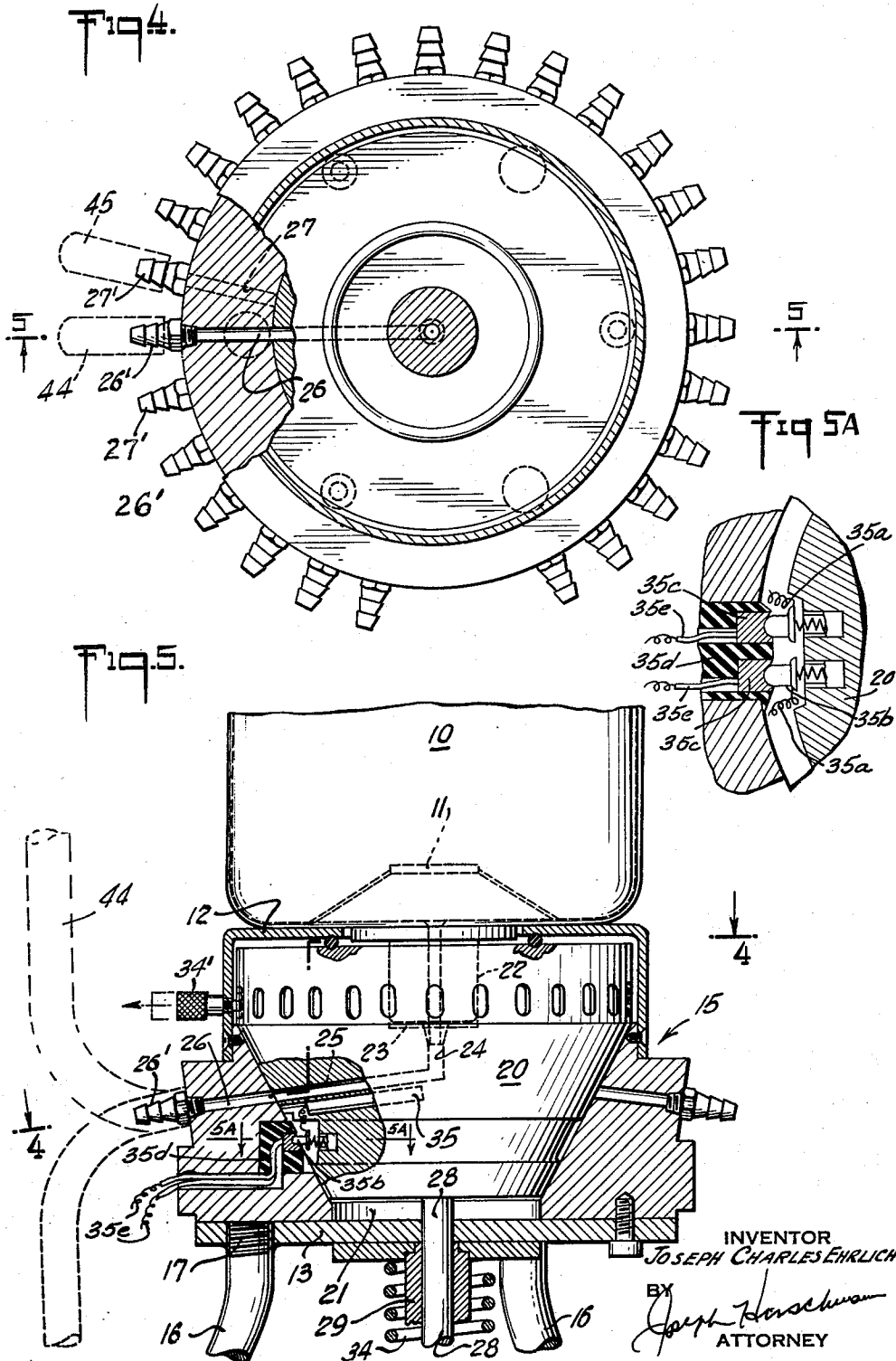
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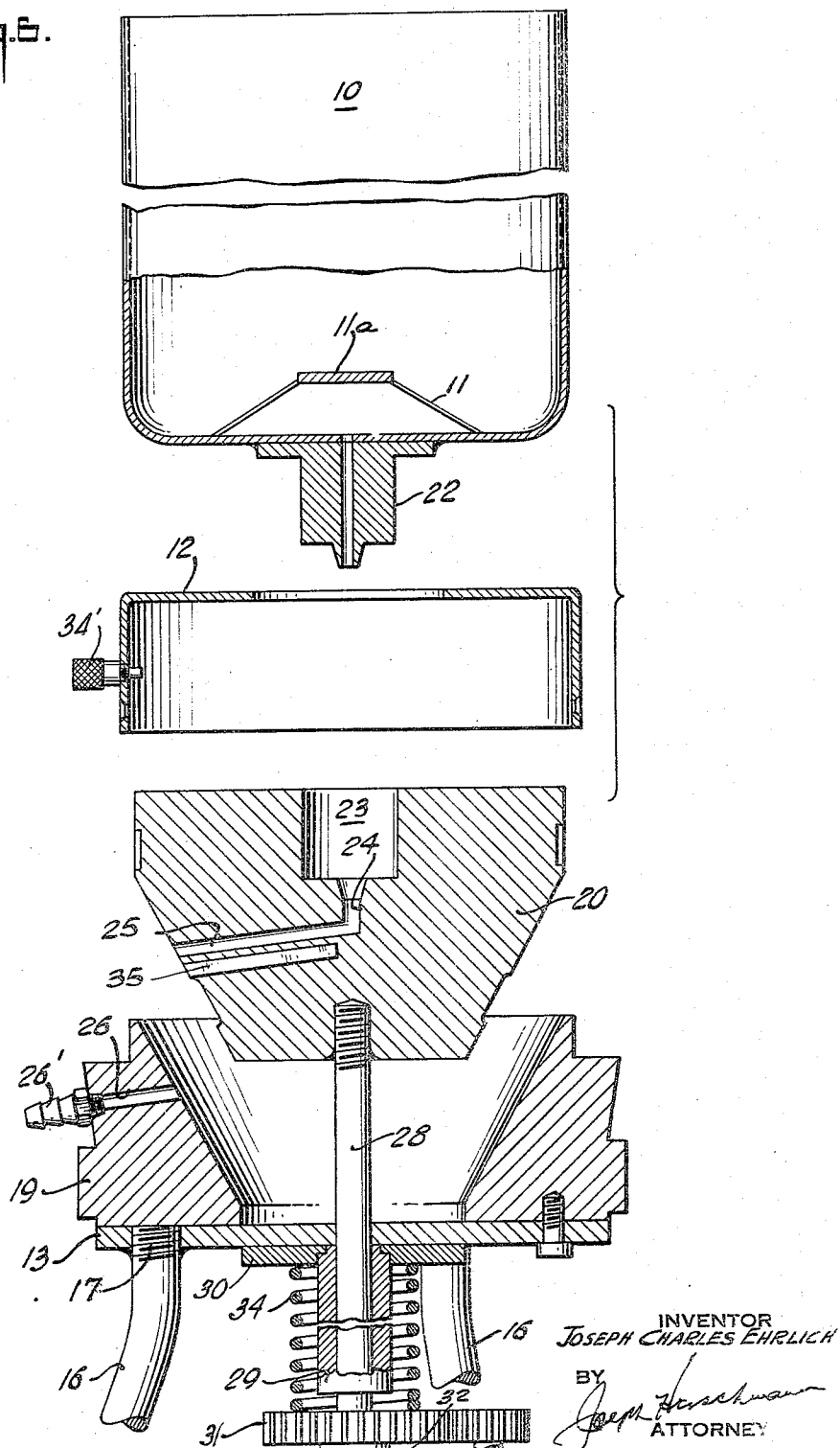
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APPARATUS FOR MULTIPLE LIQUID TREATMENTS OF MATERIALS

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13 Claims. (Cl. 118—429)

The present invention relates to apparatus for the treatment of various materials successively with a plurality of different liquids, or with liquids having an active component of different concentrations, or with both types of liquids for effecting extraction, staining, washing or other treatment.

The invention is of particular utility for the preparation of human and animal tissue specimens for microscopic examination and will accordingly be further described, and by way of example, in connection with an apparatus for executing automatic or semi-automatic treatment of such specimens in the preparation of histological slides for microscopic examination.

It is the general object of the invention to provide an apparatus for automatically bringing a series of solutions of liquids or any desired or required number one after another into contact with the specimens to be treated, and removing the liquids or solutions from the specimens after predetermined intervals of treatment.

More specifically it is an object of the invention to provide an apparatus whereby a series of liquids operating to dehydrate completely the specimens of tissue are charged in succession to the specimens and successively removed therefrom and the specimens then infiltrated or impregnated with a substance, such as paraffin, in order to prepare the specimens for embedding, cutting and staining for the completion of histologic preparations for microscopic study.

For many years, the objective of the serial and consecutive immersion or treatment of specimens of tissue in different fluids was accomplished by individual manual transfer of the specimens from one container of fluid to the next at stated time intervals. The hand processing method is prolonged, consumes personnel time, is dependent on the personal equation, cannot be conveniently carried out during nights, weekends or holidays because of the absence of personnel and is altogether antiquated and inadequate for the needs of modern-day tissue diagnosis, which depends to an important degree on the shortness of the time interval between the removal of the tissue specimen from the patient and the presentation of a completed histologic slide to the pathologist for microscopic diagnosis.

During recent years, an automatic processing machine has been employed which involves the use of a carriage or basket into which the specimens are placed, such carriage or basket being rotated step-by-step and being automatically actuated to dip into a solution and is then, after a predetermined time interval, lifted out of such solution and rotated into a position above the next container holding a solution into which it is then dipped, and this series of movements is repeated for every liquid-containing receptacle. The various receptacles are arranged on the circumference of a circle, and the carriage or basket is suspended from an arm, which consists of a radius of such circle attached to a post in the center of the circle, the whole being actuated by an electric clock

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mechanism whose successive instants of stopping and starting are pre-set. This arrangement has proved in actual practice to be excessively complex and is subject to repeated breakdown from a variety of mechanical causes resulting in repeated instances in which the specimens remain suspended in their basket without being immersed in a fluid. Such occurrences are extremely serious since the tissues thus suspended dry out during the hours of the night or weekend and are destroyed. In consequence, the surgical procedure to which the patient was subjected is vitiated, the diagnosis cannot be made, and either the patient must be subjected to another operation to obtain additional tissue, or if the entire diseased tissue was completely removed at the first operation, a diagnosis can never be made because of the irreplaceable loss.

It is accordingly a further object of the invention to provide an improved apparatus for automatically charging a plurality of liquids in succession into a receptacle which is characterized by a minimum of moving parts and wherein the movements are of such simple nature that the danger of mechanical failure is practically eliminated.

It is also an object of the invention to provide an apparatus of the type indicated wherein the control of the feed of the various liquids is effected primarily by means of a rotatable valve mechanism of simple construction.

Other features and advantages of my invention will become apparent from the more detailed description thereof hereinafter.

The apparatus of the present invention is capable of accomplishing the automatic processing of specimens without the hazard of destruction of the specimens and with a marked increase of capacity and of efficiency of dehydration or other treatment because of the higher available ratio of fluid to specimens. According to a preferred form of the invention, there is provided a single central receptacle of suitable capacity in which a large number of specimens can be placed with any required or preferred ratio of volume of fluid to volume of specimens, said receptacle with its contained tissues remaining stationary during the processing. My invention makes possible the complete elimination of a perforate basket container for the specimens and also of the steps of repeated immersion and lifting out and re-immersion in a succession of containers, the result being that at no time are the specimens which had been originally placed in the receptacle removed therefrom until after the completion of the cycle of chosen processing steps. Instead of the specimens being carried in succession from one receptacle of fluid to another, the fluids themselves are automatically conducted to and from the specimens. In my improved apparatus the fluids are separately and successively caused to flow into a fixed receptacle, and after a predetermined period of time each is drained from the receptacle, after which the next fluid enters the receptacle and is later drained therefrom, this being repeated for a selected number of steps. The consecutive exchanges of fluids are accomplished by a novel multiple valvular device which operates automatically from an electrically driven motor mechanism, which is in turn actuated for stopping and starting, for each of the steps in the processing procedure, by a conventional electric clock mechanism of a type which permits the pre-setting of chosen time intervals. The central receptacle which holds the specimens is provided with a suitable cover, so that in the event of some unforeseen failure of the automatic mechanism at a moment when the receptacle is in the drained or partly drained condition, it will be impossible for the specimens to become dried out or destroyed, or even spoiled to any critical degree, by virtue of the fact that in the covered receptacle the specimens will remain immersed in an

atmosphere of vapor of the treating fluid, such vapor sufficing to keep the specimens in a moist and well-preserved condition for many days, within which time the mechanical failure would be discovered by the personnel in charge of the apparatus. Furthermore, the liquid containers and the receptacle and other parts of my apparatus are made of metal, thus eliminating completely the hazards of breakage of glass containers of the type currently in use. Finally, in one form of my invention, there is only a single moving part, namely the automatic multiple valve with its associated electric motor drive and the automatic "stop and start" clock mechanism.

In the simplest form of my apparatus, the force for the movement of fluid is provided by gravity. The arrangement of inlets and outlets of the multiple valve is such that all containers of fluid to be charged into the central receptacle containing the specimens are on a higher level than the top of said central receptacle, and all containers for receiving discharged fluid from the central receptacle are located on a lower level than such central receptacle. It is the function of the automatic multiple valve to choose serially each fluid for entry into the central receptacle from the containers on the higher level, and then to discharge them in turn into the containers on the lower level. For the resetting and re-operation of the instruments the following day or the next occasion for use, it is necessary only for the attendant to raise each container from the lower level and manually pour the contents thereof into the respective container on the upper level. Since the containers on both the upper and lower levels will be made of metal, these can be designed of suitable rectangular form and height so that they will occupy a minimum of shelf space and provide as many changes as needed up to as much as twenty four, instead of the conventional twelve changes currently available. In the case of substances which must be maintained at higher than room temperatures, such as the commonly used paraffin, the container on the upper and lower level for such paraffin and also the central receptacle with its contained specimens, the multiple valve itself, and also the ducts connecting these last named units, could be heated automatically to the proper degree by thermostatically controlled electric heating elements.

A preferred embodiment of the invention is diagrammatically illustrated on the attached drawing, wherein:

Fig. 1 is a perspective view of my complete apparatus, mounted on a table;

Fig. 2 is an enlarged sectional view in plan taken along the line 2—2 of Fig. 3;

Fig. 3 is a view of the apparatus in elevation, partly in section;

Fig. 4 is an enlarged section taken through the distributing valve along the line 4—4 of Fig. 5;

Fig. 5 is a further enlarged view of the distributing valve structure in elevation, partly in section, and is taken along the line 5—5 of Fig. 4;

Fig. 5A is a horizontal section along the line 5A—5A of Fig. 5; while

Fig. 6 is an exploded view of the distributing valve and its associated parts, the same being in vertical section.

In the form of the invention illustrated, which is intended for use in the treatment of human and animal tissues to prepare the same for microscopic study, there is arranged a central receptacle 10 which may be provided with a foraminated support 11 for one or more specimens of tissue and having a cover through which passes an agitator for insuring thorough impregnation of the tissue material with the successive treating liquids, the agitator being operated by a motor which may be mounted on the cover. As this mechanism is conventional, it has not been illustrated in the drawing. The receptacle may be provided with a baffle plate 11a to prevent geysering of the liquid flowing into the receptacle.

The receptacle 10 is supported on a plate 12 between which and a second plate 13 is disposed a valve 15 which will be described shortly. The lower plate 13 is mounted on supporting legs 16 by way of threaded connections 17, and the legs in turn may be anchored to the floor or other support by means of bolts or screws 18.

The valve 15 arranged between the plates 12 and 13 is composed of a valve casing 19, which is stationary, and a movable valve body 20. The valve casing 19 has a central opening which is preferably of conical shape, as shown, and the valve body is similarly of frusto-conical shape, so as to insure a tight fit between the valve casing and body. The casing extends below the valve body to provide an excess space 21 to allow for relative movement between the body and casing, in the event of unequal expansion of the parts. The valve casing and body, and likewise the plates 12 and 13, are preferably made of metal. The valve body can be packed with a grease or the like which is insoluble in the treating liquids to insure a liquid-tight fit between itself and the casing.

The receptacle 10 is provided with a nipple 22 which passes through the plate 12 and into a central opening in the valve body 20. This nipple fits snugly into an opening 23 in the valve body, and is in communication with a central bore 24 in the valve body which leads to a duct or passageway 25 opening on the outside conical face of the valve body. Upon rotation of the valve body, the passageway 25 is brought into communication with an alternating series of bores 26 and 27 in the stationary casing 19 which communicate with fittings 26' and 27' respectively. The fittings 26' are adapted to receive tubes 44, preferably flexible in character, leading from a bank of supply containers 40 for the bodies of treating liquid arranged above the level of the receptacle 10, while the fittings 27' are similarly adapted to be connected by flexible tubes 45 to a bank of receiving or drainage containers 41 arranged below the level of receptacle 10. The containers are spaced approximately uniformly about the axis of the central receptacle 10.

It will be evident from the foregoing that upon stepwise rotation of the valve body 20, the passage 25 will be brought into communication with the successive bores 26 and 27, so as to receive a body of liquid from a supply container 40 and thereafter discharge such liquid into its associated drainage container 41, after which the passageway 25 is brought into communication with the next bore 26 connected with the next supply container, and this is repeated until the tissues in the receptacle 10 have been subjected to the complete cycle of treatment. To insure complete drainage of the receptacle 10, the passageway 25 and the bores 27 are pitched downwardly, similarly to the downwardly pitched bore 26 shown in Fig. 5, while the supply bores 26 may, if desired, be pitched upwardly or they may extend horizontally or downwardly, the last-named condition being shown in Fig. 5.

The valve body 20 is rotated in stepwise fashion and in a constant direction by means of a shaft 28 which is suitably fixed thereto and is centered with the aid of a sleeve 29 depending from a plate 30 bearing against the plate 13. Splined to the shaft is a gear 31 which is operated in stepwise fashion by means of a motor 42 and suitable clock mechanism 43, a spring-pressed detent or similar device 34' (Figs. 3 and 5) being provided to insure successive registry of the passageway 25 with the bores 26 and 27.

The gear 31 bears against a fixed collar 32 which is secured to shaft 28 by a set screw 33 or the like. A coil spring 34 between plate 30 and gear 31 exerts a downward pull on the valve body 20 and insures a liquid-tight fit with the valve casing. The diameters of the drain bores 27, and if desired also of bores 26, may be made slightly larger than that of passageway 25 to allow for relative adjustment between parts 19 and 20.

It will be seen from the above that I have provided an

extremely simple apparatus for effecting the treatment of tissues and other materials with a plurality of liquids without mingling of the liquids and with a minimum of moving parts, so that the possibility of mechanical failure is practically completely obviated. It will also be apparent that the supply containers in the above described apparatus need not all be on the same level, as in the known device, but may be on two or more levels above that of the receptacle 10, and the same is true of the drainage containers, below the receptacle, provided, however, that the bottoms of all of the supply containers are above the level which the liquid reaches in the receptacle 10, while the tops of all of the drainage containers are not substantially higher than the bottom of the receptacle. The capacity of the apparatus can thus be increased without increase of its area, or the same capacity obtained with a smaller area, so that a more compact device is obtained.

In all of the forms of the invention above described, there may be and preferably is provided an electric heating coil adjacent to one or both of the passageway 25 and bore 27, in order to keep in fluid condition a material, such as paraffin, which has a melting point above room temperature. Such heating means is indicated diagrammatically at 35 in Fig. 2. The paraffin or other higher melting point material is rendered fluid by suitable heating means in its container and, as is known, is employed both to displace the chloroform employed in the preceding treatment (which in turn was utilized to remove the previously employed alcohol) and to impregnate the tissues to produce a more or less rigid mass at room temperature which can be conveniently cut into thin films. The heating means 35 (Fig. 5) in the valve can be charged with current in timed relation to the operation of the valve, that is, when the duct 25 is brought into communication with that one of the tanks 40 shown in Figs. 2 and 3 which contains molten paraffin wax. Thus, as shown diagrammatically in Fig. 5, the leads 35a which supply current to the heater 35 are connected to a pair of spaced and insulated spring pressed contacts 35b mounted in the rotary valve body 20 and adapted to engage a pair of horizontally spaced and insulated contacts 35c positioned in an insulating block 35d. The contacts 35c are connected by the conductors 35e to a source of current. It will be apparent that as the valve body 20 rotates in stepwise fashion under the control of the timing mechanism, the contacts 35b and 35c will engage each other for a predetermined interval during which the duct 25 receives liquid paraffin from the supply container. It will be evident that should it be desired to begin heating of the duct 25 prior to its alignment with the conduit leading from the liquid paraffin container, various simple measures can be provided to effect such result. Thus, the contacts 35c can be arranged one above the other, and likewise the contacts 35b; and the contacts 35c can be elongated so as to close the circuit to the contacts 35a before the duct 25 is in position to receive liquid paraffin. Similarly, should it be desired to insure that no paraffin congeals in the duct 25 when the latter is moved out of registry with the paraffin supply duct, the contacts 35c can be elongated in the opposite direction, so as to supply current to the heater 35 during the discharge of the paraffin from the receptacle 10. Alternatively a separate set of contacts 35c connected in parallel with those shown in Fig. 5A, can be arranged at the preceding station of the conduit 25, and if desired, also a second separate parallel set at the next station after that shown in Figs. 5 and 5A.

I claim:

1. In an apparatus for charging and discharging a plurality of separate bodies of liquid in succession into and from a receptacle for the treatment of material therein, the combination of a plurality of supply containers, conduits connected to the bottom of said containers, a recep-

tacle normally disposed below the level of said supply containers to receive a body of liquid from said containers in succession by gravity, drainage means for draining the receptacle between successive deliveries of bodies of liquid thereto, valve mechanism provided with a duct leading to the bottom of the receptacle, and means for operating said valve mechanism in timed relation to bring said duct successively into communication with one of the conduits and with the drainage means to cause alternate charging and discharging of the receptacle with the liquid from the different containers in succession.

2. The combination as defined in claim 1, wherein the supply containers are arranged in fixed position about the receptacle.

3. In an apparatus for charging and discharging a plurality of separate bodies of liquid in succession into and from a receptacle for the treatment of samples of animal tissue material therein, the combination with said receptacle, of a plurality of supply containers disposed at a higher level than said receptacle, a valve comprising a casing having a plurality of separate ports adapted to be connected to said plurality of supply containers, a rotatable valve body having a passageway communicating with the interior of the receptacle and adapted to be placed in communication with each of the said ports in succession, drainage means in said valve casing separate from said parts, and means for rotating the valve body in stepwise fashion to connect the receptacle with each of the supply containers in succession and alternately with the drainage means at predetermined time intervals.

4. The combination as defined in claim 3, wherein said drainage means comprises a second set of ports in said valve casing adapted to be connected to a plurality of receivers, said valve body being movable to establish periodic communication between its passageway and said second set of ports in succession for connecting the said receptacle with the respective receivers for the associated supply containers to effect draining of the receptacle prior to connection with the next supply container.

5. The combination as defined in claim 3, wherein the supply containers are arranged in fixed position about the receptacle.

6. In an apparatus for charging and discharging a plurality of separate bodies of liquid in succession into and from a receptacle for the treatment of material therein, the combination of a first bank of containers for treating liquids, a receptacle adapted to contain the material to be treated and to receive the said bodies of liquid in succession from said containers and arranged below the level of the said first bank of containers, a second bank of containers arranged below the level of the receptacle for receiving the respective bodies of liquid separately and in succession from said receptacle, a valve mechanism comprising a casing having peripherally spaced supply and drainage ports adapted to be connected with the containers of both banks in alternation, a valve body in said casing and having a passage therein connected with the interior of the receptacle and arranged to be connected with the supply and drainage ports in the valve casing and after predetermined time intervals, and means for rotating the valve body in stepwise manner to connect the receptacle with the supply and drainage containers in alternation.

7. The combination as defined in claim 6, wherein the supply containers are arranged in fixed position about the receptacle.

8. The combination as defined in claim 6, wherein the valve casing is provided with a conical opening and wherein the valve body is of frusto-conical shape, the passageway in the valve body including a central axial portion communicating with the interior of the receptacle.

9. The combination as defined in claim 6, including upper and lower plates between which the valve casing and body are arranged, the receptacle resting upon the upper plate and having a nipple passing through such plate and received in a bore in the valve body.

10. The combination as defined in claim 6, wherein the valve casing is provided with a conical opening and wherein the valve body is of frusto-conical shape, the passageway in the valve body including a central axial portion communicating with the interior of the receptacle and means for resiliently urging the body of the valve in the direction of the apex of its conical surface.

11. The combination as defined in claim 6, wherein the valve casing is provided with a conical opening and wherein the valve body is of frusto-conical shape, the passageway in the valve body including a central axial portion communicating with the interior of the receptacle, the sides of the valve body converging in the downward direction, said rotating means for the valve body comprising a shaft secured to said body, a gear mounted on the shaft and a spring bearing on the gear and acting to exert a downward pull on the valve body.

12. The combination as defined in claim 6, including heating means disposed in the valve casing and valve body and arranged adjacent to the passageway in the valve body and at least two of the bores of the valve casing for keep-

ing fluid a treating material whose melting point is above room temperature.

13. The combination as defined in claim 6, including heating means in the valve body arranged adjacent to the passageway therein for keeping fluid a treating material whose melting point is above room temperature.

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