March 11, 1969 J. B. McCORMICK ETAL 3,431,886

APPARATUS FOR APPLYING LIQUID TO SLIDES

Filed June 7, 1965 Sheet 1 of 5

FIGURE 1.

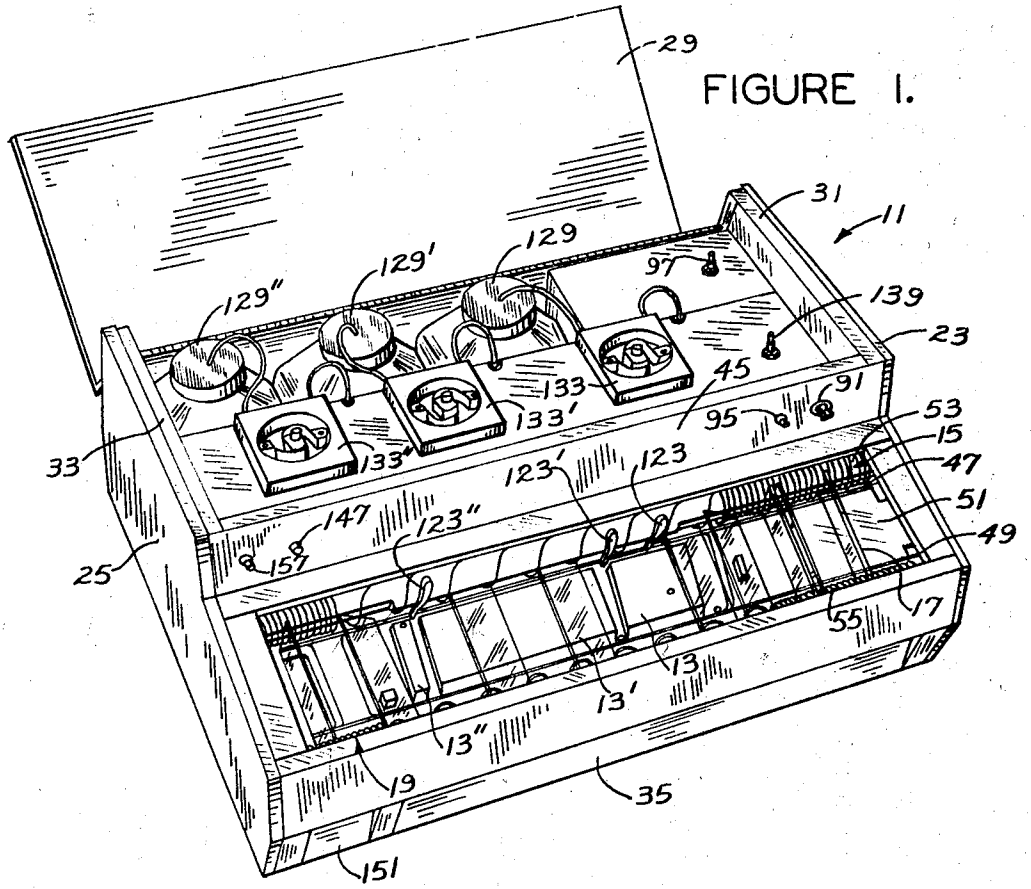
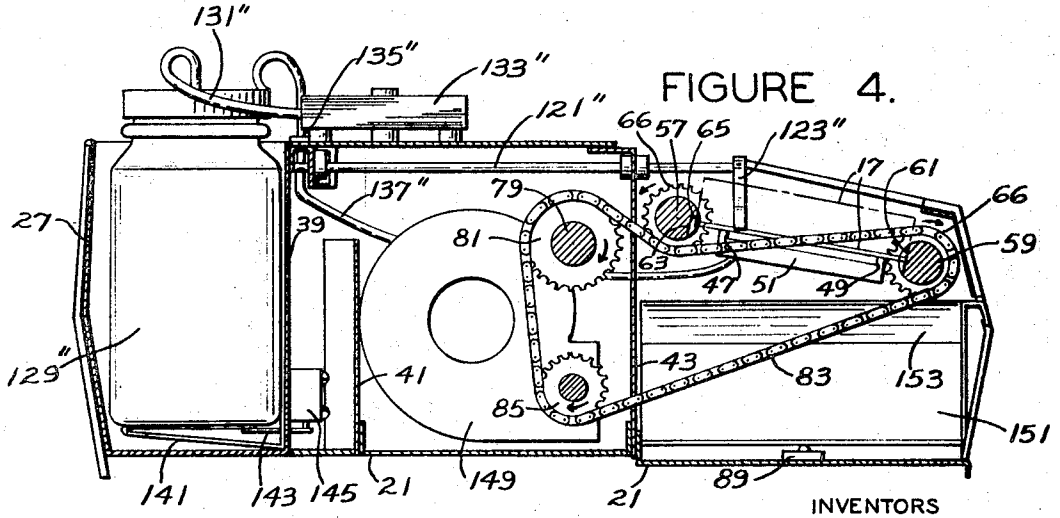


FIGURE 4.



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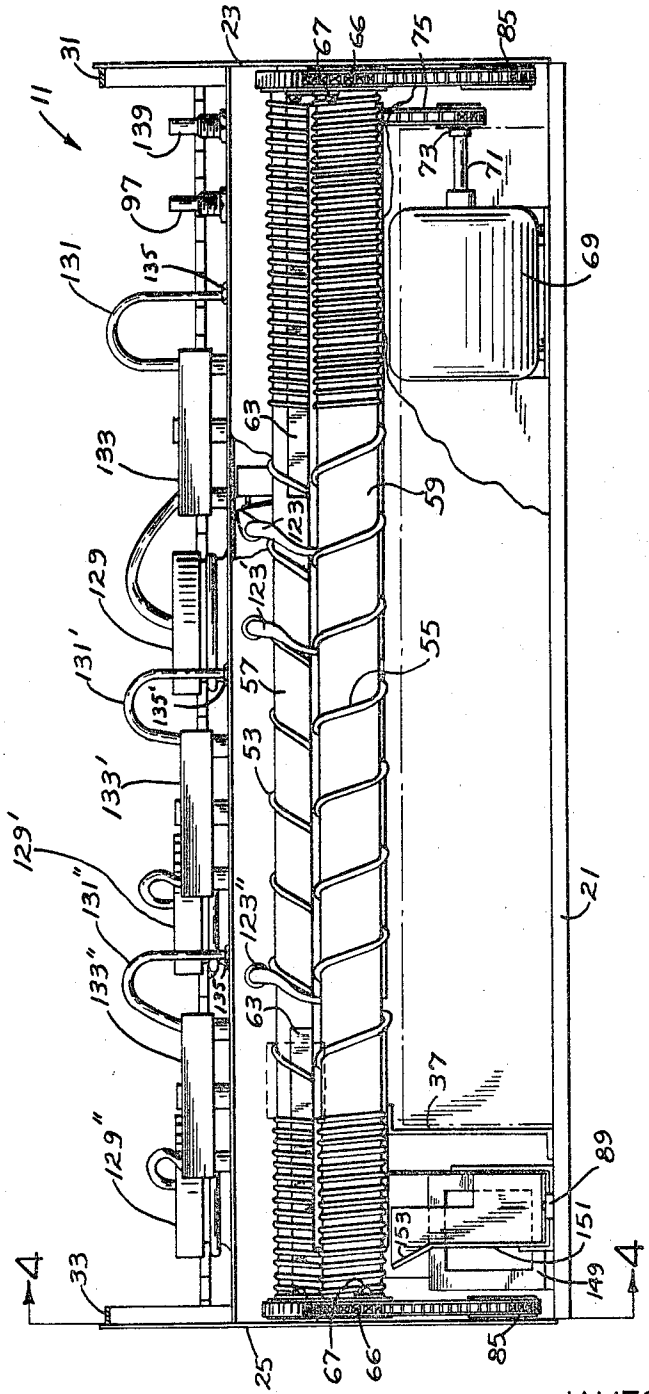


FIGURE 2.

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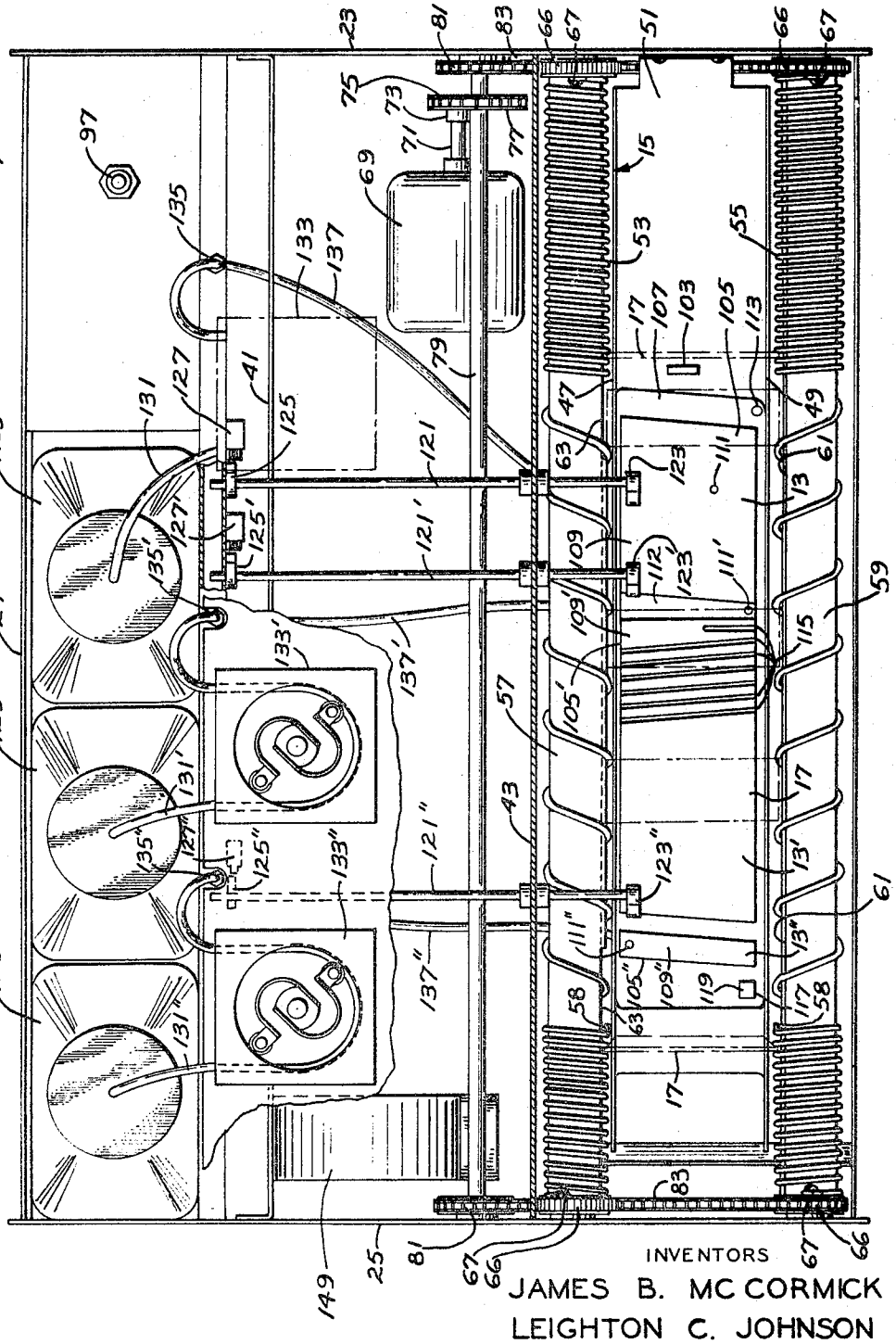


FIGURE 3.

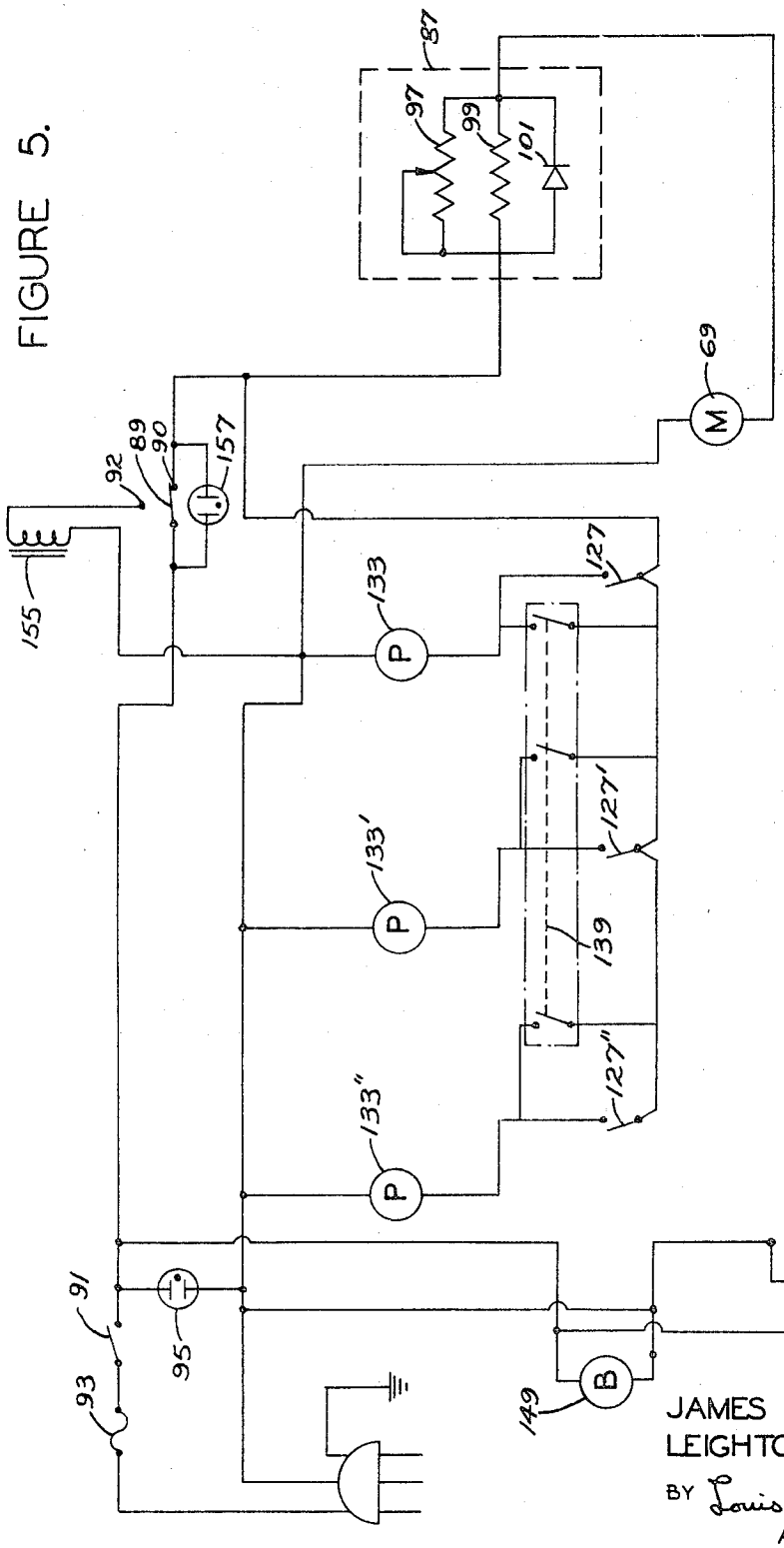
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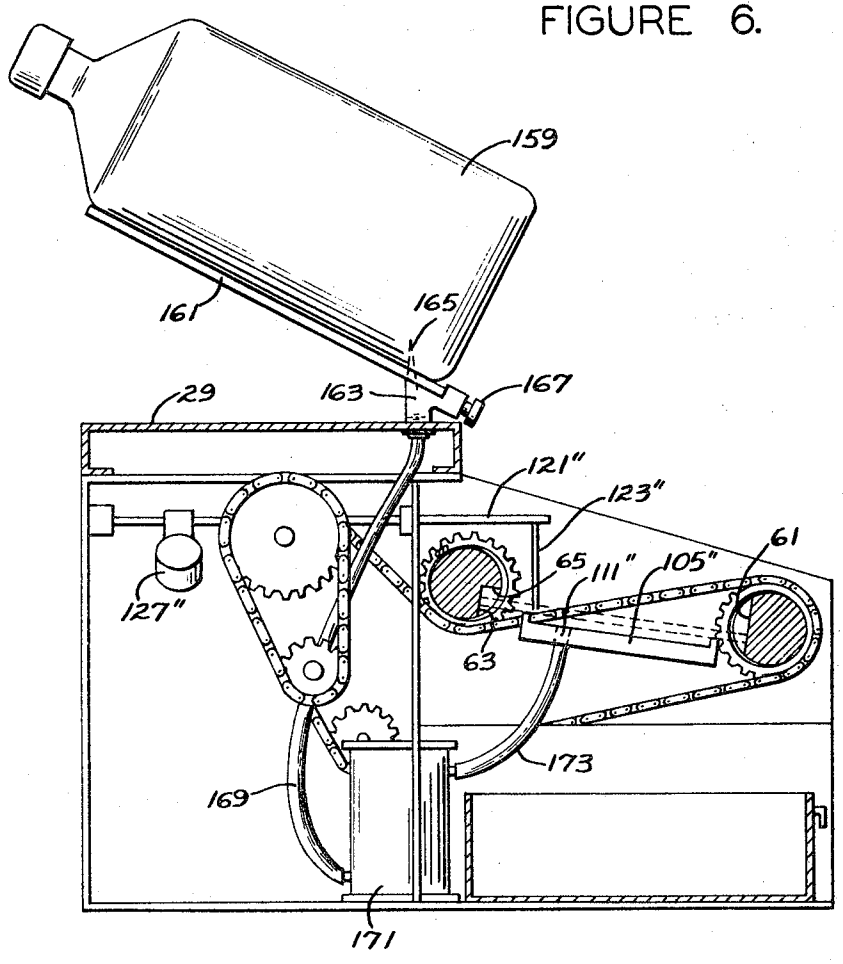
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FIGURE 5.



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FIGURE 6.



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United States Patent Office 3,431,886 Patented Mar. 11, 1969

3,431,886

APPARATUS FOR APPLYING LIQUID TO SLIDES

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Continuation-in-part of application Ser. No. 379,822, July 2, 1964. This application June 7, 1965, Ser. No. 461,613

U.S. Cl. 118—10 10 Claims

Int. Cl. B05c 5/02, 3/20

ABSTRACT OF THE DISCLOSURE

Apparatus and the method of operation thereof is described for conveying objects, such as microscope slides, over a flat liquid applying surface and injectiing a treating liquid into the space between the object and the surface. Helical conveying apparatus is also described for moving the slides from a substantially vertical position to a substantially horizontal position prior to conveying the slides over the liquid applying surface.

This application is a continuation-in-part of our copending application Ser. No. 379,822 filed on July 2, 1964, now abandoned.

The present invention relates to apparatus for advancing an object through a station at which one face of the object is treated. More particularly, the invention relates to apparatus for applying a liquid to one face of a microscopic slide. Still more particularly, the invention relates to apparatus for automatically and successively staining material carried on a plurality of microscopic slides.

In the microscopic examination of certain material, particularly cellular materials such as blood, tissue, etc., it is customary to place a smear of a liquid or substrate containing the material (e.g., a smear of plasma containing blood cells), or a thin section of the material itself (e.g., a thin slice of animal tissue) on a transparent plate or slide. Thereafter, the material is stained by subjecting it to contact with solutions which stain or dye only certain constituents of the cell to thus provide a contrast which facilitates visual examination.

Various staining procedures are utilized to produce different desired effects. For example, a solution may be employed to color a transparent substrate and thus provide contrast to essentially colorless cells; other solutions may be utilized to effect color differences between various parts of a cell. Solutions may be used to stain only portions of a cell, e.g., the nuclei and not the cytoplasm and, in a procedure known as negative staining, the cells may be caused to appear colorless against a colored background. Certain of the procedures are relatively simple and require the use of only a few solutions. Others, however, are complex and require successive applications of a relatively large number of different solutions.

In many of these staining procedures, certain of the solutions merely prepare or fix the substrate whereas the actual stains are made by one or more natural or synthetic dyes. The dyes selected are, of course, suited for the type of cell and the staining desired. The oxazine dyes, the triphenylmethane dyes, and the thiazine dyes are examples of some families of dyes that are commonly used.

In a conventional staining procedure it has been the general practice to dip the slide successively into each of a series of containers holding an appropriate solution, the slide being allowed to remain in each solution for a predetermined time interval of perhaps several minutes before being removed and dipped into a succeeding solution. Usually, the last container holds a wash, such as water, after which the slide is dried for examination. Regardless of what solutions are used, however, each step in the staining operation is usually performed manually by a technician.

Depending upon the nature of the material being stained and the type of staining desired, as many as twelve solutions may be required and the overall procedure, when performed in the above-described manner, is thus quite time-consuming. The fact that many slides are frequently involved merely multiples the problem. Furthermore, when successive slides are passed through the same container of solution, as is the case where dipping is employed, there is a danger of contamination of the solution. This danger increases when the same solution is used in different staining procedures for different types of materials and substrates.

It is an object of the present invention to provide an improved apparatus for treating one face of a generally flat object. It is another object of the present invention to provide an improved apparatus for automatically and successively applying liquid stain to materials carried on a plurality of slides. Still another object of the invention is to provide an improved apparatus for automatically staining material carried on a slide by successively effecting contact between such material and each of a plurality of solutions. A further object of the invention is to provide an improved apparatus for automatically staining material carried on one face of a slide by successively applying solutions only to that face of the slide carrying the material. It is a still further object of the invention to provide an improved apparatus for automatically staining material carried on a plurality of slides by applying a metered quantity of previously unused solution for each application to each slide, and it is still a further object of this invention to provide an improved control system for controlling the operation of a slide staining apparatus. These and other objects of the invention are more particularly set forth in the following detailed description and in the accompanying drawings wherein:

FIGURE 1 is a perspective view of the apparatus showing various of the features of the present invention;

FIGURE 2 is an enlarged front view of the apparatus shown in FIGURE 1 with the lid, the control panel and the front portion of the housing removed, and with some parts broken away for clarity of illustration;

FIGURE 3 is an enlarged top view of the apparatus shown in FIGURE 1, with the lid, the control panel and the front portion of the housing removed and with some parts broken away for clarity of illustration, some slides being shown in phantom;

FIGURE 4 is a sectional side view taken along line 4—4 of FIGURE 2;

FIGURE 5 is a schematic diagram of the electrical control circuitry of the apparatus shown in FIGURE 1; and

FIGURE 6 is a sectional side view taken on a plane similar to that of FIGURE 4 of an alternate embodiment of the invention.

Very generally, the present invention provides apparatus for automatically applying liquid to one face of a slide the application being of a single or of multiple solutions as selected. This apparatus is particularly useful for automatically staining material carried on one face of each of a plurality of slides. In the embodiment illustrated in FIGURES 1 to 4, a slide-staining apparatus **11** is provided which comprises a plurality of treating, i.e., liquid-applying, stations **13**, **13'** and **13''** and a feed mechanism **15** for advancing generally flat objects, such as transparent glass slides **17**, past said plurality of treating stations. A liquid-applying device located at each of

the stations automatically subjects one face of each slide **17** to contact with a metered quantity of desired liquid.

To provide a compact apparatus capable of handling a fairly large number of slides, the feed mechanism **15** is designed to accept slides **17** aligned in generally parallel face-to-face relationship and each disposed so as to rest upon a longitudinal edge and thereby lie in generally vertical planes. As the slides **17** are advanced by the feed mechanism **15**, they are rotated so as to be aligned in generally parallel edge-to-edge relationship and thereby lie in a generally horizontal plane as they pass through liquid-applying stations. After the slides **17** have passed the last of these stations, they are returned to their previous generally vertical orientation. A drying and collection station **19** is located adjacent the output end of the feed mechanism **15**, which first dries the slides **17** and then automatically removes them from the feed mechanism **15**.

Now referring more particularly to the drawings, the apparatus **11** includes a base **21**, a pair of end plates **23** and **25**, a back plate **27**, a control panel **45**, and a top cover or lid **29** which is hinged to the back plate **27** and when closed is supported by inwardly directed flanges **31** and **33** on the end plates **23** and **25** respectively. A side intermediate support plate **37** (FIGURE 2) and rear intermediate support plates **39**, **41** and **43** (FIGURE 4) extend upwardly from the base **21** and, together with the base, the end plates **23** and **25**, and the control panel **45**, support the various operative components of the apparatus **11**.

The feed mechanism **15** includes a track which extends longitudinally of the apparatus **11** and is defined by a pair of generally parallel rails **47** and **49** which are spaced apart horizontally a distance less than the length of a standard glass slide which, conventionally, is about three inches in length and one inch in width. Rails **47** and **49** may be formed from separate bars or rods, for example. Preferably rails **47** and **49** are formed from up-turned edges of a track member **51** which will be described in more detail later. In the operation of the apparatus, the slides **17** straddle or span the rails **47** and **49** with each rail engaging each slide at a point spaced inwardly from an end thereof (FIGURE 3). If desired, the slides may be inclined slightly during their movement along the track so that any applied liquid may have a greater tendency to drain therefrom. One way to accomplish this is to have the upper surface of the rear rail **47** elevated slightly relative to the front rail **49**. This difference in elevation of rails **47** and **49** is shown in an exaggerated manner in FIGURES 2, 4 and 6.

To advance the slides **17** along the rails **47** and **49** and to maintain a predetermined spacial relationship between said slides, the feed mechanism **15** includes a pair of conveyor elements **53** and **55** which flank the rails **47** and **49**. The conveyor element **53** is positioned behind and extends generally parallel with the rear rail **47** and may be in the form of a heavy wire wound to provide, for example, a left-hand helix (using standard screw terminology). The conveyor element **53** is supported by a stationary rod **57** extending coaxially therethrough and suitably supported at its opposite ends by the end plates **23** and **25**. The conveyor element **55** is positioned in front of and extends generally parallel with the front rail **49** and may be in the form of a heavy wire wound to provide, for example, a right-hand helix. The conveyor element **55** is supported by a stationary rod **59** extending coaxially therethrough. The conveyor elements **53** and **55** are preferably substantially identical except for the direction of their helical configurations. The pitches of the helices which form conveyor elements **53** and **55** vary along the length of conveyor elements **53** and **55**. At the right hand end of the conveyor elements, as seen in FIGURES 1 and 3, the pitches of the conveyor elements are such that the turns of the helices are quite close together. The gap between adjacent turns of a given helix being only slightly greater than the thickness of the flat object to be treated, e.g., a glass slide. The pitches of the helices change in their intermediate portions so that the gap between adjacent turns is enlarged to a distance slightly greater than the width of the flat object to be treated. At the left hand end of the conveyor elements, the pitches of the helices again are such that the turns of the helices are quite close together. The changes in pitch of each of the helices **53** and **55** enable the slides to be rotated from a generally vertical position (normal to the plane of the track) to a generally horizontal position (parallel to the plane of the track) and then back to a generally vertical position as the slides move along rails **47** and **49**. This rotation of the slides will be described in more detail later. Because the helices of the conveyor elements **53** and **55** are designed principally for use with glass slides, they are preferably made from a material which withstands wear against glass, such as chrome plated stainless steel wire. When the slides are to be inclined slightly, as described above, rod **59** may be at a slightly lower elevation than rod **57** to accommodate the inclined disposition of the slide **17** positioned on the inclined track member **51** wherein rail **47** is elevated slightly relative to rail **49**.

The inner diameters of the helical conveyors **53** and **55** are somewhat greater than the diameters of the rods **57** and **59** which they surround so that the helical conveyors can be freely rotated thereabout said rods in a manner soon to be described. In addition, the spacing between the conveyors **53** and **55** is such that the minimum distance between conveyors **53** and **55** is less than the length of a standard slide. Thus, slides **17**, engaged by or supported upon the rails **47** and **49**, are positioned with their ends inserted between adjacent turns of the helicals **53** and **55** and are maintained in spaced relation to one another thereby. An inside segment (facing rod **57**) of rod **59** is removed providing a flat chordal surface **61** which acts as a guide for the adjacent edge of slide **17**. Inside end segments of rod **57** are similarly provided with flat chordal surfaces **63**. The central portion of rod **57** is cut away to provide a flat surface connecting and substantially coplanar with flat surfaces **63** and a downwardly facing shoulder **65** which is positioned to overlap the rear ends of slides **17** as they are moved along the rails **47** and **49**, as will become more apparent shortly. The spacing between rods **57** and **59** is such that the distance between flat chordal surfaces **61** and **63** is only slightly greater than the length of a standard slide. To improve clarity of illustration, the glass slides **17**, which are shown in FIGURES 1 and 6, are omitted from FIGURE 2 and are shown in phantom in FIGURES 3 and 4.

Rotation of the helicals **53** and **55** is accomplished by drive means including similar sprocket wheels **66** rotatably carried on each end of each rod **57** and **59**. Each sprocket wheel **66** includes an inwardly facing shoulder to which the adjacent end of a respective helical is attached, as by a screw **67**. The drive means further includes an electric motor **69** (FIGURES 2 and 3) having an output shaft **71** which has a small sprocket **73** affixed thereto which is connected via a short roller chain **75** to a larger sprocket **77**, affixed to a drive shaft **79**. The shaft **79** extends longitudinally completely across the apparatus **11** and is appropriately journalled in bearings carried by the end plates **23** and **25**. Similar drive sprockets **81** are fixedly mounted on the shaft **79** near each end thereof, and similar roller chains **83** connect the sprockets **81** and the adjacent two sprocket wheels **66** at the respective ends of the apparatus. The roller chains **83** are further engaged with idler sprockets **85** which are rotatably mounted on the inner surfaces of end plates **23** and **25**.

It will be noted that by virtue of the manner of connection of the chains **83** to the sprocket wheels **66**, the helicals **53** and **55** are rotated in opposite directions, the rear helical **53** being rotated in a counter-clockwise direction as viewed in FIGURE 4, whereas the front helical **55** is rotated in a clockwise direction. Accordingly, since

injected into the space between the upper surface 109 of platen 105 and an overlying slide to thereby contact with said liquid the lower surface of the slide and the material carried thereby. Since the lower face of slide 17 is in close proximity to platen surface 109, e.g., a spacing of a few thousandths of an inch, the surface tension of the injected liquid is sufficient to completely fill the laminar volume between these two flat surfaces. As the slide advances along the rails 47 and 49 and across the platen 105, the entire lower surface area of the slide which passes in face-to face relation with surface 109 of platen 105 is thus brought into contact with the liquid and the material carried thereby is similarly contacted by the liquid. The surface tension of the liquid causes said liquid to be retained in the space between the platen 105 and slide 17 until the slide has passed completely beyond the platen, and as the slide leaves the left hand edge of the platen 105, the liquid is wiped from the slide due to the tendency of the liquid to adhere to the platen rather than to the slide. Thus, the slide 17 is only moist as it proceeds toward the next station 13' and has no droplets of liquid adhering to it. The liquid wiped from the slide flows into the recessed portion 107 of track 51, then into a drain 113 which communicates with a drip tray 35 removably positioned thereunder.

As shown in FIGURE 3, the left-hand edge of platen 105 is positioned at an acute angle with respect to the front edge of the platen such that the leading edge of the slide 17 is wiped in a downward direction as the slide passes beyond the platen 105. This aids in wiping and also in efficient collection of the wiped liquid at the lower region of the recessed portion 107 of track member 51.

As shown in FIGURE 3 the platens 105 and 105' are preferably formed from a unitary member having a recess 112 extending from front to rear between said platens. A liquid injecting orifice 111' is provided in the recess 112 so that after a slide leaves the platen 105 of first liquid-applying station 13, it then passes over orifice 111' and the second liquid-applying station 13'. When the lower face of slide 17 is positioned over at least a portion of the upper surface 109' of platen 105', a predetermined quantity of liquid is injected from orifice 111' against the lower face of the slide. This injected liquid then flows into the laminar space between the lower face of the slide and the upper surface 109' of platen 105'. The recessed portion 112 acts a liquid reservoir to provide liquid for this laminar space.

As the slide 17 is slowly advanced across platen 105', there is a circulatory motion set up in the liquid film between the lower face of the slide and the upper surface 109' of said platen. This circulatory motion tends to cause desired mixing of the liquid film with the liquid retained on the slide from the previous station. In the preferred form of the invention, grooves 115 are placed in the upper surface 109' of platen 105' to promote this circulatory motion and mixing action. The grooves 115 act as capillary channels which conduct the liquid across the face 109' of the platen 105'. The grooves 115 are preferably positioned at a generally obtuse angle with respect to the front edge of the platen such that the capillary action draws the liquid upward along the slide as it passes over the platen and grooves. The grooves 115 may, however, be positioned at an acute angle with respect to the front edge of the platen such that the capillary action draws the liquid downward along the slide as it passes over the platen and grooves. The number, size and specific location of the grooves will vary depending upon the particular staining or liquid-applying procedures being employed. It is within the knowledge of those skilled in the art to determine these apparatus variations.

As a slide 17 leaves the left-hand edge of platen 105', the excess applied liquid is then wiped off the slide in the same manner as at platen 105. The slide then passes over platen 105'' of the third liquid-applying station 13'' where liquid is injected through orifice 111'' formed in the upper surface 109'' thereof, and the lower face of the slide is exposed to the injected liquid in the same manner as at stations 13 and 13' described above. The slide is also wiped by the left-hand edge of platen 105'' in a manner described above. To insure substantially complete removal of excess liquid from the lower face of the slide, it is passed over a platen 117 having an upper surface 119 of reduced area disposed in substantially the same plane as the platen upper surfaces 109, 109' and 109'' and aligned with the front edges thereof. Surface 119 is located so as to wipe off any droplets which may have collected on the lower surface of a slide passing thereover.

The orifices 111, 111' and 111'' described above can be located in any convenient place on or adjacent to respective platens 105, 105' and 105''. The orifice locations shown in FIGURE 3 are employed when the track member 51 is tilted slightly so that rail 49 is slightly lower than rail 47. The upper surfaces 109, 109' and 109'' of the platens 105, 105' and 105'' are inclined downwardly toward the front of the apparatus. When liquid is introduced into the space between the lower face of the slide and the upper surfaces of the platens from orifices 111 and 111' at stations 13 and 13', it is desirable to have such liquid be introduced at the lower portion of such space and thus push any interfering air in such space out through the top of the space. In the washing step of the third stage 13'', it is desirable to have quick and complete contact of the lower face of the slide with the washing liquid. Orifice 111'' is thus located at the top of platen 105'' to enable a film of liquid to flow down under the influence of gravity over surface 109'' prior to the passage of the slide over surface 109''.

As will be noted in FIGURE 3, each platen is of a width, measured in a direction from rail 47 toward rail 49, slightly less than the length of a slide measured in the same direction so that the film of liquid is in contact with a major portion of the lower face of the slide as the slide is moved across the platen. The length of the platen, measured in a direction from right to left along track member 51, determines the length of time during which the liquid remains in contact with the material on the slide and hence, varies with the treatment to be accomplished. In the illustrated embodiment, the first platen 105 encountered by the slide has a length about 1½ times the width of a standard slide, the second platen 105' has a length over five times the width of a standard slide, while the length of the last platen 105'' is less than the width of a standard slide.

Track member 51 is preferably formed as a single element containing rails 47 and 49, platens 105, 105' and 105'', recessed portion 107, orifices 111, 111' and 111'', recess 112, drain 113, grooves 115 and platen 117. Such single element can conveniently be formed by metal molding.

To provide timely injection of liquid at each liquid-applying station, a liquid pumping and switching mechanism is provided in association with each of the liquid-applying stations. The switching mechanism for station 13 includes a horizontally disposed shaft 121 extending from front to rear and suitably journalled at its rear end near the intermediate support plate 39. The shaft 121 extends through a bearing in the intermediate support plate 43 and overhangs slightly the track 51, terminating at a point between the rails 47 and 49. A depending finger 123 is rigidly affixed to the front end of the shaft 121 and is of sufficient length so that it is adapted to be engaged by the leading edge of the slides 17 moved along the track

When the finger 123 is pivoted through contact with moving slide 17, the shaft 121 is rotated, causing a cam 125 affixed to the rear end of the shaft to rotate and actuate a normally open lever switch 127. This activates a liquid supplying means causing liquid to flow through orifice 111. The weight of the finger 123 together with the force of the spring return on switch 127 is such to

helical 53 is left-handed and helical 55 is right-handed rotation thereof as described above causes slides 17 supported between the turns thereof to be advanced from right to left across the apparatus (FIGURES 1, 2 and 3). Of course, if two right-handed helices or two left-handed helices were used, the chain drive would be modified so that they would both be driven in the same direction. However, the illustrated arrangement is preferred because it reduces or eliminates friction which might tend to undesirably tilt the slides 17 on the rails 47 and 49 if two helicals wound in the same manner were used.

As best seen in FIGURES 1 and 3, slides 17 which are vertically seated in the input end of the feed mechanism 15, at the right-hand side of the apparatus 11, are advanced to the left past the various liquid-applying stations 13, 13' and 13" incident to rotation of the helicals 53 and 55. At the input end, the turns of the helicals 53 and 55 are quite close together, the gap between adjacent turns being only slightly greater than the thickness of the flat object to be treated, e.g., a glass slide. However, the pitches of the helicals change in their intermediate portions so that the gap between adjacent turns is enlarged to a distance slightly greater than the width of the flat object to be treated. This construction enables the flat objects handled, as they are advanced from right to left, to be rotated from the vertical face-to-face relationship to a generally horizontal edge-to-edge relationship in which the lower faces thereof rest on the rails 47 and 49, as distinguished from the prior relationship wherein only the lower longitudinal edges of the flat objects touched the rails. When microscopic slides are handled in the illustrated apparatus the material to be stained is carried by the lower face of the slides when the latter travel in the horizontal position past the liquid-applying stations.

More specifically, as the slides 17 in generally vertical face-to-face disposition are advanced into the sections of the helicals 53 and 55 wherein the change in pitch occurs to increase the gap between adjacent turns, their upper edges are slowly tilted forwardly in the direction of advancement, i.e., the upper edge of the slide becomes the slide leading edge and the bottom edge of the slide becomes the slide trailing edge. In order to assure that this initial transition from the generally vertical position to the generally horizontal position takes place as planned, a barrier arm 103 (see FIGURE 3), preferably constructed of a resilient material such as rubber, is attached to track member 51 in a location where it successively engages each of the slides 17 near the lower edge thereof at the position along the feed mechanism 15 where the pitch of the helicals 53 and 55 begins to change. The frictional engagement of the lower edge of a slide 17 by barrier arm 103 tends to hold the lower edge of the engaged slide in place while the upper edge of said slide is free to move forward and downward as the helicals 53 and 55 advance the slide along rails 47 and 49 and as the spacing between turns of helicals 53 and 55 increases. Other barrier means can also be used in any convenient manner to aid in turning the slides from a generally vertical position to a generally horizontal position.

After passing the various liquid-applying stations, 13, 13' and 13", the advancing slides 17 are returned to the generally vertical face-to-face relation as they approach the left-hand end of the apparatus 11, and move into the left-hand end portion of the helicals 53 and 55 which are closely wound. At the point of this second pitch transition, it can be seen that the helicals 53 and 55 lift the leading edge of successive generally horizontal slides 17 upwardly and rearwardly into a substantially vertical orientation. This rotation of the slides is aided by lugs 58 (see FIGURE 3) attached to helicals 53 and 55 near the point of second pitch transition. These lugs pass up under the leading edge of the adjacent slide and start the lifting motion. The change in pitch of the helicals 53 and 55 completes the slide rotating action. Thus, the slides 17 are in vertically disposed face-to-face relation when they enter the drying and collection station 19.

As described above, the feed mechanism 15 maintains the flat objects to be treated, such as glass slides, in close-spaced generally vertical face-to-face relation both before and after they pass through the treating stations. These vertical dispositions have several advantages. First, in such vertical positions, the slides occupy a relatively small amount of track space and a track of much lesser length is capable of serving a given number of slides as compared with track length required when all the slides are continuously maintained in a generally horizontal edge-to-edge disposition. Viewed in another way, a track having a given length can accommodate a substantially larger number of slides in vertical face-to-face relation than it can in edge-to-edge relation. A large number of vertically disposed slides can be placed in the input end of the apparatus, thus permitting continuous operation of the apparatus, without the constant attentions of a technician. The vertical disposition of the slides at the output or drying and collection end of the apparatus has additional advantages. As described below, the slides are dried by blowing air over them. The vertical position of the slides facilitates drainage and aids in obtaining desirable drying air flow over the slides. Also, the slides in closely-spaced vertical disposition take a relatively long period of time to pass through the output end of the apparatus and are thus satisfactorily dried.

Referring to FIGURE 5 which illustrates an electrical circuit for the apparatus, the motor 69 of the drive means for rotating helicals 53 and 55 is connected in series with a speed control means 87, a basket switch 89, an on-off switch 91 and a fuse 93 to a conventional source of electrical power (not shown). An indicator light 95 which is illuminated by closure of switch 91 is connected in parallel with the power source. The speed control means 87 includes, for example, a variable resistor 97 in parallel with a fixed resistor 99 and a diode 101. A means of varying the speed of the motor 69 is desirable in order to increase the versatility of the apparatus 11 by permitting variation in the speed at which the helicals 53 and 55 are rotated and thereby a variation in the speed at which the slides 17 are advanced along the rails 47 and 49. For many applications, however, a constant speed motor operating at approximately one revolution per minute is satisfactory.

FIGURE 5 also shows a basket indicator light 157, buzzer 155, liquid level switch 145, liquid level indicator light 147, pumps 133, 133' and 133", pump switches 127, 127' and 127", triple pole pump priming switch 139 and blower 149. These circuit elements will be described in more detail later.

Referring now to the treatment of a generally flat object, as illustrated by application of liquids to a slide for staining a substance positioned thereon, the illustrated apparatus 11 includes three separate liquid-applying stations 13, 13' 13". It is to be understood, of course, that any number of such stations may be provided and that the number shown is only illustrative of a particular staining procedure, namely, the Wright procedure for staining blood smears. In carrying out the Wright procedure in the improved apparatus, the staining liquid is applied at the first station, a buffer liquid is applied at the second station and a washing liquid is applied at the third station.

Each of the liquid-applying stations, exemplified by station 13, includes a stationary platen 105 (FIGURE 3) securely mounted within a recessed portion 107 of track member 51 and between the rails 47 and 49. The platen 105 is positioned so that its upwardly facing surface 109 is parallel with and closely subjacent to the plane of the upper surfaces of the rails 47 and 49 so as to be parallel with and in close proximity to the lower face of a slide 17 supported by rails 47 and 49 and positioned over said platen. The platen 105 is provided with an orifice 111 through which a predetermined quantity of liquid can be

cause the switch **127** to open and the shaft **121** to rotate to its initial position after the finger **123** is no longer engaged by the slide **17**. Similar switching mechanisms are triggered by fingers **123'** and **123"** for stations **13'** and **13"** respectively.

As shown in FIGURE 5, the motors for pumps **133**, **133'** and **133"** are connected to a power source (not shown) through pump switches **127**, **127'** and **127"**, respectively, as well as basket switch **89**, on-off switch **91** and fuse **93**. The pump motor for pump **133**, for example, is energized by closing switch **127**. Triple-pole switch **139** by-passes switches **127**, **127'** and **127"** and can be used to simultaneously energize pumps **133**, **133'** and **133"** as described below.

The liquid to be injected against the lower face of a slide at station **13** is stored in a container or bottle **129** located to the rear of apparatus **11**. A flexible, for example, plastic, tube **131** having one end inserted into the container and down into the stored liquid passes through a peristaltic pump **133** to a fitting **135**. A second tube **137** conducts the liquid from the fitting **135** to the orifice **111** in the platen **105**. The liquid thus flows through the orifice **111** only when the peristaltic pump **133** is operating. The pump **133** is electrically powered and is controlled by switch **127** in response to movement of the slide engaging finger **123**. Similar pumps **133'** and **133"** for stations **13'** and **13"** are similarly connected to liquid containers **129'** and **129"** and are operated in a similar manner.

In order to have positive liquid flow through orifices **111**, **111'** and **111"** at predetermined times controlled by engagement of slides **17** with fingers **123**, **123'** and **123"**, the fluid lines **137**, **137'** and **137"** communicating with orifices **111**, **111'** and **111"** should be full of liquid. One convenient way to accomplish this is to operate pumps **133**, **133'** and **133"** to fill these lines prior to passing the slides **17** over platen **105**. This specific "pump priming" action can be conveniently accomplished by pushing triple-pole priming switch **139** (FIGURES 1, 2 and 5) which by-passes pump switches **127**, **127'** and **127"** and thus energizes pumps **133**, **133'** and **133"** until liquid begins to flow out of orifices **111**, **111'** and **111"**.

Proper operation of this apparatus in applying liquid to slides, for example, can only be accomplished if sufficient liquid is applied at each liquid-applying station. It may be convenient to have indicating means to show when the quantity of liquid in the bottles **129**, **129'** and **129"** is below a desired amount. One means for achieving this result is shown in FIGURE 4, and it is understood that this means is illustrative only and that other means may be employed if desired. As shown in FIGURE 4, the container **129"** is supported upon a spring platform **141** secured to intermediate wall **39**. An arm **143** is secured to the spring loaded platform **141** and projects through an opening in wall **39** to a position below microswitch **145** also mounted on wall **39**. The spring action of the platform is such that when the bottle contains more than a predetermined minimum amount of liquid, its weight is sufficient to depress the platform **141** and arm **143** to a position out of actuating engagement with the normally open microswitch **145**. As liquid is pumped from the bottle, the spring platform will rise and, upon discharge of substantially all the liquid, the platform, together with the arm **143**, will rise, causing arm **143** to activate the microswitch **145** and illuminate indicator light **147**. The circuitry is shown in FIGURE 5. Thus, a warning system is provided which will give an indication to the technician when the quantity of the liquid is low, thereby preventing improper staining and possible damage to the specimens carried on the slides. The illustrative apparatus has only a single indicator light governed by the liquid level in a single bottle. It is understood that the inventive apparatus can have an indicator means of this type for each liquid container, or the single light can be governed by the quantity of liquid in a bottle different from that shown in the figures. Other means can also be used which are responsive to the amount of liquid in the liquid supply means.

As previously described, each glass slide **17** is returned to a generally vertical position after passing the last liquid-applying station **13"** so that it is vertically disposed when it reaches the drying and collection station **19**. To assure that the slide and the material carried thereon are completely dry before the slide has an opportunity to come in contact with another slide, a small blower fan **149** (FIGURES 2, 3, and 4) is disposed in the rear, left-hand corner of the apparatus **11** and directs a gentle current of air outwardly past the slowly advancing slides. Because the pitch of the helicals **53** and **55** is only slight at this final station, it takes the slides **17** a relatively long period of time to pass through drying and collection station **19**. Thus, each slide is exposed to the air currents supplied by the fan **149** for a sufficient length of time to assure that it is entirely dry.

As the glass slides **17** advance through the drying and collecting station **19** and reach the end of the track formed by rails **47** and **49**, they drop from between the helicals **53** and **55** into a collection container or basket **151** which rests on a microswitch **89** positioned between collection container **151** and the base **21** of the apparatus **11**. A slanted upper lip **153** is provided at the top of the left-hand wall of the container **151**, as seen in FIGURE 2, to direct the falling slides **17** into the container **151**. The short drop into the container **151** does not cause sufficient shock to break the slide and is not harmful to the stained material carried thereon.

A basket signal means is provided to signal the technician when the basket **151** requires emptying. This means comprises the microswitch **89** which is activated when the weight of the container **151** and a desired number of slides therein is reached. The movable contact of the switch **89** normally is in electrical connection with contact **90** (FIGURE 5) completing the connection between the motor **69** and a conventional power source. As the slides drop into the basket the total weight of the basket and slides increases. When the total weight of the basket and slides reaches a predetermined value representative of a desired number of slides, the movable contact of the microswitch **89** moves out of engagement with contact **90** and into engagement with contact **92**. In this position the motor **69** and any operative peristaltic pumps **133**, **133'** and **133"** are stopped and a buzzer **155** is activated, signalling the technician that the basket is ready for removal and emptying. Further, an indicator light **157** is thereby illuminated. This protective device eliminates the possibility that the basket will overfill, causing the slides to jam in the helicals and consequently break. With this possibility eliminated, the technician's mind is free from concern and can be devoted to more essential tasks.

The above description was directed to one form of the invention wherein the liquid to be applied to an object is mechanically pumped through an orifice. An alternative embodiment, shown in FIGURE 6, employs gravity feed of the liquid from the storage containers positioned in an elevated location with respect to the application orifice. In this embodiment, the illustrated liquid container **159** is supported atop the apparatus cover **29** in a suitable cradle **161** mounted on a valve **163**. The valve **163** includes a hollow needle **165** which extends through the cradle **161** and is adapted to puncture container **159**, which is conveniently formed from soft plastic material. Thus, when the bottle **159** is pressed down on the valve **163**, it is securely impaled upon the hollow needle **165**. The rate of flow through valve **163** can be regulated by means of a threaded valve stem **167** which screws into the front of the valve. From the valve **163**, the liquid passes through a conduit **169** into a metering valve **171** which conveniently may be solenoid-operated. From the metering valve **171**, a second piece of tubing **173** conducts the liquid to the orifice **111"** in platen **105"**. Ac-

cordingly, the liquid flows through orifice 111'' when the valve 171 is open, and the flow ceases when valve 171 is closed. The operation of opening and closing valve 171 may be carried out in a manner described above for operating pump 133'' wherein depending finger 123'' engages a slide causing shaft 121'' to rotate and actuate switch 127''. Instead of controlling a motor the switch would control the valve 171 in the embodiment of FIGURE 6.

The above-described apparatus makes possible the conveying of generally flat objects in a novel manner from an input station successively past one or more treating stations in a predetermined orientation and thence to a collecting station. In the illustrated form of the invention a large number of slides can be automatically and successively treated with staining liquids. Thus, the tedious and repetitive job which lab technicians were formerly required to perform to stain slides for microscopic examinations is eliminated. The invention provides improved economy in staining because only a small measure, usually about 1 cc., of liquid needs to be expended for each slide at each station. Furthermore, superior quality and reproducibility of results is provided because the human factor is removed, insuring uniform performance of each step, and because each slide is always contacted with fresh liquid.

What is claimed is:

1. Apparatus for conveying along a predetermined path an object having similar flat end portions comprising a pair of similar helical elements spaced a distance apart less than the length of the object to accommodate an object which extends therebetween and is positioned with the opposite flat end portions disposed between adjacent turns of said helical elements respectively, each of said helical elements having a first portion in which adjacent convolutions thereof are spaced apart a distance slightly greater than the thickness of the end portions of said object and a second portion of greater pitch in which adjacent convolutions thereof are spaced apart a distance slightly greater than the width of said object end portions, said helical elements also each having an intermediate portion of increasing pitch which connects said first and second portions, a track located between said helical elements and adapted for engagement by an object being conveyed, and means for rotating said helical elements so as to cause an object extending therebetween and engaged by said first portions thereof to be moved along said track and into engagement with said intermediate and second portions thereof successively, the change in pitch of said helical elements at said intermediate portions causing said object to be turned from an initial orientation generally normal to the plane of said track to a second orientation generally parallel to the plane of said track as it is advanced along said track in contact with said intermediate portions.

2. Apparatus according to claim 1 wherein at least one liquid applying station is positioned adjacent the track and also adjacent the second portions of the helical elements.

3. Apparatus according to claim 2 wherein said liquid applying station comprises an element having a generally flat surface positioned adjacent said track with the plane of said flat surface disposed parallel to and spaced slightly from the plane of the portion of the track adapted to be contacted by a flat object to be treated, said apparatus also having means for supplying a liquid to said flat surface, the disposition of said track with respect to said flat surface affording limited space between said flat surface and the adjacent surface of a flat object disposed in engagement with said track and in face-to-face relation with said flat surface, said liquid being supplied in a quantity sufficient to fill said space.

4. Apparatus for applying liquid to a microscope slide having a generally flat face, which apparatus comprises a track adapted for engagement by and support of said microscope slide with its face disposed parallel to the plane of the track, means for advancing said microscope slide along said track, an element positioned adjacent said track having a generally flat surface disposed parallel to but spaced slightly from the face of said microscope slide advanced along said track and past said element, a source of liquid to be applied to said face of said microscope slide, and means for supplying a predetermined quantity of liquid from said source onto said generally flat surface so as to fill the space between said flat surface and said microscope slide when the microscope slide is disposed in face-to-face relation with said flat surface.

5. Apparatus according to claim 4 wherein the means for supplying the liquid onto said flat surface includes a pump.

6. Apparatus according to claim 4 wherein the generally flat surface of the element is provided with a plurality of grooves.

7. Apparatus according to claim 4 including indicating means to warn of low liquid supply.

8. Apparatus according to claim 4 wherein the track supports the microscope slide being treated and terminates short of the end of the means for advancing the microscope slide so that the microscope slide drops from the end of said track, there being means at the end of said track for receiving the treated microscope slide as it drops from the track.

9. Apparatus according to claim 8 wherein indicating means is employed in combination with the means for receiving the microscope slide, said indicating means being activated when a predetermined number of microscope slides have been deposited in said receiving means.

10. An apparatus for treating material disposed on one face of a slide for a predetermined period of time by effecting contact between the material and each of various liquids utilized incident to the staining of the material, which apparatus comprises means for advancing a slide along a predetermined path at a predetermined speed with the one face thereof oriented in a predetermined manner, at least two platens spaced from one another along said path, each of said platens defining a generally flat surface disposed so as to be parallel to and spaced slightly from the one face of a slide advanced along said path, means for supplying a previously unused portion of a different liquid to the flat surface of each of said platens, each of said patens having a length measured in the direction of said path such that a slide advanced along said path at said predetermined speed is in face-to-face relation with said surface of each platen a length of time equal to the predetermined period of contact time for the liquid supplied to the respective platen, said liquid being supplied to said surfaces in an amount sufficient to fill the space between the respective surfaces and a slide moved therepast.

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U.S. Cl. X.R

118—401; 198—33