

[54] **AUTOMATIC FILLING APPARATUS
FOR CELL WASHING CENTRIFUGE**

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[58] Field of Search **233/26, 21, 12, 13, 14 R, 1 R,
233/17, 19 R; 137/240; 141/90, 130; 23/253,
259; 128/214 R**

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Primary Examiner—Jordan Franklin

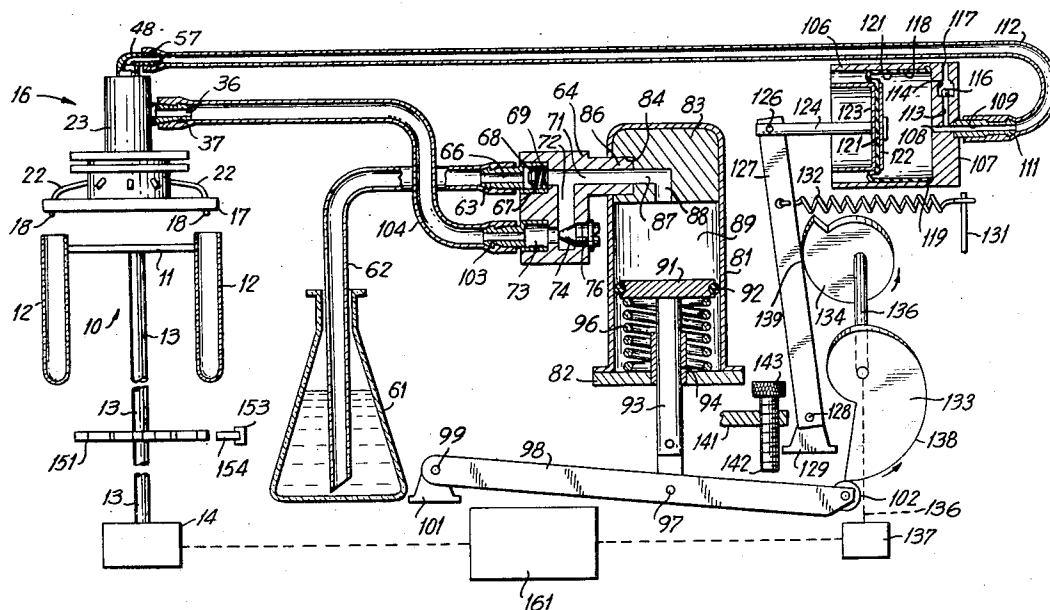
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[57] **ABSTRACT**

Automatic filling device for cell washing centrifuge in which a liquid pump and an air pump are operated in alternating timed sequence whereby a plurality of centrifuge tubes arrayed on a rotor are first filled simultaneously with a metered amount of washing liquid through a plurality of injection nozzles, and subsequently the said nozzles are purged of residual liquid by discharge of an air stream under pressure. An injection nozzle manifold is mounted above the centrifuge rotor whereby each nozzle is aligned to inject wash liquid directly into a respective centrifuge tube. Means are also provided for varying and controlling the amount of wash liquid to be injected into the centrifuge tubes. Further means are provided for repeating the sequential filling and purging cycle for successive washing procedures.

23 Claims, 3 Drawing Figures



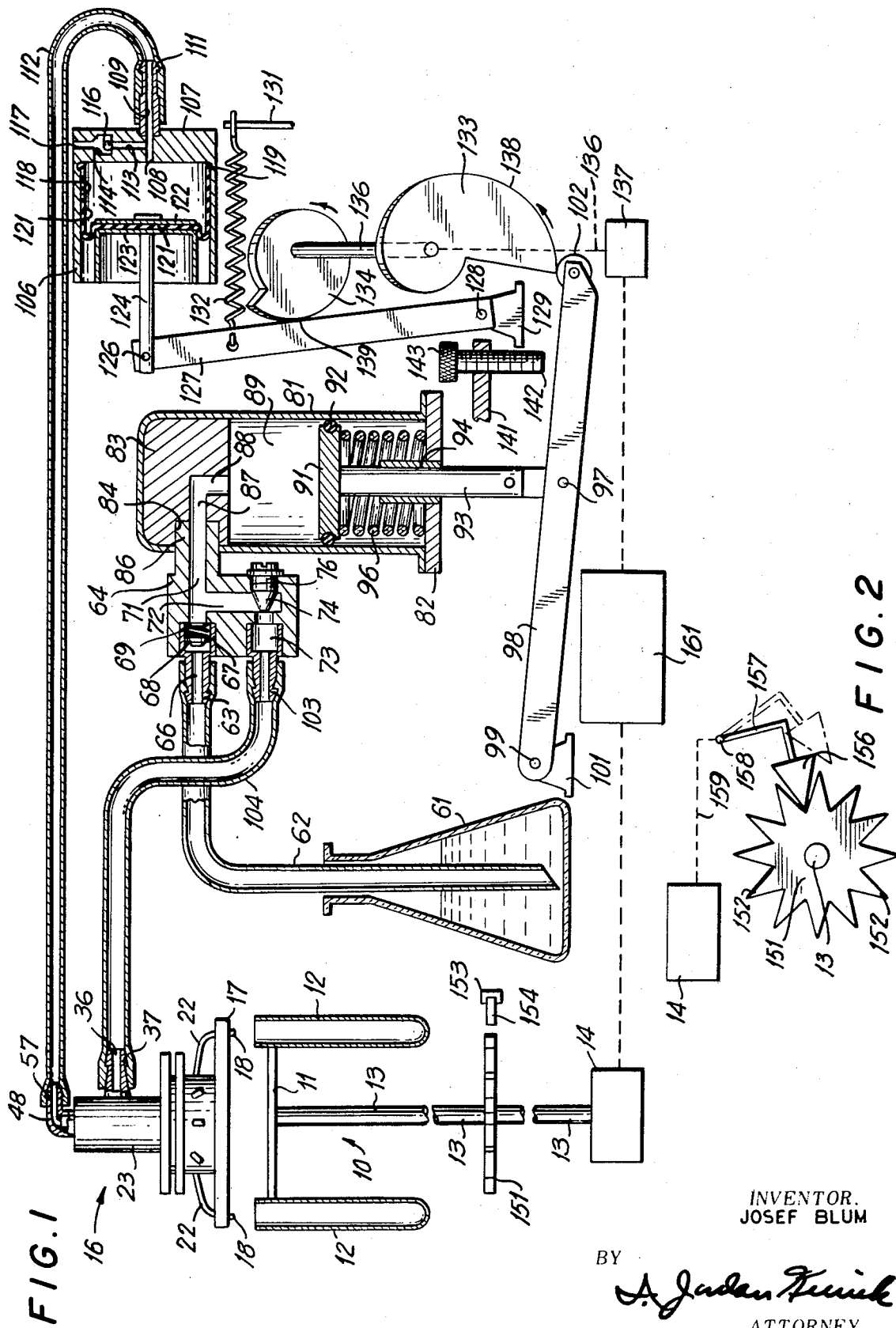
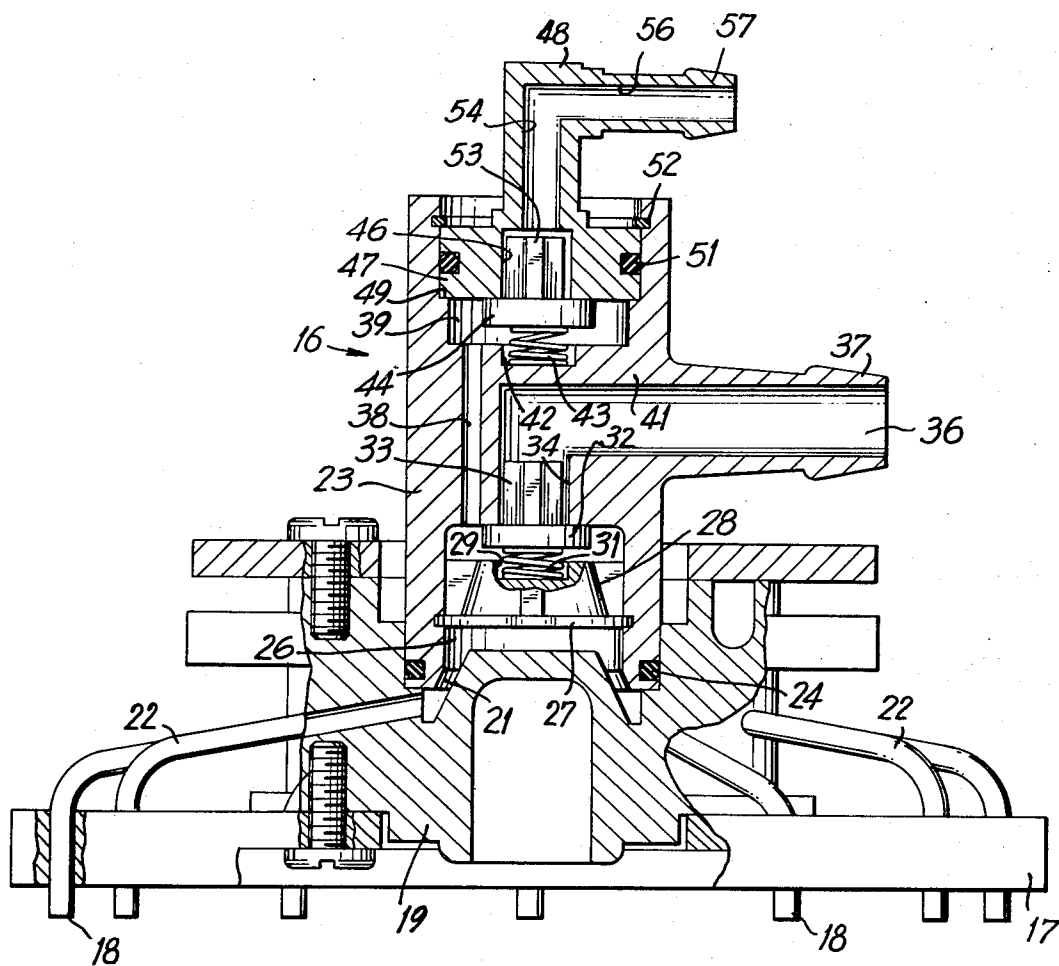


FIG. 3



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AUTOMATIC FILLING APPARATUS FOR CELL WASHING CENTRIFUGE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to cell washing centrifuges and, more particularly, to an automatic wash liquid filling device, the injection nozzle manifold of which is mounted above the cell washing centrifuge whereby metered amounts of wash liquid are injected into the centrifuging tubes by means of a plurality of injection nozzles aligned with said tubes and connected to a liquid pump. Means are also provided for purging of residual wash liquid from the manifold and from the injection nozzles into the centrifuge tubes by a jet air stream delivered from an air pump which operates after the liquid pump has completed its operation to ensure that subsequent wash liquids delivered to the centrifuge tubes will not be altered in concentration.

2. Description of the Prior Art

The prior art comprises U.S. Pat. No. 3,420,437, issued Jan. 7, 1969, which discloses a cell washing centrifuge in which biological materials are successively centrifuged and washed in repeated cycles. Said patent makes possible automatic centrifugation and decantation but it is necessary manually to refill the centrifuge tubes with successive quantities of wash liquid. This procedure is time-consuming, entails repeated handling of the apparatus, and diminishes the possibility of achieving uniform results. It would be desirable to provide a system for automatically injecting the centrifuge tubes with successive quantities of wash liquid after each decantation step takes place in the apparatus described in said patent.

SUMMARY OF THE INVENTION

In order to improve upon the operation of the cited patented device, there is provided herein a means for automatically introducing successive quantities of wash liquid simultaneously into a plurality of separate centrifuge tubes mounted on a rotor whereby manual handling is considerably diminished, errors of operation are considerably lessened, and substantially uniform standardized procedures are achieved.

The apparatus comprises a novel valve body and nozzle apparatus mounted above the centrifuge rotor illustrated in said U.S. Pat. No. 3,420,437, said manifold including a circular array of injection nozzles mounted above and equal in number to the number of centrifuge tubes arrayed in a circle on the rotor. Connected to the manifold is a liquid supply pump which, when said centrifuge rotor is at rest, causes the injection of a metered amount of wash liquid through said injection nozzles discretely into the corresponding centrifuge tubes. An air pump operating in timed sequence with the liquid pump after the liquid injection has taken place, discharges a controlled jet stream of air under pressure through the valve body and through said injection nozzles to purge any residual wash liquid that may have remained therein. This purging action eliminates the chance of excess spray or carryover into the next fill cycle. The importance of this air discharge operation is manifest when it is realized that if residual wash liquid, saline, for example, were retained in the valve body and manifold tubes and nozzles and allowed to dry, the next cycle of wash liquid would deliver a solution of higher

salt concentration. Furthermore, the liquid check valve is located in conjunction with the manifold injection nozzles whereby dead volume beyond the valve is substantially eliminated, and thereby ensuring the delivery of an equal quantity of wash liquid for each centrifuging cycle. The jet air stream check valve is also located in a position relative to the liquid check valve to permit the air stream to purge liquid from the manifold chamber, the channels, and injection nozzles. This feature is also important in order to prevent residual wash liquid from spilling onto unwanted places when the enclosure of the centrifuge and manifold is opened.

Another feature of the invention is the provision of a cam operated liquid supply pump whose piston is retracted during the suction stroke against the action of a heavy mechanical spring which stores up a large amount of energy notwithstanding the use of a relatively small motor. When the piston rod actuator is suddenly released from the high point of the spiral-shaped cam, this stored energy produces a rapid pressure stroke on the part of the piston, whereby the wash liquid is delivered in the form of a strong jet stream from the injection nozzles into each of the corresponding centrifuge tubes. This strong jet stream function is important in order physically to disperse or resuspend the button or clump of cells remaining in each of the tubes after successive decantations have taken place as described in the aforementioned patent.

The liquid pump and the air pump are operated by respective cams mounted on a common shaft and in alternating timed sequence relative to each other. The cam shaft, in turn, is operated in a timed relationship to the operation of the centrifuge rotor so that the liquid and air pumping operations occur after decantation from the centrifuge tubes has taken place, as described in said patent. Further means are also provided for coordinating the location of said centrifuge tubes when the rotor is at rest by suitable indexing and detent means so that the upper open ends of said tubes will be aligned directly below their respective injection nozzles to receive the wash liquid without any mishap.

These and other novel features and advantages of the present invention will be described and defined in the following specification and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of the automatic filling system and apparatus of the present invention, some parts being omitted, the components shown in said drawing not necessarily being in accurate scale relative to each other and with the intention that the components in the actual working embodiment of the apparatus are in different planes relative to one another where necessary;

FIG. 2 is a plan view of the star-shaped indexing wheel shown in edge view in FIG. 1, together with an alternate form of detent mechanism; and

FIG. 3 is a greatly enlarged schematic vertical section view, partly in elevation and partly broken away, of the injection nozzle manifold and check valve body assembly shown in elevation in a portion of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Throughout the following description, reference will be made to U.S. Pat. No. 3,420,437, issued Jan. 7, 1969, to J. Blum, in which cell washing centrifuges are illustrated and described, and in conjunction with which the automatic filling system and apparatus of the present invention is intended to operate. It is to be assumed that the apparatus of that patent, which performs alternating centrifuging and decanting operations, is utilized in conjunction with the apparatus and system of the present invention which causes said centrifuge to proceed automatically through a succession of wash cycles.

Although the various components in the accompanying schematic drawings do not appear to be secured to any framework, it is understood that said components are mounted firmly upon a frame or in a suitable enclosure by means well known to instrument makers, and that suitable bracketing and fastening fixtures can be improvised by the mechanic skilled in the art. It is also understood that all of the components are located in proper relationship to one another in order to perform their respective functions, notwithstanding the schematic illustration of FIG. 1 which appears to place several of them in the same plane.

Referring now to the drawings in detail, there is shown in FIG. 1 a schematic representation of a swinging bucket centrifuge, generally designated 10, as described in said patent, and which is schematically represented in FIG. 1 by rotor plate 11, to the periphery of which are pivotally connected a plurality of symmetrically spaced apart centrifuge tubes 12, which may be twelve in number. Tubes 12 are arrayed in a circle around rotatable shaft 13 to which rotor plate 11 is secured. The lower end of shaft 13 is connected to a suitable electric motor 14 for spinning rotor plate 11 at centrifuging speeds.

Mounted above centrifuge 10 is a combined injection nozzle manifold and check valve assembly, generally designated 16, shown in enlarged detail in FIG. 3. A suitable base and enclosure, not shown, supports both the centrifuge 10 and assembly 16 whereby said assembly 16 is coaxially aligned with centrifuge 10. Both of said components are enclosed within a suitable cabinet, or the like, not shown, in order to protect the apparatus and the materials being processed therein. Assembly 16 comprises a circular injection nozzle support head 17 which supports downwardly extending injection nozzles 18 in spaced apart circular array and which are equal in number to the number of centrifuge tubes 12. Support head 17 is mounted in the cabinet in a position to locate the lower ends of nozzles optimally spaced apart from the upper open ends of tubes 12.

Support head 17 is connected to a distributor body 19 in the center of which is located a circular array of distributor channels 21. The upper portions of injection nozzles 18, in the form of tubes 22, extend radially inwardly and terminate in corresponding channels 21 whereby liquid entering said channels from above is distributed evenly through tubes 22 and downwardly through injection nozzles 18.

Mounted coaxially on body 19 is a check valve housing 23 with an O-ring 24 establishing liquid-tight seal therebetween. The bottom central portion of housing

23 comprises a distributor chamber 26 within which is secured a lock ring 27 on which there rests a spring support block 28. The top of spring support block 28 has a central recess 29 within which one end of spring 31 bears, the other end of said spring bearing upwardly against a check valve 32 which, in turn, bears against a shoulder formed at the upper end of chamber 26. Check valve 32 has a stem 33 which extends into and is movable freely within a central channel 34 which communicates with a laterally extending channel 36 in connector 37. Liquid entering under pressure into channel 36 and channel 34 causes the downward movement of valve 32 against the action of spring 31 to permit said liquid to enter chamber 26. This is made possible by the fact that stem 33 has recessed longitudinal peripheral flutes which permit the liquid to bypass said stem and enter into the upper end of chamber 26. It will also be noted that spring support block 28 has peripheral longitudinal recessed flutes which extend inwardly a greater distance than the inside diameter of lock ring 27 whereby liquid can pass from the upper portion of chamber 26 to the lower portion thereof and into channels 21 and thence through nozzles 18.

Located in the interior of check valve housing 23 is at least one or a plurality of longitudinal air channels 38, the lower ends of which communicate with chamber 26 and the upper ends of which communicate with air chamber 39. Channel 36, in the interior of housing 23, is bounded on top by a horizontal shoulder 41 in the top surface of which is a central recess 42 in which is located one end of air check valve spring 43, the upper end of which bears against the bottom of air check valve 44. Check valve 44 is urged upwardly against a shoulder surrounding central aperture 46 in the base 47 of an air inlet elbow 48. Base 47 rests upon an annular shoulder 49 within the upper end portion of check valve housing 23 and has a suitable annular recess which accommodates an O-ring 51 to serve as an air-tight seal between said base and said housing. Base 47 is secured in position by means of a retaining ring 52. Air check valve 44 has an integrally formed stem 53 which extends upwardly into axial aperture 46, said stem having longitudinal peripheral flutes which permit air to pass downwardly from aperture 46 into air chamber 39 when air check valve 44 is moved by air pressure downwardly against the action of spring 43. Aperture 46 communicates with a vertical channel 54 in elbow 48 which terminates in a laterally extending channel 56 in connector 57.

In one embodiment of the apparatus described herein, the cabinet encloses both the centrifuge 10 and assembly 16, except for the exposure of connectors 37 and 57 which extend outwardly therefrom to enable flexible tubes to be attached to said connectors to deliver wash liquid and air under pressure for performing the functions to be described hereinafter.

The wash liquid supply for injecting wash liquid into centrifuge test tubes 12 is located in a reservoir container 61 in which is located one end of a flexible liquid supply tube 62, the other end of which is connected to a connector 63 formed on a cylinder feed block assembly 64. Channel 66 of connector 63 communicates with a valve chamber 67 in the interior of assembly 64. Located in chamber 67 is a check valve body 68 which is normally urged to close channel 66 by means of

check valve spring 69. Valve chamber 67 communicates with channel 71 in the interior of assembly 64, the latter having intermediate its ends a bypass channel 72 which, in turn, communicates with an outlet channel 73. Located at the juncture between channels 72 and 73 is a control valve 74 which is mounted on a stem 76 which extends threadably through a wall of assembly 64 and which can be adjusted to locate valve 74 in a desired position relative to the inner end of outlet channel 73 whereby the flow speed of liquid from channel 72 into channel 73 may be determined. Stem 76 can be locked in the desired position by means of nut 77. By this means, the force of the jet streams of wash liquid from nozzles 18 into tubes 12 may be adjusted and controlled.

The wash liquid pressure component of the apparatus comprises a tubular cylinder 81 mounted on a suitable base 82 secured firmly to the apparatus frame, not shown. Occupying the upper portion of cylinder 81 is a block 83 having a lateral recess 84 which accommodates boss 86 integrally formed on assembly 64, said boss surrounding channel 71. The side wall of cylinder 81 has a suitable aperture which accommodates boss 86 with a close fit. A laterally extending channel 87 in block 83, aligned and communicating with channel 71, communicates also with vertical channel 88 which, in turn, communicates with the chamber 89 of cylinder 81.

Movable reciprocally within cylinder chamber 89 is a piston 91 having a peripheral annular recess which accommodates a suitable O-ring seal 92. Connected to piston 91 is a piston rod 93, a portion of which is movable reciprocally within a sleeve 94 mounted in base 82. Located within cylinder chamber 89, below piston 91, is a spring 96, the lower end of which bears upon base 82 and the upper end of which bears upon the bottom surface of piston 91 and normally urges the latter in an upward direction to perform its pressure stroke.

The lower end of piston rod 93 is connected by means of a pivot pin 97 to the intermediate portion of cantilever arm 98. One end of arm 98 is connected by means of pivot pin 99 to a bracket 101 secured firmly on the frame of the apparatus, not shown. Rotatably mounted on the free end of cantilever arm 98 is a cam roller 102.

During the downward suction stroke of piston 91 against the action of spring 96, wash liquid is drawn from reservoir 61 through tube 62 into chamber 89 of cylinder 81. During this action, valve 68 is retracted against the action of spring 69 to permit said liquid to flow through channels 71, 87 and 88 into chamber 89. During the upward pressure stroke of piston 91, spring 69 urges valve 68 against and closes channel 66 of connector 63 whereby wash liquid under pressure passes through channels 88, 87 and 72, and 73, through connector 103 and by way of flexible tube 104 to connector 37, whereby said wash liquid passes through channels 36 and 34 into chamber 26 and thence through tubes 22 and injection nozzles 18 into centrifuge tubes 12. The pressure under which wash liquid is transmitted, causes the downward movement of valve 32 against the action of spring 31. During the downward suction stroke of piston 91, spring 31 acts to urge valve 32 upwardly to seal off the bottom of channel 34.

The air pressure component of the apparatus comprises a tubular cylinder 106 which is secured firmly upon the apparatus frame, not shown. Cylinder 106 has a cylinder head 107 having a central channel 108 with which is aligned channel 109 of connector 111 to which one end of flexible tube 112 is attached, the other end of which is attached to connector 57 of check valve housing 23. Communicating laterally with channel 108 in cylinder head 107 is an air inlet channel 113 which terminates in a valve chamber 114 in which is located a ball valve 116. Valve chamber 114, in turn, terminates in an air inlet port 117.

Secured adjacent cylinder head 107 within chamber 118 of cylinder 106 is the rim 119 of a flexible diaphragm piston 121, the closed end portion of which is mounted fast between a pair of piston plates 122 and 123, said plates, in turn, being mounted on an axial piston rod 124. During the leftward movement of rod 124 which causes the flexible diaphragm 121 and the piston plate assembly 122, 123 to produce a suction stroke, atmospheric air is drawn into port 117 and through channel 113 into chamber 118 of cylinder 106. During this suction stroke, channel 54 in elbow 48 of the check valve housing 23 is closed off by the action of spring 43 against air check valve 44. During the movement of rod 124 to the right, thereby causing piston plates 122, 123 and flexible diaphragm 121 to produce a pressure stroke, ball valve 116 is urged upwardly against the tapered walls of valve chamber 114 to seal off port 117 whereby air is delivered under pressure through channels 108 of cylinder head 107, channel 109 through tube 112, and through channels 56 and 54 of elbow 48 to urge check valve 44 downwardly against the action of spring 43 whereby air is transmitted through channels 38 to injection tubes 22 and thence through injection nozzles 18.

It will be noted that ball valve 116, as shown in the retracted position in FIG. 1, appears to rest upon the end of channel 113. Notwithstanding the schematic showing of FIG. 1, it is intended that the upper end of channel 113 is suitably fluted, or the like, in order to permit air to bypass said ball valve 116 when air is being drawn into chamber 118 of cylinder 106. In one embodiment, ball 116 may rest on a metal screen lying across the upper end of channel 113. Other suitable means for accomplishing this function are well known in the mechanical arts.

The outer end of piston rod 124 is connected by pivot pin 126 to one end of lever arm 127, the lower end of which is connected by means of pivot pin 128 to a stationary base 129 mounted on a portion of the apparatus frame, not shown.

Connected to a suitable portion of the frame is a stationary post 131 to which is connected one end of a spring 132, the other end of which is connected to lever arm 127. The action of spring 132 normally causes the clockwise pivoting motion of lever arm 127 to cause piston rod 124 and piston plates 122, 123 and diaphragm 121 to produce an air pressure stroke within cylinder 106.

The timed and coordinated alternating action of the wash liquid pump and the air pump is accomplished by means of liquid pump cam 133 and air pump cam 134, both of said cams being mounted on a shaft 136 rotated counterclockwise by an electric motor 137. Cam 133

cooperates with roller 102 on cantilever arm 98, while cam 134 cooperates with lever arm 127. Spiral cam surfaces 138 and 139 of came 133 and 134, respectively, are located in relationship to each other whereby their respective positive actions produce successive alternating pressure strokes within liquid cylinder 81 and air cylinder 106, respectively.

During the rotation of cam 133, cam surface 138 causes the downward pivotal movement of cantilever arm 98 as well as the downward movement of piston shaft 93 to cause piston 91 in cylinder 81 to produce a liquid suction stroke against the action of spring 96. In the illustration in FIG. 1, piston 91 has been retracted in its suction stroke to the limit of its movement since roller 102 is at the peak of cam surface 138. It is intended that said piston always produce a full suction stroke in the manner indicated in FIG. 1. As cam 133 continues its counterclockwise rotation, roller 102 will drop off the peak edge of cam surface 138 whereby spring 96 is suddenly released to urge piston 91 upwardly to produce its pressure stroke.

In order to vary the amount of wash liquid to be delivered to centrifuge tubes 12, there is provided a stationary bracket 141 mounted on a suitable portion of the apparatus frame, not shown. Threadably engaged in bracket 141 is a control screw 142 having a knurled head 143. The lower end of screw 142 is located in a position where, upon the release of roller 102 from the peak of cam surface 138, cantilever arm 98 moves upwardly under the action of spring 96 and abuts said screw to limit its upward motion, thereby limiting the pressure stroke of piston 91 so that the quantity of wash liquid delivered from the liquid pump is also limited. By adjusting the location of the end of screw 142, the precise quantity of wash liquid to be delivered to centrifuge tubes 12 may be adjusted and controlled.

The strength of spring 96 is selected to produce jet streams of sufficient and controlled force to be delivered by nozzles 18 so that agglomerated buttons or clumps of cells remaining in centrifuge tubes 12 after prior decantation, will be dispersed and resuspended in the fresh wash liquid to enable subsequent satisfactory wash centrifugation to take place. In order to produce the desired strong impulse of the wash liquid jet streams, it is advantageous that spring 96 be released quickly to cause piston 91 to produce a swift thrust during its pressure stroke. Accordingly, the contour of that portion of cam 133 located between the high and low radius points of cam surface 138 may be countersunk or recessed so that cam roller 102 will make a rapid drop from the crest of the cam surface to the low point thereof.

The operation of the air pump is controlled by cam surface 139 of cam 134 against which lever 127 is continually urged by the action of spring 132. As lever 127 pivots leftward, it causes the leftward movement of piston rod 124, of piston plates 122, 123 and of diaphragm 121 whereby the latter produces its suction stroke against the action of spring 132. It will be noted that the crest or highest point of cam surface 139 bearing against the edge of arm 127 is not reached until after roller 102 has dropped from the outermost crest of cam surface 138 of cam 133. When the crest of cam surface 139 of cam 134 passes beyond its contact with the edge of lever arm 127, spring 132 will cause the

rapid movement of said arm and piston rod 124 to the right to produce the pressure stroke of the air pump which, in turn, will produce a rapid jet stream of air to purge the interior channels and chambers of check valve housing 23 and of injection tubes 22 and injection nozzles 18.

Cams 133 and 134 are fixed in a predetermined relationship on shaft 136 whereby piston 91 in wash liquid cylinder 81 starts and completes its pressure stroke prior to the start of the pressure stroke of diaphragm 121 in air cylinder 106.

In order to provide proper operation of the manifold injection system in conjunction with the centrifuge tubes 12, it is necessary to align the upper open ends of said tubes with respective injection nozzles 18. Accordingly, one mode of accomplishing this alignment can be achieved by mounting fast on shaft 13 a star wheel 151 having a plurality of peripherally radiating star points 152 equal in number to the number of centrifuge tubes 12 and jet nozzles 18. Mounted on a bracket 153 secured to a portion of the apparatus frame, not shown, is a magnet 154 which is slightly spaced apart and aligned in the same plane with the periphery of star wheel 151. After each successive wash procedure, including centrifugation and decanting, motor 14 is shut off to stop the rotation of rotor 11 and centrifuge tubes 12 so that a new supply of fresh wash liquid may be injected into said tubes. The proper alignment of tubes 12 relative to injection nozzles 18 is caused by the influence of magnet 154 upon the nearest point 152 of star wheel 151 made of magnetically permeable material. Magnet 154 will attract said nearest point 152 to cause wheel 151 and shaft 13 to rotate any requisite increment whereby the desired alignment will be accomplished. The mounting of wheel 151 on shaft 13 and the location of magnet 152 are coordinated to bring about the desired result.

Alternatively, another means for accomplishing the alignment of centrifuge tubes 12 with injection nozzles 18 comprises the utilization of the same star wheel 151, but with the substitution of a wedge element 156 mounted on a lever 157 pivoting on pin 158. By suitable means well known in the art, lever 157 is connected by a mechanical element 159 to motor 14 whereby the stopping of said motor causes pivot arm 157 to move inwardly towards the star wheel 151 and to cause wedge element 156 to enter into the angled space between a pair of adjacent star points 152 to immobilize star wheel 151, thereby immobilizing shaft 13. When motor 14 is started to cause the rotation of centrifuge shaft 13, element 159 is activated to move lever 157 pivotally to withdraw wedge element 156 from engagement with star wheel 151.

The operation of motors 14 and 137 are coordinated by means of an electrical control system logic 161 connected between said motors and to a suitable electric power source, not shown. The electrical circuitry, together with the requisite on-off switches, stepping switches, control knobs, push buttons, and signal lights, serve selectively to time the successive centrifuging and decanting operations, selectively determine the different speeds of rotation during centrifugation and decanting, selectively determine the number of washing cycles to be repeated, and to signal the number of desired cycles that have been completed. These control

knobs and push buttons, manipulated in advance by the operator, start the system for automatically proceeding with several cycles of cell washing, leaving him free to attend to other duties.

Although the present invention has been described with reference to particular embodiments and examples, it will be apparent to those skilled in the art that variations and modifications can be substituted therefor without departing from the principles and true spirit of the invention. The "Abstract" given above is for the convenience of technical searchers and is not to be used for interpreting the scope of the invention or claims.

I claim:

1. An apparatus having a plurality of centrifuge tubes wherein said tubes are adapted to have wash liquid injected therein, a centrifuging rotor having said tubes circularly arrayed thereon, a plurality of nozzles for delivering liquid to respective centrifuge tubes, each of said nozzles being positioned opposite a corresponding centrifuge tube, liquid pump means for intermittently projecting a metered amount of liquid through said nozzles and directed into said corresponding tubes, air pump means for intermittently projecting air under pressure through said nozzles to purge the latter of wash liquid and means for repeatedly alternating the operation of said liquid pump means and said air pump means, said alternating means comprising a first piston in said liquid pump, a second piston in said air pump, a rotatable shaft, a first cam on said shaft for controlling the movement of said first piston, and a second cam on said shaft for controlling the movement of said second piston.

2. Apparatus according to claim 1 and further comprising means mounted on said rotor for indexing the location of said tubes when said rotor is at rest so that each of said nozzles is located directly opposite the upper open end of a corresponding centrifuge tube.

3. Apparatus according to claim 1 and further comprising means for varying and controlling the quantity of wash liquid delivered by said liquid pump means.

4. Apparatus according to claim 1 and further comprising adjustable means between said liquid pump means and said nozzles for determining the force of the jet streams of liquid delivered by said nozzles into the respective tubes.

5. Apparatus according to claim 1 and further comprising a first check valve between said liquid pump and said nozzles, and a second check valve between said air pump means and said nozzles, said liquid pump means completing its pumping operation before the operation of said air pump means, said second check valve being located in a position relative to said first check valve whereby the opening of said second check valve permits air under pressure from said air pump means to purge the passages between said first check valve and the output ends of said nozzles of wash liquid previously released by said first check valve.

6. Apparatus according to claim 1 and further comprising a source of wash liquid, a liquid transmission assembly connected between said source and said liquid pump means, an inlet check valve in said assembly permitting only one-way liquid movement from said source to said liquid pump means, liquid inlet means connected between said nozzles and said liquid trans-

mission assembly, a check valve in said nozzle inlet means normally closing the transmission of liquid from said liquid pump means to said nozzles during the suction stroke of said liquid pump means, said wash liquid being delivered to said nozzles against the action of said nozzle check valve during the pressure stroke of said liquid pump means.

7. Apparatus according to claim 1 and further comprising a first motor for rotating said rotor, a second motor for rotating said shaft, means connected to both of said motors for alternating their operation whereby said second motor brings about the action of filling said centrifuge tubes when said first motor and said rotor are at rest, and means for repeating the cycle of alternating action of said first and second motors.

8. An apparatus having a plurality of centrifuge tubes wherein said tubes are adapted for at least partial filling with wash liquid, a centrifuging rotor having said tubes circularly arrayed thereon, a first means including a first piston pump for projecting said liquid under pressure simultaneously into each of said tubes, a second means including a second piston pump for subsequently discharging a stream of air under pressure through said first means to purge any residual wash liquid remaining in said first means, a rotatable shaft, a first spiral-shaped cam and a second spiral-shaped cam on said shaft, said first and second cams cooperating with said first and second pumps, respectively, to produce their respective pressure strokes, said cams being arrayed on said shaft to cause said first pump to complete its pressure stroke before the operation of the pressure stroke of said second pump.

9. Apparatus according to claim 8 and further comprising alternating means connected to said first and second piston pumps.

10. Apparatus according to claim 9 and further comprising fourth means for operating said third means to produce repetitions of the alternating operations of said first and second means.

11. Apparatus according to claim 8 and further comprising adjustable fourth means for controlling the length of the pressure stroke of the piston in said pump to deliver a desired metered quantity of liquid into said tubes.

12. Apparatus according to claim 8 and further comprising means for controlling the force of the jet streams of liquid projected into said tubes.

13. Apparatus according to claim 8 wherein said first piston pump completes its function before said second piston pump operates.

14. Apparatus according to claim 8 and further comprising first and second springs cooperating with said first and second pumps, said springs producing the pressure strokes of said respective pumps after the latter have been released from the high radius points of their respective cams.

15. Apparatus according to claim 8 and further comprising a manifold and check valve assembly, a plurality of nozzles in spaced circular array on said manifold and equal in number to said centrifuge tubes with each nozzle located above and serving a corresponding tube, a first connection between said first means and said manifold for transmitting liquid under pressure to said manifold, a second connection between said second means and said manifold for transmitting air under

pressure to said manifold, a first check valve in said manifold for said first connection, and a second check valve in said manifold for said second connection, both of said check valves alternately permitting communication between the respective first and second piston pumps on the one hand, and said nozzles on the other hand when said respective means are in alternating pressure operation.

16. Apparatus according to claim 8 and further comprising a first piston rod operating said first piston pump and a second piston rod operating said second piston pump, a first lever connected to said first piston rod, a second lever connected to said second piston rod, a rotatable shaft, a first cam on said shaft for operating said first lever, a second cam on said shaft for operating said second lever, said cams being arranged on said shaft whereby, upon their rotation, one of said pistons performs and completes its respective pressure stroke prior to the other piston performing and completing its pressure stroke.

17. Apparatus according to claim 16 wherein both of said cams have spiral-shaped camming surfaces and wherein the increasing radii of said surfaces cause their respective corresponding pistons to perform their respective suction strokes.

18. Apparatus according to claim 17 and further comprising a first spring for said first piston, a second spring for said second piston, both of said springs causing their respective pistons to perform their respective pressure strokes during the drop of the respective levers from the high radius points to the low radius levels of the respective first and second cams.

19. Apparatus according to claim 8 and further comprising a manifold located above said rotor, a distributor chamber in said manifold, a plurality of nozzles in spaced circular array on said manifold communicating

with said distributor chamber, the outlet of each of said nozzles each being aligned with and spaced apart from the upper open end of a corresponding centrifuge tube, a first liquid inlet on said manifold connected to said first means and communicating with said distributor chamber, a first check valve mounted between said first inlet means and said chamber, a second air inlet on said manifold connected to said second means and communicating with said distributor chamber, and a second check valve located between said second inlet means and said distributor chamber.

20. Apparatus according to claim 19 wherein said distributor chamber, said first check valve, and said second check valve are axially aligned with each other and with the axis of said rotor.

21. Apparatus according to claim 19 wherein said second inlet means and said second check valve are located above said first inlet means and said first check valve, and further comprising at least one channel between said air inlet means and said distributor chamber which bypasses said first inlet means and said first check valve.

22. Apparatus according to claim 21 wherein the output end of said channel is located in a position to project purging air in the space from said first check valve through said distributor chamber and through said nozzles.

23. Apparatus according to claim 19 and further comprising a plurality of distributor tubes mounted radially on said manifold, the inner ends of said tubes communicating with said distributor chamber, the outer ends of said tubes terminating in the form of said nozzles, said nozzles being arrayed vertically to project fluid and air alternately into corresponding centrifuge tubes.

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