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R. J. ROSOV

3,778,351

AUTOMATIC BACTERIAL SPECIMEN STREAKER

Filed March 16, 1971

4 Sheets-Sheet 1

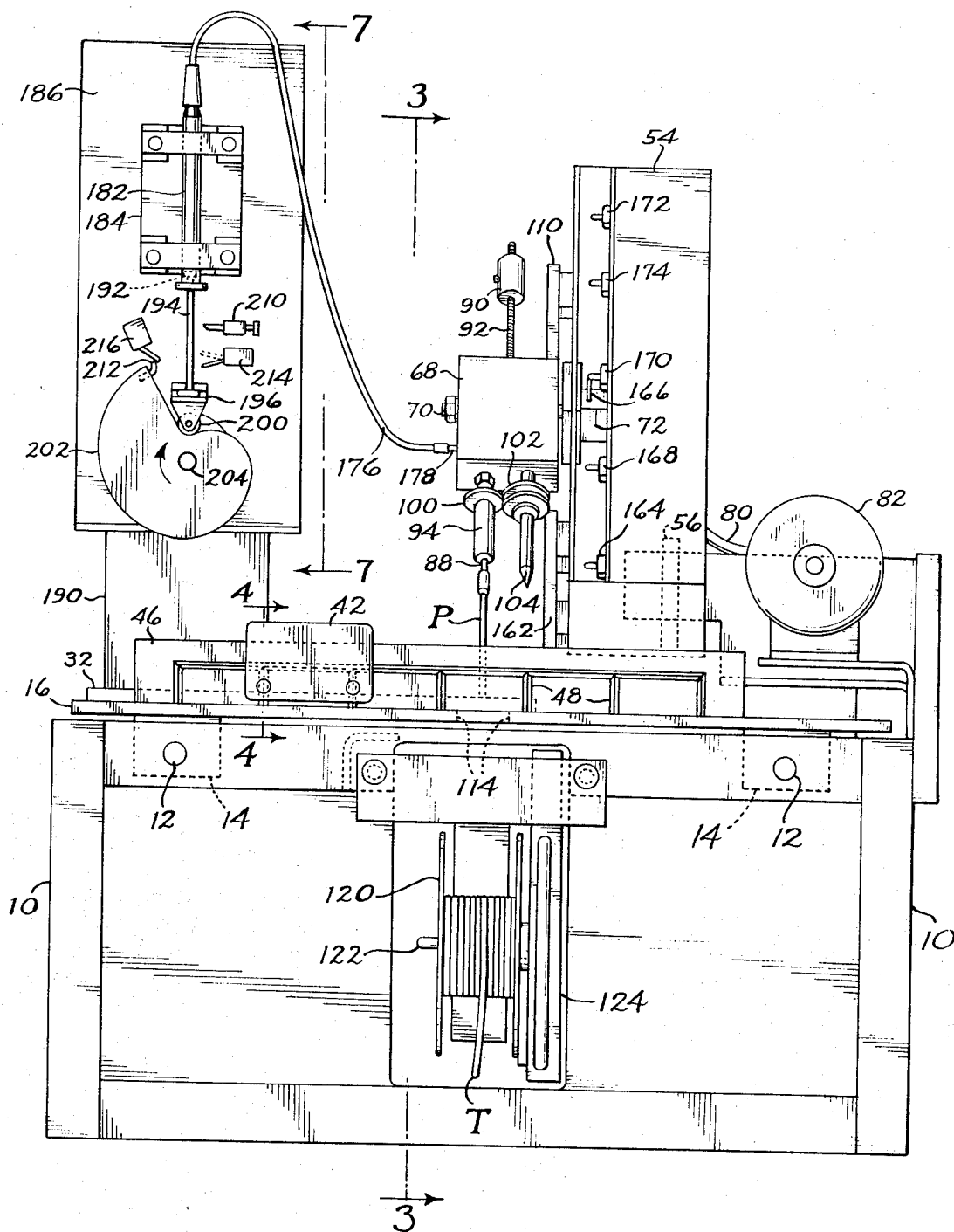


Fig. 1.

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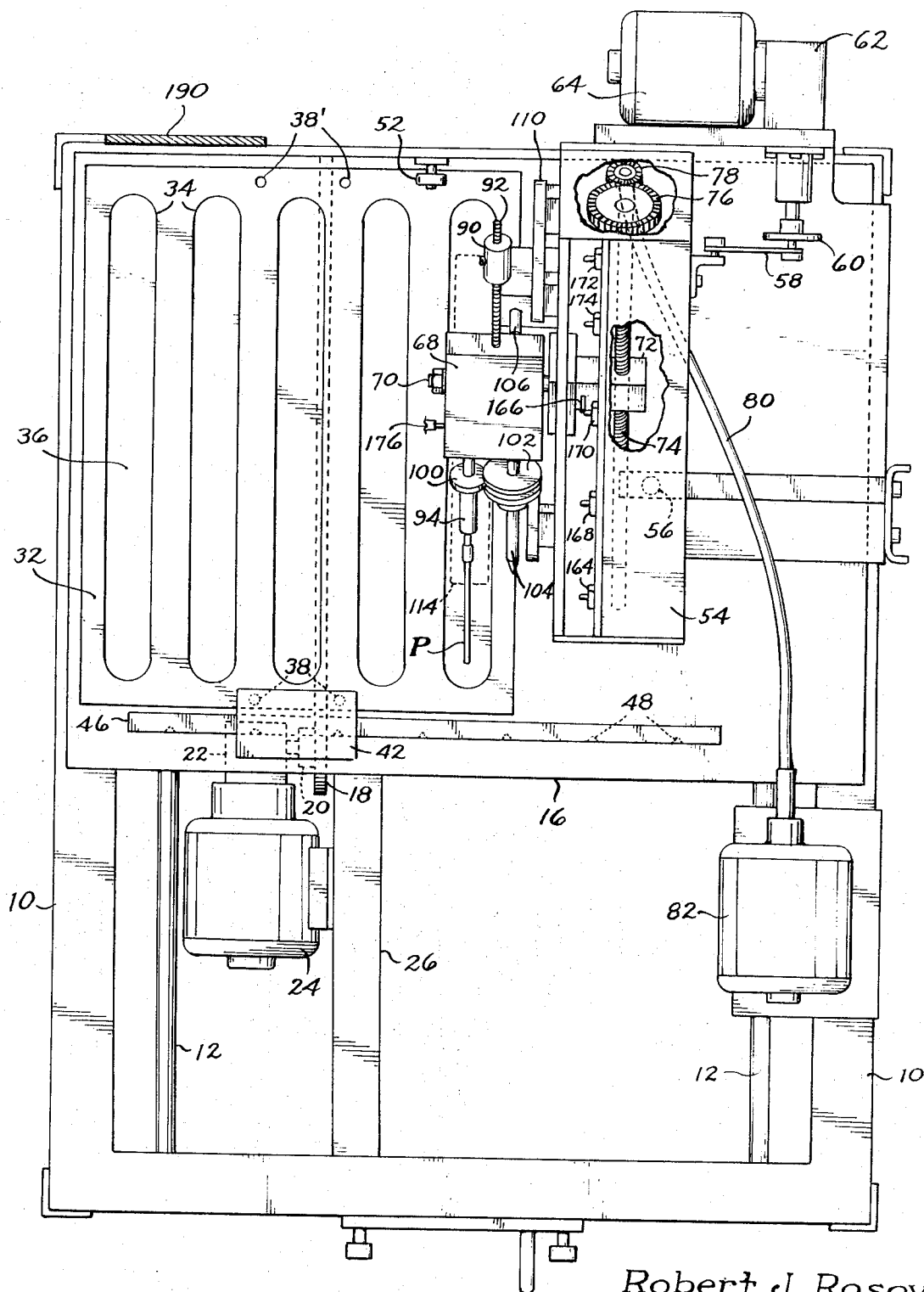
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4 Sheets-Sheet 2



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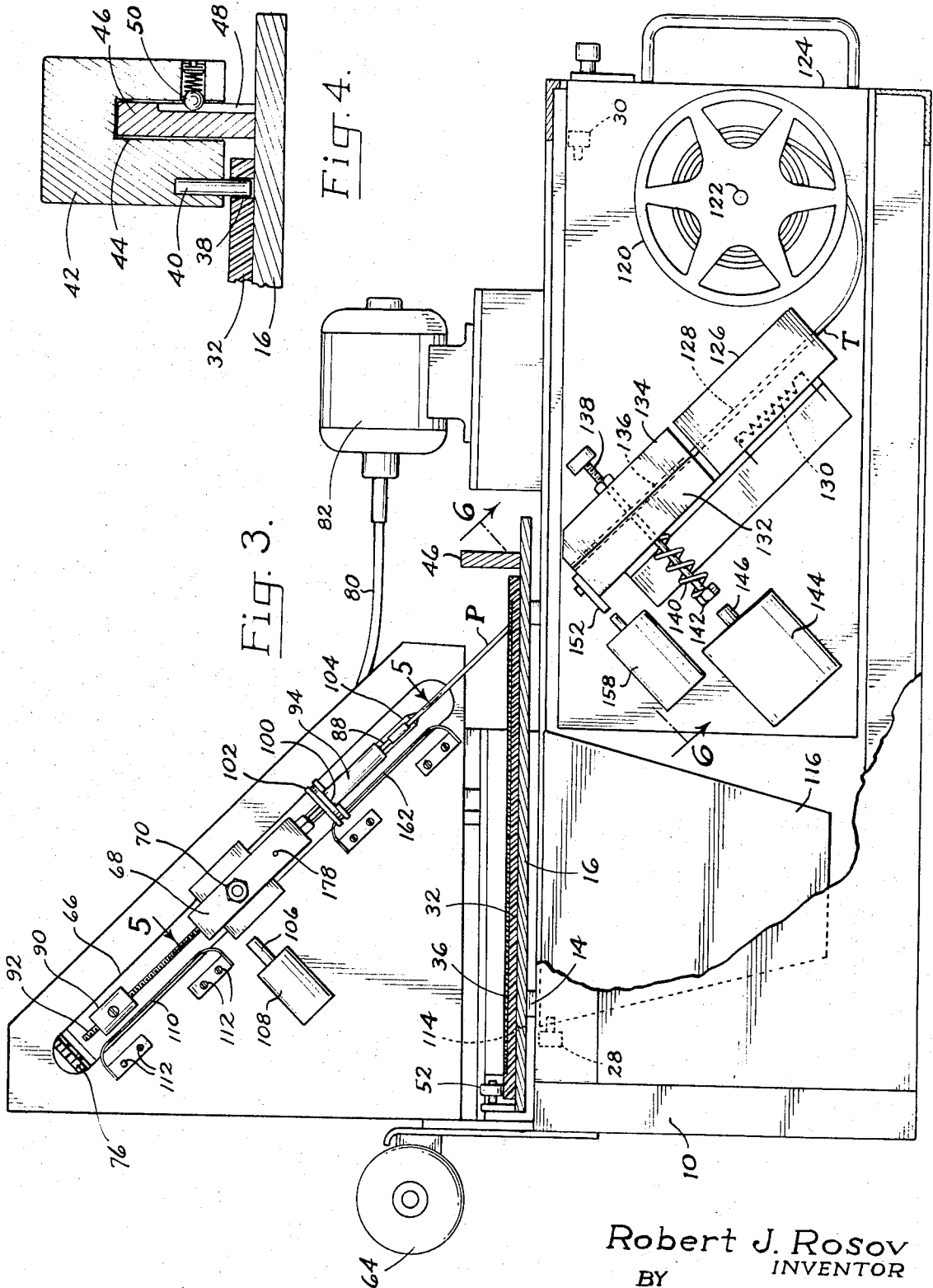
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AUTOMATIC BACTERIAL SPECIMEN STREAKER

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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

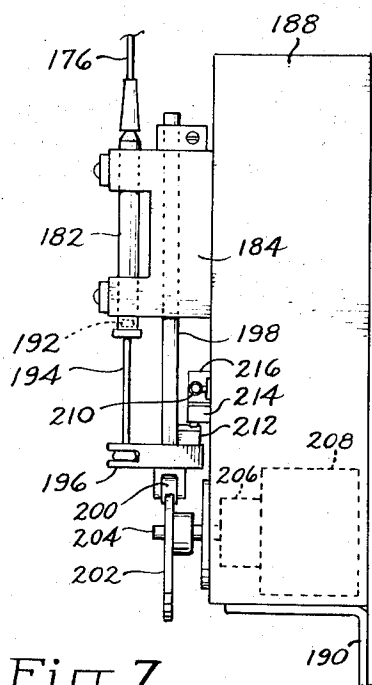


Fig. 7.

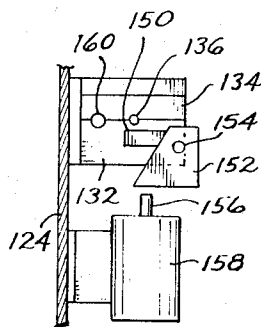


Fig. 6.

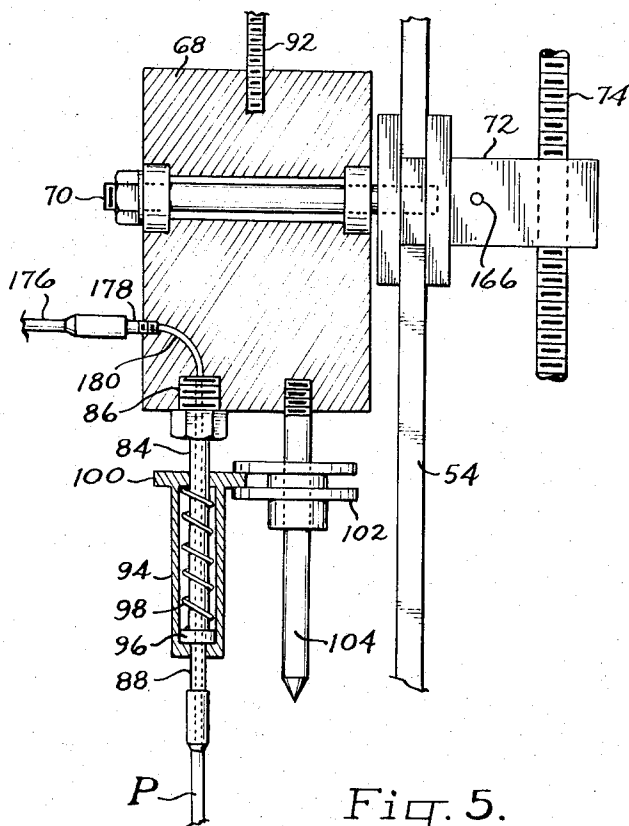


Fig. 5.

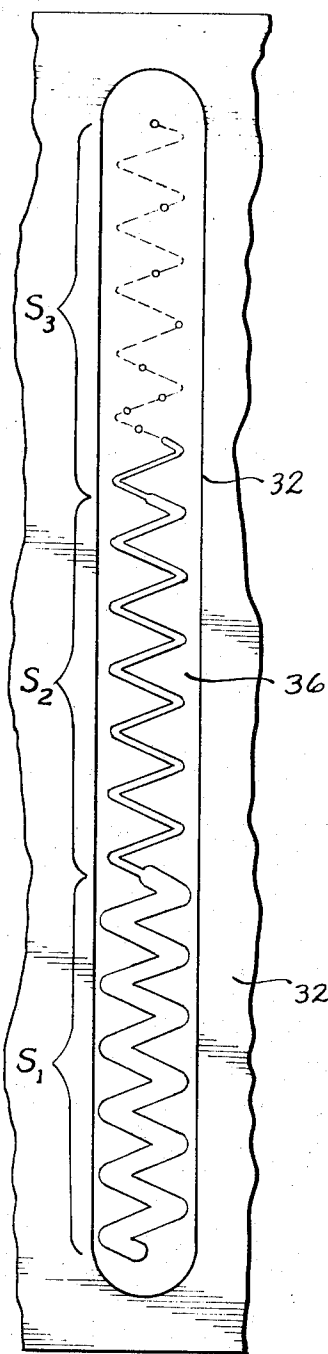


Fig. 8.

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1

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AUTOMATIC BACTERIAL SPECIMEN STREAKER
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Int. Cl. C12k 1/10

U.S. Cl. 195-127

8 Claims

ABSTRACT OF THE DISCLOSURE

A frame mounts a table for controlled movement in the longitudinal direction of a specimen plate supported on the table while a disposable pipette mounted on a sub-frame above the specimen plate oscillates transversely of the latter to deposit a specimen on the plate in a sinusoidal pattern. Means is provided for controlling the volume rate of delivery of specimen from the pipette to the specimen plate. Automatic means is provided for discarding each pipette after use and for producing pipettes from a supply coil of plastic tubing.

BACKGROUND OF THE INVENTION

This invention relates to the preparation of bacterial specimens for visual counting, typing and other analysis of the bacterial populations, and more particularly to apparatus by which to prepare such specimens automatically and with a high degree of reproducibility.

The preparation of bacterial specimens for analyses heretofore has been done by hand. For example, the determination of bacterial number heretofore has involved the pouring of two samples of the specimen, in different dilutions, into separate Perti dishes, adding agar to each and mixing by agitation. These preparations are allowed to gel and then they are incubated for eighteen hours. Thereafter, a part or the whole of the better sample is counted. The random arrangement of colonial growth renders counting tedious and susceptible of considerable error.

The preparation of a bacteria specimen for the determination of type heretofore has involved the collection of a sample onto a wire loop and then streaking it across various types of agar on Perti dishes. These are then incubated for eighteen hours and thereafter examined for identification. Manual streaking of the specimens results in uneven and non-reproducible deposit, rendering typing and other analyses questionable.

Thus, not only has it been required that separate specimens be prepared for the determination of bacteria number and type, which preparations involve considerable time and therefore expense, but in addition such manual preparations are characterized by deficiencies which render the analyses difficult and the results questionable.

SUMMARY OF THE INVENTION

In its basic concept, the apparatus of this invention provides for the controlled relative movement of a specimen plate and dispensing pipette and the controlled volume rate of delivery of specimen from the pipette to the plate, to effect the preparation of a specimen having predetermined and reproducible characteristics of pattern and concentration.

It is by virtue of the foregoing basic concept that the principal objective of this invention is achieved; namely, to overcome the aforementioned disadvantages of prior preparation procedures.

Another object of this invention is the provision of apparatus of the class described which accommodates the preparation of a plurality of bacterial specimens of the same or different types, on the same or different types of

2

growth media, with speed and precision and without cross-contamination between specimens.

Still another object of this invention is the provision of apparatus of the class described which accommodates the preparation, on a single specimen plate, of a plurality of separated specimens of different types, on the same or different types of growth media, thereby enhancing the ease and facility of multi-culture handling, incubation and storage.

A further object of this invention is the provision of apparatus of the class described which is of relatively simplified construction for economical manufacture, which is capable of adjustment with speed and facility for varying the characteristics of specimens, and is capable of long service life with minimum maintenance and repair.

The foregoing and other objects and advantages of this invention will appear from the following detailed description, taken in connection with the accompanying drawings of a preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in front elevation of an automatic bacterial specimen streaker embodying the features of this invention.

FIG. 2 is a plan view of the streaker shown in FIG. 1, parts being broken away to disclose details of internal construction.

FIG. 3 is a sectional view taken along the line 3-3 in FIG. 1.

FIG. 4 is a fragmentary sectional view taken along the line 4-4 in FIG. 1.

FIG. 5 is a fragmentary sectional view taken along the line 5-5 in FIG. 3.

FIG. 6 is a fragmentary sectional view taken along the line 6-6 in FIG. 3.

FIG. 7 is a fragmentary vertical end elevation as viewed in the direction of the arrow 7-7 in FIG. 1.

FIG. 8 is a fragmentary plan view illustrating a pattern of specimen deposition resulting from operation of the streaker.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The apparatus illustrated includes a main frame 10 upon which the components of the apparatus are supported. Extending between the front and rear ends of the frame, inwardly of an adjacent the opposite sides of the latter, are a pair of table guide rods 12. Apertured guide blocks 14, provided with suitable anti-friction bearings, are mounted on these rods and are secured to the underside of a table 16 which overlies the frame. An elongated rack 18 (FIG. 2) on the underside of the table extends parallel to the guide rods is engaged by a pinion 20 connected to the output shaft of a gear reduction unit 22 driven by a reversible electric motor 24. The gear reduction unit and motor are mounted on an intermediate member 26 of the frame.

The table thus is supported for longitudinal reciprocation between the front and rear ends of the frame. The limits of longitudinal reciprocation of the table may be established by various means. For example, limit switches 28 and 30 (FIG. 3) in the electric circuit of the drive motor 24 may be mounted on the frame for engagement by the blocks 14 movable with the table.

The table supports a specimen plate 32 which is made of a material, such as polycarbonate synthetic plastic resin, that is inert and is capable of being autoclaved. The plate also preferably is transparent. In the preferred embodiment illustrated the specimen plate accommodates the preparation of a plurality of bacterial specimens sepa-

rated from each other. Thus, the plate is milled or otherwise fabricated to provide a plurality of laterally spaced, elongated grooves 34 which terminate inward of the front and rear edges of the plate. These grooves are adapted to be filled with agar, or other material 36 suitable as a base for the growth of bacteria, upon which the inoculum is to be streaked, as explained hereinafter. Thus, each groove may contain a different type of agar and one specimen may be streaked over each. Alternatively, the grooves may be filled with the same type of agar and a different type of specimen streaked over each.

Means is provided for indexing the specimen plate to bring each groove into alignment with specimen dispensing means described hereinafter. Thus, the specimen plate is provided adjacent its front edge with a pair of laterally spaced holes 38. These are arranged to receive correspondingly spaced locking pins 40 (FIG. 4) projecting downward from an indexing block 42. A transverse groove 44 in the block slidably receives a transverse guide plate 46 which is secured to and projects upward from the table adjacent the front edge thereof. The guide plate is provided with a plurality of laterally spaced grooves 48 on its front face. The indexing block is provided with a pair of spring pressed detent balls 50 spaced laterally the same distance as the spacing between adjacent pairs of the grooves 48. The grooves are arranged on the guide plate such that as the detent balls engage adjacent pairs of the grooves a corresponding groove 34 in the specimen plate, locked to the indexing block, is brought into alignment with specimen delivery means described hereinafter.

The rearward end of a specimen plate is held firmly against the table by means of a resilient roller 52 (FIGS. 2 and 3) which allows the specimen plate to slide laterally over the table.

To render the specimen plate reversible, end for end, there is provided adjacent the rear edge thereof a similar pair of laterally spaced openings 38' for receiving the locking pins 40 of the indexing block.

Means is provided for supporting a dispensing pipette in cooperative relation to the specimen plate, for dispensing bacterial specimen in predetermined quantity and streak pattern onto the specimen plate. To this end a sub-frame 54 is mounted above the table on a vertical pivot shaft 56 supported by a bracket on the main frame. This pivot shaft mounts the sub-frame intermediate the front and rear ends of the latter. Adjacent the rearward end of the sub-frame is pivotally mounted one end of a link 58 (FIG. 2). The opposite end of the link is connected pivotally to an eccentric 60 mounted for rotation with the output shaft of a gear reduction unit 62 the input shaft of which is driven by an electric motor 64 mounted on the main frame. By this means the sub-frame is caused to oscillate about the vertical mounting shaft 56, for purposes explained in detail hereinafter.

The sub-frame is provided with an elongated slot 66 (FIG. 3) which functions as a guide track for a pipette holder assembly. As best illustrated in FIG. 5, this assembly includes a main holder block 68 mounted pivotally on a shaft 70 supported by a carriage 72. The carriage projects through the guide slot in sliding engagement therewith. The terminal end of the carriage has a threaded bore through which an elongated drive screw 74 extends, parallel to slot 66. The drive screw is mounted adjacent its opposite ends in bearings on the sub-frame for axial rotation, but is constrained against longitudinal displacement. One end of the drive screw mounts a gear 76 which meshes with a second gear 78 mounted on a shaft which is connected through an elongated flexible drive cable 80 to the output shaft of an electric drive motor 82 mounted on the main frame. The flexible drive cable permits unencumbered oscillation of the sub-frame, as will be understood.

Rotation of the drive screw thus results in reciprocative movement of the pipette holder block and carriage as-

sembly parallel to the guide slot. The slot preferably is arranged to provide this movement on a line extending substantially 45° with respect to the plane of the table 16.

The holder block removably mounts a hollow pipette holder 84. This holder has a threaded fitting 86 at one end threaded detachably to a threaded bore in the holder block. The opposite end portion 88 of the holder functions as a mounting tip for removably mounting a pipette P. For this purpose it is reduced in external diameter substantially to the internal diameter of a pipette, so as to frictionally engage the bore of the latter. Pipettes of different internal diameters may be utilized simply by replacing the hollow pipette holder 84 with ones having pipette mounting tips 88 of diameters corresponding to the bores of the pipettes.

A counterweight 90 is mounted adjustably on an elongated threaded rod 92 extending rearward of the pivoted holder block 68. The counterweight is adjustable to varying distances from the pivot shaft 70 to counterbalance the weight of the components forward of the pivot shaft. In this manner the dispensing end of the pipette P may rest in contact with the agar base 36 on the specimen plate 32 with a minimum of force.

Means is provided for removing a pipette P from the mounting tip 88 mechanically after the pipette has served its purpose. Thus, a hollow pipette stripper sleeve 94 (FIG. 5) is mounted slidably on the pipette holder 84. The front end of the sleeve is provided with a wall having a central aperture which receives the mounting tip slidably therethrough. The enlarged intermediate portion of the holder has an annular shoulder 96 on its forward end, adjacent the mounting tip, which serves as an abutment for the forward end of a coil spring 98 which encircles the holder within the sleeve. The rearward end of the spring abuts the rearward end of the sleeve, whereby to urge the latter to its normally retracted position.

An annular shoulder 100 projects from the rearward end of the sleeve. It is confined in the annular groove of a collar 102 mounted slidably on an elongated guide pin 104. The guide pin projects from the main holder block 68 parallel to the pipette holder. The guide pin serves an additional function described more fully hereinafter.

A pipette stripper bar 106 (FIGS. 2 and 3) forms the armature of an electric solenoid 108. The solenoid is mounted on the sub-frame 54 for reciprocation of the bar 106 toward and away from the collar 102. Thus, upon energization of the solenoid the end of the stripper bar adjacent the collar 102 is extended to intercept the latter. Then, upon further retraction of the pipette holder assembly, with the stripper bar preventing further retraction of the collar and stripper sleeve 94, the mounting tip 88 is moved rearward relative to the stripper sleeve. The rearward end of the pipette P mounted on the tip thus is brought into abutment with the forward end of the stripper sleeve which thereupon strips the pipette from the tip.

Means is provided for preventing pivoting of the holder block 68 and supported components during the pipette stripping operation. Thus, in the embodiment illustrated an elongated stabilizer bar 110 is mounted on the sub-frame 54, as by the screws 112, for sliding engagement of the holder block when the latter is in the partially retracted position for operation of the stripper assembly. Engagement of the holder block with the bar thus prevents pivoting of the block and stabilizers the assembly for the pipette stripping operation.

The used pipette thus stripped from the tip falls by gravity through an opening 114 (FIGS. 1, 2 and 3) in the table 16 into a receptacle 116 positioned below it. For this purpose it will be understood that the specimen plate 32 must be retracted fully to its leftwardmost position (FIG. 2) in order to expose the opening in the table.

The pipette P preferably is of the disposable type. To this end it is made of a length of inexpensive tubing of synthetic thermoplastic resin, such as polyethylene. Although the pipettes may be provided as prefabricated individual units, means is provided in the preferred embodiment illustrated for producing individual pipettes automatically from a supply coil of plastic tubing. This not only minimizes the cost but also minimizes handling and consequent contamination.

A supply coil of plastic tubing T (FIGS. 1 and 3) is supported on a reel 120. The reel is mounted rotatably on a shaft 122 secured to a sub-panel 124. The latter is mounted retractably on the main frame 10. Also mounted on the sub-panel adjacent the reel is a heater block 126. This block has a longitudinal bore 128 through it for the passage of plastic tubing from the reel. Electrical resistance heater means 130 in the block functions to heat and straighten the length of plastic tubing confined in the bore.

Also mounted on the sub-panel at the outfeed end of the heater block is a combination cooling and clamping block assembly. This block assembly is spaced or otherwise insulated from the heater block, in order to be maintained at substantially room temperature. The block assembly includes a fixed block 132 secured to the sub-panel and an overlying clamping block 134 which is movable relative to the fixed block. A longitudinal bore 136 is provided through the block assembly by registering semi-circular grooves in the abutting faces of the blocks 132 and 134. This bore has a diameter slightly less than the external diameter of the plastic tubing T, whereby the latter is clamped securely in said bore.

Means is provided for urging the confronting faces of the fixed and clamping blocks resiliently together. Thus, an elongated bolt 138 extends through registering transverse openings in the blocks, with a threaded portion of the bolt engaging corresponding threads in the opening in the fixed block. A coil spring 140 encircles the bolt projecting from the clamping block. One end of the spring abuts the clamping block and the opposite end abuts a head 142 threaded onto the end of the bolt.

Means is provided for separating the blocks 132 and 134 for releasing the tubing clamped between them. In the embodiment illustrated, such means comprises an electrical solenoid 144 mounted on the sub-panel with its armature registering with the head 142 of the clamp bolt 138. Upon energization of the solenoid coil the armature 146 is caused to extend, moving the bolt with it against the resistance of the clamping spring 140. The upper, clamping block 134 thus is moved upward, releasing the tubing from clamping pressure.

Means also is provided for severing lengths of tubing drawn outwardly from the block assembly. In the embodiment illustrated, a cutter blade 150 (FIG. 6) is secured releasably to a blade holder 152. The latter is mounted pivotally on the outfeed end of the clamping block, by pivot pin 154. The projecting portion of the blade thus is pivotable with its holder to traverse the axis of the clamp bore 136. The blade holder extends downward for abutment by the armature 156 of an electric solenoid 158 mounted on the sub-panel. Upon energization of this solenoid the armature is extended upward, pivoting the blade holder and moving the cutter blade upward through the plastic tubing projecting from the cooling and clamping block assembly. Upon deenergization of the solenoid, its armature is retracted and the blade holder is pivoted downward by gravity.

The pipette holder assembly is movable downward along the guide slot 66, by operation of the drive screw 74, to a position at which the pipette mounting tip 88 enters the confronting open end of the plastic tubing T held in clamped position in the cooling and clamping block assembly.

To insure proper alignment of the pipette mounting tip

88 with the plastic tubing held in the cooling and clamping block assembly, the elongated guide pin 104 extending from the main holder block 68 is arranged for reception in a corresponding guide bore 160 in the clamping block assembly.

A stabilizer bar 162, similar to bar 110, is mounted on the sub-frame for sliding engagement of the holder block 68 during movement of the latter toward fully extended position, further to insure proper alignment of the tip 88 with the tubing and also guide pin 104 with bore 160.

With the tubing thus secured frictionally to the mounting tip 88, upward retraction of the pipette holder assembly along the guide slot is effected by energizing motor 82, following unclamping of the clamping block 134. The plastic tubing thus is drawn forward from the block assembly. When a desired length of plastic tubing has thus been drawn from the block assembly, the blade operating solenoid 158 is energized to effect severing of the tubing.

The various operative positions of the pipette holder assembly described hereinbefore preferably are established by means which allows automatic operation. Thus, the position of full extension of the carriage 72, wherein the mounting tip 88 enters the plastic tubing T clamped between the fixed and clamping blocks, is established by a limit switch 164 (FIGS. 1 and 2) in the electric circuit of the drive motor 82. This switch is mounted on the sub-frame for actuation by an actuator pin 166 projecting from the carriage.

The position of partial retraction of the carriage, at which a desired length of tubing has been drawn from the cooling and clamping block assembly to provide a pipette P of desired length, is established by a limit switch 168 in the electric circuit of the motor 82 and mounted on the sub-frame for engagement by the pin 166.

The next position of retraction of the carriage, wherein the dispensing end of the pipette P is positioned for engagement with the growth base 36 on the specimen plate 32, is established by the limit switch 170 in the electric circuit of the motor 82 and mounted on the subframe for engagement by the pin 166.

The position of full retraction of the carriage is established by the limit switch 172 in the electric circuit of the motor 82 and mounted on the sub-frame for engagement by the pin 166.

Stripping of the pipette from the tip 88 preferably is accomplished automatically. To this end a limit switch 174 in the electric circuit of the solenoid 108 is mounted on the sub-frame 54 for actuation by the pin 166 when the stripper bar 106 is brought into registry with the space between the collar 102 and the holder block 68.

The foregoing limit switches, as well as others identified herein, cooperate with control switches (not shown) which function to activate the various motors and solenoids with which the limit switches are associated. Such control switches may be of the manual type or of the timer controlled type, as will be apparent.

Means is provided by which a pipette P mounted on the tip 88 may be filled with a pre-determined quantity of specimen contained in a test tube. Thus, one end of an elongated flexible plastic tubing 176 (FIGS. 1 and 7) is connected to a fitting 178 on the main holder block 68 which communicates through a bore 180 in the latter and the hollow holder 84, 88 with the pipette. The opposite end of the tubing is connected to the upper end of an elongated air cylinder 182 supported vertically by a mounting block 184. The block is secured to the front panel 186 of a housing 188 supported above the main frame 10 by a bracket 190. A piston 192 is reciprocative in the cylinder and has a piston rod 194 extending downward therefrom. The lower end of the piston rod is connected to a cam follower block 196 which is guided for vertical reciprocation by an elongated guide rod 198 extending through aligned openings in the mounting block

The cam follower block 196 mounts a cam follower roller 200. This roller bears upon the operating surface of a cam member 202. The cam member is secured to the output rotary shaft 204 of a gear reduction unit 206, the input shaft of which is connected to an electric drive motor 208 mounted within the housing 188.

It will be apparent that when the piston 192 is moved downward in the cylinder 182 a partial vacuum is created in the pipette P. Accordingly, with the pipette extending into a test tube containing a quantity of specimen, the latter will be forced into the pipette, to fill the latter to a predetermined volume. Then, when the piston is moved upward in the cylinder the specimen is forced outward of the pipette.

In one mode of operation of the dispensing mechanism, the dispensing cam member 202 is rotated counterclockwise (FIG. 1) in the direction to elevate the cam follower block 196 and move the piston upward in the cylinder. A retractable catch 210 is mounted on the front panel 186 in position to releasably engage the block at its limit of upward movement by the cam member. During this upward movement of the piston by the cam member, the specimen in the pipette is dispensed onto the specimen plate. When the cam member reaches its limit of dispensing rotation a projection 212 on the cam member engages a limit switch 214 mounted on the front panel and arranged in the electric circuit of the drive motor 208 which, in this instance, is of the reversible type. Actuation of this limit switch effects reversal of rotation of the drive motor and cam member, to return the latter to its start position. In this latter position the projection on the cam member engages a limit switch 216 mounted on the front panel and arranged in the electric circuit of the drive motor 208 to effect deactivation of the latter at this start position.

With the cam member returned to the start position, preparatory to dispensing a second specimen, a test tube containing the specimen is slipped upward over the dispensing end of the pipette and the catch 210 released to allow the cam follower block 196 to move downward until the roller 200 engages the operating surface of the cam member at the start position. During this downward movement the piston 193 is retracted downward in the cylinder, causing the specimen to be aspirated into the pipette.

Although the catch 210 is illustrated as being manually retractable, it will be apparent that it may be operated automatically by an electric solenoid or other suitable means.

In an alternative mode of operation of the dispensing mechanism, the cam member is rotated in one direction only. Thus, the cam member is rotated counterclockwise in the dispensing direction from its start position until termination of the dispensing operation as determined by engagement of the projection 212 with the limit switch 214. Then, with a test tube of specimen slipped over the pipette, the cam drive motor 208 is again energized to continue the rotation of the cam member in the same direction. As the cam surface disposed farthest outward from the mounting shaft 204 passes from under the roller 200, the cam follower block and connected piston gravitate downward until the roller engages the cam surface adjacent the start position. This start position is established by engagement of the projection 212 with the limit switch 216, as previously described. The specimen thus is aspirated into the pipette.

It will be recognized that this alternative mode of operation does not require the provision and manipulation of the catch 210 previously described, nor does it require the motor 208 to be of the reversible type.

The capacity of the pipette P is chosen to exceed the volume of specimen to be dispensed therefrom, in order to prevent specimen from contacting any portion of the pipette holder assembly. Thus, for example if the volume of specimen to be dispensed is chosen to be one hundred

microliters the capacity of the pipette is selected to substantially exceed one hundred microliters. In this manner all possibility of contamination of specimens is eliminated.

The dispensing cam member 202 may be contoured to provide for the dispensing of specimen from the pipette in any desired predetermined manner. In the embodiment illustrated the cam is contoured to provide for the dispensing of one hundred microliters of specimen from the pipette sequentially in three different volumes per unit of length of the specimen plate.

Thus, for example assuming that the specimen is to be deposited on the agar base 36 over a length of nine inches, the contour of the cam member provides for the deposit of ninety microliters of specimen over the first three inches, nine microliters over the next three inches and the remaining one microliter over the last three inches. In this latter regard, the last one microliter of specimen is drawn from the pipette by surface tension.

The operation of the apparatus described hereinbefore is as follows:

Assuming that a one hundred microliter sample of bacterial specimen is to be deposited over a nine inch length of agar surface on the specimen plate, the following operating parameters may be utilized: The table 16 is moved forwardly at a rate of one-half inch per second, the subframe 54 is oscillated at a rate of one cycle per second and the dispensing cam member 202 is rotated through the 300° operating range in twelve seconds. These conditions result in the deposit on the agar surface, in a sinusoidal pattern, of ninety microliters of specimen over the first three inches, nine microliters of specimen over the next three inches and the remaining one microliter of specimen over the final three inches.

Let it be assumed that the components of the apparatus are in the initial start condition. Thus, the table 16 is fully retracted to its rearwardmost position away from the operator standing at the front of the frame 10. The specimen plate 32 is indexed to the position next adjacent the leftwardmost position, wherein the right hand agar-containing groove 34 of the plate is aligned with the pipette assembly. The pipette holder assembly is in the retracted position, subsequent to the stripping of a previous pipette from the mounting tip 88. The dispensing cam member 202 is positioned with the projection 212 engaging the limit switch 214, which is the position immediately following the dispensing of a specimen from a previous pipette. The cam follower block is held in elevated position by the catch 210. Plastic tubing T extends from the reel 120 through the heater block 126 and the cooling and clamping block assembly, and the latter is in clamping position.

The drive motor 82 for the pipette holder assembly is energized to extend the holder assembly fully forward, as determined by limit switch 164, to bring the mounting tip 88 into frictional engagement with plastic tubing clamped in the block assembly. The solenoid 144 is energized to release the block assembly and the motor 82 is energized to retract the pipette holder assembly a distance predetermined by the limit switch 168 to provide a pipette P of desired length. At this position of retraction, the solenoid 158 is energized to drive the cutter blade 150 upward to sever the plastic tubing. The motor 82 is again energized to fully retract the pipette holder assembly, as determined by limit switch 172.

A test tube containing a bacterial specimen is slipped over the free end of the pipette. The dispensing cam motor 208 is energized to rotate the cam member 202 clockwise forward the start position. With catch 210 released, the cam follower roller retraces along the surface of the cam member and returns to the start position. The piston 192 in the cylinder 182 thus is retracted downward, creating a partial vacuum above it. The bacterial specimen thus is aspirated from the test tube into the pipette.

The pipette holder assembly now is extended downward, by activation of the motor 82, until the terminal end of the pipette is brought into contact with the agar base 36 on the specimen plate. This position is determined by limit switch 170. The sub-frame oscillation motor 64, the table drive motor 24 and the dispensing cam motor 208 then are energized substantially simultaneously.

As the table 16 moves forward, toward the operator, and the sub-frame is oscillated to move the pipette P transversely of the forwardly moving specimen plate 32, the dispensing cam 202 rotates to drive the piston 192 upward in the cylinder. During the first 150° of rotation of the dispensing cam, ninety microliters of bacterial specimen S₂ (FIG. 8) is dispensed at a constant rate and in a sinusoidal pattern over the first three inches of the agar base. During the next 150° of rotation of the dispensing cam, nine microliters of the specimen S₂ are dispensed in the same sinusoidal pattern over the next three inches of the agar base.

At this point the dispensing cam motor 208 is deenergized by operation of the limit switch 214. The remaining one microliter of the specimen S₃ in the pipette then is drawn from the latter, by surface tension action, and deposited in the sinusoidal pattern on the next three inches of the agar base. The major portion of this remaining specimen usually streaks out as individual colonies, as illustrated in FIG. 8. By virtue of the counter-balancing of the pipette and holder assembly by the counterweight 90, the pipette rides on the agar surface with a constant force of but a few grams, independent of the pipette tip and irregularities of the agar surface. This insures maximum uniformity and reproducibility of deposition of the specimen.

With the specimen thus having been deposited on the specimen plate, and assuming that a different specimen is to be deposited on the next growth base 36, the plate is retracted laterally leftward to the leftwardmost index position, exposing the opening 114 in the table 16. The pipette holder assembly then is retracted, by activation of the motor 82, to the position determined by limit switch 174, at which the stripper bar 106 is aligned with the rearward side of the collar 102. The solenoid 108 is energized to extend the stripper bar, whereupon the pipette is stripped from the mounting tip 88. The used pipette falls by gravity through the opening 114 in the table into the collecting receptacle 116.

If the same specimen is to be deposited on the next growth base, the same pipette may be used over again. In such a case the pipette holder assembly is retracted to the extent necessary to slip the specimen-containing test tube over the pipette.

The foregoing cycle of operation may be repeated, as desired, to effect the deposit of additional bacterial specimens on the remaining agar bases contained in the remaining grooves in the specimen plate. The specimen plate then is removed from the table to an incubator for further processing, as previously described.

From the foregoing it will be appreciated that this invention provides relatively simplified and correspondingly inexpensive apparatus by which to produce streak specimens of bacteria with maximum precision and reproducibility. The apparatus may be substantially fully automated by appropriate use of limit switches or other conventional control mechanism. The apparatus includes means for producing disposable pipettes at minimum cost and insures against cross contamination of specimens by confining the specimen to the pipette.

It will be apparent to those skilled in the art that various changes may be made in the size, shape, type, number and arrangement of parts described hereinbefore without departing from the spirit of this invention.

Having now described my invention, I claim:

1. Bacterial specimen streaking apparatus, comprising:
 - (a) a specimen plate including a plurality of laterally

elongated grooves adapted to contain a bacterial specimen growth base material,

- (b) pipette support means mounted above the specimen plate and adapted to support a pipette,

- (c) specimen plate supporting means comprising

- (1) a frame,
- (2) a specimen plate support table mounted on the frame for movement in one direction, and
- (3) indexing means on the table engaging the specimen plate and movable relative to the table in a direction normal to the table movement for aligning each groove selectively with a pipette supported by the support means, and

- (d) pipette aspirating and dispensing means communicating with a pipette on the pipette support means for filling specimen into and dispensing specimen from the pipette.

2. Bacterial specimen streaking apparatus, comprising

- (a) a specimen plate,
- (b) means supporting the specimen plate for movement in one direction,

- (c) pipette support means mounted above the specimen plate and adapted to support a pipette comprising a length of disposable, flexible tubing, the pipette support means including

- (1) a frame,
- (2) pipette carriage means mounted on the frame for reciprocation toward and away from the specimen plate,
- (3) drive means on the frame engaging the carriage means for oscillating the latter, and
- (4) hollow pipette mounting means on the carriage means adapted to enter the bore of a pipette frictionally to secure the latter thereto, and

- (d) pipette aspirating and dispensing means communicating with the hollow pipette mounting means for filling specimen into and dispensing specimen from the pipette.

3. Bacterial specimen streaking apparatus, comprising

- (a) a specimen plate,
- (b) means supporting the specimen plate for movement in one direction,

- (c) pipette support means mounted above the specimen plate and adapted to support a pipette comprising a length of disposable, flexible tubing, the pipette support means including

- (1) a frame,
- (2) pipette carriage means mounted on the frame for reciprocation toward and away from the specimen plate,
- (3) drive means on the frame engaging the carriage means for oscillating the latter,
- (4) hollow pipette mounting means adapted to enter the bore of a pipette frictionally to secure the latter thereto,
- (5) pivot means supporting the pipette mounting means on the carriage means,
- (6) counterbalance means associated with the pipette mounting means for counterbalancing the weight of the latter and a pipette mounted thereon, and

- (d) pipette aspirating and dispensing means communicating with the hollow pipette mounting means for filling specimen into and dispensing specimen from the pipette.

4. Bacterial specimen streaking apparatus comprising

- (a) a specimen plate,
- (b) means supporting the specimen plate for movement in one direction,

- (c) pipette support means mounted above the specimen plate and adapted to support a pipette comprising a length of disposable, flexible tubing, the pipette support means including means for oscillating a pipette supported thereby substantially normal to the

11

direction of movement of the specimen plate and simultaneously with said movement of the specimen plate for depositing a sinusoidal pattern of specimen on the plate, and means for reciprocating a pipette supported thereby toward and away from the specimen plate between positions for dispensing specimen on the plate, for removing a pipette from the pipette support means and for installing a new pipette on the pipette support means, and

(d) pipette aspirating and dispensing means communicating with a pipette on a pipette support means for filling specimen into and dispensing specimen from the pipette.

5. Bacterial specimen streaking apparatus, comprising

(a) a specimen plate,

(b) means supporting the specimen plate for movement in one direction,

(c) pipette support means mounted above the specimen plate and adapted to support a pipette comprising a length of disposable, flexible tubing, the pipette support means including means for reciprocating a pipette supported thereby toward and away from the specimen plate between positions for dispensing specimen on the plate, for removing the pipette from the pipette support means and for installing a new pipette on the pipette support means,

(d) pipette stripper means on the pipette support means operative in a retracted position of a pipette thereon away from the specimen plate to remove the pipette from its support means, and

(e) pipette aspirating and dispensing means communicating with a pipette on a pipette support means for filling specimen into and dispensing specimen from the pipette.

6. Bacterial specimen streaking apparatus, comprising

(a) a specimen plate,

(b) means supporting the specimen plate for movement in one direction,

(c) pipette support means mounted above the specimen plate and adapted to support a pipette,

(d) pipette aspirating and dispensing means communicating with a pipette on the pipette support means for filling specimen into and dispensing from the pipette, and

(e) pipette forming means comprising

(1) a support,

(2) means on the support for mounting a length of flexible, synthetic plastic tubing,

(3) tube straightening means on the support adapted to receive and straighten plastic tubing,

(4) tubing clamp means associated with the straightening means and operative releasably to secure plastic tubing against longitudinal movement, and

(5) tubing cutter means adjacent the clamp means and operative to cut plastic tubing extending from the straightening means,

(6) the pipette support means being movable to a position adjacent the clamp means for engaging plastic tubing secured thereby.

7. The apparatus of claim 6 wherein the tubing straightening means comprises

(a) tubing heater means on the support having an opening therethrough for the passage of plastic tubing for softening the latter, and

12

(b) tubing cooler means on the support adjacent the heater means having an elongated straight opening therethrough for receiving and straightening plastic tubing heated by the heater means.

8. Bacterial specimen streaking apparatus, comprising

(a) a specimen plate including a plurality of laterally spaced elongated grooves adapted to contain a bacterial specimen growth base material,

(b) specimen plate supporting means comprising

(1) a frame,

(2) a specimen plate support table mounted on the frame for movement in one direction, and

(3) indexing means on the table engaging the specimen plate and movable relative to the table in a direction normal to the table movement for aligning each groove selectively with a pipette supported by the support means,

(c) pipette support means mounted above the specimen plate and adapted to support a pipette, the pipette support means including

(1) means for oscillating a pipette supported thereby substantially normal to the direction of movement of the specimen plate, and

(2) means for reciprocating a pipette supported thereby toward and away from the specimen plate,

(d) pipette aspirating and dispensing means communicating with a pipette on the pipette support means for filling specimen into and dispensing specimen from the pipette, the pipette aspirating and dispensing means comprising

(1) a support,

(2) a piston-cylinder unit mounted on the support for reciprocative movement of one of the piston and cylinder members of said unit,

(3) drive means on the support engaging the movable member of the piston-cylinder unit, and

(4) conduit means communicating one end of the cylinder member with a pipette on the pipette support means, and

(e) pipette forming means comprising

(1) a support,

(2) means on the support for mounting a length of flexible synthetic plastic tubing,

(3) tubing straightening means on the support adapted to receive and straighten plastic tubing,

(4) tubing clamp means associated with the straightening means and operative releasably to secure plastic tubing against longitudinal movement, and

(5) tubing cutter means adjacent the clamp means and operative to cut plastic tubing extending from the straightening means,

(6) the pipette support means being movable to a position adjacent the clamp means for engaging plastic tubing secured thereby.

References Cited

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