An automatic inoculating apparatus for agar trays and the like uses a simple inoculating element such as a cotton swab or inoculating loop. The apparatus includes a movable carriage for supporting the tray to be inoculated, a drive motor for moving the tray along a trackway and a swabbing motor for automatically swabbing the tray during the movement thereof. The inoculating swab or loop being mounted in a crank arm driven by a swabbing motor. An actuator motor controls lowering of the inoculating element onto the tray and lifting of the inoculating element therefrom. An electrical control system including limit micro-switches enables automatic control of the actuator motor and return of the carriage to the initial position thereof after inoculating is completed.

10 Claims, 9 Drawing Figures
AUTOMATIC INOCULATING APPARATUS

ORIGIN OF THE INVENTION

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

FIELD OF THE INVENTION

The present invention relates to a mechanical device for automatically and uniformly inoculating a surface using a cotton swab or the like.

BACKGROUND OF THE INVENTION

A sterile cotton swab is perhaps the most widely used method of collecting samples from a variety of clinical and environmental sources. Since the introduction of the swab, very few changes have been made either in the design thereof or the use thereof in sample collecting. Further, the processing of a collected sample in a microbiological laboratory generally involves the use of such swabs and is basically performed using one or the other of two methods, namely, (1) rubbing a swab along a small area of the agar surface in a Petri dish, a sterile inoculating loop being used to streak the original inoculum in order to obtain isolated colonies and (2) simply rubbing the swab over the entire agar surface. The latter of these is the less widely used and in either case, if additional selective or differential media are required, the process is repeated for each additional Petri dish.

Both of these methods suffer serious disadvantages. In particular, in both methods (1) the chances of contamination increase with each additional manipulation of the swab, (2) the inoculating procedures are entirely subjective, and there are wide differences between different operations, i.e., wide person-to-person differences, and (3) it is difficult to visualize the quantitative, and to some extent, the quantitative, relationships of mixed flora when separate Petri dishes are employed.

A further prior art device of interest is that described in the article “The automatic spreading of bacterial culture over a solid agar plate” by R. E. Trotman, J. Appl. Bacteriol. 34:615–616, 1971. This article describes an automatic device for spreading inoculum by moving a bacteriological loop along the radius of a rotating agar plate. Although this technique removes the operator from the manual task of streaking the plate, the technique suffers important disadvantages. For example, the inoculum must be added separately to the plate and additional plates have to be streaked if more than one medium is used. Further, and more generally, the device in question is relatively complex, with the attendant disadvantages of relatively high cost of manufacture and maintenance.

SUMMARY OF THE INVENTION

In accordance with the present invention, an inoculating apparatus is provided which utilizes a simple inoculation element, such as a conventional cotton swab or inoculating loop, to automatically and uniformly inoculate a culture container such as a plastic tray containing selective or differential media. The apparatus is simple in design and provides automatic, fool-proof operation. In this regard, the apparatus, being mechanical and fully automated, eliminates operator error and the person-to-person differences in inoculation discussed above. The apparatus also provides the capability of using a variety of media in one tray to select out and/or differentiate between bacterial types and of performing simultaneous tests such as used in determining antibiotic sensitivity.

According to a preferred embodiment, the apparatus includes a swabbing device comprising a crank arm in which the swab is mounted, and a drive motor for imparting a predetermined motion to the swab. The motor is supported in a single gimbal ring mounted at one end of a trackway for the tray. A motor-driven carriage mounted on the trackway carries the tray and provides movement of the tray relative to the swabbing device. The longitudinal position of the swabbing motor in the gimbal ring can be adjusted as can the angle of the motor with respect to the tray, these adjustments enabling variation in the pressure and angle of attack of the swab or loop relative to the tray. An actuator arm driven by a further, actuator motor provides lifting and lowering of the drive motor and hence of the swab or loop relative to the tray. An incline located at the other end of the trackway provides a ramp for the tray at the end of its travel and enables completion of the inoculating operation without interference from the end of the tray.

The electrical control system for the apparatus includes a limit microswitch which, when actuated by the carriage at the end of its travel in a direction away from the swabbing motor, causes reversal of the direction of travel of the tray so that the tray is returned to the initial position thereof. At the same time, an actuator motor is energized to cause lifting or loop from the tray. A further limit microswitch located at the other end of the trackway de-energizes all motors when the carriage returns to the initial position.

Other features and advantages of the invention will be set forth in, or apparent from, the detailed description of a preferred embodiment found hereinbelow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1(a) to 1(d) are perspective views of the automatic inoculating apparatus of the invention showing the apparatus during various stages of an inoculation operation;

FIGS. 2(a) to 2(d) illustrate the movement of an inoculating loop driven by the apparatus of the invention, the arrows indicating the direction of movement of the loop; and

FIG. 3 is a schematic circuit diagram of the electrical system of the apparatus of FIGS. 1(a) to (d).

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIG. 1, an inoculating apparatus in accordance with a presently preferred embodiment of the invention is denoted 10 and includes a motor-driven carriage 12 which rides on doubled rail track 14. The rails 14a and 14b of track 14 are mounted above an elongate plate 16 by brackets 18a and 18b located at the opposite ends of plate 16. The plate 16 itself is supported by posts 20 located at the corners thereof and forms the top wall of a housing generally denoted 22. Housing 22 also includes a bottom wall or base plate 24 and serves to house the electrical control system for the apparatus described below. Carriage 12 is connected
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by a cable 26 to a drive motor 28 which can be a model 43A 106-1 motor manufactured by Globe Industries. Cable 26 forms a complete loop which extends around a pair of grooved discs or wheels 30 mounted for rotation at opposite ends of plate 16, only the upper portion of cable 26 extending between tracks 14a and 14b parallel thereto, being illustrated in FIGS. 1(a) to 1(d). With this arrangement, rotation of looped cable 26 results in longitudinal displacement of carriage 12 along rails 14a and 14b of track 14. Housing 22 also includes a side plate 32 which mounts a start switch 34 and carriage speed control knob 36 the functions of which are described hereinbelow. Speed control knob 36 controls the setting of a rheostat 39 shown in FIG. 3.

A swabbing motor 38 is mounted at one end of track 14 in a single gimbals 40. In an exemplary embodiment, motor 38 is a model 6907 motor, manufactured by Globe Industries. Gimbal 40 is formed by pivot pins 42 (only one of which is shown) which extend through upturned portions 44 a pair of upright support posts or brackets 46 (one of which can be seen in FIGS. 1(a) to 1(d) located on opposite sides of track 14 and including inwardly extending support arms which terminate in gimbals mount 40. Pivot pins 42 engage a mounting collar or yoke 48 attached to motor 38 which includes outwardly extending rods 50 on both sides and 52 on the front side only. Motor 38 also includes a contoured annulus or ring 54 which cooperates with an actuator arm 56 to control raising and lowering of the motor 38 as described hereinbelow. Support brackets 46 are rigidly affixed to housing 22 by suitable means (not shown) to form a unitary structure. A swabbing crank arm 58 is detachably secured to the armature of motor 38 by suitable means such as set screw 60. Crank 58 includes an aperture (not shown) which provides a friction fit for a swab S received therein.

An incline 62 is located at the other end of plate 16 and is formed by a sheet of material such as metal which is bent generally in the shape of an inverted "V" as illustrated, and includes a generally vertical, support portion 64 and an angled or slanting portion 66 which forms a 45° incline with respect to plate 16. Tabs 68, bent out of the more or less vertical support portion 64, are secured to plate 16 by suitable means such as screws 70 and are provided in sufficient numbers to accommodate cable 26 and associated wheel 30 whereas the free end of incline portion 66 is spaced from plate 16 so that cable 26 and rails 14a and 14b lie therebetween.

Actuator arm 56 is pivotally mounted at one end to bracket 46 and includes a generally U-shaped hook portion 56a at the free end thereof. The pivoting movement of actuator arm 56, and hence lifting and lowering of swab S, is controlled by an actuator motor 72 mounted within housing 22. Actuator motor 72 can be a modified Barber Coleman, part DYL M 43301-20. The housing 24 also houses a series of three relays 76, 78 and 80 which can be 14.0 volt d.c. relays manufactured by Allied Control Co.

Referring to FIG. 3, a schematic circuit diagram of the electrical system of the apparatus of FIGS. 1(a) to 1(d) is shown. As shown, carriage drive motor 28 and swabbing motor 38 are connected in parallel, a diode 82 being connected between motors 28 and 38 as shown. The circuit also includes the relay coils 76C, 78C and 80C of relays 76, 78 and 80 mentioned above. Start switch 34, which, as indicated, is a push button switch, controls connection of coils 76C, 78C and 80C to a suitable power source such as battery 84. In a specific embodiment, electrical power for the system is provided at 15 volts and 2 amps by a model HH32-15 d.c. power supply manufactured by Trygon Electronics. Relay coil 76C controls opening and closing of two sets of contacts 76R1 and 76R2 whereas relay coil 78C similarly controls contacts 78R1 and 78R2. Relay 80C controls switching between three switching contacts 80R1, 80R2 and 80R3. Contacts 80R1 and 80R3, when closed, enable energization of actuator motor 72 although the current flow through motor 72 is reversed in one instance as compared with the other. Contact 80R2 is open, as illustrated. A pair of limit switches 86 and 88, which are not shown in FIGS. 1(a) to 1(d) but comprise microswitches located at opposite ends of track 14 so as to be contacted by carriage 12 at the end of the travel thereof, respectively limit the leftward and rightward movement of carriage 12 as viewed in FIG. 1.

In operation, a cotton swab S to be processed is attached to swabbing crank 58 and a plastic tray T containing the appropriate media is placed on carriage 12 and the lid removed. Push-button start switch 34 is then depressed and power thus supplied to swabbing motor 38, carriage drive motor 28 and actuator motor 72. Referring to FIG. 3, with switch 34 closed the circuit for relay coil 76 is completed so that relay coil 76C is energized and normally open contact 76R1 and 76R2 are closed thereby activating motors 28 and 38. In addition, relay coil 80C is energized, closing contacts 80R1 and energizing actuator motor 72. Contacts 76R1, when closed, provide a short circuit shunt around start switch 34 to keep relay coils 76C and 80C energized.

The next sequence of events is illustrated in FIG. 1(b). Actuator motor 72 causes arm 56 to pivot forwardly thereby lowering swabbing motor 38 and hence swab S, so that the latter contacts the agar surface of tray T. At the same time carriage 12 and thus tray T begins movement along tracks 14 responsive to energization of motor 38, swab S remaining in contact with tray T throughout the longitudinal movement of the latter. The tray T then proceeds up the inclined portion 66 of incline 62 as shown in FIG. 1(c) so that the trailing edge of the tray T does not interfere with the swabbing action. When tray T is completely innoculated by swab S, “left” microswitch 86 is actuated by carriage 12 which has continued to move to the left as viewed in FIG. 1(c) as tray T moves up incline 62. Referring to FIG. 3, actuation of limit switch 86 causes de-energization of relay coil 76C and energization of relay coil 78C so that relay contacts 78R1 and 78R2 are closed and the direction of current flow through drive motor 28 reversed. Thus, the direction of travel of carriage 12, and hence tray T, is reversed. At the same time, the current through relay coil 80C is also reversed and actuator motor 72 energized through contact 80R3. This reverses the direction of movement of an actuator arm 56 and causes actuator arm 56 to lift up motor 38 to the more or less horizontal position shown in FIG. 1(d) so that swab S is removed from contact with the swabbing surface. Carriage 12 continues to move to the right until “right” microswitch 88 is engaged thereby and actuated. As is evident from FIG. 3, actuation of limit switch 88 will cause de-energization of relay coils 78C and 80C and hence of drive motor.
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28 and actuator motor 72. This completes the cycle. It is noted that all operations are conducted inside a clear plastic box (not shown) which is equipped with ultraviolet lamps. The atmosphere and temperature within the box can also be controlled for some operations if desired.

The swabbing motor 38 and associated crank arm 58 produce the side-to-side or back and forth swabbing pattern, using India Ink illustrations, shown in FIGS. 1(c) and 1(d). In addition, the swab itself also follows a spiralling pattern. As discussed above, an inoculating loop can be used rather than a swab. FIGS. 2(a) to 2(d) illustrate the spiralling pattern referred to above for an inoculating loop L used in stirring an agar surface, the arrows showing the direction of travel of the loop L. In FIG. 2(a), the position of loop L when initial contact is made with the agar surface is shown. FIG. 2(b) shows the flat side of the loop L in contact with the agar so that there is subsequent release of cells from the ruptured film. In FIG. 2(c), the loop L is shown at the completion of the streak motion across the width of the tray. Finally 2(d) shows loop L during the return motion thereof illustrating the spiral action resulting in contact of the loop edge with the agar surface. It should be noted that the inoculation patterns for a loop and a cotton swab are distinctly different. With a swab, a brush-type effect is produced which results from the swab maintaining almost continuous contact with the agar surface during the side to side streaking action. It is only during the spiralizing action along the longitudinal axis that the swab tip touches the agar. This results in a uniform distribution of cells from one end of the tray to the other. With the inoculating loop the major portion of the inoculum is deposited on the agar surface during the initial streaking with a gradual release of cells as streaking continues along the length of the tray. When only the leading edge of the tip of the loop remains in contact with the agar, single cells or small clumps can be released which results in isolated colonies. The production of such "clumps" can be influenced by controlling the rate of tray travel. The pressure exerted by cotton swab or inoculating loop and the angle of the swab or loop relative to the agar surface of the tray can be adjusted by adjusting the relative position of motor 38.

Considering a specific example, plastic trays, 3.4 inches wide and 9.8 inches long were utilized, and rheostat 39 (FIG. 3) adjusted to provide speed ranges from 6.6 inches/min. to 8.4 inches/min., with a total length of carriage travel of 9 inches. With the speed control rheostat 39 set at the midpoint the tray travels at a speed of 7.5 inches/min. with 2.5 swab strokes per inch.

The apparatus described above can be used to successfully inoculate various combinations of selective and differential media with a variety of bacteria, environmental samples, and clinical specimens. One attractive feature of the invention is the capability of incorporating various combinations of differential and relative media in one tray. For example, Blood Agar (BA) in one section of the tray permitted growth of a mixture of Staphylococcus aureus and Escherichia coli while Phenylethyl Alchohol Agar (PEA) in another section suppressed E. coli while allowing S. aureus to grow and MacConkey's Agar (MAC) in a third section allowed only the E. coli to develop. As mentioned above, another attractive feature of the invention is that the operator is permitted to quickly visualize the overall relationship of the various bacterial types in the sample inoculated. In addition, determination of a semi-quantitative relationship of the various bacterial types is also possible. For example, with the cultures tested, and using a cotton swab, discrete separate colonies developed only when the sample contained < 10^4 cells/ml while at higher concentrations confluent growth was observed.

Although the invention has been described with reference to an exemplary embodiment thereof, it will be understood that variations and modifications can be effected in this embodiment without departing from the scope and spirit of the invention.

We claim:

1. An automatic inoculating apparatus for inoculating agar trays and the like with an inoculating element selected from the group consisting of a cotton swab and inoculating loop, said apparatus comprising a moveable carriage for supporting the container for the culture to be inoculated, swabbing means for automatically swabbing the container to be inoculated, said swabbing means including as an inoculating element a cotton swab or an inoculating loop, a support arm for supporting the inoculating element and swabbing motor means for imparting a predetermined motion to said support arm, actuator means for controlling the positioning of said swabbing means relative to said carriage such that said support arm is moved between a first, operative position wherein the inoculating element carried thereby contacts the container and a second, inoperative position wherein the inoculating element is out of contact with the container, and drive means for causing longitudinal movement of said carriage relative to said swabbing means to provide inoculation of the container carried by said carriage along the length thereof.

2. An apparatus as claimed in claim 1 wherein said swabbing motor means includes a swabbing motor and means for pivotally mounting said swabbing motor said actuator means including an actuator motor and an actuating arm driven by said motor for controlling pivotally of said swabbing motor so as to cause movement of the inoculating element carried by said support arm into and out of engagement with a container carried by said carriage.

3. An apparatus as claimed in claim 2 wherein said support arm comprises an elongate crank arm rotatably affixed at one end to the armature of said swabbing motor and including an aperture in the other end for receiving an inoculating element.

4. An apparatus as claimed in claim 2 further comprising a tracking arm on which said carriage rides.

5. An apparatus as claimed in claim 4 wherein said drive means includes a drive motor, and said apparatus further comprises an electrical control system for controlling energization of said drive motor, said actuator motor and said swabbing motor.

6. An apparatus as claimed in claim 5 wherein said electrical control system comprises a start switch for, when closed, initially energizing said motors and a microswitch located along said trackway and actuated responsive to the travel of said carriage a predetermined distance along said trackway, for, when actuated, causing reversal of the direction of current through said
drive motor so that the direction of travel of said carriage is reversed.

7. An apparatus as claimed in claim 6 further comprising a further microswitch located at the other end of said trackway for de-energizing said motors when said carriage returns to the initial position thereof.

8. An apparatus as claimed in claim 6 wherein said electrical control system includes means responsive to the actuation of said limit microswitch for causing said actuator motor to raise said swabbing motor to a position wherein the inoculating element is removed from contact with the container.

9. An apparatus as claimed in claim 4 further comprising an incline located at an end of said trackway remote from said swabbing means upon which said container rides during the travel of said carriage so that swabbing of the surface of the container can be completed without interference from the container.

10. An apparatus as claimed in claim 5 further comprising a housing located beneath said trackway for housing said motors and said electrical control system, said mounting means for mounting said swabbing motor comprising first and second support posts located on opposite sides of said trackway and secured to said housing.

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