(19.)

DESCRIPTION *of an* APPARATUS[1] *for* MAINTAINING *a* CONSTANT TEMPERATURE *under the* MICROSCOPE. By E. A. SCHÄFER, Assistant-Professor of Physiology in University College, London.

THE necessity of having the means of conveniently, but at the same time accurately, maintaining objects, especially the living tissues, under observation at a uniform temperature (generally that of the body) becomes more obvious every day. The existing methods of effecting this are, as a rule, not sufficiently accurate for exact investigations; and, on the other hand, the more accurate modes are frequently inconvenient of application. For example, the apparatus described by Stricker and Burdon-Sanderson in this Journal for 1870,—although it is possible by its aid to maintain a constant temperature under the microscope for a considerable time,—yet requires that there should be a vessel of water constantly boiling near the observer, and that the water in this vessel should be maintained at a uniform level, necessitating a supply tube from a cistern, and an overflow tube to a waste pipe. Moreover, since the temperature of the stage is regulated by the rate at which the heated water is allowed to flow through it, and this again is made to depend upon the difference of level between the orifice of the exit tube which leads from the stage and the height of the boiling water in the reservoir, and since this requires a rather complicated screw mechanism accurately to adjust the level for different temperatures (not to mention the numerous india-rubber tubes requisite for connecting the various parts of the apparatus), it is evident that, although the apparatus in question may be well enough adapted for a laboratory, it is less applicable to individual and private work. The apparatus to be here described, the main principles of which are a constant *circulation* of water and the introduction of a gas regulator, will, it is believed, be found simple and convenient in application, and capable of maintaining with almost absolute constancy any desired temperature for an indefinite time.

The apparatus consists of a closed brass box, oblong in form (fig. 1, *a*), which rests upon the stage of the microscope, a cylindrical chamber (fig. 2, *b*, in vertical section) being left in the centre of the box for the transmission of light from

[1] Made for me by Mr. Casella, of 147, Holborn Bars.

the mirror to the object (as in Stricker's warm stage). From each end of the box a tube passes (inlet and outlet), and the tubes are connected the one to the other by india-rubber

FIG. 1.

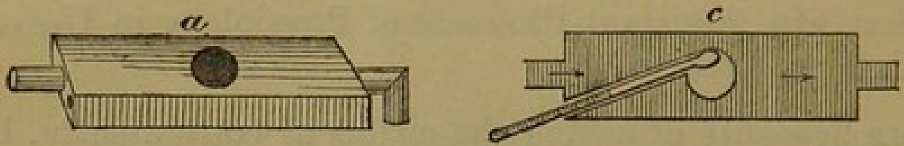

FIG. 1.—*a.* View of warm stage with inlet and outlet tubes, unconnected with heating apparatus. *c.* Horizontal section of stage, showing the manner in which the thermometer is passed into the central chamber, and the direction of the current of water in the stage.

tubing, so that there is thus formed a closed circuit, which, when the apparatus is ready for working, is entirely filled with water. A vertical reservoir (fig. 2, *c*), of not much greater capacity than an equal length of the connecting tube,

FIG. 2.

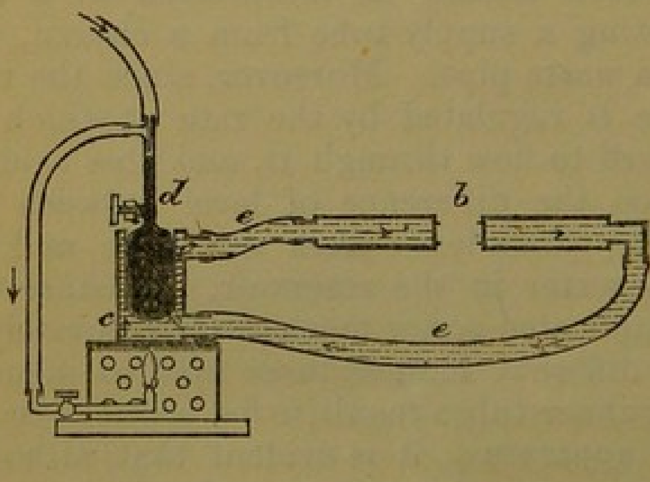

FIG. 3.

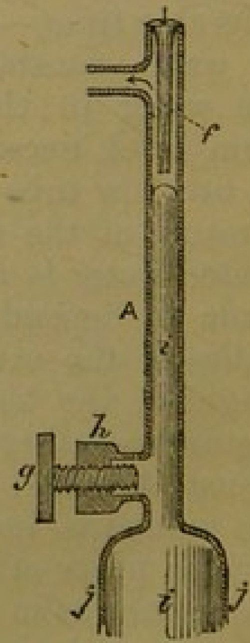

FIG. 2.—Ideal section of apparatus. *b.* Central chamber in stage. *c.* Vertical reservoir heated by small gas flame below, and enclosing bulb of mercurial regulator, *d.* *e*, *e.* Connecting tube of india rubber. The arrows show the direction of the gas in the regulator and of the currents of water in the heating apparatus respectively.

FIG. 3.—Gas regulator, about natural size. *j*, *j.* Upper part of bulb (rather small in proportion). A. Tube with side openings, to the lower of which is attached the steel collar *h*, in which works the screw *g.* *f.* Small steel tube with slit. *i*, *i.* Mercury. The arrows show the direction of the gas.

is interpolated in the circuit at a point not far from the inlet of the stage, in such a manner that the upper end of the reservoir is connected with the inlet tube, the lower end with the outlet. The reservoir surrounds the bulb of a mercurial gas regulator (fig. 2, *d*; and fig. 3), and is heated below by a minute gas flame; it will be readily understood that the heated water in the reservoir must rise up through the inflow tube into the stage, while the colder fluid passes into the reservoir through the lower tube to supply its place.

The chamber in the centre of the stage is, when in use, closed below by a circular cover-glass, which is placed on a rim made for its reception, and previously oiled; above, it is covered by the cover-glass, on which the object is placed; it communicates, however, with the exterior by means of a small lateral tube which passes through the body of the stage, but is entirely shut off from the surrounding fluid. The bulb of a small thermometer may be introduced through this lateral tube whenever it is wished to ascertain the temperature of the central chamber (see fig. 1, *c*, in horizontal section). This method of measuring the temperature has a considerable advantage over that in which the thermometer-bulb encircles the wall of the chamber and lies in the surrounding fluid, for this last is always very perceptibly warmer than the interior of the chamber. It has the dis-advantage that observations cannot be made while the thermometer is *in sitû*, but this can be met by slightly withdrawing the instrument into the lateral tube. Indeed, ordinarily it will be sufficient, when the desired temperature is attained and the regulator set, to remove the thermometer altogether; the lateral tube may then serve, if necessary, for the introduction of a small tube conducting gas or vapour to the specimen under observation.

The gas regulator may be described as a mercurial thermometer with its tube open above, and with two side tubes leading from it, one near the bulb, the other near the top (fig. 3). To the lower side tube is cemented a steel collar (*h*), in which a screw of the same metal accurately fits; by working this screw the mercury may be raised or lowered in the thermometer tube. A fine steel tube (*f*), with a slit at its lower end, passes down a certain way into the thermometer, being cemented around its upper orifice. The gas is made to pass down this fine steel tube, and then up between it and the walls of the thermometer tube; finally, it is conducted out by the upper side tube, and by means of india-rubber tubing to the burner below (as indicated by the arrows in figs. 2 and 3).

To "set" the regulator, when the central chamber of the stage has attained the desired temperature, all that is necessary is to turn the steel screw until the mercury is forced up to the slit in the steel tube; the gas is now cut off, except what can pass through the slit, and the flame is consequently very small; the temperature of the water in the reservoir consequently tends to be diminished, and the mercury in the thermometer tube to fall, but the moment this commences more of the slit becomes uncovered, more gas passes through, the flame is increased, and the temperature re-established. It is easy to understand that if the steel screw below is withdrawn somewhat, the mercury will not rise up to the slit, and will not therefore cut off the gas until the temperature of the water has risen proportionately higher than before. By screwing out or in every needful variation of temperature of the water in the reservoir, and through this of the stage, may, as before said, be obtained.

It is easy to fill the closed circuit before described—consisting of the reservoir, the stage, and the connecting tube of india-rubber—with water (which should have been previously boiled and allowed to cool), and once filled it will remain so, provided the india rubber be securely "wired" over the metal so as to exclude the possibility both of leakage and of the admission of air. The india rubber will, of course, readily adapt itself to the varying volume of the fluid, consequent on the changes of temperature to which it is exposed. It is important to employ as wide india-rubber tubing as the metal tubes will allow, so that no obstruction may be offered to the free circulation of the water.

In the first experiments the gas regulator, which in that case was made to depend on the expansion of air, was placed within the body of the stage, but under these conditions the temperature was found to vary within slight limits, according to the varying pressure of the gas supply, just as an air thermometer varies with the barometric pressure; there is, besides, a disadvantage in having the regulator at a distance from the source of heat. By employing the expansion of mercury to cut off all the superfluous gas, and by placing the regulator directly over the flame, the utmost constancy and delicacy are attained.

It is much to be regretted that, although we can learn the exact temperature of the chamber, we have at present no means of ascertaining how much that of the object under examination may differ from this; nevertheless, it is certain that the proximity of the objective of the microscope produces a considerable amount of cooling. If it be desired to reduce this by warming the objective, it is not difficult to introduce by means of glass T-tubes a secondary circuit of india rubber, the middle of which shall coil around the objective, whilst the ends shall be connected, the one with the ascending or inflow tube of the primary circuit, the other with the descending or outflow tube.

The reader will have noticed that the method by which the circulation is maintained in the apparatus here described is precisely the same as that employed in the hot-water apparatus now so extensively used for warming houses and conservatories; moreover, the principle of gas regulation is familiar to every laboratory student, and the screw regulator below is a modification of a contrivance used in some forms of barometer for altering the level of the mercury. Nothing, therefore, is claimed on the score of novelty, at the same time it is hoped that this adaptation of ordinary means to microscopical ends may prove of some service to the histologist.[1]

[1] The author regrets that the figures have been executed on too small a scale. The following are some of the actual measurements (in inches and fractions of an inch) of the different parts of the apparatus:

Stage.—$3\frac{3}{4} \times 1\frac{1}{2} \times \frac{9}{16}$ inch; diameter of central chamber of stage $\frac{3}{4}$ inch; diameter of inlet and outlet tubes $\frac{7}{16}$ inch; diameter of tube for thermometer $\frac{1}{4}$ inch.

Reservoir.—Height 2 inches; outside diameter $1\frac{3}{8}$ inch; diameter of cavity for gas-regulator 1 inch; stand for reservoir (containing pin-hole gas burner) about $2\frac{1}{2}$ inches high. The stand may be of the same diameter as the reservoir, but, for the sake of stability, should have a broad, heavy foot.

Gas-regulator.—Bulb $1\frac{3}{4} \times \frac{7}{8}$ inch; lumen of tube about $\frac{1}{10}$ inch; length of tube 3 or 4 inches; thickness of side-screw about $\frac{1}{5}$ inch.