CLXXI. A CELL FOR THE MEASUREMENT OF THE SPECIFIC CONDUCTIVITY OF THE BLOOD-SERUM.

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INTRODUCTION.

DURING work at Bethlem Royal Hospital, it became necessary to measure the specific conductivities of the blood-sera of various patients. It was found that the existing types of cells were not suitable for this particular work, and a new cell of rather unusual type was therefore worked out. As it was found to give excellent results, it has been described here.

The conductivity was measured by using the Wheatstone bridge method, with induction coil and telephone.

In using the ordinary Kohlrausch cells it was found at once that they gave very poor results with serum owing to the fact that they are usually used with very dilute solutions, with correspondingly high resistances. With such solutions they worked well and gave a sharp "silent point" on the bridge wire, but with serum they gave a very broad silent point, extending over as much as 10–20 cm. The reason for this lies in the fact that to get a sharp silent point it is necessary to have (1) large electrodes and (2) a high resistance; for the purpose in hand the volume of fluid required must be small.

It was found possible to achieve all three requirements by constructing a cell with two large flat electrodes close together and then inserting between them an insulating plate with a small hole in the middle; by this means the resistance of the cell may easily be increased a thousand times. Such a cell is difficult to clean, so it should be capable of being taken to pieces, cleaned, and reassembled without disturbing the original dimensions.

DESCRIPTION.

The cell is constructed on an arbitrary plan, and allowance is made for individual peculiarities by standardising it afterwards with a known solution.

Three stout microscope slides, $3'' \times 1''$, are selected so that all three are of exactly the same width. Two of these are taken and cut down to $2'' \times 1''$. To each is cemented with Canada balsam a flat gold plate (the thickness prohibits platinum) measuring $1\frac{3}{4}''$, leaving an overlap at one end of $\frac{1}{4}''$; this overlap is bent back before sealing so that the connecting wires may be clipped on to it.

(See *A* and *B* of the diagram.) The gold plate used was of the type used by dentists for dentures and was rolled flat. Pressure must not be used during the drying as the balsam has a strong tendency to run in or out when the pressure is released. The third glass slide is now taken, marked "*B*" (bottom) at one end, and a hole about 1 mm. in diameter is drilled through exactly 1" from this end. This forms the central plate. It must always be used the same way up. Finally a fourth slide is chosen, of exactly the same width as the others, and 1.0 mm. in thickness. It is cut into six pieces, two of $\frac{13}{16}'' \times 1''$ (*C* and *D* in the diagram), and four of $\frac{3}{16}'' \times \frac{1}{4}''$ (*E*, *F*, *G*, and *H*). One of the large pieces and two of the small are then marked with a diamond so that they may always be used together. These space the electrodes from the central plate.

A clip to hold the cell securely together is made by cutting out a cross of tin, and bending up the four arms so that two press at the flat sides of the cell and two at the edges.

The cell is now assembled by sealing it with the minimal quantity of melted vaselin. Finally vaselin is run along the edges of the three slides, and two slides are pressed against them, thus sealing up the cell. It must now be held firmly and pressed down into the clip.

1.0 cc. of serum is run in on one side. The serum runs through the hole and fills the other side. It is tilted about to wet both plates and is allowed to settle level; this amount of serum will extend just as far above the hole as below it.

Cleaning. At the end of the day the cell should be taken down and cleaned, particularly care being taken to keep the electrodes and the central hole free from vaselin. In changing the serum, however, it may be cleaned thus: (1) wash out with normal saline several times, using a capillary pipette with teat; (2) wash out thoroughly with distilled water; (3) wash out with acetone; (4) dry by blowing in air from a foot pump using a fine glass tube. Alcohol and ether must not be used for drying. Adequate cleaning is essential.

The accuracy of the cell. This was tested directly in the following manner. About 10 cc. of serum was obtained and well mixed. The specific conductivity of this serum was then measured six times in succession, the cell being emptied, cleaned, and refilled between each measurement. The readings of the different samples of the serum were corrected for temperature (see below), and the variations between them were noted. It was found that the coefficient of variation of the six determinations was 0.53 % of the mean specific conductivity. This means, in the crude but current phraseology, that it has an accuracy of

Diagram of the cell. It is not drawn to scale, and in order to show the component parts more clearly the side pieces have been removed.

"about 1 in 200". Throughout the work ten readings of the silent point were made, and their mean was taken as the reading for that specimen.

Standardisation. Dissolve 0.744 g. of pure potassium chloride in recently boiled distilled water and make up to 100 cc. Put 1 cc. in the cell. Stand the cell in a basin of water, set up the circuit and allow the temperature to settle. Read the temperature and measure the resistance of the cell in the usual manner. Call the resistance of the cell R ohms, and the temperature t° . If n ohms $^{-1}$ be the specific conductivity of KCl at t° , and if 1 cc. of an unknown solution in that cell has a resistance of r ohms $^{-1}$, its specific conductivity will be $\frac{nR}{r}$ ohms $^{-1}$.

Correction for temperature. The necessity for correction may be avoided by using a thermostat, but unless the thermostat is of high quality, greater accuracy with less expense may be obtained by keeping the cell in a basin of water and reading the temperature. On measuring the effect of temperature for this work, I found that the conductivity over a range of a few degrees from 18° is almost exactly a linear function of the temperature, a rise in temperature of 1° increasing the conductivity of the serum by 1.69×10^{-4} ohms $^{-1}$. To correct for temperature, therefore, add (algebraically) $1.69 (18^\circ - t^\circ) \times 10^{-4}$ to the uncorrected specific conductivity. This coefficient (1.69×10^{-4}) is not the same as that for KCl.

Polarisation. This may be avoided by assembling the Wheatstone bridge circuit with the induction coil joined to each of the bridge wires so that only a small fraction of the current will go through the cell (if the cell has a high, and the bridge wire a low, resistance).

Loss of CO_2 to the air. Serum was tested to see if the loss of CO_2 into the air made any difference to the conductivity. No significant difference could be detected.

SUMMARY.

1. A cell is described for the measurement of the specific conductivity of blood-serum, which combines large electrodes, with a high resistance, and only needs 1 cc. of serum.
2. Instructions for making, cleaning and standardising it are given.
3. It is found to have a coefficient of variation of 0.53 %, and to be free from polarisation effects.
4. The temperature coefficient of the specific conductivity of serum is given.

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