NEW APPARATUS

A LINEAR OPTICAL DENSITY POTENTIOMETER FOR USE IN PHOTOELECTRIC SPECTROPHOTOMETRY

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THE potentiometer incorporated in the Unicam SP500 spectrophotometer consists of a slidewire bearing a linear transmission scale and a logarithmic density scale. Many workers, finding that the use of the logarithmic scale is apt to lead to confusion and error, and that inadequate discrimination is obtained when the density of the solution under test exceeds 0·2, prefer to make use of the linear transmission scale; it is then necessary to calculate the density d from the transmission reading t by means of the relationship $t = 10^{-d}$. The linear optical density potentiometer now described was designed with the object of avoiding this inconvenient procedure.

If a resistance r_1 is connected in series with a slidewire of ohmic value r_2, the range of the slidewire will extend from zero to an increment ρ in density, the value of which is given by the relationship

$$r_1 = (r_1 + r_2)\ 10^{-} \quad .. \quad .. \quad .. \quad .. \quad (1)$$

Provided that the increment ρ is sufficiently small, the calibration of the slidewire in terms of density is then approximately linear, i.e. equal increments in the resistance of the slidewire correspond to approximately equal increments in density. In order to extend the maximum range of the potentiometer from ρ to 2ρ, provision may be made, by means of a selector switch, for connecting a resistance equal in ohmic value to r_2 in series with r_1 and r_2, and simultaneously connecting across the series combination of r_1 and r_2 a shunt R_1, the value of which is given by the relationship

$$R_1 = r_1(r_1 + r_2)/r_2 \quad .. \quad .. \quad .. \quad .. \quad (2)$$

If n series resistances, each equal to r_2, and n shunts, each equal to R_1, are provided and controlled by the selector switch, the latter may be used to extend the range of the potentiometer in n successive steps, each of which corresponds to an increment ρ in optical density.

The practical circuit diagram of an optical density potentiometer which was constructed in accordance with these principles is given in Figure 1. It was decided to restrict the range of the slidewire to a density increment of 0·1, and to make the total resistance of the potentiometer equal to that of the slidewire incorporated in the spectrophotometer, viz., 109 ohms. As $r_1 + r_2 = 109$ and $\rho = 0{\cdot}1$, it follows from equations (1) and (2) that the appropriate values of r_1, r_2, and R_1 are 86·56, 22·44, and 420·5 ohms respectively. The main potentiometer arm consists of a selector switch S_2 controlling a series of 9 resistance coils, each of 22·44 ohms, and a slidewire S_1, also having a resistance of 22·44 ohms. Each coil thus

corresponds to a density increment of 0·1, and the slidewire also covers a density range of 0·1; the approximately equal subdivisions of the slidewire represent density increments of 0·001. The switch S_2^1, the armature of which is capable of making 9 simultaneous contacts, is ganged with S_2. The purpose of S_2^1 is to connect a series of 9 shunts (each of which has

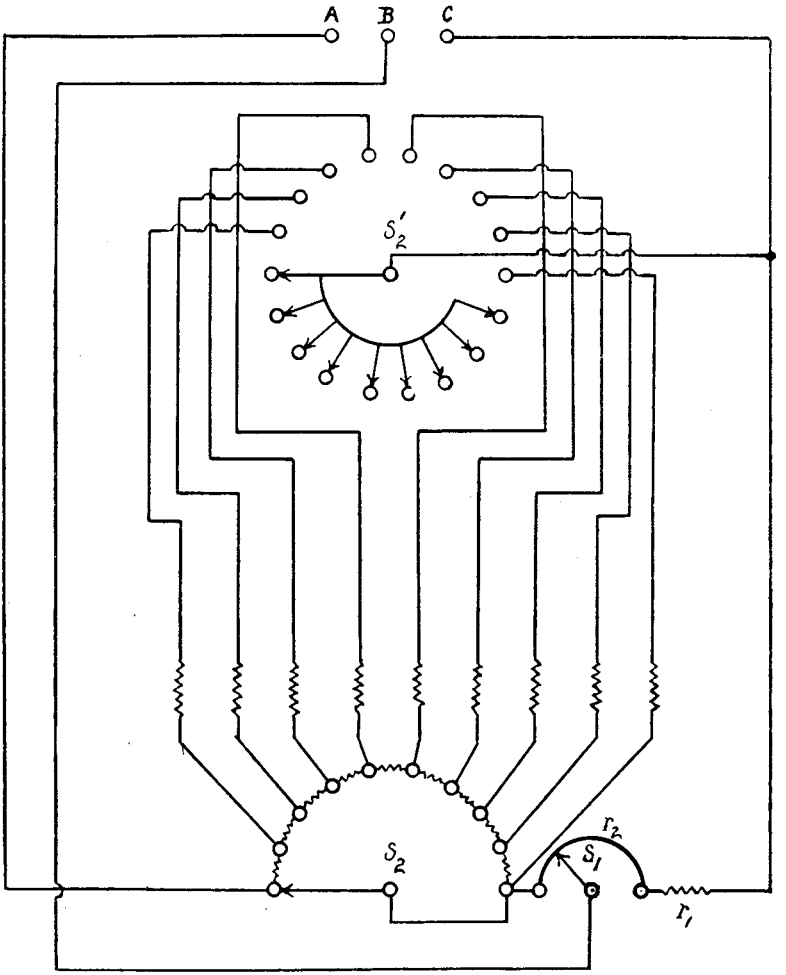

FIG. 1.

a resistance of 420·5 ohms) one by one across appropriate sections of the main potentiometer arm. The decade switch $S_2S_2^1$ and the slidewire S_1 are mounted side by side (S_2S_2' being on the left of the panel and S_1 on the right) in such a manner that the reading of these controls, i.e. the density of the solution under investigation, appears as a horizontal row of figures through an aperture in the panel.

The electrical circuit of the SP500 spectrophotometer closely resembles that of the Model DU Beckman quartz spectrophotometer, and the linear

density potentiometer now described may be used in conjunction with either of these instruments. The Beckman spectrophotometer has been described by Cary and Beckman,[1] and a modification of a simplified circuit diagram (devised by Bainbridge-Bell) of this instrument has recently been published by Beaven.[2] Diagrams of the electrical connections of the SP500 spectrophotometer are obtainable from the manufacturers of the instrument.

Figure 2 shows the manner in which the internal potentiometer R_{13} of the SP500 spectrophotometer is connected to the resistances with which it is associated in the potentiometer network; the reference letters are those used in the literature published by the manufacturer. The potentiometer

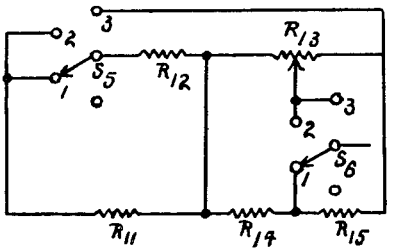

FIG. 2.

network is so designed that, when the ganged switch S_5S_6 is thrown to position 3, the voltage drop across R_{13} is reduced to one tenth of its normal value, and the upper limit of the transmission range is thereby reduced from 110 per cent. to 11·0 per cent. Presumably owing to minor changes in design, the ohmic values of the resistances incorporated in recent models of the SP500 spectrophotometer differ from those quoted in the literature issued by the manufacturer and, before modifying the instrument for use with an external linear density potentiometer, it is advisable to determine the values of these resistances. The ohmic values of the resistances in the potentiometer network must be such that the relationships $R_{15}/R_{14} = 10$, $R_{11}/R_{12} = 9$, and $R_{11} = R_{13}(R_{14} + R_{15})/(R_{13} + R_{14} + R_{15})$ are accurately satisfied; for example, if R_{13} and R_{14} are 109 and 100 ohms respectively, it is essential for the correct functioning of the instrument that R_{11}, R_{12}, and R_{15} shall be 99·17, 11·02, and 1000 ohms respectively.

In order to adapt the instrument for use with an external linear density potentiometer, the leads from the internal logarithmic potentiometer R_{13} are disconnected from the potentiometer network and reconnected, as shown in Figure 3, to a telephone jack J mounted on the panel of the spectrophotometer. The external potentiometer is mounted on a metal panel and enclosed in a small metal case. Connection to the spectrophotometer is made by means of a three-core cable connected to the terminals A, B, C (Fig. 1) and terminated by a telephone plug P (Fig. 3). When the plug is withdrawn from the jack the spectrophotometer functions normally, linear transmission readings being obtainable over the range 0 to 110 per cent. when the switch S_5S_6 is in position 2, or from zero to 11·0 per cent. with S_5S_6 in position 3. On inserting the plug P in the

jack J, the internal potentiometer R_{13} is replaced by the external linear density potentiometer. Linear density readings are then obtained throughout the density range 0·0 to 1·0 when the switch S_5S_6 is in position 2, or from 1·0 to 2·0 when S_5S_6 is in position 3.

Provision for the further extension of the maximum density range of the potentiometer may be made, if required, by means of additional decade

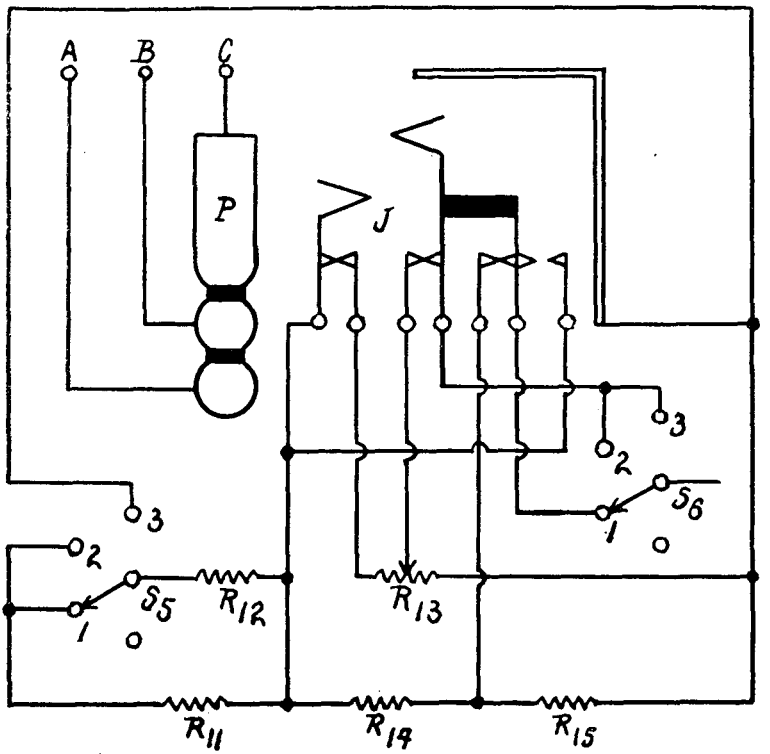

FIG. 3.

switches controlling series resistances and shunts of appropriate ohmic value. For example, in order to extend the range of the potentiometer in n^1 successive steps, each of which corresponds to unit increase in density or, in other words, to increments of 10ρ, n^1 series resistances of ohmic value r_3^1 and n^1 shunts, each of resistance R_1^1, may be provided and controlled by means of a second selector switch. The ohmic values of the resistances required for this purpose may be calculated from the relationships $r_3^1 = 0{\cdot}9(r_1 + r_2)$ and $R_1^1 = (r_1 + r_2)/9$. As $r_1 + r_2 = 109$, it follows that the appropriate values of r_3^1 and R_1^1 are 98·1 and 12·11 ohms respectively. The voltage sensitivity of the amplifier incorporated in the SP500 spectrophotometer is, however, insufficient to permit of a high degree of discrimination when the density of the solution under test exceeds 2·0; for this reason, and also on account of the magnitude of the

optical errors which are incurred in the measurement of high densities, it was not considered desirable to provide for the extension of the density range beyond the upper limit of 2·0.

SUMMARY

1. A description is given of a linear optical density potentiometer, interchangeable with the logarithmic density potentiometer incorporated in the Unicam SP500 and Beckman DU photoelectric spectrophotometers.

2. The potentiometer covers the density range 0·0 to 2·0; each of the approximately equal subdivisions of the scale throughout this range represents a density increment of 0·001.

3. The arrangement of the controls is such that, on the completion of the measurement, the density of the solution under investigation is indicated by the appearance of a horizontal row of figures, visible through an aperture in the panel.

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REFERENCES

1. Cary and Beckman, *J. Opt. Soc. Amer.*, 1941, **31**, 682.
2. Beaven, *Photoelectric Spectrophotometry Group Bulletin*, 1950, No. 2, 30.

(ABSTRACTS *continued from p. 147*).

Streptomycin and Isoniazid in Miliary Tuberculosis and Tuberculous Meningitis. G. M. Ritchie, R. M. Taylor and J. C. Dick. (*Lancet*, 1953, **265**, 419.) The post-mortem findings in 6 patients with both miliary tuberculosis and tuberculous meningitis treated with combined streptomycin and isoniazid are compared with those in 48 patients with either or both of these conditions not treated with isoniazid. The dosage adjusted for age corresponded to adult daily totals as follows: isoniazid, 150 mg. per day rising in 3 or 4 days to 400 mg. per day; streptomycin, intramuscular, 1 g. per day; streptomycin, intrathecal, 100 mg. per day; aminosalicylic acid, 20 g. per day. The lesions in the patients on combined therapy showed reversal of their process of formation. Caseation was absorbed, epithelioid cells had reverted to macrophages and diminished in number, a few polymorphs had appeared, there was no infiltration with leucocytes and no fibrosis had developed. In small miliary lesions, there was complete resolution. The miliary lesions in these 6 patients were in no way responsible for death. Streptomycin alone caused regression in small recent lesions but not resolution. In large and older lesions, streptomycin therapy was followed by regressive fibrosis, but with isoniazid in addition there occurred greatly increased vascularity, absorption of caseation, diminution of epithelioid cells and loosening of old fibrous tissue. The changes with isoniazid occurred even in old densely fibrosed lesions which were not affected by streptomycin. It is suggested that the effect of isoniazid is due to its more ready diffusibility. In tuberculous meningitis the addition of isoniazid led to more thorough control of the infection and changes in the lesions indicated that resolution was proceeding. In 4 patients these changes were followed by cerebral softening or fits due to swelling of tuberculomata and these harmful effects of isoniazid must be balanced against its advantages. H. T. B.