crosses over to B and, after filling a turn or two of B, is taken through a hole in B to a terminal on the underside of the baseboard A. The circuit is made from one terminal, to the wire on the insulating drum B, to the metal drum H, to the other drum H *via* the flexible connexion, back to the other drum B and to the second terminal. To increase the resistance the knob E is turned in the direction of the arrow, causing the spindle G to rotate round B, B. The gearing causes the wire to unwind from H, H on to B, B, under the constant tension applied by the spring couplings, so that the total length of the wire between the terminals and the *metal* drums H, H is increased. In its present form, in which the precautions against residual inductance have not been pressed very far, a rheostat of 5·5 ohms maximum has an inductance of 3·0 microhenrys at maximum and of 0·9 microhenry at the 3 ohms position.

COPPER TO GLASS SEALS. By H. de LASZLO, M.A., Ph.D.,

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[*MS. received 12th April*, 1933.]

Skinner and Burrow* have described a method of joining copper to "pyrex" seals which has proved very satisfactory for seals down to 10 mm. internal diameter. However, a number of seals of about 6 mm. internal diameter were required and the method of preparation is described below.

We use No. 8 copper detonator caps (supplied by Nobel's Explosive Co., Ltd., of Polmont, Stirlingshire) which are 6·5 mm. external diameter by 6·0 mm. internal diameter and 55 mm. long. A piece of tool steel is turned down to 6 mm. external diameter and cut off to about 1·5 cm. length; this is hardened by heating and quenching. Alternatively a piece of 6 mm. roller steel may be used, such as is supplied by The Hoffmann Manufacturing Co., Ltd., of Chelmsford. The steel plug is pushed into the copper tube until only 3 mm. protrudes, the whole is clamped in a split chuck so that about 7 mm. of copper are visible. One taper cut of 2° is then taken off the tube, the steel plug acting the while as a support for the thin-walled copper. About 5 mm. length of the copper is thus tapered to a feather edge. The tube is then gripped at the closed end in the chuck and polished with fine emery paper, after which the steel plug is removed and the operation repeated on another tube. Once set up the operation can easily be repeated on many tubes at the rate of about one a minute.

The polished tube is now ready for the boraxing process. For this purpose it is gripped in the chuck at the closed end and allowed to rotate slowly while a fine oxygen-gas flame is allowed to play on it about 3 cm. from the open end, but must on no account be moved from this position. The copper oxidizes and the operation is continued until the open end is of a uniform grey-black colour. The flame is then removed and, after waiting a short time for the copper to cool below 100° C., a saturated solution of borax in water is painted on. The flame is then played on the same spot until all the borax has melted and formed a glaze over the tube which occurs at a low red heat. It is allowed to cool below 100° C. and the operation repeated. The tube must be rotated slowly throughout this process and the flame must never touch the feathered edge. With practice this takes about two minutes. On cooling, the tubes will be covered with an even glaze of reddish-purple copper borate. Tubes so treated may be stored indefinitely until required for making seals.

Processed copper tubes may be joined with equal facility to soda glass or "pyrex." A piece of glass is selected of such internal diameter that about 3 mm. of the feathered end can be

* *J. Sci. Instr.* 7 1930 (290).

inserted into it. The tube and glass are then rotated synchronously and the glass heated with a fine air-gas flame, whose point is directed against the glass about 2 mm. from the end of the copper tube. At a red heat the copper borate will be seen to melt and form a continuous area of contact between the glass and the metal. The seal is then cooled slowly in a smoky flame. When cool the seal should appear red in colour and be free from bright copper-coloured patches.

The copper to glass seals described above will stand sudden changes of temperature limited only by what the glass itself will stand. Thus "pyrex" seals are the most satisfactory in this respect. The closed ends of the metal tubes may be cut off and rods of metal fitted inside and soldered or brazed to the copper. Thus leads carrying several kilowatts into evacuated containers may be constructed in this way. We have used them as an extension of a liquid air trap so as to obtain a metal surface in a vacuum at a very low temperature connected electrically with the exterior of the apparatus.

Correction

The address given in Mr A. G. Tarrant's letter published in the August number of the *Journal* (p. 260) should of course have read "Road Research Laboratory, Harmondsworth, West Drayton, Middlesex," and not "Radio Research Laboratory, Harmondsworth."

NEW BOOKS

The String Electrometer. By THEODOR WULF. Pp. 147. 27 figs. (Berlin: Ferd. Dümmlers Verlag.) Price M. 6.

The appearance of a book on string electrometers by such an authority as Herr Theodor Wulf will be much appreciated. Hitherto information relative to these useful electrical instruments has been somewhat meagre and could only be found in widely scattered literature. In the present small volume the author has remedied this state of affairs by describing in considerable detail the construction and uses of the two types of instrument—the single and double string electrometers. As might be anticipated Herr Wulf's main concern is with the instruments which he has himself designed and which are now so familiar in electrical laboratories.

An opening chapter deals with electrometers in general and with their applications to the measurement of electrical potential, quantity and energy. The remainder of the book is divided into two parts, the first of which is devoted entirely to the two-string electrometer and the second to the single-string instrument. Part I, the two-string electrometer, contains five chapters. The first of these gives details of construction, the strings and the method of mounting, the container, the microscope and the illumination. Subsequent chapters give further descriptive details, the determination of the capacity of the instrument, and applications to various electrical measurements.

Part II, the single-string electrometer, opens with a description of the string, method of mounting between the field-plates, and the compensation of the disturbance due to the presence of the microscope. This is followed by details of electrical circuits in which the instrument may be used. A useful list of references is appended.

Herr Wulf's book will be valuable as a source of reference to all users of the string electrometer, and should be read with interest by others who are not yet personally acquainted with these versatile electrostatic instruments. A. B. W.