

THE TECHNIQUE OF COPPER-PYREX TUBE-SEALS.

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ABSTRACT. A method of making seals between copper tubing and Pyrex glass tubing is described. The joints so constructed behave very satisfactorily under the most rigorous heat treatment.

THE technique of seals between copper and soft-glass tubing is now fairly well known. The copper is turned down as thin as possible into a cone of about 2° semi-angle and, after a slight preliminary oxidation of the copper and application of a thin layer of borax from solution, the glass tubing is slipped over with an overlap of a few millimetres and the whole heated in the blowpipe. For large sizes, the use of some type of glass-blowing lathe is almost essential. The colour of the seals may vary from bright copper to red according to the oxidation treatment and the length of heating. The best colour is perhaps pale pink. This type of seal with the glass outside is the most usual, though it is possible to make seals with the glass inside.

Of course the expansion coefficient of the copper is about double that of the soft glass. Hence the possibility of making satisfactory seals depends on the fact that the glass is stuck hard to the copper by means of a thin borate or silicate layer, and on the fact that the copper is capable of yielding inelastically to the stress caused by differential expansion. The seals so made are quite satisfactory if they are not heated to too high a temperature, but after heating to the bake-out temperature of the glass (namely 450°) experience shows that cracks often develop, especially if the heat treatment is repeated several times. The copper having the larger coefficient of expansion is stretched when the joint is cooled from the blowpipe and this it stands very well; but the resistance of the joint to heating (when the copper has to be compressed) is less satisfactory. This is probably due to the tendency of the metal to buckle.

At the present time apparatus is often made of Pyrex glass on account of its low coefficient of expansion and high bake-out temperature; thus a need is sometimes felt for Copper-Pyrex seals, but the technique of their manufacture does not seem to be well known, at any rate in England. The expansion coefficient of Pyrex is only about half of that of soft glass, and thus the differential expansion between the copper and the Pyrex is much more appreciable even than in the case of soft glass. In practice it was found, on attempting to make seals in the same way as with soft glass, that on cooling the Pyrex almost always cracked away from the copper, even though the metal had been turned as thin as possible. It was noticed that a layer of glass was left on the copper, the glass having simply fractured under the strain.

In order to gain additional strength, it seemed desirable to place a layer of glass inside as well as outside the copper. This type of seal would not be satisfactory with soft glass on account of the tendency of thick layers of soft glass to crack. But with Pyrex this consideration may be safely left out of account. The procedure was found entirely successful, provided that the copper is turned down on a mandrel as thin as possible. A 2° cone as for a soft glass joint is not admissible, the metal should be turned into a cylinder (or nearly so) with a thickness of not more than $1/10$ mm. and length about 5–7 mm.

Since the precise technique of making the seals required some trouble to work out, it may be worth while to give it here in detail. First we shall describe the method of making small seals (less than 10 mm. diameter) by hand. The copper is turned down to a thin cylinder as

stated and is then heated gently in the blowpipe (so that the thin part is heated by conduction) and oxidized until it appears of a metallic grey colour. Borax is then applied from a dilute solution and allowed to dry. Two pieces of glass are selected. The first slips tightly over the turned-down copper; the second, which may be of any convenient size, is drawn down until it slips inside the copper and a short length is cut off from the first piece. Fig. 1 shows the placing of the glass and copper before heating is begun. The metal parts are shown black and the glass clear. The join is heated strongly in the usual air-oxygen blowpipe used for Pyrex blowing until the glass is stuck round *A*. The two tubes are then fused round *B* and blown out. Then an iron rod, previously prepared so that it will just not pass through the constriction of the inner tube, is inserted and is pushed through the heated seal in order to make sure of the inside tube being stuck to the copper. This precaution was found to be essential because it is difficult to draw off the inner glass tube to be an exact fit. The join is then heated as strongly as possible without fusing the copper. It may be necessary to prod down the glass slightly on the outside, and it is desirable finally to heat the copper rather

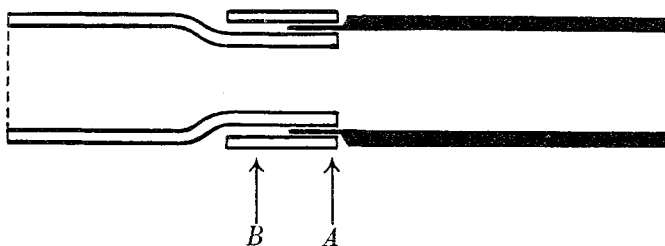


Fig. 1



Fig. 2

above the seal and very slightly to pull off the glass. The final heating should be continued until the seal, when cold, appears either of a bright copper or of a golden yellow colour; experience will soon show how much heating is necessary. The finished join is shown in Fig. 2.

It would probably be hard to construct larger seals by hand in this way. A glass-blowing lathe is desirable in this case. Actually it was convenient to adopt a somewhat different method, making the seal in two stages. The first is, after the preliminary oxidation, to seal a ring of glass inside the copper tube, pressing it into contact with a tool. The glass must overlap the copper slightly. After cleaning up the outside of the copper and re-oxidizing as before, a closely fitting tube is sealed on the outside, pressed down with a tool, and is joined to the overlap of the inner tube. To finish, it is advisable to press down the inside with a long iron rod, to heat strongly and to pull off slightly in the same way as described in the previous method.

The Copper-Pyrex seals are more liable to crack on cooling if there are any slight defects in their manufacture than soda-glass seals. But once perfectly made, they are far more robust. For example, they may be heated directly in an air blowpipe, and repeated baking out at 550°C . does not harm them.