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FABRICATION OF CRYOGENIC ELECTRICAL FEEDTHROUGHS

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The availability of strong filled epoxy[1] with high thermal conductivity, expansion coefficient closely matching the one of metals, and low viscosity before setting make the fabrication of vacuum tight electrical feedthroughs that operate at cryogenic temperatures a simple matter. Feedthroughs made in the manner described below have been proven very reliable in ultra low temperature cryostats. For several years they have been used between superfluid helium and vacuum, cycled to room temperature innumerable times (>100) and thermal shocked many times without any deleterious effect. On the other hand the availability of equivalent feedthroughs in the commercial market is not well established and difficulty in their procurement justifies in-house fabrication.

The feedthrough is fabricated by potting the end of a metal tube, through which enamel insulated wires go, with epoxy. Proper preparation of the tube consists of feathering its edge and, if possible, annealing it[2]. Before potting all parts should be degreased, with thrichloroethylene for instance. The support for the tube, Part A of Figure 1, and the mold itself, Part B, can be readily made from a teflon cylindrical rod by drilling in a lathe. Alignment of the setup can then be easily obtained, using masking tape. Extra holes in Part A serve for the wires to come out and for the introduction of the epoxy, using hypodermic syringe.

The amount of epoxy used for one feedthrough is small (~1 cm^3) compared to what is needed to get a reasonable accuracy in the mixture (6½ to 7½ parts of Catalyst 24LV by weight for each 100 parts by weight of Stycast 2850FT). Storage of just prepared mixture in small, moisture tight containers in liquid nitrogen is a good solution to this problem. The recommended curing time at room temperature (75°F) is overnight, or 2 hours at 150°F for oven cure.

Different kinds of tubes, like 1/4" diam .010" wall CuNi alloy, 3/8" diam .020" wall and 3/8" diam .030" wall aluminum[3] have been used successfully. Their length depends on the application. The thing to have in mind here is the need to keep the molded epoxy below its heat distortion point (347°F) when soldering or welding the feedthrough. Protecting the wire insulation from burning and the molded epoxy from overheat in this operation can usually be accomplished with the help of wet asbestos paper.

Polyurethane enamel insulated constantan wires of .004" and .008" diameter have been used without any problems. Their high mechanical strength is their main advantage over similar copper wires. The geometry of the feedthrough, besides allowing for a simple molding setup, permits a protective attachment of the wires to the epoxy by means of tape or thread and varnish (GE7031). See Figure 2. Feedthroughs with 20 wires can be easily made.

I would like to thank J.Houkal for fabricating several of these feedthroughs at Fermilab.

References:

1. Stycast 2850FT with low viscosity Catalyst 24LV, a product of Emerson and Cuming, Inc., Canton, Mass. The use of this epoxy for feedthroughs was first suggested by A.C.Anderson more than 10 years ago.
2. J.C.Wheatley, Rev. Sci. Instr., 35, 765 (1964); O.V.Lounasmaa, "Experimental Principles and Methods Below 1K", p. 9, Academic Press, Inc., London, 1974.
3. P.Sanger, private communication.

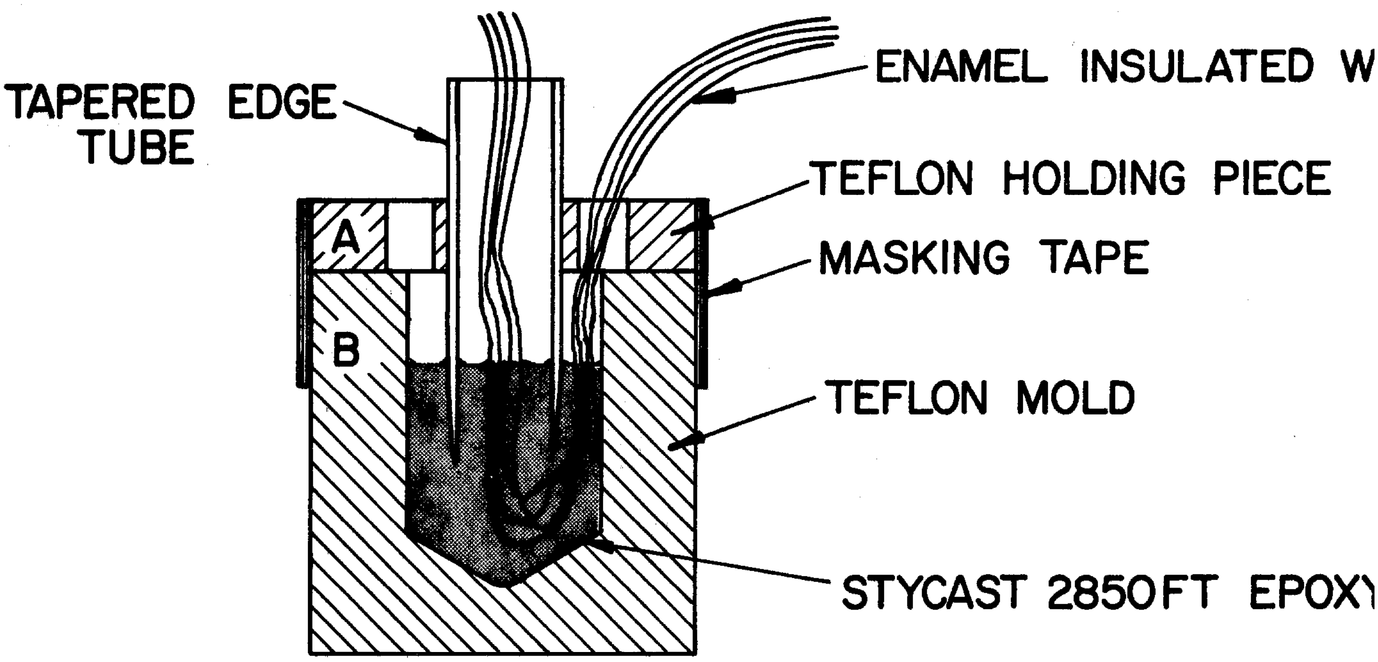

Figure 1. Curing setup.

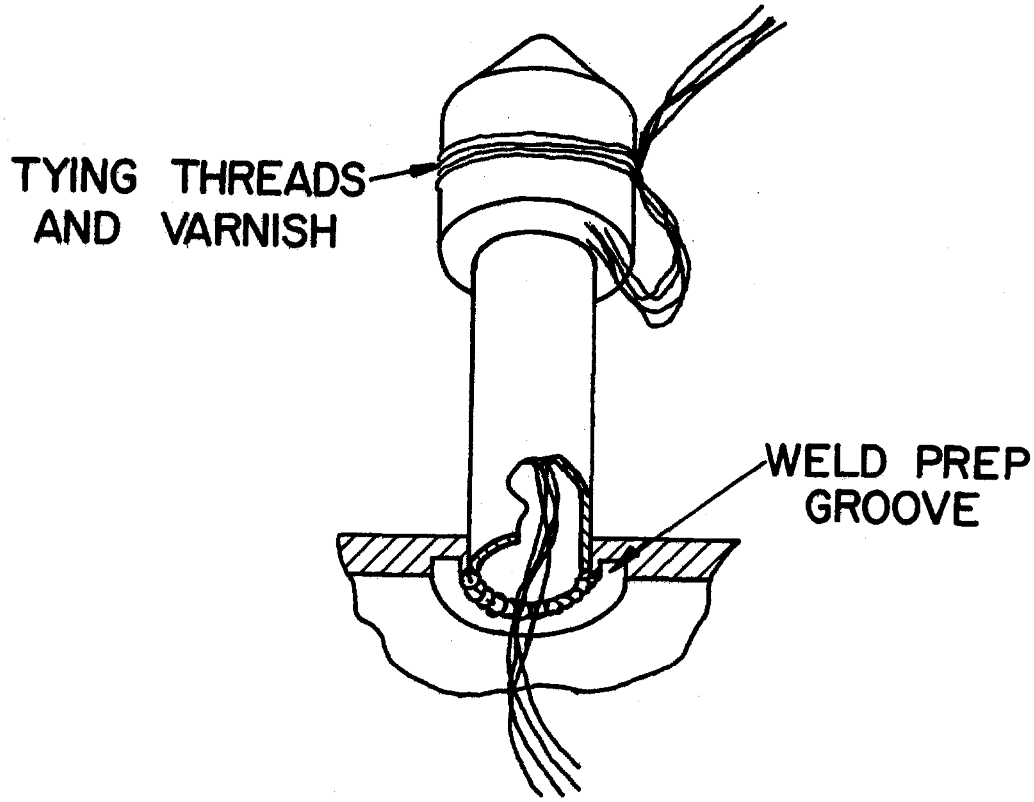

Figure 2. Example of welded feedthrough.