Processing Long Lengths

Of Superconductive Columbium-Tin Wire

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Superconductivity at average current densities exceeding 150,000 amp per sq cm in magnetic fields as large as 88,000 gauss has been obtained on heat-treated *composite wire* consisting of columbium sheathing over a core containing a mixture of columbium and tin powders.¹ The superconductive medium is the Cb_3Sn compound formed in the central core by heat treatment. This disclosure suggests the feasibility of constructing compact superconducting solenoid magnets capable of yielding fields exceeding 100,000 gauss. Such magnets are desired for laboratory use and for containing plasmas for nuclear fusion reactions. The construction of such solenoid magnets requires lengths of wire exceeding 5000 ft to facilitate compact continuous winding and to avoid difficulties associated with splicing short lengths together.

A process has been developed for preparing long lengths of composite wire containing a core of columbium tin powder. The initial step involves filling a 20 ft length of 0.528 in. OD x 0.328 in. ID annealed columbium tubing with pressed cylindrical slugs of a mixture of columbium and tin powders. Uniform density of the slugs—about 75 pct of theoretical—is obtained by pressing on a standard tableting machine. After filling the tube with slugs, annealed nickel plugs are inserted in both ends which are then swaged to prevent expulsion of the core material during subsequent processing. The columbium tube containing the slugs is cold drawn to 0.250 in. diameter and inserted into a length of annealed nickel tubing. The entire composite is cold drawn to 0.032 in. diameter wire. A cross sectional macrograph of the finished wire (Fig. 1) shows good concentricity of the core and outer shells. The outside diameter of the columbium tube is approximately 0.024 in. and the core diameter 0.013 in. It is apparent that the extensive cold drawing causes a com-

plete fragmentation of the pressed slugs into a powdered core material. A continuous length of about 8000 ft of 0.032 in. diameter wire was obtained. A few breaks occurred during processing due mainly to inexperience in handling this type composite wire on commercial drawing equipment. A piece of the 0.032 in. diameter wire was cold drawn further to 0.020 in. diameter, thereby indicating feasibility of preparing longer lengths having small cross sectional areas. From experience gained so far it appears possible to prepare longer continuous lengths of composite wire, especially since longer starting tubes can be obtained which can be processed using existing commercial equipment.

Ductility tests on this wire show that it can be wrapped satisfactorily around a $\frac{1}{4}$ in. diameter mandrel. Measurements on wire samples that were heat treated 16 hr at 1000°C in vacuum indicate that the composite wire will be satisfactory for con-

struction of experimental superconducting solenoid magnets. This has been confirmed recently by measurements on heat-treated solenoid magnets made using a few hundred feet of the composite wire. The performance of the wound wire in the magnets was consistent with that obtained on short lengths.

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¹J. E. Kunzler, E. Buehler, and F. S. L. Hsu: Superconductivity in Cb_3Sn at High Current Density in a Magnetic Field of 88 K gauss, *Physical Review Letters*, vol. 6, no. 3, Feb. 1961.

Fig. 1 — Cross section of 0.032-in. diameter composite wire. 50X