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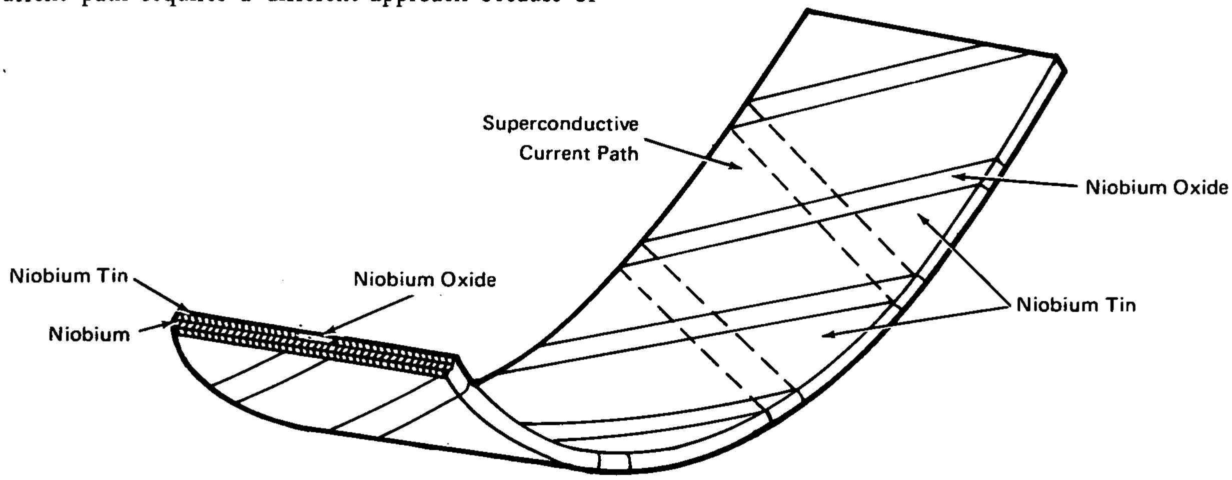
A Spiraled Niobium Tin Superconductive Ribbon

A method has been developed for producing a continuous band of niobium tin superconducting alloy in a spiral path around a thin niobium ribbon: niobium oxide separates the turns of the niobium tin spiral. Niobium tin has the desirable characteristic of remaining in the superconductive state (non-resistive) to higher values of magnetic field strength, temperature, and current density than most other superconductive materials. The thin ribbon form is desirable because the niobium tin is very brittle and thin sections are required to achieve flexibility. The spiral path for the superconductor permits maximum useful current flow in the superconductive state by reducing induced magnetization current.

With superconductors, it is necessary to reduce the induced magnetization current because there is a critical current density for the superconductor at which it reverts to a resistive state. With ductile superconductive alloys, a spiral path to reduce magnetization current is formed by dividing the superconductor into many fine filaments embedded in a copper matrix and then twisting the resulting composite conductor. With the thin ribbon niobium tin superconductor, forming a spiral current path requires a different approach because of its brittleness. This innovation provides a means of forming the spiral current path without physically distorting the ribbon, as shown in the figure.

To fabricate this conductor, the niobium ribbon 0.025 millimeter (0.001 inch) thick and 1.25 centimeters (0.5 inch) wide is first thoroughly cleaned. A film of copper is then vapor-deposited on the ribbon and the copper coating is built up to a thickness of about 0.006 millimeter (0.00025 inch) by electroplating. Next, the copper coated ribbon is sprayed on both the sides and edges with a photosensitive etch-resistant material and oven dried. Photographic film masks with an opaque-band to transparent-band width ratio of 1:3 are placed on each side of the ribbon with opposite slopes as viewed from one side. The masks are indexed to match opaque bands and transparent bands at the edges of the ribbon so that continuous paths are formed across the faces and around the ribbon edges (see figure). Thin transparent plastic sheets are placed on each side of the array to prevent misalignment. The array is then exposed to ultraviolet light. After exposure, the ribbon is placed in a developer, rinsed and dried. The photosensitive etch-resistant material remaining on



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the ribbon where it was exposed to the light is in the form of a continuous spiraling band. The ribbon is then submerged in an etchant such as ferric chloride which removes the copper from the unprotected area, exposing the niobium. The ribbon is then exposed to a high temperature oxidizing atmosphere resulting in the formation of niobium oxide on the exposed areas. The photosensitive material is then removed and the ribbon immersed in molten tin at a temperature between 930 and 970° C, resulting in the formation of niobium tin to a thickness of about 0.025 millimeter (0.001 inch) by diffusion reaction on the areas covered by the thin plating of copper. No reaction occurs on the areas covered with niobium oxide. Thus the ribbon consists of a continuous spiraling path of niobium tin separated by niobium oxide.

Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)
   Reference: NASA TM-X-68124 (N72-32715), Twisted, Multifilament Nb_3Sn Superconductive Ribbon
2. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B73-10044

Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:

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Mail Stop 500-311
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Source: W. D. Coles
Lewis Research Center
(LEW-11726)