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BRITISH DEVELOPMENTS IN SUPERCONDUCTIVITY APPLICATIONS*

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INTRODUCTION

Progress in any technological development program is a function of the financial resources available, and the usual criterion for determining the latter is the probable return on the investment. In the United Kingdom, the Ministry of Technology [1] has been supporting the development of superconducting materials and studies on their behavior since 1963, and substantial sums have been allocated to private industry, government, and quasi-governmental laboratories and universities. This funding does not, in general, cover the development of hardware, although some financial support of government origin has been directed towards the industrial exploitation of superconductivity. The work on filamentary superconductors at the Rutherford Laboratory of the Science Research Council (in collaboration with Imperial Metal Industries, IMI) is an example of this development.

On the industrial scene of the United Kingdom there is no longer any significant activity on superconducting transformers. Detailed studies were carried out by a number of transformer manufacturers in collaboration with the Central Electricity Research Laboratories (CERL). The conclusions of these studies are that the prospects for superconducting transformers are bleak, and there is little or no justification for further expenditure as far as large power transformers are concerned. The development of superconducting power transmission cables is passing through a period of consolidation following the experimental program of CERL and the British Industries Construction Corporation (BICC) reported [2] in 1969. This paper offers a brief account of the present activity and climate of opinion on superconducting cables. The most significant developments in the industrial applications of superconductivity in the United Kingdom are taking place at the International Research and Development Co. Ltd. (IRD) at Newcastle upon Tyne. The development of superconducting homopolar machines at IRD has been in progress since 1963, and an account [3] of this work was given in 1969. A review of the progress in this field is made with particular reference to a 3250-hp motor and to the applications for superconducting dc motors and generators.

Finally, consideration must be given to the status of large superconducting ac generators which present an exciting challenge to the power industry. There is no doubt that the improvements in the performance of superconductors over the past year have enhanced the prospects for ac generators, and significant development

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programs may be anticipated. As far as the United Kingdom is concerned, very little information is available, but reference is made to a novel method proposed [4] by CERL.

**SUPERCONDUCTING TRANSFORMERS**

The conclusions reached by those who have been active in the consideration of superconducting transformers require no further amplification. The following is probably representative of informed opinion [5].

"An estimate of the cost and power savings shows that the superconducting transformer is more expensive than the conventional one. Only a drastic saving in cost would make the technical difficulties worth attempting... If a superconductor could be developed with about thirty times the critical current density of the present Nb3Sn, ... it would be worthwhile to reconsider such a transformer in detail."

**SUPERCONDUCTING POWER TRANSMISSION CABLES**

The transmission of ac power by superconducting cables is under investigation in the United Kingdom largely by CERL. The "superconducting link" designed and constructed by BICC and reported [2] in 1969 has completed the tests for which it was designed, and no further experimental work on this scale is planned at the present time. At CERL a reasonably large research team is investigating various aspects of the superconducting ac transmission problem. The view of CERL is that the economic position has not changed significantly from that described by Swift [6] in 1967. Fig. 1 (from his study) shows comparative costs per MVA per km as a function of power rating. A 750-MVA, 33-kV superconducting cable is about 50% more expensive than a conventional cable, and a rating of perhaps 2000 MVA is necessary to be cost-effective. However, before this can be realized there are a number of problems to be solved. On the materials side, CERL are collaborating with IMI to produce copper tubes up to about 140 mm in diameter with Nb on the outside or inside. Niobium thicknesses of about 0.001 in. have been achieved in a three-component composite, i.e., with Nb–Zr between the niobium and copper, to carry fault currents. An experimental project is planned to measure ac losses and to perform tests with rated current and fault current on an 8-m length of a three-component straight tube. On the dielectric

![Fig. 1. Cable cost as a function of power rating [6]. (a) Superconducting cable meeting conventional specifications; (b) superconducting cable whose specification has been modified to favor this type of system; (c) conventional cable with external water cooling; and (d) overhead lines.](image-url)