Letters to the Editor

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Supraconductivity of Films of Tin

EXPERIMENTS on the relation of high frequency currents to the phenomenon of superconductivity led to work at Toronto with films of superconducting metals. The films (of tin) were produced by 'tinning' the surface of fine wires which themselves were not superconducting: in the early experiments a coating of tin 2×10^{-4} cm. in thickness was 'wiped' on constantan wire of 0.016 cm. diameter. In this way one obtains the equivalent of a thin cylinder of superconducting metal, and the resistance of the whole becomes zero below the transition temperature of the superconducting element used¹.

With the intention of studying further the effect of high frequency currents, samples of such coated wires were plated with other metals—for example, copper and nickel—which are not superconductors; an example of such a combination is constantan covered with tin and then plated with copper. The diameters of the wires forming the core were as follows: for constantan 0.056 cm., for copper 0.040 cm. and for nickel 0.045 cm.

Preliminary experiments were carried out on these samples to confirm their reaction with respect to direct currents—the ordinary superconductivity test—and it was found that thin films of tin cease to show superconductivity when these films are themselves plated over with a film of a non-superconducting metal, for example, copper or nickel. This surprising result shows itself only with thin films, but a number of repetitions of the experiments renders the results unmistakable. The accompanying table shows the nature of the phenomenon: so far, only the superconductor tin has been tested in this way.

No.	Sample	Thickness of Tin Film (cm. $\times 10^{-4}$)	Thickness of outer layer (cm. $\times 10^{-4}$)	Superconductive Action, direct current of 200 ma.
1a	Constantan-Tin	10	0	Transition point 3.69°K
1b	Constantan-Tin-Copper	10	100	Not superconducting at 2°K
2a	Copper-Tin	9	0	Transition point 3.58°K
2b	Copper-Tin-Copper	9	100	Not superconducting at 2°K
3a	Nickel-Tin	9	0	Transition point 3.42°K
3b	Nickel-Tin-Copper	9	100	Not superconducting at 2°K
4	Constantan-Tin	6.8	0	Transition point 3.49°K
5	Constantan-Tin	2	0	Transition point 2.48°K
6	Constantan-Tin-Copper	18	40	Not superconducting at 2°K
7	Constantan-Tin-Copper	4	20	Not superconducting at 2°K
8	Constantan-Tin-Nickel	15	30	Not superconducting at 2°K
9	Constantan-Tin (wiped)	90	0	Transition point 3.68°K
9a	Constantan-Tin-Copper	90	80	Transition point 3.44°K
10	Constantan-Tin (electro-plated)	200	0	Transition point 3.76°K
10a	Constantan-Tin-Copper	200	80	Transition point 3.73°K
11	Tin Wire	diameter	0.085	Transition point 3.77°K

It is seen that as the film of tin increases in thickness, a point is reached at which the superconducting property of the tin film is not lost by surface plating.

This phenomenon will undoubtedly be of importance in framing a satisfactory theory of superconductivity—a consideration of utmost importance in dealing with metallic conduction. This work is being carried on by J. O. Wilhelm and A. D. Misener.

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McLennan Laboratory,
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Feb. 17.

¹ E. F. Burton, "Superconductivity" (University of Toronto Press, and Oxford University Press), p. 70. J. C. McLennan, NATURE, **130**, 879, Dec. 10, 1932.

Persistent Currents in Supraconductors

UNTIL recently it was generally assumed that it was possible to predict, by the ordinary electromagnetic equations, the persistent current produced in a supraconductor cooled below the transition point in a constant external magnetic field after the field was switched off. Thus H. A. Lorentz¹ calculated the current induced in a supraconducting sphere, that is, the effective magnetic dipole when an external magnetic field is established.

According to results recently published by Meissner and Ochsenfeld², the matter is not so simple as might at first sight appear. Instead of the lines of force being 'frozen in' as had been previously assumed would happen when a supraconductor was cooled below the transition point in a magnetic field, it appeared that the field increased in the neighbourhood of the supraconductor, which behaved as a body of zero permeability. If this were so, the flux of induction in the supraconductor should be zero and one might expect, in contradistinction to the old view, that no persistent current or effective induced dipole would be produced by switching off the external field.

The following experiments seem to show that although supraconductors do not conform to the older theory, neither do they behave as though they had zero permeability.

(1) A solid tin sphere of 1.5 cm. radius was cooled from 4.2°K. to 2.5°K. (the liquid helium was produced in a liquefaction apparatus utilising the expansion method of Simon) in a field of 70 gauss. When the field was switched off, the magnetic moment of the sphere was observed with a test coil. Its magnitude was about one sixth of that calculated according to the Lorentz equation.

The magnetic moment remained almost constant whilst the temperature of the sphere rose from 2.5° to 2.9°; with a further rise in temperature it decreased steadily, becoming zero at 3.7°, the normal transition point of tin. Plotting the magnetic moment against the temperature, one obtains a curve of similar shape to that found for the magnetic threshold values.

(2) The same sphere was cooled to 2.5° without any external magnetic field, a field of 230 gauss (higher than the threshold value at this temperature) was switched on and immediately switched off. The magnetic moment thus produced in the sphere at 2.5° was 8 per cent greater than that produced in the previous experiment using 70 gauss, but as the temperature rose it decreased and at 2.9° it reached the same value as the magnetic moment at this temperature in the previous experiment. From 2.9° to 4° the curve coincided with that found in experiment (1).

(3) Similar experiments to those described above