Preface

The intriguing properties of matter which are inherent only at low temperatures led IBM to initiate a low-temperature research program in 1954. The application of some of these properties to circuit components has been recently demonstrated by the use of superconductivity for computer components by D. A. Buck and by the development of the Solid State Maser by Bell Telephone Laboratories.† This work has spearheaded a serious investigation into the possibility of using components that require low temperatures (below 10°K) in circuits of practical interest. Progress in this area has been greatly facilitated by the development of the Collins Cryostat manufactured by the A. D. Little Company. This has made liquid helium readily available to numerous laboratories.*

The use of persistent circulating currents occurring in superconducting materials suggests itself as a means of storing information. The possibility has been investigated by Crowe and Garwin, and the following papers are the first to describe this new work. The results have been most encouraging and have led us to look forward with enthusiasm toward the future possibilities of low-temperature circuitry.

D. R. Young, Manager
IBM Cryogenics Research Department

*D. A. Buck, *Proc. IRE* **44**, 482 (April 1956).
†Scovil, Feher and Seidel, *Phys. Rev.* **105**, 762 (Jan. 15, 1957).

J. W. Crowe

Trapped-Flux Superconducting Memory*

Abstract: A memory cell based on trapped flux in superconductors has been built and tested. The cell is constructed entirely by vacuum evaporation of thin films and can be selected by coincident current or by other techniques, with drive-current requirements less than 150 ma. The short transition time of the trapped-flux cell indicates its possible use in high-speed memories. The superconductive film memory does not exhibit the problems of "delta noise" in core memories resulting from the difference in half-select pulse outputs.

Introduction

The discovery of superconductivity in 1911 by H. Kamerlingh Onnes[1] opened up an entirely new dimension in physical research: investigation of the phenomena of electrical properties at low temperatures. Between 1911 and 1952 the theoretical aspects of superconductivity generally have been studied according to six basic categories: (1) transition to zero resistance; (2) intermediate-state; (3) flux-trapping; (4) flux-exclusion, i.e., Meissner effect; (5) the destruction of the superconductive state by means of a current; and (6) sharpness of threshold. More recently (1953-1956) D. A. Buck's[2] work with the cryotron demonstrated that superconductive metals could be used in flip-flop circuits, gates, counters, and other computer circuitry. In the area of flux-trapping studies, an extension of some previous demonstrations of supercurrents by S. C. Collins[3] at MIT showed that trapped flux could be maintained in a superconducting ring for more than two years.†

Since the work of Buck, Collins and others showed the feasibility of computer components that would respond to the magnetic control of the superconducting and normal states in tantalum, work was started at this laboratory on the study of a high-speed, high-capacity memory based on the principle of trapping flux in a superconduct-

Figure 1 **Superconducting cell showing detail of U-shaped Y drive wire.**

*Presented in part at Conference on Low Temperature Physics, at Madison, Wisc., August 26, 1957. Conference was jointly sponsored by International Union of Applied Physics, American Physical Society and University of Wisconsin.

†No perceptible decay was noticed from March 16, 1954, when the test was initiated, until September 11, 1956, at which time the test was discontinued. In order that no change of flux be detectable the resistance must be less than 10^{-21} ohms, assuming a measurement accuracy of 1%.