

RESEARCH FACILITIES AND PROGRAMS

Far infrared detection by Josephson junctions

A group at Bell Telephone Laboratories has reported using superconducting point contacts that show zero-voltage Josephson current as "sensitive, broadband, high-speed detectors of millimeter and submillimeter radiation." The work was done by C. C. Grimes, P. L. Richards and S. Shapiro and reported in *Physical Review Letters* 17, 431 (1966).

The behavior of the currents in such junctions was first predicted (in 1962) by Brian Josephson (see *PHYSICS TODAY*, Sept. 1965, page 97). What Josephson predicted was that a sufficiently thin tunneling junction between two superconductors could support a lossless current. The current would be dc if the voltage across the junction was zero, but ac for a finite voltage. The ac characteristics aroused especial interest because they indicated that Josephson junctions might be sources or (as in the present experiment) detectors of electromagnetic radiation.

The junctions can be made in a number of ways, so long as there is a weak coupling between two superconductors. The weakness can be provided by a thin layer of insulator, a constriction, or the surface roughnesses coming together in a point contact. Grimes, Richards and Shapiro used point contacts made by pressing a wire with a sharpened end against one with a flattened end. Voltage-current characteristics of the junctions could be varied by changing the contact pressure. The junctions were made superconducting by immersion in liquid helium.

When radiation was incident on a junction the magnitude of the zero-voltage current decreased. The detector output was a voltage related to this change in current. In the absence of radiation no voltage appears across the junction until the current exceeds the maximum dc Josephson current. At this point the voltage rises rapidly for a further small increase of current. By using constant current bias to a point in

this region of rapidly rising voltage, the change in zero-voltage current produced by radiation led to a change in the voltage across the junction at the bias point. This voltage constituted the detector output. Using a one cycle bandwidth, better than 10^{-14} watts was detected.

The high sensitivity of the junctions made it possible to use them as detectors in a far-infrared Fourier transform spectrometer and thereby measure the response of the Josephson current as a function of frequency. Spectra were obtained which showed structure near the superconducting energy gap; namely, a peak in the response for indium-indium junctions but a dip in the response for niobium-niobium junctions. These results provided the first experimental evidence for frequency-dependent Josephson current amplitudes, an effect suggested in recent theoretical work.

Southern hemisphere astronomy

Northern Chile is about to become a new international center for optical astronomy. At present three observatories are under construction at sites within 150 km of the provincial capi-

tal of La Serena at about 30 deg south latitude. They include the European Southern Observatory at La Silla, the southern station of the Association of Universities for Research in Astronomy at Tololo, and the Carnegie Southern Observatory at Morado.

The current rush (in terms of astronomical construction) to the Chilean sierras is one aspect of efforts by various institutions and governments to correct an acute shortage of equipment for observing the southern sky. In addition to the Chilean construction, there are other projects in Argentina, Australia and New Zealand.

The shortage of southern equipment is mainly a result of a serious asymmetry in terrestrial geography. Although the southern sky has a population of stars and other astronomical species generally equal to the northern, the forces that shaped the surface of the earth did not provide for the future needs of astronomers: They put most of the land in the north, a tectonic process that insured not only a lack of places to stand on dry land in the southern hemisphere but also a generally small population compared to the north. This pretty much insured that when as-

CURRENT-VOLTAGE FUNCTION for a Josephson junction. Curve A shows characteristic in absence of radiation. A small amount of radiation shifts function to dashed line B. If junction is operated at a constant current (I_{bias}), application of radiation shifts operating point from C to D, corresponding to voltage increase across the junction. When infrared is turned on and off, an alternating voltage appears across junction, following configuration shown in square wave drawn above C.

