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.

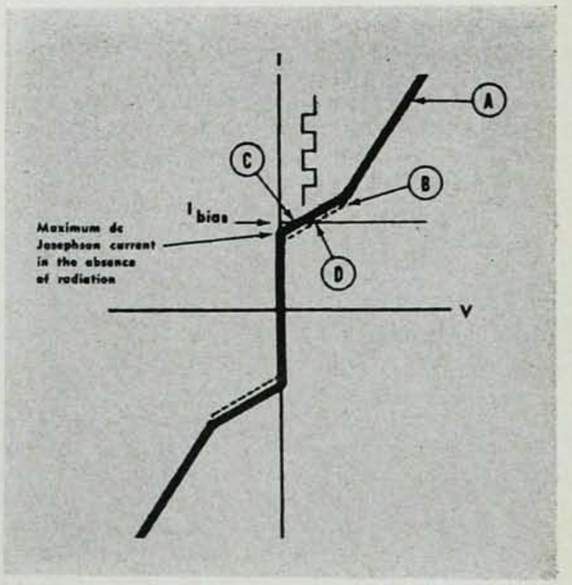
Southern hemisphere astronomy

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 capital 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.



SCIPP ANALYZERS: ARE THEY "MORE ANALYZER"

Purchasing "too much" analyzer can be almost as much folly as purchasing too little. Only you can know your immediate requirements. But what about your future needs; will the analyzer you buy today be outdated tomorrow?

Not if you purchase a SCIPP. We make them in several types, only two of which are shown here: SCIPP 32/64/104 (left), and SCIPP 400/1600. Each has its own advantages and features, many of which are exclusive to the SCIPP line. All have several things in common: Expansibility potential as your needs dictate, highest possible quality of construction, and latest state-of-the-art design.

Programming. With SCIPP set for automatic mode, analysis proceeds for preset live or clock time after which it automatically goes into readout mode. Digital readout follows accumulate period with memory being erased during readout. After readout, SCIPP returns to accumulate mode for same selected period.

SCIPP can be programmed to accumulate, readout and transfer a background spectrum from one half of memory to other half. Live and clock time circuits have a separate crystal-controlled oscillator and register for storing live or clock time. In live time mode, live timer automatically corrects for dead time. Use of a separate timing register results in no additional dead time since memory circuits are not used for storing live time counts.

Analog-to-Digital Converter. Since each ADC has upper and lower level discriminators, pulses outside desired region can be rejected before digitizing. With peak detector ON input gate closes when pulse peak is detected; when OFF, gate closes at fixed time after incidence of input pulse (1.5 — 3 microsec, internally adjustable).

Use of two pulse stretchers permits measurement of a wider range of pulse widths. First stretcher, with short time constant, can respond to fast pulses. Stretched pulse is then delivered to secondary stretcher for conversion. This two-stretcher design thus gives capability of temporarily storing a second pulse during time ADC is busy and enables SCIPP to accept two pulses separated by 10 microsec or more.

Each ADC has its own address register which provides buffered outputs to memory section. Each address register can hold digital representation of a pulse until memory is ready to accept the information.

Minimum Dead Time. A significant advantage of SCIPP is that digital information is transferred to memory following conversion and ADC is immediately free to accept the next pulse; ADC is not dead during memory cycle. Since SCIPP uses a separate register for time counts, live timer makes no contribution to dead time. No memory cycle is needed to store live time pulses.

Display Modes. A 5" CRT is standard. On SCIPP 400 and 1600 analyzers a 425-1535 volt HV supply can be provided. Unit is capable of showing sequential presentation of information in memory channel by channel, contour display, and oblique display giving an isometric view of data accumulated in the two parameter mode.

Counts full scale in linear mode is selected digitally with a factor-of-two step from a full scale count range of 100 to 1 million counts full scale. Within each decade, a factor-of-two selection (1, 2, 4, 8 within each decade) can be made.

Upper and lower level discriminators on display unit can set limits on count scale for intensification. Logarithmic display is optional at time SCIPP is ordered, or can be added subsequently. Logarithmic display is standard on big SCIPP analyzers. A static live display, particularly useful at low acquisition rates, is standard. In this mode, memory system can display data by scanning memory while ADC is on line processing a pulse. When ADC gives command that conversion or processing is complete, display mode is interrupted so that memory can store count.

Data Differentiation. Data differentiation via paper tape reader is standard. Multiplication factors from 10^{-3} to 10^{3}, in steps of 10, can be applied to data on tape as data is read into memory. Data on tape can be added to or subtracted from data in memory. Intra-memory digital data differentiation is optional. Area integration can be provided by an auxiliary data register and a digital level selector with auxiliary data register storing the answer.

Data processing features — intra-memory stripping (digital data differentiation) and peak area and curve integration — can be ordered with SCIPP systems, or added later.

Readouts. Digital level selector in readout mode selects a specific section of memory for readout on the digital equipment. SCIPP can readout to serial or parallel equipment. In serial output, a Page printer or Teletype BRPE high speed tape punch can be used, or for read-in, a Teletype CX high speed tape reader. For parallel output, Monroe high speed printer can operate at rates greater than 20 channels/second.

On SCIPP 400 and 1600 systems, multiplex mode is optional which enables one to simultaneously accumulate a spectrum via each ADC, with appropriate spectrum being stored in its own memory section. Since the only time-sharing is in analyzer memory, it is possible to accumulate two or more spectra simultaneously.

On larger SCIPP Systems multiplex mode is standard, as are digital indicators for computer section. Other options include: digital indicator panels (which show state of computer registers), indicator panel for ADC, an indicator panel for auxiliary data register.

Simple Circuitry. Victoreen, always the leader in use of silicon semi-conductors for analyzers, uses them exclusively. Also, all circuit design is based on "worst case" philosophy for maximum reliability. Repeated use of NAND gate in logic circuits leads to easier understanding and analysis of all circuits throughout the computer section.

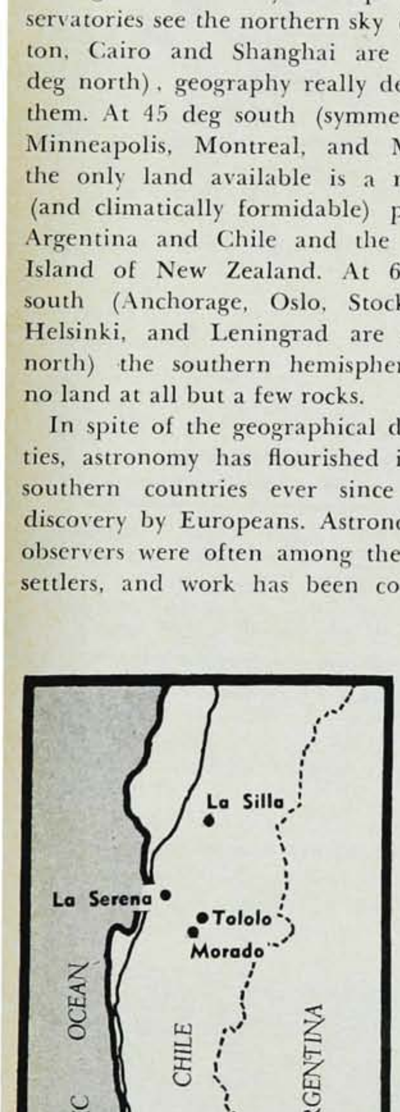
Serviceability. All circuits are readily accessible from front or rear by opening doors. Plug-in circuit boards have test points at connectors. A meter and switch, provided on power supply, make it easy to monitor any supply voltage. Another important SCIPP feature is the marginal checking feature by which it is possible to vary bias supply to transistors in logic circuits and determine any marginal transistors, either noise receptability or low beta.

Technical Manuals. SCIPP Systems are furnished with comprehensive technical manuals covering installation, operation, theory, trouble shooting. The manuals document signals available at each connection. Combined with readily accessible connections, the manuals simplify test and checkout.

tronomers evolved, the overwhelming majority of their equipment would be built in the north.

To give a specific example: The parallel of 30 deg south, after its passage across Chile, Argentina and a small tip of Brazil, crosses only Australia and the Republic of South Africa. Most of its circuit is open ocean. Thirty degrees is a good location for southern observing, but if astronomers want to see the extreme southern sky with the same advantage as ordinary European observatories see the northern sky (Houston, Cairo and Shanghai are at 30 deg north), geography really deprives them. At 45 deg south (symmetric to Minneapolis, Montreal, and Milan) the only land available is a narrow (and climatically formidable) part of Argentina and Chile and the South Island of New Zealand. At 60 deg south (Anchorage, Oslo, Stockholm, Helsinki, and Leningrad are at 60 north) the southern hemisphere has no land at all but a few rocks.

In spite of the geographical difficulties, astronomy has flourished in the southern countries ever since their discovery by Europeans. Astronomical observers were often among the early settlers, and work has been continu-



NORTH CHILEAN REGION **where large new astronomical observatories are being constructed.**

ous ever since. But the quantity of work has never come near to matching the quantity of work put out by northern observatories although the countries have generally provided as much equipment as their resources made reasonable. In the past therefore, northern institutions have often constructed southern stations either alone or in concert with local institutions. Until recently such activity has been small compared with the northern institutions' expenditures nearer home. Now, however, the push is on to build observatories for the southern sky to equal the biggest ones operating in the north.

For both bigness and international coöperation the European Southern Observatory is a good example of the new trend. It had its beginning in a 1953 conversation between Walter Baade and J. H. Oort. These gentlemen agreed that if a consortium of European nations were to build a large new observatory, it should be constructed in the southern hemisphere. Their view prevailed, and the organization known as the European Southern Observatory was set up with headquarters in Hamburg. Originally the organization included Belgium, France the Netherlands, Sweden and West Germany. More recently Denmark has joined.

ESO considered sites in Australia, South Africa and South America. It wanted a site with as many clear nights per year as possible and an elevation between 2000 and 3500 meters to lessen atmospheric extinction of radiation.

Australia was ruled out because its mountainous regions do not have good enough weather. The choice was left between South Africa and South America, and at one time South Africa seemed to be favored. Meanwhile American astronomers had been making a three and a half year survey of the Chilean Andes to pick a location for AURA's Cerro Tololo Inter-American Observatory. These findings were pooled with ESO's work, and after visits to Chile by European astronomers, the site at La Silla (elevation 2440 meters) was chosen. (Ironically, the American astronomers' choice of Chile had been one of the reasons the Europeans originally leaned toward South Africa as a kind of eastern hemisphere—western hemisphere balance.)

Access roads have already been constructed, and work on the buildings is now under way. Meanwhile the first telescope, a one-meter reflector for photoelectric observations has already been landed in Chile. It was made by Rademakers of Holland and Jenoptik of Jena, East Germany. Other equipment for ESO now under construction in Europe includes a photometer for the one-meter telescope (by astronomers in Groningen), a 1.5-meter reflector for spectrographic work (being built in Paris), and a one-meter Schmidt reflector (Zeiss/Oberkochen, West Germany). The biggest piece will be a 3.5-meter reflector. Work on its mirror blank has been started by Corning Glass International and will be taken over by a European firm later on.

On its mountain (Cerro Tololo) 100 km to the south of ESO, AURA is working on equipment of the same order of magnitude, including a 1.5-meter reflector and smaller telescopes.

Baseball magnetic field

A magnet coil shaped like the seams on a baseball is being used to study plasma containment and stability at Lawrence Radiation Laboratory in Livermore. The baseball-seam coils produce a minimum-B magnetic field, in which field intensity is a minimum in the center, increasing in all directions outward. Such a system is hydromagnetically stable (no fluting). The first baseball assembly began running in April and a superconducting version will soon be up to bat.

Baseball fields are part of the Livermore Alice program, which uses neutral beam injection to study containment and stability of high temperature plasma.

The idea of using baseball coils for an Alice experiment occurred to Richard Post and Charles Damm about two years ago (who benefited from earlier ideas of Harold Furth of Livermore and J. B. Taylor of Culham Laboratory). Besides the advantage of being a minimum-B system, Damm says that the baseball coil offers excellent beam access, room for