law must (and indeed do!) occur at sufficiently low temperatures, and thus for accurate work it is necessary to make an absolute calibration in the very low temperature region. This, in principle, can be done by various methods involving the second law of thermodynamics, by taking the salt through a reversible cycle. However, a difficulty arises in the fact that the calibration found does not always agree from laboratory to laboratory, or indeed necessarily from one sample of a salt to another, since the behavior may depend on the previous history of the specimen. One solution is to use as a thermometer an auxiliary sample of a paramagnetic salt (such as cerium magnesium nitrate) which is known to obey Curie's law down to rather low temperatures, but of course this all adds to the experimental difficulties involved. In principle, a very attractive solution would be one in which use was made of the electrical Brownian movement ("thermal noise") in a resistor for thermometry, but there are many difficult technical problems as yet unsolved, not the least of which is that of measuring the very small noise voltage with some accuracy.

Another challenging aspect of the measurement of thermoelectric power at very low temperatures is the problem of measuring the small thermoelectric voltages involved in many cases. The superconducting reversing switch (see Fig. 9) and superconducting modulator developed in these laboratories by Templeton (*11*) have proved invaluable, and we feel that the limit of sensitivity has by no means yet been reached (*12*). All in all, it appears that the study of thermoelectricity at very low temperatures is full of promise, and "Cinderella" may yet turn out to be the "belle of the ball."

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News of Science

White House Reports on Scientific Aspects of Radiation Belts Created by Argus Experiments

Three nuclear test explosions, in a series called Project Argus, were set off 300 miles above the earth on 27 and 30 August and 6 September 1958 by a Navy task force in the South Atlantic Ocean. These tests, the first such explosions in outer space, are reported to have had a force measured in kilotons.

Argus was first announced by the New York Times *on 19 March. The announcement was promptly confirmed by the Department of Defense, but Deputy Secretary of Defense Donald Quarles, speaking at a news conference, was reluctant to go into any details and expressed regret that the project had been made public. On 25 March the White House released a report on the Argus experiments prepared under the direction of the President's Science Advisory Committee and the International Geophysical Year Committee of the National Academy of Sciences. The text of the report follows.*

Committee's Report

This report discusses the scientific as distinct from the military results and implication of the Argus experiments. Because of the fact that many of the experiments performed in connection with these atomic bursts involved both the election trapping phenomenon and classified military effects phenomena, it was considered advisable to withhold all results classified until a proper sorting of the information could be accomplished. Since reports on relevant military aspects have only become available within the last two weeks, it has not heretofore been possible to release any of this information.

The scientific aspects of these experiments, involving three high-altitude small atomic bursts over the South Atlantic in August–September 1958 are regarded by many participants as one of the major achievements of the International Geophysical Year. The execution of these experiments engaged the coordinated resources of large segments of the scientific talent of the nation, and it was apparent that the effects of the experiment, if successful, would be recorded by instruments of the far-flung international network of the IGY. The compilation of the observational and interpretative contributions by the many participants will doubtless stand as a durable milestone in the development of man's knowledge of the great natural phenomena of the earth's atmosphere which have engaged his study for many centuries.

Christofilos Proposal

The underlying idea for the Argus experiments was due to Nicholas C. Christofilos, physicist of the Lawrence Radiation Laboratories of the University of California. In October 1957 he called attention to the fascinating physical effects which might be expected to follow an atomic burst in the near-vacuum of outer space, high above the earth and its dense atmosphere. Of the various effects contemplated, the most interesting one promised to be the temporary trapping of high-energy electrons at high altitudes in the magnetic field of the earth. Following the burst there would be thrown off in all directions nuclei of intermediate atomic weight. Most of these nuclei, as is well known, are radioactive and subsequently decay with the release of energetic electrons and gamma rays. Most of the decays occur within a few minutes. The fission fragments themselves are electrically charged and move at high velocity. Hence, their paths in the near-vacuum conditions of outer space would be controlled, in the main, by the earth's magnetic field and would be helical ones around magnetic lines of force. The electrons resulting from their decay would likewise move in helical paths in the magnetic field. In accordance with the theory of such motion, which has been known and demonstrated on a laboratory scale for many years, it could be expected that these high-energy electrons would be trapped in the outer reaches of the earth's magnetic field and would only slowly "leak" down into the atmosphere and be lost due to collisions with air molecules in the tenuous upper atmosphere. The trapping region would be in the form of a thin "magnetic shell" encircling the earth and bounded by lines of force. Trapping times ranging from minutes to weeks were estimated for electrons whose helical paths ranged as close to the solid earth as 100 to 2000 miles, respectively.

Idea Was Studied

The proposal of Christofilos captured the imagination of a number of other scientists and the idea was studied intensively during the following months.

Meanwhile, the United States had succeeded in launching its first IGY satellite, Explorer I, which had as its primary purpose the study of cosmic radiation in the vicinity of the earth. The observations with this satellite as well as those with Explorer III, launched soon afterwards, led to the discovery of a major new phenomenon—namely, the existence in the region around the earth of a belt of high-intensity corpuscular radiation due to natural geophysical causes.

The first public report of this discovery and of its interpretation in terms of magnetic trapping was made on May 1, 1958, at an IGY symposium of the National Academy of Sciences and the American Physical Society. The report was given by James A. Van Allen, who with his colleagues of the State University of Iowa had planned and carried out the experiments.

The existence of the natural, trapped radiation served as an over-all validation of the proposal of Christofilos. At the same time it posed the problem of whether observation of the effects of an artificial injection of electrons would be possible in the presence of the natural "background."

Initiation of Argus Experiment

The fate of the entire enterprise was laid before the President's Science Advisory Committee, since it was clear that the undertaking involved a mixture of scientific and military interest. At the suggestion of the President's Science Advisory Committee, a group of representatives of the scientific community and the defense community were brought together to appraise all aspects of the matter. It was decided in late April 1958 to proceed with the Argus experiments as a major national undertaking. The operational and technological management of the project was vested in the Advanced Research Projects Agency of the Department of Defense. In his capacity of chief scientist, Herbert York, directed the program for that agency.

The Air Force Special Weapons Center undertook the preparation of a series of high-altitude sounding rockets for the study of the lower fringes of the expected effect at altitudes of about 500 miles, utilizing a five-stage solid propellant rocket vehicle that had been developed by the NACA. The Air Force Cambridge Research Center and the Stanford Research Institute developed, located, and prepared to operate a variety of equipment at suitable ground stations and aboard aircraft and ships. The difficult mission of delivering three small-yield atomic devices to high altitude and detonating them there at a pre-chosen location over the South Atlantic Ocean was undertaken by a Navy task force specially organized for the purpose.

Explorer IV

Meanwhile, the Academy's IGY group was planning to pursue vigorously further studies of the Van Allen radiation belts, initially revealed by Explorers I and III. To secure more detailed knowledge of the Van Allen radiation belts, and to observe any artificial phenomenon from the proposed Argus experiment, instrumentation was accordingly designed and developed at the State University of Iowa. Jupiter C rockets of the type developed by the Army Ballistic Missile Agency and the Jet Propulsion Laboratory of the California Institute of Technology had already been scheduled as satellite vehicles. The result of this program was the launching of Explorer IV.

Conduct of Argus Experiment

On July 27, 1958, Explorer IV was successfully placed in an orbit inclined at a 51-degree angle with the equator and, with all equipment operating perfectly, immediately began transmitting valuable new information on the nature, intensity, and distribution of the natural radiation. The high inclination orbit proved to be a distinct advantage over the previously used 34-degree inclination orbits due to its much greater spatial coverage. Meanwhile the new observing stations were being set up and the Navy task force was en route to the designated area of the South Atlantic. Preliminary sounding rocket flights were being conducted at Wallops Island in Virginia, Ramey Air Force Base in Puerto Rico, and Patrick Air Force Base in Florida.

Bursts occurred on the 27th and 30th of August in the early morning hours and on the 6th of September shortly before midnight, Greenwich time. In order to produce an electron shell having quantitative significance, it was desirable to minimize the loss of electrons to the atmosphere, and calculations showed that this could best be done by placing the source of the shell between longitude 0° and longitude 30° W. This follows from the fact that the earth's magnetic axis is tilted and displaced with respect to its rotational axis, so that the edges of the shell would come closest to the surface at these longitudes. The approximate latitude was 45° S.

Because of the small yields involved and the high altitude of the bursts there was no fallout hazard.

Aurora Followed Blast

A fascinating sequence of observations was obtained. The brilliant initial flash of the burst was succeeded by a fainter but persistent auroral luminescence in the atmosphere extending upward and downward along the magnetic line of force through the burst point. Almost simultaneously at the point where this line of force returns to the earth's atmosphere in the Northern Hemisphere—the so-called conjugate point—near the Azores Islands, a bright auroral glow appeared in the sky and was observed from aircraft previously stationed there in anticipation of the event, and the complex series of recordings began. For the first time in history, measurements of geophysical phenomena on a worldwide scale were being related to a quantitatively known cause—namely, the injection into the earth's magnetic field of a known quantity of electrons of known energies at a known position at a known time.

The diverse radiation instruments in Explorer IV recorded and reported to ground stations the absolute intensity and position of this shell of high-energy electrons on its passes through the shell shortly after the bursts. The satellite continued to lace back and forth through the man-made shell of trapped radiation hour after hour and day after day. The physical shape and position of the shell were accurately plotted out and the decay of intensity was observed. Moreover, the angular distribution of the radiation was measured at each point. The shape and form of a selected magnetic shell of the earth's magnetic field was being plotted out for the first time by experimental means.

Rocket Soundings Made

In their helical excursions within this shell the trapped electrons were traveling vast distances and were following the magnetic field pattern out to altitudes of over 4000 miles. The rate of decay of electron density as a function of altitude provided new information on the density of the remote upper atmosphere, since atmospheric scattering was the dominant mechanism for loss of particles. Moreover, continuing observation of the thickness of the shell served to answer the vital question as to the rate of diffusion of trapped particles transverse to the shell. All of these matters were of essential importance in a thorough understanding of the dynamics of the natural radiation and were now the subject of direct study by means of the "labeled" electrons released from Argus I.

Throughout the testing period the planned series of firings of high-altitude sounding rockets was carried out with full success and with valuable results in the lower fringes of the trapping region.

Explorer IV continued to observe the artificially injected electrons from the Argus tests, making some 250 transits of the shell, until exhaustion of its batteries in late September, though by that time the intensity had become barely observable above the background of natural radiation at the altitudes covered by the orbit of this satellite.

It appears likely, however, that the deep space probe, Pioneer III, detected a small residuum of the Argus effect at very high altitudes on December 6, 1958. But the effect appears to have become unobservable before the flight of Pioneer IV on March 3, 1959.

The site of the Argus tests was such as to place the artificially injected radiation shell in a region where the intensity of the natural radiation had a relative minimum. If the bursts had been produced at either higher or lower latitudes, the effects would have been much more difficult to detect, plot, and follow reliably for long times after the blasts.

The immense body of observations has been under study and interpretation by a large number of persons for about seven months. Only now are satisfactory accounts becoming available from the participating scientists. From these observations we have learned, to cite by two examples: (i) There was no diffusion of electrons transverse to the electron shell since the thickness of the shell remained constant. Also traces of the shell persisted for many days and possibly weeks; (ii) Extrapolations of the earth's magnetic field into space, which have been based on surface measurements, were confirmed by the experiment. The experiment has made it possible to predict the shape and intensity of the earth's field with considerable accuracy out to distances of the order of several earth's radii.

The directness and clarity of the artificial injection tests have provided a sound basis for interpretation of the natural radiation trapped around the earth. It is likely that many important contributions will continue to arise from the great diversity of geophysical observations being conducted by other countries participating in the International Geophysical Year.

The IGY group of the National Academy of Sciences planned, as with its other program, to make the scientific results of Explorer IV available as rapidly as analytical procedures permitted. In view of the progress made by experimenters and analysts, the academy took steps more than a week ago to arrange for a presentation of summary papers at its annual meeting on April 27–29, 1959.

IAEA Head Says Member Nations Fail to Give Full Support

W. Sterling Cole, director-general of the International Atomic Energy Agency, has urged that his agency be allowed to perform the functions for which it was established. He says that the failure of nuclear powers to cooperate fully with the IAEA is hampering development of the atoms-for-peace program.

Background Cited

In a stirring address before the American Association for the United Nations, which met in Washington in March, Cole pointed out that the measure of success of a U.N. specialized agency is not so much in the efficiency of management of the organization itself as in the extent to which the supporting governments will actually use the international channels provided. Cole reminded the audience that when President Eisenhower made his atoms-for-peace proposal to the United Nations in 1953 which led to the formation of the IAEA, the underlying idea was entirely new. Cole commented: "For the first time in history it was proposed that a tremendous force usable for war and destruction be dedicated to the benefit of mankind everywhere and that knowledge in the peaceful application of this new-found force be shared without favor or discrimination."

Cole emphasized that the IAEA "constitution" is a treaty-statute approved by more than 80 nations. The agency's constituent assembly is an annual general conference of the member states, now numbering 70. Its managing directorate is a 23-member board of governors carefully balanced to include representation of the atomic-industry nations, the material-supply nations, the recipient nations, and the several major geographic regions of the world. He pointed out further that the agency has a staff of outstandingly competent scientists, engineers, administrators, and diplomats made up of representatives of more than half the member states.

Recommendations Offered

Cole summarized his recommendations as follows.

"The first decision which must be made is clear and straightforward. It is simply the decision that, having created an international body for defined purposes in connection with atomic energy, the Agency should be supported not only with generous financial contributions—as has been the case of the United States—but fully and without qualification in its operational aspects. We can be only partially effective if some nations maintain parallel machinery to do the same thing as the Agency but subject to individual nation selection, manipulation and control.

"Once this decision has been made, and with determination to sustain it, the subsequent steps become equally clear and straightforward: to discontinue further bilaterals or multilaterals [agreements], to begin to place under Agency administration the health and safety and materials safeguard measures embodied in existing bilateral and multilateral agreements, to begin to channel all atomic foreign aid through the Agency, and to start work on the instrument which will make possible the registration and accounting control of the nuclear fuel materials."

The United States has 42 bilateral and multilateral agreements with 40 countries, and one with the city of West Berlin, to assist in the peaceful development of atomic energy. Some 45,000 kilograms of U-235 has been set aside in accordance with these cooperation agreements.

This country has made 5000 kilograms of U-235 available to the IAEA and has promised to match the allocations of other countries. So far the United Kingdom has pledged 20 kilograms of U-235; the U.S.S.R., 50 kilograms. In addition, Portugal will provide 100,000 kilograms of normal uranium concentrate. The first purchase of nuclear fuel by any country through truly international channels was completed on 24 March, when Japan signed an agreement with the IAEA to buy 3 tons of natural uranium, provided by Canada, to be used in a 10-megawatt research reactor.

Antarctic Science

Albert P. Crary reported recently on his 2½ years in Antarctica as deputy chief scientist of the United States–International Geophysical Year program of the National Academy of Sciences. Crary has just returned from an assignment that also involved serving as station scientific leader at Little America. From that station, he led two major journeys of scientific exploration, the second ending on 1 February 1959.