Some things have been done in the way of diversifying research in the manpower-rich AEA and of encouraging industry-oriented research elsewhere in the government scientific establishment, but the measures up to now have been relatively gentle ones. Benn's warning that he does "not intend to authorize non-nuclear work for the Atomic Energy Authority solely in order to absorb surplus staff at Culham or elsewhere" strikes a tough new note and could signify a harder line in government use of its budget and program powers to effect a redeployment of scientists and engineers into applied research. Given the traditional attitudes of British scientists toward applied research, this may mean that storm signals are going up for British science policy.

—JOHN WALSH

Ionosphere after IQSY: London Meetings Review Findings

London. The F-region of the ionosphere is now becoming fairly well understood, and the outstanding problems are yielding to theoretical treatment. The new explanations often involve large-scale movements of charged particles in the upper atmosphere. Attention will now turn to lower layers (the D-region and below) where recent studies indicate unexpected interactions between the ionosphere and the stratosphere. These views were set forth by S. A. Bowhill of the University of Illinois, the last of a group of nine ionosphere physicists who summarized conclusions from measurements made during the International Years of the Quiet Sun (IQSY 1964–65). The occasion was the symposium on the results of the IQSY, held in London from July 17 to 21.

The Committee on Space Research (COSPAR) postponed its annual plenary meeting to run concurrently with the London IQSY assembly; evidence both of the contribution of rockets and satellites to the work of the IQSY and of the interest in solar-terrestrial physics that dominates current space science. Of the various research topics discussed at the combined meetings, the ionosphere accounted for the greatest number of papers. Sounding rockets, satellites (including topside sounders for studying the ionosphere from above the electron maximum), and, most recently, parachute-borne probes have provided new ways of looking at the ionosphere. Indeed, K. Rawer of the Ionosphere Institute, Breisach, West Germany, complained that the planetary network of ionosphere ground stations had not evolved to meet the many needs of the space era.

The ionosphere is a sensitive indicator of changes in solar-terrestrial relationships during the solar cycle: The amount of ionization, the variation with latitude, and the patterns of diurnal change in the ionosphere are all affected by events on the sun. The temperature of the F-region at middle latitudes has proved a reliable indicator of solar activity. Nevertheless, research during the recent period of solar quietude has been as much concerned with continued study of general features of the ionosphere as with solar-cycle investigation. The presentations at the IQSY symposium were not limited to the calendar years nominally under discussion.

Bowhill's provocative suggestion that the F-region phenomena were virtually explained followed brisk disputes between the participants about the relative importance of neutral winds, electric forces, and diffusion in moving the electrons about at different places and times. To have a choice of mechanism for vertical movements is certainly better than to have none, and makes several anomalies in the behavior of the F-region less perplexing. Moreover, as H. Kohl of the Max Planck Institute für Aeronomie emphasized in a theoretical paper, neutral winds and electromagnetically controlled drifts of ionization are intimately connected. For example, vertical drifts due to electric fields must be reduced by interaction with the neutral air. On the other hand, winds produced by pressure gradients in the atmosphere will drive the ionization along the local lines of force of the earth's magnetic field, which generally have a vertical component; as a result, the wind is subject to frictional drag.

For J. W. King, of the Radio and Space Research Station, Slough, England, the neutral winds provided sufficient explanation for some important vertical drifts. Winds of 150 meters per second give, for example, vertical drifts of about 75 meters per second at middle latitudes. In the F-region, the neutral winds blow constantly across the poles, from the late-afternoon meridians to the early-morning meridians, preserving that direction in space as the Earth rotates underneath. At night, therefore, the wind components parallel to the lines of force act toward the equator (from north and south) and upward, lifting the ionization to heights at which recombination is less likely. This mechanism helps to preserve the ionization at night. In the early afternoon, the wind components are reversed and sweep the ionization downward into regions where recombination is greater. This movement explains, according to King, the so-called "bite-out" of ionization, lost at a wide range of middle latitudes after midday. Calculations by Kohl and King of diurnal ionospheric changes at a given location (Port Lockroy), based on this theoretical interpretation, accord well with the observation. And in the ionosphere over Antarctica, the upward and downward motions are conspicuous, as the magnetic pole revolves around the geographic pole.

Other F-region vertical movements have been well explained by electromagnetic forces. In particular, workers in the United States and Britain arrived at an explanation of the rise of the "equatorial arch," discovered in the data from the topside sounding satellites. This arch is a large region of enhanced electron concentration following the lines of the geomagnetic field, and it rises through the F-region during the day. The phenomenon can be understood as a combined effect of the geomagnetic field and a horizontal electric field oriented east-west across the magnetic field. Electrons in the crossed fields experience a force at right angles to both fields—upward and outward.

F-Region Phenomena

Among the F-region phenomena discussed by Rawer, of Breisach, was the difference between the northern and southern hemisphere, which Rawer judged to be real and attributable chiefly to excess ionization over South America. The global map of the F-region is not to be interpreted simply in terms of the local magnetic dip angles and the relative position of the sun; it seems that magnetic declinations also have to be taken into account. Studies of lunar tides in the ionosphere have revealed an interesting phase shift: there is a difference of about 5 lunar hours between the tides at altitudes of 160 and 320 kilometers.

The molecular and atomic species in the ionosphere, in their neutral and ionized forms, were described by C. Y. Johnson of the Naval Research Laboratory, Washington, in a report based primarily on mass-spectrometer measurements during NRL rocket flights over White Sands in the period 1963 to 1966. Above the level of maximum ionization in the F-region, there is a good match between the abundance of ions and the abundance of corresponding neutral species, with monatomic oxygen ions predominating up to 900 km by day and 500 km by night, and monatomic hydrogen above that height. Defining the "top of the atmosphere" as the level at which the neutral oxygen density falls below the oxygen ion density, Johnson put it at about 800 kilometers altitude, at least for the period of the IQSY.

Below the F-region maximum the correspondence between neutral and ionic distributions disappears. Here nitric oxide ions share the dominant role with molecular oxygen ions, even though neutral nitric oxide molecules are very rare; molecular nitrogen is very abundant, yet its contribution to the ionization is very small. The reason for this state of affairs is found in laboratory studies of ion chemistry and particularly of reaction rates between ionized and neutral species. Molecular nitrogen ions react rapidly with atomic oxygen to form nitric oxide ions; the latter are also formed abundantly by reaction between nitrogen molecules and atomic oxygen ions.

Johnson cited the measurements of ionic composition in the D-region reported last year by R. S. Narcisi of the U.S. Air Force Cambridge Research Laboratories. At these lowest levels of the ionosphere (60 to 90 kilometers) ions of water vapor, hydrated protons and metallic ions tend to predominate.

In a paper for the COSPAR meeting, Narcisi reported an analysis of rocket measurements in the lower ionosphere during a meteor shower. He found, at an altitude of 98 kilometers, a layer of metallic ions (mainly magnesium and iron) 2 kilometers thick, and, at the same altitude, very striking minima in the density of nitric oxide and oxygen molecular ions. The latter are apparently too short-lived to be transported into the metallic ion layer. Narcisi also concludes that the lighter metal ions form layers more readily than the heavier ones.

It is in studies of the D-region that conclusive evidence has emerged of interactions between the stratosphere and the ionosphere. The conditions during the IQSY were particularly favorable for observing this connection, which contradicts the long-made assumption that events above and below a 50-kilometer altitude were different in kind and wholly unconnected. Radio absorption in the D-region, measured by multifrequency techniques, declines with the general decrease in solar activity. But an anomalously high absorption occurs on a relatively small number of days in winter, even when the sun is quiet. In a review of studies since 1954, Bowhill of the University of Illinois, summarized the evidence that enhanced ionospheric absorption occurs during periods of marked warming in the stratosphere. Meteorologically, these warmings are associated with a deviation of the interhemispheric front. The question of how warming in the stratosphere affects the ionization in the ionosphere is open, although Bowhill outlined various possibilities, dependent either upon photochemical processes or upon changes in the frequency of collision of electrons with neutral molecules within the lower ionosphere. He hoped that rocket-borne mass-spectrometer observations of the ionic species would help to settle the matter.

Sporadic E, the intermittent appearance of anomalous thin layers of ionization in the E-region, has long been a mystery. Attempts to explain it directly, in terms of geomagnetic effects, or the occurrence of meteor showers or thunderstorms, have not succeeded. Rawer reported a lack of any detectable influence of the solar cycle on the occurrence of sporadic E. The past 2 years have brought strong evidence in support of the view that sporadic E is due to long-lived ionic species concentrated by strong wind shear. Canadian chemical-release experiment with gun-launched projectiles have established a correlation of sporadic E with wind shear at 100 kilometers altitude, and Johnson was able to report, at the London symposium, NRL soundings which showed magnesium, sodium, silicon, and possibly iron as ionic species present in the sporadic E layer.

Other Research

The COSPAR meeting brought reports of studies of ion densities and compositions below the D-region, largely based on the use of parachute-borne devices. For example, H. Ishikawa and his colleagues of Nagoya University, Japan, reported measurements of ion density and mobility made with a Gerdien condenser suspended 15 meters below a parachute. They observed large ions with mobilities ranging from one-tenth and one-thousandth of those of the normal small atmospheric ions, at 30 to 55 kilometer altitudes. L. C. Hale of Pennsylvania State University and his colleagues summarized the results of 16 parachute-borne experiments in which they used blunt probes as a means of collecting charge. During a polar-cap absorption event at Fort Greeley, Alaska, they observed a nearly constant density of positive ions (about 7000 per cubic centimeter) between 40 and 80 kilometer altitudes. Soviet workers (Y. A. Bragin and colleagues of The Central Aerological Observatory, Moscow) concluded, from 12 condenser experiments between 10 and 80 kilometers altitude, that there is a maximum density of charged particles of the order of 10^4 per cubic centimeter, between 15 and 25 kilometers. In their theoretical interpretation they suggest that the electron density is negligibly small and that the distribution of positive ions is greatly influenced by the presence of negative ozone ions produced by reaction between negative oxygen ions and neutral ozone molecules.

Growing interest in the lower ionosphere and the underlying regions of the atmosphere was evident in the London discussions about the ionosphere. As discipline representatives for the ionosphere in the Inter-Union Commission on Solar Terrestrial Physics (IUCSTP), Bowhill and King analyzed the responses from 60 of their colleagues, to the question of what international collaboration should be planned for the coming solar maximum. The London poll showed that the strongest interest lay in positive and negative ions in the D-region; and waves and turbulent motions in the D- and E-regions. Other topics concerned ionospheric photoelectrons; winter absorption anomalies, polar-cap absorption events, sunrise effects in the E-region, and plasma oscillations in the F-region. There were new proposals for conjugate-point ionospheric studies, for comparisons of the ionosphere at the two poles, and for investigations of solar radiation effects in the stratosphere and mesosphere.

In the development of techniques to be used during the next solar maximum (1968–69) the physicists gave high priority to a solar-monitoring satellite, to continued flights of satellites measuring electron and ion temperature, to ground-based studies of the upper ionosphere (and especially of ion-drift velocities) with the incoherent back-scatter technique, and to radar studies of the movements of meteor ionization trails. King was seeking support for the concept of an internationally equipped and operated satellite for routine monitoring observations.

The other disciplines represented were engaged in similar discussions during the IQSY/COSPAR meetings. On this basis, overall proposals for the solar maximum were being drafted for submission to the International Council of Scientific Unions and to the adherent nations and specialist unions. H. Friedman, president of IUCSTP, remarked in London that the international program in this field would no longer be a "stop-and-go" operation. His commission's work will continue indefinitely. Friedman identified three phases in the development of proposals for programs in solar-terrestrial physics. In the first, the capabilities developed in the IQSY are to be exploited further though with some changes in emphasis, for example, to encourage regional, rather than global, studies of "mesoscale" phenomena. Second, a number of new programs will be initiated. And, third, the Commission will seek to identify suitable topics and occasions for major undertakings. Even though the full Commission was meeting for the first time, in London, there was a sense of urgency. With the solar maximum approaching rapidly, some of the programs will have to be under way next year.

—NIGEL CALDER

APPOINTMENTS

A. F. Spilhaus

C. H. Townes

Athelstan F. Spilhaus, dean of the School of Science and Technology, University of Minnesota, to president of the Franklin Institute, Philadelphia. He succeeds **Wynn L. LePage**, who is to become chairman of the board at the Institute. . . . **Charles H. Townes**, Nobel Prize laureate and Institute Professor, Massachusetts Institute of Technology, to Professor-at-Large, University of California. . . . **Francis A. Arnold, Jr.**, assistant surgeon general and chief dental officer of the Public Health Service, to coordinator of research, School of Dentistry, University of the Pacific, San Francisco. . . . **A. Starker Leopold**, professor of zoology, University of California, Berkeley, to an additional position of chief scientist of the National Park Service. . . . **Lewis M. Alexander**, on leave from position of chairman of the department of geography, University of Rhode Island, to deputy director of the Commission on Marine Science, Engineering and Resources. . . . **James E. Banta**, chief of the technical resources staff, Office of International Health, to director of the Office of International Health, Public Health Service. . . . **George H. Vineyard**, associate director, Brookhaven National Laboratory, to deputy director. He succeeds **Clarke William**, who is to retire. . . . **Paul G. Klemens**, manager of transport properties of solids department, Westinghouse Research Laboratories, to head of the department of physics, University of Connecticut. . . . **Walter D. Knight**, professor of physics, University of California, Berkeley, to dean of the College of Letters and Science, at the Berkeley campus. . . . **George E. Schafer**, vice commander of the Aerospace Medical Division, to commander of the U.S. Air Force School of Aerospace Medicine. . . . **John M. Anderson**, associate professor of biology, Carleton University, Ottawa, to director of the Fisheries Research Board of Canada Biological Station. . . . **Wright Adams**, associate dean and chief of the clinical staff of the Division of Biological Sciences, University of Chicago, to executive director of the Heart Disease, Cancer and Stroke Regional Planning Program for Illinois. . . . **James H. Werntz**, associate professor of physics, University of Minnesota, to director of the Center for Curriculum Studies at the university. . . . **John F. Mullan**, professor of neurosurgery, University of Chicago, to director of the Division of Neurosurgery, Department of Surgery, at the university. . . . **Joseph C. Olson, Jr.**, professor of bacteriology, University of Minnesota, to director of the Division of Microbiology, Food and Drug Adminstration. . . . **Leon Eisenberg**, professor of child psychiatry, Johns Hopkins University School of Medicine, to head of the Harvard department of psychiatry, Massachusetts General Hospital, and **Seymour S. Kety**, chief of the Laboratory of Clinical Science, National Institute of Mental Health, to professor of psychiatry, Massachusetts General Hospital.

RECENT DEATHS

Justin M. Andrews, 64; retired director of the National Institute of Allergy and Infectious Diseases, NIH; 30 June.

Charles Armstrong, 88; retired chief of the division of infectious diseases, NIH; 22 June.

Theodore H. Barth, 75; co-inventor of the Norden bomb sight and founder of the Norden Laboratories, Danbury, Conn.; 19 June.

William H. Emig, 78; professor emeritus of botany, University of Pittsburgh; 8 June.

Klaus Epstein, 40; chairman of the department of history, Brown University; 23 June.

Samuel Kagan, 50; supervising psychiatrist, Hudson River State Hospital; 3 July.

Jihei Konishi, 41; lecturer in the faculty of Fisheries, Mie Prefecture University, Tsu, Japan; 4 June.

Charles A. Kraus, 91; professor emeritus of chemistry, Brown University; 28 June.

Otto L. Mohr, 81; retired rector, Oslo University, Norway; 23 June.

Sam Switzer, 36; assistant professor of medicine, Albert Einstein College of Medicine; 2 June.