SPUTNIKS, THE ATMOSPHERE AND ELECTRONS

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THE Northern Lights—the thousand-kilometre long glowing streamers in the upper atmosphere—and variations caused by them in the Earth's magnetic field have long been attracting the attention of scientists. These phenomena, it has been found, depend on solar activity. It has also been determined that they arise hundreds and thousands of kilometres away from the Earth's surface, in a region called the magnetosphere, where the influence of the magnetic field of the Earth is beginning to tell.

The studies of upper atmosphere have also shown that at altitudes, from 100 to 300 kilometres from the Earth's surface, a certain proportion of gas atoms and molecules, that make up the upper layers of the atmosphere, are being continuously ionised, or in other words, are being split into ions and electrons, which form together the ionosphere. During northern lights the process of ionisation is intensified and becomes more chaotic. As a result, the concentration of ions and electrons becomes subject to quick variations, the ionospheric "mirror" which reflects radio-waves loses its homogeneous nature and radio communications are dislocated.

For many years scientists have sought to elucidate the nature of the ionisation process in the upper atmosphere during northern light displays by analysing spectroscopically their glow. These investigations have led to a major conclusion showing that during an Aurora Borealis the upper atmosphere is pierced by streams of electrons with energies ranging from about 1 to 30 kev. The collisions of electrons with the atoms and molecules of the atmosphere cause the latter to ionise and glow. From time to time the atmosphere is also invaded by streams of ionised atoms of hydrogen—protons. Unlike electrons, they enter the denser layers of the atmosphere roughly with the same intensity and simultaneously over large areas. Although such invasions do not result in bright glow, they bring in within a few hours considerable amounts of energy into the atmosphere.

INTERFEROMETERS

Investigations involving the use of special spectral instruments—interferometers—have demonstrated that at the time of intensive northern lights the temperature at altitudes of 300 to 500 kilometres rapidly rises and reaches 2,000 to 3,000 degrees, whereas the normal temperature there is 800 to 1,200 degrees at night and approximately 1,500 to 2,000 degrees in the daytime. The heated regions of the atmosphere get expanded and the atmospheric density at great heights is increased. There is also a corresponding rise in the resistance which the atmosphere, although a tenuous one, exerts on the motion of artificial satellites. This, too, markedly influences their orbits. The analysis of the orbit motion of artificial satellites has confirmed the conclusion arrived at by terrestrial observers that the temperature in the upper layers of the atmosphere rises not only in the daytime—due to the absorption of solar ultra-violet radiation—but also at night at the time of northern light displays. This means that the total energy absorbed by the atmosphere during Aurora Borealis is very great.

Ground observations made by all available geophysical methods can furnish data only on those processes which occur when this radiation interacts with the upper atmosphere. Primary geoactive corpuscles can be studied only when we go beyond the boundaries of the absorbing atmosphere. The remarkable achievements of rocket engineering have opened up possibilities for a basically different approach to space exploration by geophysics and astronomy—possibilities of making a first-hand study of aerospace with the aid of artificial satellites.

The irregular nature of solar activity—the original cause of these geophysical phenomena and the diversity of forms in which they appear have suggested the development of geophysical sputnik stations with a long life and high informative ability for continued exploration of geoactive corpuscular radiation.

This complicated task has been successfully tackled by Soviet designers, engineers and scientists. Cosmos 3 and Cosmos 5 were placed into orbit around the Earth on April 24 and May 28, 1962 respectively. It is already several months that geoactive molecules are being investigated by them. The long service life of the sputniks enabled measurements to be made both in periods of quiet magnetic field and when there were strong geomagnetic or ionospheric disturbances. Information about solar and geomagnetic activity regularly received from the World Centre for collection of geophysical data by the Institute of Terrestrial

Magnetism, Ionosphere and Wave Propagation of the USSR Academy of Sciences, enables the scientists to predict geomagnetic disturbances and make measurements, by means of sputniks Cosmos 3 and Cosmos 5, choosing periods with different geophysical conditions.

Originally, the distances of Cosmos 3 and Cosmos 5 from the Earth were respectively 229 and 203 kilometres in perigee and 720 and 1,600 kilometres in apogee. But their orbits do not remain constant. As time goes on, perigee and apogee distances are shortened due to the resistance offered by the atmosphere to the motion of the sputnik. An ellipse along which the sputnik is revolving around the Earth's centre, owing to the flattening of the planet at the poles, gradually rotates so that the perigee and apogee points also follow a kind of orbit, completing a full revolution approximately in 100 days.

Measuring Density

With the continued stay of Cosmos 3 and Cosmos 5 in space, it becomes possible to measure with a high degree of accuracy the average density of the upper atmosphere and its variations with time of the day and with latitude at the perigee distance (about 200 kilometres). These data are furnished by the decelerations of the sputniks and also by changes in their periods of revolution about their axes.

The instrumentation carried by Cosmos 3 and Cosmos 5 is intended for the investigation of geoactive corpuscles whose energy is relatively small. Such corpuscles are only capable of penetrating through very insignificant masses of matter, and such radiation is called, therefore, a soft radiation.

Electrons are recorded by means of transducers consisting of a fluorescent screen, which emits light under the action of corpuscular radiation, and a photo-multiplier for measuring the intensity of screen brightness. From outside, the screen is protected with aluminium foil with a thickness of only several microns. Soft radiation could not have penetrated through a thicker barrier. This design of the device ensures high sensitivity with respect to electrons of lower energies and at the same time a low sensitivity to electrons and ions of very great energies and to X-ray radiation. This is very important, because different types of radiation are possible in the upper atmosphere, and instruments must not "confuse" between them. Three instruments are directed parallel to the sputnik's axis of symmetry, one faces the reverse direction, and one is mounted perpendicular to the sputnik axis.

The first three transducers have foils of different thicknesses (1·5–2·3–4·2 microns). The voltage that is applied to them is periodically changed, in a stepwise fashion, passing through the following values with respect to the sputnik shell: + 150, + 3,000, + 6,000, + 11,000 volts. Lower-energy electrons that are trapped by the transducer are accordingly accelerated, and the signal from them is changed, too. This arrangement separates a lower-energy electron signal from other signals.

It has been established with the aid of these transducers that at high altitudes, the soft corpuscular radiation, first discovered by the third Soviet sputnik, is found not only at higher latitudes, but also at medium and lower latitudes. Thus, near the Brazilian magnetic anomaly at altitudes from 650 to 1,600 kilometres, several tens of millions of electrons with energies of more than 40 kev. are falling on the transducer screen every second. To give one an idea of what it is, it may be pointed out that with such an exposure the screen is blue violet and bright enough to be visible by the unaided eye. If such an energy stream had been absorbed by the atmosphere at altitudes of 200 to 300 kilometres, this would have led to its considerable heating.

Corpuscular Radiation

The remaining two electron transducers make it possible, using the sputnik's rotation around its axis, to study the distribution of directions of electron velocities in the Earth's magnetic field. Knowing this distribution and the laws governing the motion of charged particles in a magnetic field, it is possible to calculate the intensity of corpuscular radiation at the lower levels. In this way the intensity of corpuscular radiation can be determined not only at those altitudes where the sputnik is passing but also at other points along the same magnetic line of force.

Knowing the fashion in which the intensity of an electron stream depends on its direction, we can answer the question whether or not geoactive corpuscular radiation invades the denser layers of the atmosphere. A charged particle moving spirally around a magnetic line of force can enter the absorbing layers of the atmosphere at altitudes of 100 to 300 kilometres only if its direction of motion at very great heights is sufficiently close to that of the magnetic line of force. Normally, when the transducers "face" that way, they do not register such particles. But if the axis of the transducer is perpendicular to the magnetic line of force, then the encountered stream of particles is very intense. This means that the recorded corpuscles "spend their lifetime" at high altitudes in the tenuous layers of the atmosphere where there is no absorption.

These particles are said to have been trapped by the Earth's magnetic field. But at the time of northern lights a tremendous amount of new corpuscles appear in the magnetosphere. The ability of the magnetic field to retain charged particles is diminished. At the same time the density of the atmosphere at great heights is increased. All this leads to a stronger absorption of geoactive particles by the atmosphere. Their stream from above downwards becomes, in fact, much greater than in the reverse direction. These cases can be detected by comparing the recordings of the transducers facing in the opposite directions. The data that have been analysed to this day show that at lower latitudes the magnetic trap in most cases is not destroyed. This suggests that corpuscular streams do not enter the denser layers of the atmosphere.

To study streams consisting of the softest corpuscles, the sputniks Cosmos 3 and Cosmos 5 carry special magnetic traps for the analysis of soft-ion energies.

Geiger Counter

The sputnik instrumentation also includes a standard Geiger counter with a 3-mm. lead shield. This makes it possible to compare the intensities of soft geoactive corpuscles and electrons and ions of very high energies forming radiation belts around the Earth. At high altitudes in the radiation belts the counting rate of this instrument is greatly increased. Above the Brazilian magnetic anomaly high count rates are recorded not only at considerable heights, but also at relatively small altitudes of the order of 200 to 400 kilometres. The intensive streams of low-energy corpuscles are often observed where the intensity of particles making up the radiation belts is small.

The continued operation of the sputniks inevitably calls for control and calibration of measuring instruments in the course of flight. To keep continuous watch over the functioning of the involved automatic gauges, regular check-ups are carried out in the sputnik on the power supply voltage, the work of particular units, the physical conditions in the hermetically sealed compartment and conditions on the surface of the sputnik. The analysis of these data has revealed a high degree of stability in all systems of the sputnik.

The sensitivity of the electron transducers during flight is controlled by means of a radioactive standard containing a hydrogen isotope—tritium. During measurements a stream of electrons emitted due to the radioactive decay of the tritium is not hitting the screen and so does not interfere with the measurement of geoactive corpuscles. But a special generator, which is switched on and off automatically, at regular intervals applies high voltage to the standard. The trajectory of electrons emitted by the standard becomes curved in such a way that the exposure of the screen becomes significant. Since the rate of radioactive decay of tritium is known and remains practically unaffected during the sputnik's functioning, such a procedure enables periodic check-ups to be made of the sensitivity of the electron transducers.

A great deal of information received from the sputniks Cosmos 3 and Cosmos 5 is still in the process of deciphering. The observations continue.

UNIVERSITY DEVELOPMENT IN INDIA (A STATISTICAL REPORT, 1961-62)

WE have received a copy of the report prepared by the Statistical Section of the University Grants Commission, Rafi Marg, New Delhi-1, priced Rs. 3·50 nP. or 5 *sh*. It provides a useful and convenient summary of the latest facts and figures about the Indian Universities, and will be of value to all concerned in the development of higher education in India.

There are 53 universities in India of various types distributed among the 16 States (including Delhi), which means that there is one university for every 8·34 millions of population. The total number of colleges is 1,783 of which 107 are university colleges, 1,223 are private colleges and 453 Government colleges Of the 1,783 colleges 1,194 are Arts, Science and Commerce colleges and 589 are professional colleges.

The total number of students enrolled during 1961-62 was 980,380 of which 169,627 were women.
