CIA/PB 131632-17

UNCLASSIFIED- SOVIET BLOC INTERNATIONAL GEOPHYSICAL YEAR INFORMATION

JUNE 6 1958

 PB 131632-17

(13)

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June 6, 1958

U. S. DEPARTMENT OF COMMERCE
Office of Technical Services
Washington 25, D. C.

Published Weekly from February 14, 1958, to January 2, 1959
Subscription Price $10.00 for the Series

PLEASE NOTE

This report presents unevaluated information on Soviet Bloc International Geophysical Year activities selected from foreign-language publications as indicated in parentheses. It is published as an aid to United States Government research.

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I. DETAILS ON SPUTNIK III

Introduction

The 18 May issue of Pravda devotes two full pages to a description of Sputnik III and the experiments which are being conducted by it. Separate sections are devoted to the "Satellite Orbit and Observation of its Movement"; "Sputnik III Equipment"; "Study of the Ionosphere," including "Measurement of the Concentration of Charged Particles," "Investigation of the Composition of the Ionosphere," and "Investigation of Electrostatic Fields"; "Measurement of the Earth's Magnetic Field"; "Study of Cosmic Rays;" "Investigation of Corpuscular Radiation of the Sun"; "Measurement of Pressure and Density of the Atmosphere"; "Investigation of Micrometeors"; and "Sources of Equipment Power Supply."

The Pravda article is accompanied by a photograph showing an external view of Sputnik III and two schematic diagrams. One diagram, on page 3, shows the external disposition of some of the scientific equipment carried by the satellite. (1) magnetometer, (2) photomultipliers for registering corpuscular radiation of the Sun, (3) solar batteries, (4) instrument for registering photons in cosmic rays, (5) magnetic and ionization manometers, (6) ion traps, (7) electrostatic fluxmeters, (8) mass-spectrometer tube, (9) instrument for registering heavy nuclei in cosmic rays, (10) instrument for measuring the intensity of primary cosmic radiation, and (11) transducers for registration of micrometeors. The electronic units of scientific equipment, radio-measuring systems, the programing-timing device and the electrochemical power supplies, which are located inside the satellite body, are not shown in the schematic.

The second diagram, on page 4, is a sketch of the satellite being separated from the carrier-rocket showing (1) the satellite, (2) the carrier-rocket, (3) the separating protective cone, and (4) the shields being separated from the satellite.

The following is the full text of the 18 May Pravda article.

Basic Information

The launching of the third Soviet artificial Earth satellite was accomplished on 15 May 1958. Sputnik III was placed in orbit with the aid of a powerful rocket-carrier. When the rocket-carrier with the satellite had attained in the specified trajectory a flight velocity of more than 8,000 meters per second, the satellite was separated from the rocket-carrier by special devices and began to move in an elliptical orbit around the Earth. During the separation of the satellite from the rocket carrier, the protective cone and protective shields were discarded. The rocket-carrier with the protective shields and the protective cone move in an orbit close to the satellite orbit.

According to its specifications, Sputnik III by far surpasses the first artificial Earth satellites.

The weight of Sputnik III is equal to 1,327 kilograms, and the total weight of the scientific and measuring equipment, together with power supplies which are mounted in the satellite, is 968 kilograms.

The satellite has a form which is approximate to a cone. The length of the satellite is 3.57 meters, and its largest diameter is 1.73 meters not considering the protruding antennas. A large number of systems for conducting complex scientific experiments are installed in the satellite. The experiments are intended basically for studying phenomena occurring in the upper layers of the atmosphere and the effect of cosmic factors on processes in the upper atmosphere.

Sputnik III is equipped with improved measuring radio engineering apparatus, providing exact measurement of its orbital movement and a radio telemetering apparatus which continuously records the results of scientific measurements, "stores" them during the entire time of the satellite's flight and then transmits them to Earth during the satellite's flight over special stations situated in the USSR which receive the accumulated information. There is a programing device on the satellite which ensures automatic functioning of its scientific and measuring apparatus. This programing device is made entirely of semiconductors. In addition, all measuring, scientific, and radio engineering devices are made with the wide usage of new semiconductor elements. The total number of semiconductor elements on board the satellite is several thousand. The power supply of the apparatus is provided by the best improved electrochemical sources of current and by semiconductor silicon batteries which convert the energy of solar rays into electrical energy.

The great weight of Sputnik III testifies to the high qualities of the rocket-carrier which carried it into orbit. The weight of the Sputnik I was equal to 83.6 kilograms. The weight of scientific measuring equipment of Sputnik II was 508.3 kilograms. Sputnik III weighs 1,327 kilograms. The total weight of equipment for scientific research and radio measuring equipment, together with power supplies of Sputnik III, is 968 kilograms.

The continuous increase in the weight of the Soviet satellites testifies to the future possibilities of our rocket engineering. Already today, there is a possibility of launching a rocket into the cosmos beyond the limits of the Earth's gravitation. So that this would have scientific significance and would be a real stride in accomplishing interplanetary flights, it is necessary that such a cosmic rocket is sufficiently equipped with scientific and measuring apparatus and, as a result of its launching, obtains new information on physical phenomena of the Universe and on conditions of cosmic flight.

The scientific equipment on Sputnik III makes it possible to study a wide circle of geophysical and physical problems. The structure of the ionosphere will be studied by means of observations of the propagation of radio waves which are emitted from the satellite by a high-powered radio transmitter. In this connection, an apparatus for direct measurement of the concentration of positive ions along the satellite orbit has been installed. A special apparatus will permit the measurement of the natural electrical charge of the satellite and the electrostatic field in the layers of the atmosphere through which the satellite passes. Measurements of density and pressure in the upper layers of the atmosphere are being conducted. A mass spectrometer mounted in the satellite makes it possible to determine the spectra of ions which characterize the chemical composition of the atmosphere.

For studying the Earth's magnetic field at high altitudes, a self-orienting magnetometer which measures the full intensity of the magnetic field has been installed.

A number of experiments are devoted to the study of various radiations falling to Earth and having an effect on important processes in the upper layers of the atmosphere. The study of cosmic rays in corpuscular radiation of the Sun is being conducted by the satellite. Registration of the intensity of cosmic rays, being conducted almost over the entire surface of the Earth, will give new information on cosmic radiation and on the Earth's magnetic field at high altitudes. Experiments for determining the number of heavy nuclei in cosmic radiation are being conducted. Experiments in corpuscular radiation of the sun will throw a new light on the nature of the ionosphere, aurora, and other phenomena in the atmosphere. Several transducers will record micrometeor impacts.

A new experiment on registering photons in the composition of cosmic radiation is very important and will make it possible to obtain information on short-wave electromagnetic radiation in the cosmos. This is the first experiment permitting the study of cosmic radiation absorbed by the atmosphere and the first step in opening a new stage in astronomy -- study of phenomena in the universe according to short-wave radiation of luminary bodies. A number of experiments have been set up for investigating flight conditions in cosmic space. Included in these experiments is the study of the heat regimen in a satellite, orientation of a satellite in space, and other experiments.

The abundance of scientific investigations on Sputnik III characterizes it as a genuine cosmic scientific station. The creation of such a station on an advanced technical level and the placement of so broad a complex of equipment on it became possible thanks to the fact that a satellite of such large dimensions was created.

The satellite trajectory will pass over all points of the globe lying between the north and south polar circles. This increases even more the value of scientific experiments being conducted by the satellite. The parameters of the satellite's orbit were selected in a manner that would guarantee the conduct of scientific investigations in the most interesting range of altitudes.

The Satellite Orbit and Observation of Its Movement

Sputnik III was placed into an elliptical orbit with an apogee altitude (the highest point of the orbit from the surface of the Earth) of 1,880 kilometers. After introduction into orbit, the satellite was separated from the rocket-carrier. The period of its rotation around the Earth at the beginning of movement was 105.95 minutes. In a day, the satellite completes around 14 orbital revolutions. Later on, the rotation period and the apogee altitude of the orbit will gradually decrease because of deceleration of the satellite in the upper layers of the atmosphere. According to preliminary estimates, the movement of Sputnik III in orbit will be longer than the movement of the first two Soviet Earth satellites.

The plane of the orbit is inclined to the equatorial plane at a 65° angle.

The rocket-carrier, immediately after placing the satellite in orbit, itself began to orbit close to the satellite orbit at a comparatively short distance from it. During the course of time, the distance between the satellite and the rocket-carrier will be changed constantly in connection with the different degree of its deceleration in the atmosphere. The various degrees of deceleration occur because lifetime of the rocket-carrier will be less than the time of existence of the satellite.

Using data accumulated during launchings of the first Soviet artificial satellites, the lifetime may be predicted exactly after processing of the first results of measurements of the parameters of the orbit of Sputnik III.

The movement of the Sputnik III in relation to the Earth is similar to the movement of the first Soviet artificial satellites. In the middle latitudes, each successive revolution over the Earth's rotation and the precession of the orbit occurs approximately 1,500 kilometers west of the

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preceding revolution. The rate of precession of the orbit is around 4° daily. Observations of satellite movement are conducted by radio engineering and optical methods. The equipment and methods of observation have been significantly improved for Sputnik III. The satellite is equipped with several radio transmitting devices which make it possible to conduct measurements of its coordinates during movement in orbit. These measurements are made by a series of specially created scientific stations equipped with a large number of radio engineering devices.

Data on satellite coordinates, which are measured by radar equipment, are automatically recorded simultaneously with unified astronomical time. Then, these data are transmitted along special communication lines to the general coordination-computation center. In the coordination-computation center, measurement data, received from various stations, is automatically fed into high speed electronic computers, which perform joint processing and compute the basic parameters of the orbit. On the basis of these calculations, the future movement of the satellite is predicted, and its ephemerides are given. Such a complex of measuring equipment, which includes a great number of electronic, radio engineering and other devices, ensures the measurement of satellite coordinates and the rapid determination of the parameters of its orbit with an accuracy which exceeds by far the accuracy of measurements of the movement of the first satellites.

Dosaaf [Volunteer Society for Cooperation With the Army, Air Force, and Navy], clubs, radio direction-finding stations, and a large number of individual radio amateurs are taking part in radio observations of the satellite at the same time. A radio transmitter operating on a frequency of 20,005 megacycles and continuously transmitting radio signals in telegraphic form with a duration of 150-300 milliseconds is installed on the satellite. The radiating power of the transmitter provides sure reception of its signals at great distances with the use of the usual amateur receivers. Systematic recording of these signals, especially recording on magnetic tape, which is easily done by radio amateurs, will have great scientific significance.

Radio observations of the movement of the satellite based on the use of the Doppler effect is of considerable interest. As the observations of the first Soviet satellites demonstrated, this method is very effective and under conditions of good tying in of results of measurements to astronomical time, it will be possible to obtain precise data on satellite movement.

In the organization of optical observations of the movement of Sputnik III, the experience obtained in observing the first satellites is also taken into consideration. The network of ground stations for optical observations has been expanded, and a number of foreign observation posts have been added to it. Photographic methods of observation have been significantly improved.

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The use of an electron-optical converter in photographing the satellite which makes possible a sharp photographic image at very great distances is of special interest. Models of the apparatus for photographing satellites with the use of the electron-optical converters were successfully tested in observations of Sputnik II,

Sputnik III Equipment

Sputnik III in the full sense of the word is an automatic scientific station in the cosmos. Its equipment and design are considerably more improved than the design of the first sputniks. In designing Sputnik III, a whole number of specific requirements connected with the conduct on it of various scientific experiments and the disposition of a large number of scientific and measuring equipment was considered. The possibility of mutual influence of individual scientific instruments required careful packaging in the satellite and placement of sensing elements of scientific apparatus.

The hermetically-sealed body of the satellite has a conical form and is made from aluminum alloys. Its surface, just as the surface of the first satellites, was polished and subjected to special processing to give it the necessary coefficient values of emissivity and absorptivity of solar radiation. The removable rear bottom of the satellite is fastened with joint frame bolts. The hermetic quality of the joint is ensured with special sealing. Before launching, the satellite is filled with gaseous nitrogen.

Within the body of the satellite, in the rear instrument frame made of magnesium alloy, the following are situated: radiotelemetering apparatus, radio apparatus for measuring satellite coordinates, programing-timing device, apparatus for the heat regulating system and for measuring temperature, an automatic system which provides for switching on and switching off the apparatus, and chemical sources of power supply. Instruments for measuring the intensity and composition of cosmic radiation and apparatus for recording micrometeor impacts are also mounted on the rear frame. The frame is fastened to a power pack on the casing of the body.

The basic section of instruments for scientific investigations, together with power supplies, is also located in the satellite -- on the second instrument frame located in the front of this section. On this frame are mounted electronic units of equipment serving to measure pressure, ion composition of the atmosphere, concentration of positive ions, magnitude of electric charge and intensity of the electrostatic field, intensity of the magnetic field, and the intensity of the corpuscular radiation of the Sun. The radio transmitter is also mounted here.

The disposition of sensing elements (transducers) of the scientific equipment is determined by their purpose. A magnetometer is placed in the forward section of the satellite for its maximum removal from the rest of the equipment. Cosmic ray counters are installed inside the satellite. Other transducers of the scientific equipment are located outside of the hermetically sealed body of the satellite. Photomultipliers serving for registering corpuscular radiation of the Sun are fastened to the forward section of the frame. In cylindrical vessels, which are molded in the form of a shell in the forward section of the satellite, one magnetic and two ionization manometers which measure the pressure of the upper layers of the atmosphere are installed. Two electrostatic fluxmeters serving to measure the electrical charge and intensity of the electrostatic field, as well as a tube of a radio-frequency mass-spectrometer which determines the composition of ions at great altitudes, are placed near them.

On two tubular rods, which are fastened to the body casing by hinges, are mounted spherical net-like ion traps which permit the measurement of the concentration of positive ions during the satellite's orbital movement. During the placing of the satellite in orbit, the rods with the traps are pressed to the surface of the body. After placing of the satellite in orbit, the rods turn around on the hinges and are set perpendicularly to its side surface.

On the rear bottom of the body four transducers for recording micrometeor impacts are installed.

The solar semiconductor battery is situated in the form of individual sections on the surface of the body. Four small sections are established on the forward bottom, four sections on the side surface, and one section on the rear bottom. Such disposition of the sections of the solar battery guarantees its normal operation, independent of the satellite's orientation with respect to the Sun.

The forward section of the satellite is covered with a special protective cone which is discarded after the satellite is placed in orbit. The protective cone preserves the forward section of the satellite, on which are mounted transducers of the scientific equipment, from heat and aerodynamic influences during passage of the rocket-carrier through the dense layers of the atmosphere. The cone consists of two half-shells which are separated when discarded. Besides the protective cone, a considerable section of the external surface of the satellite during orbit placement is covered by four special shields joined by hinges to the body of the rocket carrier. After separation of the satellite, these shields remain attached to the rocket carrier.

On the external surface of the satellite, a number of antenna sections are mounted in the form of rods and tubular design of complex form.

The multichannel radio telemetering system of the satellite is characterized by high sensitivity. It can transmit to Earth an exceptionally large amount of scientific information concerning the scientific measurements being conducted on the satellite. The radio telemetering system includes a number of devices continuously storing data on scientific measurements during the satellite's flight in orbit. During the flight of the satellite the "stored" information is transmitted from the satellite to ground measuring stations with great speed.

A system available on the satellite for measuring temperature continuously registers the temperature at various points on its surface and inside it.

Automatic control of the operation of all the scientific measuring equipment, its periodic switching on and switching off is accomplished by an electronic programing-timing device. This device also periodically gives time markers with great accuracy, which are necessary for subsequent tying in of results of scientific measurements to astronomical time and geographical coordinates.

A stable temperature regimen in the satellite is provided by a system of heat regulation which is considerably improved in comparison with the systems of heat regulation used in the first satellites. Regulation of the heat regimen is accomplished by means of a change of gaseous nitrogen by forced circulation in the satellite, and also by changing the coefficient of natural radiation of its surface. For this purpose, on the side of the surface of the satellite, regulating jalousies consisting of 16 individual sections are mounted. Opening and closing of these jalousies is accomplished by electric drives controlled by the apparatus of the heat-regulating system.

Study of the Ionosphere

In the program of scientific investigation conducted with the help of Sputnik III, great attention is given to the study of the ionosphere.

A number of important ionosphere characteristics have not yet been studied sufficiently. Up to now, only in single rocket experiments were direct data obtained on the distribution of the electron concentration with respect to the altitude of the outer ionosphere above 300 kilometers. Still less information is available on the ion concentration. The information on the chemical composition of ions, which is highly important from the viewpoint of explaining the process of ionosphere formation and the laws governing their changes with time, are available only for relatively low altitudes. Information on ionosphere inhomogeneities is insufficient and contradictory.

A detailed study of ionosphere structure and its principal characteristics is one of the most important geophysical problems. It should be pointed out that the solution of this problem has lirect bearing on a reliable ground radio communication with cosmic rockets, as well as for precise radio measuring, connected with the flights of such rockets.

As in the flight of the first two artificial earth satellites, during the flight of Sputnik III, an extensive program of ground observations of radio waves radiated from the satellite will be conducted.

Measurement and registration of the Doppler effect (frequencies), of the intercepted radio waves, of the field intensity, fixing the instant of "radio-rise" and "radio-set" of the satellite, of the rotation of the plane of polarization of radio waves, and of the angle of arrival of the radio waves will be conducted. The results of such observations should provide extensive material on the state of the ionosphere.

In conjunction with the ground observations, Sputnik III will conduct direct measurements of ionosphere characteristics.

The peculiarity of direct measurement of ionosphere characteristics with the aid of instruments placed on the satellite is that, in contrast to the methods based on the study of radio wave propagation, the results of measurements do not depend on the characteristics of the whole thickness of the ionosphere between the earth and satellite, nor the processes occurring it it.

The concentration of charged particles in the ionosphere and the mass spectrum of positive ions are determined by the satellite. Together with measurements of the electrostatic field at the satellite surface, which affect the results of these tests, the enumerated measurements represent a single complex of experiments, each complementing the other.

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1. Measurement of Concentration of Charged Particles

In the ionosphere, there are three basic types of free charged particles -- positive and negative ions and electrons. The sum of concentration of negative ions and electrons is equal to the concentration of positive ions. The ionosphere is electrically neutral. Therefore, by measuring the concentration of positive ions, it is possible to determine the complete concentration of free charged particles.

The study of radio waves reflected from the ionosphere or passed through it permits obtaining information primarily on the electron concentration, since the effect of the heavy charged particles, the ions, on the propagation of radio waves is more than a thousand times weaker than the effect of the lighter electrons. Since until recently, radio waves were the main means for investigating the ionosphere, all the basic information about the content of the charged particles in the ionosphere had relation only to the electron concentration. Practically nothing was known about the ion distribution.

For measuring the concentration of positive ions along the orbit, two spherical net-like ion traps are mounted on the surface of the satellite. Inside each of the traps is placed a spherical collector which has a negative potential with respect to the shell. The electric field thus formed attracts to the collector all the positive ions entering the trap and repels all the negative particles. Since the satellite velocity exceeds many times the mean velocity of the thermal movement of the ions, it can be considered that for the conditions of the spherical shape of the traps, the ion flow to the surface of the trap is fully determined by the motion of the satellite, and is independent of the air temperature, which changes with the altitude, and the orientation of the satellite with respect to its velocity. Exceptions are the cases when the trap enters the region of high vacuum which forms behind the satellite. When there are two traps located in the indicated manner, then at least one of them is always outside of such a region. By the magnitude of ion current flowing in the trap collector located at the moment in the stream, it is possible to determine the concentration of positive ions in the vicinity of the satellite.

The relation between the measured ion current and the concentration of ions is rather simple if the electrical potential acquired by the satellite in its course of flight in the ionosphere is sufficiently small (for example, not exceeding one to 2 volts). But, if such potential is great, then it can affect the magnitude of the measured current to a considerable degree and, therefore, should be taken into account. For this purpose, to the net-like shells of the traps are fed periodically, short voltage pulses with respect to the satellite frame.

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A volt-ampere characteristic is taken at this time, which makes it possible to introduce the correction, taking into account the effect of the satellite potential on the value of ion current of the trap. The device makes it possible to measure the ion concentrations in the range from 10,000 to 25 million ions in a cubic centimeter.

The measurement of the positive ion concentration makes it possible for the first time to obtain data about the full concentration of charged particles in the ionosphere over various geographical regions of the earth, for various altitudes, as well as its changes during the transitions from the regions illuminated by the Sun into the region of shade and vice versa. These data are rather important for understanding the processes of the interaction of the Sun's radiation with the Earth's atmosphere.

Comparison of the measurements conducted in the region located below the so-called main ionization maximum, which is located at an altitude of 300 to 350 kilometers, with the results of ground ionosphere stations has made it possible to draw a series of conclusions about the concentration of negative ions at such altitudes and about the ionization of the air caused by the motion of the satellite itself.

It can be expected that the measured concentration of positive ions will provide new data on the structure of the outer region of the ionosphere, which will provide additional information about this region as previously obtained from rocket launchings and the first two artificial earth satellites. It can also be expected that the magnitudes of the ionosphere inhomogeneities will also be measured.

2. Investigation of the Composition of the Ionosphere

The earth's atmosphere consists of a great variety of gases. Its composition at the earth's surface has been studied sufficiently well. The data on the composition of the upper layer of the atmosphere are at present rather contradictory. One of the important gas characteristics entering the earth's atmosphere, as well as of all the existing elements, is their atomic and molecular weight, which are expressed in empirical units, so-called atomic mass units. For the atomic mass unit, a value equal to 1/16 of the atomic weight of oxygen is taken. The molecular weight of oxygen, composed of two atoms, is equal to 32. The atomic weight of nitrogen is 14, and the molecular weight is 28.

Analyzing the molecular and atomic weights of various compounds and mixtures, it is possible to draw conclusions about their chemical composition. For the determination of atomic and molecular weights of elements and their compounds comprising a mixture, so-called mass-spectrometers are used. The mass-spectrometer installed on Sputnik III is intended for determination of mass spectrum of the positive ions that exist in the earth's ionosphere. Knowing the mass number of the ions it is possible to draw conclusions about the chemical composition of the ionosphere.

The mass-spectrometric tube, the sensing element of the instrument, is connected with its open-entrance aperture directly to surrounding space. It contains a series of thin-wire grid-electrodes placed at fixed distances from each other. Behind the grids are collectors in the form of metallic plates which collect ions entering the mass-spectrometer tube after passing through all the grids.

The tube electrodes are fed various direct and alternating current voltages generated in the electronic unit of the mass-spectrometer. These voltages are selected in such a manner that only those ions can reach the collector which have passed the tube with optimum vector velocity. The ions passing the tube with vector velocity greater or smaller than the optimum, will not be admitted to the collector. The velocity with which the ions pass through the mass-spectrometer tube, are determined, on one hand, by their mass and, on the other hand, by the accelerating potential applied to certain grids of the tube.

The accelerating potential periodically changes from zero to its maximum value. Therefore, the optimum velocity is imparted alternately to the ions with various mass numbers. When the ions reach the collector, a current pulse is generated in its circuit which is amplified and is transmitted by a radio telemetering system to Earth. Simultaneously, the accelerating potential, available at a given moment on the tube grids of the mass-spectrometer, is also transmitted. If the ionosphere has ions of only one mass, then the receiving stations will register one pulse of ion current for each cycle of change in accelerating potential. In case of a more complex composition of the ionosphere, two or more pulses are registered for each cycle. The ion mass number, corresponding to each pulse, can be determined by means of comparison of the mass spectrum records with the records of the mass-spectrometer accelerating potential.

3. Investigation of Electrostatic Fields

As a result of a series of processes occurring in interplanetary space, as well as in the atmosphere, the earth, with its atmosphere as a whole, acquires a certain electrical charge. The electrical field caused by such a charge will act on the velocity and the direction of the charged particles traveling in interplanetary space. It can have an effect on a number of geophysical phenomena (aurorae, etc). Data on the electrical fields in the upper atmosphere might greatly help in determining the causes for the existence of the earth's negative charge and the positive charge of the atmosphere, which create between the earth and the ionosphere a potential difference of several thousand volts.

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Although a number of theories explaining the origin of aurora and corpuscular flows allow for the existence of electrical fields in the upper layers of the atmosphere, the direct measurement or their indirect determination has never been conducted. The fact remains that the favorable conducting layer of the ionosphere prevents the pentration of electrical fields into the lower layers of the atmosphere in the same manner that a giant metallic shield would do if it were substituted for the ionosphere.

For the same reason, it is impossible to measure, with the aid of instruments located below the ionosphere, the electrical fields in interplanetary space.

The measurement of the electrical fields with the aid of the satellites is complicated by the fact that any body in the upper layers of the atmosphere will acquire an electric charge, the field of which, if not taken into account, will add up with the measured field and will distort the measurements.

This charge appears as a result of the inequality of electron and positive ion velocities entering the surface of the satellite, as well as the result of phenomena such as photoeffect, i.e., the ejection of electrons from the satellite surface by light and by other radiations.

Use of satellites for studies of such characteristics of the ionosphere as the concentration of ions and their mass spectra requires accounting for such disturbances which the satellite brings to the surrounding space. Therefore, the measurement of the electric charge of the satellite, which causes the redistribution of the charged particles in its vicinity, is also desirable to improve the results of these experiments. On the other hand, the information on the electric charge in conjunction with the data on the ion concentration will make it possible in a number of cases to determine such a difficult-to-measure ionosphere characteristic as temperature.

The equipment used on the satellite consists of two sensing electrostatic flux meters having common control circuits. It is made in the form of two transducers mounted symmetrically on the side surface of the satellite, and a unit with amplifiers. The essential part of each transducer is the measuring electrode, a ten-sector plate connected to the body of the satellite through a resistor. The surface of the plate becomes, in a way, the surface of the satellite. This plate is periodically shielded by another plate, a shield, which is rotated by an electric motor. Since the measuring plate is a part of the satellite surface when it is exposed, it contains some part of the satellite's charge, as well as the charge induced by the exterior electrostatic field. When this plate is covered by the shield, the charge is removed.

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During the rotation of the shield, the charge from the measuring plate is periodically removed through the resistor forming an alternating current potential across it which is proportional to the magnitude of the plate charge. This potential is amplified, rectified, and fed to the input of the radio telemetering system. This system of measurement makes it possible to determine the magnitude of the electrostatic field, and the use of two symmetrically placed transducers of the electrostatic flux meter makes it possible to determine not only the satellite's own charge, but also the exterior electrostatic field.

During the operation of the apparatus, a special system of control makes it possible to check the reliability and accuracy of measurements.

Measurement of the Earth's Magnetic Field

The action of the Earth's magnetic field is revealed both during observations of artificial indicators of the type of magnetic needles rotating coils, etc., inserted in it, as well as during observations of a whole series of geophysical phenomena: deflections in the polar regions of charged particles emanating from the Sun, the deflection of cosmic rays, and the polarization of radio waves.

The distribution of the magnetic field according to size and intensity was studied in enough detail only over the continents in the direct vicinity of the Earth's surface. These data were widely used in the practice of prospecting for useful minerals, ship navigation, aeronavigation, etc.

The nature of the Earth's magnetic field up to now is unknown. As a result of prolonged measurements of the intensity of the Earth's magnetic field in special observatories, it was established that it changes with time. The most intensive changes of the magnetic field are called magnetic storms.

Analysis of observations showed that the principal part of the Earth's magnetic field and its secular variations are caused by sources occurring inside the Earth. On the other hand, the chief sources of short period variations of the Earth's magnetic field and magnetic disturbances are outside the Earth in the upper layers of the atmosphere.

The magnetic field of the Earth in the first approximation coincides with the field of a magnetized globe or of a strong magnet, the distance between the poles of which is extremely small, and on which the north pole of this magnet is located in the southern hemisphere of the Earth, and the south pole in the northern hemisphere. The axis forms an angle of 11.5 degrees with the axis of rotation of the Earth. This simple representation is complicated by the location of fields of continental, regional, and local anomalies. An example of the first is the East Siberian magnetic anomaly, occupying a considerable part of the continent.

Sources of local magnetic anomalies, for example the Kursk, lie in the uppermost layer of the Earth's crust, but these anomalies quickly decrease with altitude. Contradictory opinions exist concerning the localization of continental anomalies.

Mathematical methods permit the calculation of the field at high altitudes if the distribution of the field near the surface is known. Observations on the intensity of cosmic rays at different latitudes give definite information concerning the structure of the Earth's magnetic field at high altitudes. The most puzzling thing is that maps of the distribution of the magnetic field at high altitudes, according to terrestrial magnetometric data and according to observations of cosmic rays, are not in agreement. Direct measurements of the intensity of the magnetic field at high altitudes using magnetometers mounted in artificial earth satellites, permit shedding light on the cause of the observed discrepancy.

The placement of a magnetometer in a satellite permits conducting a magnetic survey of the whole of the Earth in a short period of time. Quite exceptional possibilities for the investigation of the variable part of the magnetic field are presented.

According to contemporary notions, magnetic perturbations are caused by strong currents flowing in the ionized layers of the atmosphere. Up to now, only one direct experiment was known, accomplished with the aid of a magnetometer installed in a rocket, which attested to the actual existence of such current systems.

The satellite moving along its orbit will repeatedly cross the ionized layers of the atmosphere. Thus, the existence of the current system can be noted according to jumps in the intensity of the magnetic field. Separation of the intensities of the field measured by a magnetometer, frequently related to the supposed current system, can be accomplished only by special methods of observation and processing of the data. According to the reason given, programs for the investigation of the spatial distribution of the Earth's permanent and variable magnetic fields cannot be fulfilled in one experiment.

The principal problem of the experiment by the artificial earth satellite is the investigation of the spatial distribution of the permanent magnetic field of the Earth at the highest altitudes in comparison with the spatial distribution of lines of similar intensity of the magnetic field and lines of similar intensity of cosmic rays.

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Measurement of the magnetic field with satellites is connected with considerable difficulties, which are determined by the fact that the location of the satellite relative to the vector of the Earth's magnetic field changes continuously. The magnetometer should possess high sensitivity over a large range of measurements. The influence of the magnetic parts of other inboard equipment is exerted on the transducers of the magnetometer.

A magnetometer which eliminates these difficulties is installed on board the satellite. This magnetometer is an instrument, the measuring transducer of which is automatically oriented in the direction of the full vector of the Earth's magnetic field in any orientation of the satellite. The size of the magnetic field and its variations serve as a compensating current passing through a coil, mounted on a measuring transducer, in such a direction that it fully compensates the spatial field of the earth occupied by the transducer.

Two potentiometric transducers, installed at the junction of orientation, makes it possible to determine the position of the satellite body relative to the Earth and the rate of rotation of the satellite around its own axis.

Approved For Release 1999/09/08 : CIA-RDP82-00141R000200180001-3

Study of Cosmic Rays

Investigation of cosmic radiation is making it possible to obtain information on the processes concerned in the formation of particles in the depths of outer space which possess very great energy. Moving about the universe, these particles are acted on by the effect of the medium through which they pass. Effect on cosmic radiation is caused by processes occurring on the Sun and, in particular, by streams of corpuscles ejected from within the Sun. The intensity of cosmic radiation changes under the action of electrical and magnetic fields present in these flows. Changes in the composition of interplanetary medium surrounding the Earth also leads to change in the character of the movement of particles of cosmic rays which originated in the furthermost regions of the universe and are moving in the direction of the Earth. Sometimes powerful explosive processes occur on the Sun, resulting in the appearance of cosmic rays. These processes have been little studied so far, and their investigation is of great importance.

As the result of deflection of cosmic rays in the magnetic field of the Earth, only particles with energy greater than 14 million electronic volts can reach the equatorial regions of the Earth. Particles with very small energy can reach the high latitudes. Moving about its orbit, the satellite makes it possible to register cosmic radiation of different energy.

The cosmic rays counter installed on the satellite will make it possible to obtain information on the intensity variations and the energy spectrum of cosmic radiation.

Of particular significance is the research on the smallest particles of light in the composition of cosmic rays, the photons. Photons possessing considerable energy, as the so-called gamma rays, can reveal to us where this radiation is generated better than any other component of cosmic radiation. Gamma rays should propagate themselves practically linearily in universal space. Therefore, having detected in which direction the gamma rays are moving, it is possible to designate where their source is located. In contrast to this, particles of cosmic rays having electrical charges are strongly deflected in the magnetic fields existing in the cosmos and lose their initial direction of movement.

Detection of gamma rays in the composition of cosmic radiation is connected with great difficulties, and all the more so, since at present, it is not possible to predict their intensity. The satellite existing for a long time outside the Earth's atmosphere presents an unusual possibility for detecting this new component of cosmic rays.

An instrument installed in the satellite makes it possible for the first time to realize an experimental attempt to detect gamma-rays in the composition of primary cosmic radiation. If this attempt is crowned with success, then it will be possible to speak of a new method for investigation of the universe.

It is known that about 70 percent of the primary flow of cosmic rays entering into the upper layers of the atmosphere consist of protons -- the nucleus of the lightest element, hydrogen. In addition to protons, there are also other nuclei of other elements in the primary flow of cosmic rays. Nuclei of helium (alpha particles) are present in a quantity less than 20 percent and nuclei of heavier elements make up about one percent in all. Even though the number of such particles is small, the energy which they bear consists of about 16 percent of the energy of the entire flow of cosmic rays.

It is important to know the composition of the primary flow in more detail. Information on the composition of cosmic rays in particular is of considerable significance in answer to the problem as to how and where particles with such great energies are created.

A considerable amount of information on the composition of primary cosmic rays has been obtained as the result of instruments carried into the stratosphere on sounding balloons. However, it was not possible to obtain a complete series of data of primary composition while conducting measurements in the stratosphere, as there is still a small layer of substance which is always present above the instruments and changes the composition of cosmic rays. Up to now, it is not known whether there is an observable number of nuclei heavier than the nucleus of iron in cosmic rays.

Installation of an instrument for registration of nuclei of heavy elements will make it possible to reply to this important scientific question. The basic element of this instrument is a so-called Cherenkov particle counter. Operation of this counter is based on the use of Cherenkov radiation, which is formed in such a case when a changed particle moves in a substance with a speed which exceeds the speed of light in that medium.

An important property of Cherenkov radiation is the fact that the intensity of the light flash which appears in the substance during the transit of a particle through it is proportional to the square of the charge of the particle. Therefore, particles moving with a speed smaller than the speed of light in the substance do not radiate light. This property of Cherenkov radiation makes it possible to use it for the registration of charged particles, determination of their charge, and the separation from the entire flow of particles of only those which possess sufficiently great speed.

Approved For Release 1999/09/08 : CIA-RDP82-00141R000200180001-3

The Cherenkov counter consists of a plexiglass cylinder-detector, to the end of which is attached a photoelectron multiplier. On passage of a cosmic ray particle with a speed of about 300,000 kilometers per second through the detector, Cherenkov radiation is formed in it. The rate of propagation of light in plexiglass is equal to approximately 200,000 kilometers per second and, therefore, has the necessary condition for forming Cherenkov radiation.

The light which appeared in the detector is received by the photo multiplier, which transforms it into an electric signal and amplifies it to a value which is necessary for operation of the instrument. The instrument sorts all of the signals into two groups, corresponding to the passage of particles through the detector with a charge greater than 30 and those greater than 17. On each passage of a particle through the Cherenkov counter, a signal is given as to which group the entering nucleus belongs.

Investigation of Corpuscular Radiation of the Sun

Solar electromagnetic radiation includes the infrared, visible, ultraviolet, and X-ray regions of the spectrum. At times, an erruption of ionized gases consisting of electrons and ions from the Sun shoots into interplanetary space. According to the extent of emission from the Sun, part of the ions are neutralized, that is, transformed into ordinary atoms. The emission of these particles from the Sun has come to be called corpuscular radiation of the Sun. Together with the corpuscular streams, accompanying magnetic fields are given off. According to various estimates, the corpuscles have a speed, near the earth, on the order of several thousand kilometers per second.

During the passage of the corpuscular streams close to the earth, magnetic disturbances develop, the most intensive of which are called magnetic storms. At the same time, aurorae occur. As the corpuscles penetrate the atmosphere, their ionization increases in the upper, as well as in the lower, layers. An increase in ionization in the lower more dense regions leads to a disturbance of radio communications, since an intensive absorption of radio waves occurs. Corpuscular outbreaks are accompanied by a disturbance in the thermal condition of the upper atmosphere.

A majority of the solar corpuscles is composed of charged particles. Such corpuscles most often penetrate the atmosphere near the earth's geomagnetic poles, in the polar regions. Because of the curvature of the trajectory of movement in the magnetic fields, the charge particles also penetrate on the night side of the earth in the vicinity of the polar zones. Corpuscular invasion also occurs in the middle latitudes, but here it is less intensive. Neutral corpuscles are free to penetrate at any place on the earth's surface.

Approved For Release 1999/09/08 : CIA-RDP82-00141R000200180001-3

Information on corpuscular radiation of the Sun is very poor, and little is known of its nature and properties. Until very recently, general information on corpuscular radiation has been obtained from observations of the aurorae.

Artificial earth satellites are an effective means of studying corpuscular radiation. The present time is especially favorable since this radiation has intensified because of the increase in solar activity.

Two particle detectors are located in Sputnik III. These indicators are fluorescent screens covered with aluminum foil of various thicknesses. In this manner, a rough classification is obtained of the corpuscles according to their penetration capabilities.

In front of the fluorescent screens, diaphragms are placed which restrict the solid angle of capture of the corpuscles. Because of the action of the corpuscles, the fluorescent screens glow, similar to the process in the picture tube of a television receiver of illumination of the screen by the electron beam. Radiation from the screen is received by a photoelectric multiplier tube. Its signal is "stored" by a special device and is then transmitted to earth by a radiotelemetering system.

With the help of this apparatus, it will be possible to obtain valuable material on the geographic, altitude, and diurnal distribution of corpuscular streams. For investigating the direction of approach of the particles, a rotation of the satellite is used. The Earth's magnetic field is capable of repelling the charged particles and forcing them to follow a spiral path along the lines of magnetic force. The neutral particles may travel along a straight trajectory. Such observations will provide additional data for determining the nature of corpuscles.

Together with the registration of corpuscular radiation of the Sun, the apparatus makes it possible to obtain supplementary material on X-ray radiation which will also be recorded by the corpuscle indicators. This radiation may differ from corpuscular radiation in its direction of approach and by the absence of repulsion from the earth's atmosphere. In addition, it may be registered during the time of appearance since corpuscular radiation is propagated more slowly than electromagnetic radiation.

Measurement of Pressure and Density of the Atmosphere

The study of how the pressure and density varies with altitude belongs to the number of most important geophysical investigations of the upper atmosphere. Knowing these two parameters, it is possible to determine the temperature of the atmosphere at high altitudes.

Until recently, this study was restricted to comparatively low altitudes and only high-altitude rockets made possible measurements of the pressure and density in the upper layers of the atmosphere. At an altitude of

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100 kilometers, the pressure and density are approximately 10 million times less than on the surface of the Earth. Higher than 100 kilometers, there are single rocket measurements which agree poorly with indirect data. The essential shortcoming of rocket measurements is their short duration and the fact that they are conducted only above individual points of the Earth's surface.

For geophysics, it is extremely important to have data on the density and pressure of the upper layers of the atmosphere at all longitudes and latitudes by taking measurements over a long period of time.

The use of satellites makes possible more precise and expanded information concerning the structure of the atmosphere. The prolonged stay of an instrument at an altitude, and comparison of the results of the measurement from one revolution to another, permits detailed analysis of experimental data to be made and to exclude the possibility of experimental error.

Given a sufficiently accurate experiment, it will also be possible to estimate diurnal and latitudinal variations of the density and pressure at altitudes at which the satellite is orbiting.

Manometers placed on the outside of the satellite are coupled with a measuring apparatus inside the satellite. A magnetic manometer measures pressures on the satellite within the limits of 10^{-5} to 10^{-7} millimeters of mercury, and ionization manometers make measurements in the range of 10^{-6} to 10^{-9} millimeters of mercury.

Investigation of Micrometeors

It is known that tiny solid particles, micrometeors, move about in interplanetary space. When they enter into the earth's atmosphere, they burn up. During this luminous occurrence, which can be observed with the naked eye or with the telescope, only relatively coarse particles are produced. The very fine, and presumably very numerous, particles, which are only a few microns in diameter, produce such a faint light that they can not be observed with optical instruments, nor with any other facilities of ground observation.

By means of radar observations, it has been established that the micrometeors which plunge into the earth's atmosphere at a speed of 70 kilometers per second produce an ionization of the molecules of the air. Around the flying particles, charged particles, electrons and ions, form a trail which is observable by means of radar. Even this method, however, is not able to detect the very finest micrometeors. At present, these particles can be studied only with the aid of apparatus contained in rockets and, especially, in artificial Earth satellites.

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The study of interplanetary matter is of great significance to the astronomer, the geophysicist, and the astronaut, and also for the solution of problems of evolution and origin of planetary systems and for the clarification of a number of important questions in regard to modern theories of cosmogony.

It is also very important to know accurately the average amount of meteoric matter which falls to the earth during a given interval of time. It is necessary to take into account the influence of impacts of meteoric bodies on the outer shell of a rocket and an artificial satellite and also on instruments mounted on them (for example, on the surface of optical instruments, which may be turned from transparent to opaque as a result of collisions with micrometeors), on the active surface of solar batteries, etc.

Another thing to be taken into account is the danger of the collision of artificial Earth satellites, and especially interplanetary rockets, with larger meteorites. Although the probability of such a collision is not great, it does exist, and it is important to be able to estimate it accurately.

Several methods may be used to record the collisions of micrometeors with the outer shells of interplanetary rockets and artificial earth satellites. One simple, and, at the same time, very sensitive, method is the use of piezoelectric transducers, which convert the mechanical energy of the collisions with particles into electrical energy.

The magnitude of the electrical impulse produced in such a transmitting element depends on the velocity and mass of the impinging particles, and the number of impulses is equal to the number of particles which collide with the surface of the transducer. The electrical impulses coming from the transducers are fed to an electronic device which counts the impulses and records their magnitudes.

<u>Sources of Equipment Power Supply</u>

The power supply for scientific and measuring instruments in Sputnik III is based on silver-zinc batteries and mercuric oxide elements. The various elements and batteries of this type developed by Soviet scientists have high specific electrical characteristics per unit of weight and volume and are suitable for use in the satellite.

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In addition to the chemical batteries, Sputnik III also has a series of solar batteries. These batteries convert the energy of solar radiation directly into electrical energy. Solar batteries consist of a series of elements, thin sheets of pure monocrystalline silicon, with predetermined electrical conductivity. Each of the silicon elements produces about 0.5 volt, and the coefficient of transformation of the solar energy amounts to 9-11 percent. The correct combination of elements provides the required voltage and current.

The mounting of solar batteries on Sputnik III affords the possibility of a detailed investigation of its operation under the conditions of cosmic flight.

The launching of the third Soviet artificial Earth satellite is now evidence of the success of rocket engineering in the Soviet Union. The broad complex of mutually related investigations being undertaken by the satellite will make a great contribution to the development of science. The launching of Sputnik III is one of the most remarkable events of the IGY. The great size of the satellite and its high degree of automation brings Soviet science and engineering closer to the creation of space ships. (Moscow, Pravda, 18 May 58, pp 3-4)

II. ROCKETS AND ARTIFICIAL EARTH SATELLITES

Soviets Publish Compilation of Some Results of Sputniks I and II

A full-page article in the 27 April Pravda presents a compilation of some of the results of the experiments conducted by means of Sputniks I and II. The following is a summary of the article.

The launchings of Sputnik I and II, on 4 October and 3 November, respectively, marked the beginning of man's penetration into cosmic space. Such artificial satellites open the way for the realization of a whole series of the most important scientific investigations. The study of the ionosphere and the mechanism of its formation, the effects of the Sun's radiation and cosmic rays on the Earth's atmosphere, the study of the density, temperature, and magnetic and electrostatic fields at high altitudes, and many other problems are of great scientific and practical interest.

The solution of these problems requires the conduct of direct experiments at altitudes of hundreds and thousands of kilometers above the surface of the Earth. The possibility of accomplishing such experiments appeared with the creation of artificial earth satellites which permit making the necessary scientific measurements at great altitudes over different parts of the Earth's globe over long periods of time.

Although the value of sputniks for scientific observations had been known for a long time, their launching had remained an unsolved problem. The principle difficulty was the lack of a rocket capable of imparting a speed in the order of 8,000 meters per second to them.

It was only after the creation of the intercontinental ballistic missiles in the Soviet Union thatthe launching of the first sputnik was realized. The excellent qualities of design of this rocket enabled putting sputniks into orbit with heavy loads of scientific apparatus. The weight of the first Soviet artificial earth satellite was 83.6 kilograms, but the scientific and measuring apparatus with power packs in the second Soviet satellite weighed 508.3 kilograms.

The launching of artificial earth satellites with such a large weight of apparatus makes it possible simultaneously to conduct a whole complex of scientific investigations which increases their scientific value. Only by launching such large artificial satellites can the problems of building continuously operating cosmic laboratories and of making interplanetary flights be solved.

The first Soviet artificial earth satellite was put into an orbit with a perigee of 225 kilometers and an apogee of 947 kilometers; the second, with a perigee of 225 kilometers and an apogee of 1,671 kilometers. The initial orbital period of the first sputnik was 96.17 minutes, and of the second, 103.75 minutes.

During the artificial satellites' movement along the orbital altitudes mentioned above it was possible to conduct a number of experiments for the study of the upper atmosphere (determining the density of the atmosphere, the study of the propagation of radio waves, etc.). On the other hand, at these altitudes the density of the atmosphere is low enough so that it does not distort measurements of the primary components of cosmic radiation, the spectrum of the short-wave radiation of the Sun, etc.

Scientific problems also determined the selection of the orbit's angle of inclination to the Earth's equator, equal to approximately 65 degrees. The advantage of such an orbit is that during the sputnik's flight its scientific apparatus can conduct measurements over different latitudes. It should be noted that placing an artificial satellite into an orbit with a greater angle of inclination to the plane of the equator is a far more complex task than to place it into an orbit similar to an equatorial orbit.

During the period of its existence from 4 October 1957 to 4 January 1958, the first Soviet satellite completed about 1,400 revolutions around the Earth. The second satellite, from 3 November to 14 April 1958, completed about 2,370 revolutions. With the aid of the first Soviet artificial earth satellites the projected program of scientific investigations was successfully accomplished. Some of the preliminary results of these investigations follow. On the whole, the material accumulated is very extensive, and work on it continues.

1. Radio and Optical Observations of Artificial Earth Satellites

Inasmuch as analysis of the change of the orbit of a satellite with time makes it possible to evaluate the density of the upper layers of the atmosphere, investigations of the motion of artificial satellites are very important. Orbital elements of such satellites can be determined by observations made by radiotechnical and optical methods. Among the radiotechnical methods used were radio position finding and the observation of the Doppler effect during reception of radio signals from the sputniks.

During radio observation of the signals from the first and second Soviet sputniks the frequency of the radio signals received was measured. A special radio apparatus and recording chronograph were used for this purpose.

The observations made show that the Doppler effect can be successfully used to determine the orbital parameters of sputniks. The value of this method is its simplicity and the reliability of the apparatus. With an increase in the frequency of a transmitter and with the use of a system automatically measuring the frequency, the error of the method can be substantially reduced.

For a more accurate determination of the coordinates special photographic theodolites (fotokinoteodolity) were used. Modernized aerial photographic survey cameras for obtaining photographs with the sputniks' trails were used. Timing during photography was done with the aid of a number of consecutive openings and closings of the shutter with the registration of the time of these operations by a photoelectric method. Thus a broken trail of the sputnik was obtained on the photograph.

During the observations of the artificial earth satellites a method of photographing them using highly sensitive means was developed. Among these, the use of an electronic optical converter showed special promise. The new method permits making observations for sputniks without using large optical systems. This will greatly simplify the means of observations.

2. Determination of Density of Atmosphere.

The density and temperature of the air are the most important characteristics of the atmosphere. The determination of their principal altitudes down to the boundaries of the atmosphere is essential for understanding a number of geophysical phenomena.

Even before the launching of the first artificial satellites the possibility of determining the temperature and density of the atmosphere from observations of their motion was noted. During their movement in the atmosphere the sputniks meet resistance. The strength of the resistance is proportional to the density of the atmosphere. As a result of the braking action of the atmosphere there is a gradual reduction of the altitude of the orbit. This continues up to the time the sputnik enters the dense layers of the atmosphere and ceases to exist.

The farther away from the Earth's surface, the quicker the density of the atmosphere falls. Therefore, the force of the resistance in the different parts of the orbit is not equal. In an orbit of sufficient size, the main braking force is in the perigee. This reduces the height of the apogee at a quicker rate than that of the perigee. In its evolution, the satellite's orbit thus gradually approaches a circular form.

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On the basis of a theoretical analysis of the results of the observations it was possible to determine the values of the evolution of the orbits as the product of the atmospheric density times the square root of the altitude of a homogeneous atmosphere at the perigee altitudes of 225-228 kilometers of the first satellites. The value of the density was also calculated. As a result, it was found that values of the density obtained were 5-10 times greater than the values indicated for those heights in a number of studies of the atmosphere which were based on rocket measurements before the launching of the satellites.

The Earth's atmosphere over different areas of its surface is not uniform. At one and the same altitude the density and temperature of the atmosphere change in relation to latitude and time of day. This relationship is connected with the irregular heating of the upper atmosphere by ultraviolet, Roentgen rays, and corpuscular radiation from the Sun.

As a result of the fact that the gravitational field of the Earth is different from the central field, the orbits of the artificial earth satellites changed their location in space. Thus for the first Soviet satellites the angular distance of the perigee from the midday meridian changed approximately by 4 degrees, and the latitude of the perigee changed by 0.35 degree per day.

Inasmuch as the principal influence of the atmosphere occurs in the region of the orbit's perigee, the change of its location leads to a change of the magnitude of the braking. This makes it possible to evaluate the magnitude of the latitudinal and diurnal changes of the state of the atmosphere.

On the basis of the observations, calculations were made for determining the density of the atmosphere, taking into account the changes in the location of the perigee of the orbit. The calculations showed that the product of the density times the square root of the altitude of a homogeneous atmosphere increases during the transition from the night side of the atmosphere to the day side, and reaches its maximum value at midday. Analysis of the braking also revealed a decrease of this value during the transition from the more northern region of the atmosphere to the equatorial region. It should be noted that the values of density, calculated according to the results of observations of the first and second sputniks, are in good agreement with those of the rocket carrier of the first sputnik.

On the basis of the data obtained it is possible to draw the conclusion that the temperature at altitudes of about 225 kilometers is higher, than previousl, supposed on the basis theoretical considerations.

The discovery of the high temperature of the atmosphere poses for geophysicists the problem of the sources of energy and its great heat capacity. The well-known "hard" ultraviolet and Roentgen radiations of the Sun would hardly be sufficient for this purpose. Now it is possible only to form different hypotheses on this question. For example, it can be supposed that the upper atmosphere of the polar regions is intensely heated by corpuscular radiations from the Sun. The whole upper atmosphere may be additionally heated either by infrasound waves arriving from the troposphere or by electrical currents arising in the electrical conducting ionized air as a result of its motion in the Earth's magnetic field.

Further study of the upper atmosphere using rockets and artificial earth satellites will make it possible to obtain a definitive answer to all these interesting and important questions.

3. Results of Investigations of Ionosphere

The observation of radio signals received from the first artificial earth satellites provided new data on the outer part of the ionosphere, that is, that part lying above 300-400 kilometers. The ionosphere is the upper part of the atmosphere containing a considerable quantity of free, charged particles -- electrons and ions. During the passage of radiowaves through the ionospheric layers the phenomena of their reflection, partial and full absorption, and the distortion of the paths of their propagation occur. Therefore, radio methods are the most effective means of investigating the upper layers of the atmosphere.

One of the principal parameters characterizing the state of the ionosphere is the magnitude of the electron concentration, that is, the content of free electrons per cubic centimeter. Up to now the electron concentration was measured from the lower ionospheric layers up to an altitude of 300-400 kilometers, where the electron concentration has a so-called principal maximum.

These measurements were produced mainly by ground ionospheric stations, transmitting short impulse radio signals at different frequencies and receiving their reflection from the separate layers of the ionosphere.

As a result of systematic measurements, it was established that the altitude of the principal maximum of the ionosphere and its electron concentration changed from day to night, from season to season, during the transition from north to south, and from east to west. The greatest, value of electron concentration in the middle latitudes reached 2-3 million electrons per cubic centimeter. It was found that from altitudes of 100-110 kilometers up to altitudes of 300-400 kilometers, the electron concentration becomes on the average 10-15 times as great.

It is extremely important to know how the electron concentration above the main maximum, that is, in the outer part of the ionosphere, changes. This is necessary in particular to understand the interaction of the ultraviolet radiations of the Sun with the atmosphere and to study the conditions of radiowave propagation and other processes originating in the ionosphere. Certain information on the outer ionosphere can be obtained by the study of radio emanations from the Sun and the stars and of radio signals reflected from the Moon which are received on Earth. Observations on the porpagation of radiowaves transmitted from sputniks at different altitudes is a new method of studying the outer ionosphere.

In the reception of radio signals from the first artificial earth satellites at a frequency of 40 megacycles, it was possible in a number of cases to observe, free from distortion, the "radiorise" (radiovoskhod) and "radiosetting"(radiozakhod) of the sputnik and to note the exact time of each. In contrast to the optical "rising" or "setting" of the sputnik, which are characterized by rays of light traveling in a straight line from the sputnik to the observer, during the "radiorise" and "radiosetting" the radio beams are bent by the ionosphere.

Because of this, the "radiosetting" comes later than the optical "setting" and, correspondingly, the "radiorise" outstrips the optical "rise." The difference in time between the optical "rise" and the "radiorise" (or the optical "setting" and "radiosetting") makes it possible to determine the amount of distortion of the radio beams. Inasmuch as the bending of a radio beam in the ionosphere depends on the variation of electron concentration with altitude, it is possible to establish a definite rule for the change in electron concentration and to theoretically calculate its value at different altitudes. Thus the effect of the lower layers of the ionosphere can be considered on the basis of direct measurements conducted by a network of ground stations.

The data obtained as a result of the reception of the radio signals of the first artificial earth satellites make it possible to assume that the electron concentration in the outer ionosphere (over the principal maximum) decreases with altitude at a rate of from one fifth to one sixth of the rate at which it increases below the maximum. Thus in the altitudes from 100 to 300 kilometers the electron concentration increased to ten times as much in the period of observation in October, while at altitudes from 300-500 kilometers it decreased by half.

It should be mentioned that a similar change was recorded during the launching of Soviet high-altitude rockets. In this experiment, the electron concentration at an altitude of 473 kilometers was one million electrons per cubic centimeter.

Approved For Release 1999/09/08 : CIA-RDP82-00141R000200180001-3

4. Investigations of Cosmic Rays

For the registration of cosmic radiation two instruments were installed in the second sputnik which recorded the number of particles of this radiation. During its motion around the Earth the satellite flew at different distances from its surface. Therefore, the measurement of cosmic rays by a sputnik makes it possible to show the relationship of the number of particles to the altitude. Processing of the data revealed that from the minimum orbit altitude of 225 kilometers up to an altitude of 700 kilometers there was a 40 percent increase in the intensity of cosmic rays. This increase was dependent primarily on the reduction of the screening action of the Earth with the increase of altitude, which makes it possible for the cosmic rays to reach the instrument from a greater number of different directions. The Earth's magnetic field also presents an obstacle to the fall of cosmic radiation on the Earth.

The study of cosmic rays using instruments installed in satellites can also show the dependence of the intensity of cosmic rays on latitude and longitude. This makes it possible to obtain new information on the Earth's magnetic field. Measurement of the magnetic field on the surface of the Earth makes it possible to form a representation of the nature of terrestrial magnetism and to predict what kind of magnetic field exists at greater distances from the Earth's surface.

From this the expected distribution of the intensity of cosmic rays according to the Earth's surface can be calculated. In particular it is possible to indicate the lines of constant intensity of cosmic rays (izokosmy). The measurement of cosmic rays made during flights of sputniks showed that the lines of constant intensity obtained from the experiment and those calculated in theory are substantially different. This result is in agreement with the conclusions reached by the US physicist Simpson, who organized a large series of flights with high-altitude airplanes in equatorial regions. They showed that the equator found with the aid of cosmic rays did not coincide with the geomagnetic equator.

Consequently, there is a considerable divergence between the characteristics of the Earth's magnetic field obtained on the one hand with the aid of cosmic rays and on the other hand by the measurement of the magnetic field on the surface of the Earth. This discrepancy can be explained by fact that the trajectory of the motion of cosmic rays is determined by the magnetic field at very high altitudes, while the direct measurements characterize the magnetic field near the surface of the Earth. Cosmic rays make it possible to probe the Earth's magnetic field at great distances from the Earth as well as the systems of electrical currents in the upper atmosphere.

Approved For Release 1999/09/08 : CIA-RDP82-00141R000200180001-3

Observations of cosmic rays by the earth satellites made it possible also to record the oscillations (variations) of the intensity of this radiation. These variations, obviously, are connected with the state of the interplanetary space near the Earth. One case of a sharp increase, 50 percent, of the number of particles of cosmic radiation was registered. On the other hand, ground stations, at this time, did not discover any substantial increase in the intensity of cosmic radiation. At present a detailed study of this occurrence is being conducted. It is possible that it was caused by the generation on the Sun of low-energy particles of cosmic rays (strongly absorbed by the Earth's atmosphere) or by the sputnik hitting a stream of high-energy cosmic rays (connected with the corpuscular radiation of the Sun). Such a phenomenon had not been registered before, since instruments for prolonged observations of cosmic rays were located only on the Earth's surface. Artificial earth satellites for the first time make it possible to fully investigate primary cosmic radiation.

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5. Biological Investigations

In the past decade Soviet scientists performed a large number of biological experiments in the upper layers of the atmosphere. Animals have been carried in rockets to altitudes of several hundred kilometers for direct experimental study of the biological effects present in conditions approaching those in cosmic space flight. However, only by means of a satellite was it possible to conduct a biological experiment under conditions that would be present in actual space flight. Specifically, the satellite enabled a study of the effects on a living organism of long-duration weightlessness, primary cosmic radiation, solar emissions, and other factors.

Information of great value was obtained from data on the medical-biological investigations on Layka in the second artificial earth satellite. Of special interest were the behavior and condition of the dog during the most adverse stage of flight, from the biological viewpoint, which consisted of the launching and entrance into orbit. The acceleration produced during launching was many times greater than gravity, so that the apparent weight of the animal increased correspondingly with the magnitude of acceleration. The animal was so positioned in its cabin that acceleration acted in the direction from its chest to its back. From the biological viewpoint, this was the most satisfactory position for withstanding overloading due to acceleration. Data during the flight indicated that the animal was able to oppose the apparent increase in weight only to a certain magnitude of acceleration. After this point the animal appeared to be compressed to the cabin floor, and any detectable motion was not registered.

/ Deciphering of data received from the satellite showed that immediately after launching the frequency of heart contractions was three times greater than initially. Analysis of the cardiograms showed no ill effects. A typical picture of increase in heartbeat (so-called sinus tachycardia) was obtained. Later, as the acceleration not only persisted but increased, the frequency of heartbeat decreased.

With the increase in the apparent weight due to increased acceleration, the breathing motion of the thorax became more difficult. Recordings from telemetric signals showed that the breathing frequency of the animal was three or four times greater than the original when the satellite entered orbit.

Analysis and comparison of data obtained with results of previous laboratory experiments permit an assertion that the animal quite satisfactorily endured the flight from the start of the satellite until it entered into orbit. Changes noted in the physiological functions were due to the strong sudden effects of acceleration, noise, and vibration during this period.

Approved For Release 1999/09/08 : CIA-RDP82-00141R000200180001-3

After the satellite entered its orbit, the animal began to experience weightlessness. As the thorax of the animal did not experience any more pressure which had previously existed under acceleration, its frequency of breathing decreased. After a short period of increased heart contractions, the frequency of heartbeat began to decrease and approach normal. However, the period for the heartbeat to reach normal proved to be approximately three times longer than the period in laboratory experiments when the animal was subjected to the same accelerations as those of the satellite. This was probably because after the effect of acceleration in the ground tests the animal found itself in normal conditions, whereas in the satellite the animal experienced complete weightlessness. During weightlessness the sensitive nervous centers of the animal which signal position of the body were not sufficiently affected by external irritants. The slight effect produced was responsible for the somewhat longer period that the breathing and blood circulation functions took to return to normal. Normalization of these functions shows that the factors present during launching and orbiting of the satellite obviously did not cause any substantial and lasting changes in the physiological functions of the animal.

Insurance of normal living conditions for the animal during its flight in the satellite could be provided only by means of a hermatically sealed cabin. Normal atmospheric pressure was maintained in the cabin. The oxygen content was kept in the range of 20-40 percent, and the carbon dioxide content did not exceed one percent. These percentages were maintained by highly active chemical compounds which absorbed carbon and released oxygen and absorbed other harmful gases from the living processes, such as ammonia. Analysis of data obtained showed that the content of oxygen did not decrease and that the cabin maintained its pressure.

No definite idea of the effect of cosmic radiation could be formed, since no obvious physiological effect was directly observed and it would have been necessary to observe the animal for a long period of time after the flight. This will be accomplished in future flights. The positive results of the experiment make it possible to continue and expand research aimed at ensuring the safety and health of man in cosmic flight.

Study of the great wealth of material from the first earth satellites in the experiments described in this article and other experiments performed on the first satellites in continuing. Subsequent launchings of satellites in the course of the IGY will permit an increase in the number of important scientific experiments in cosmic space and a deeper understanding of the many processes occurring in the upper atmosphere and the cosmos. (Moscow, Pravda, 27 Apr 58)

Swedish Radio Station Intercepts Sputnik III Signals

Immediately on the announcement of the firing of Sputnik III, the Enkoeping short-wave radio station began scanning for the satellite's signals. The search was facilitated by the announcement by radio from Moscow that the signals from Sputnik III are similar to the letter "L" in the Morse code.

From 1324 hours until 1332 hours, these signals were clearly intercepted in Enkoeping. The signals were found to have a frequency of 20.005-20.006 Mc. At 1511 hours, the signals were heard again, this time for 11 minutes. The frequency decreased by 1,000 cycles from the time they were first heard until the end. The signals were also heard from 1700 to 1715 hours and from 1847 to to 1903 hours. (Stockholm, Svenska Dagbladet, 16 May 58)

Soviets to Exhibit Sputnik Models in Paris

The Soviet Embassy in Paris has announced that the Academy of Sciences USSR will exhibit model earth satellites at the International Earth and Cosmos Exposition which opens in Paris on 30 May. (Paris, Le Monde, 17 May 58)

Rocket Mail Delivery to Polar Region Discussed

The main portion of an unsigned Czeck newspaper article deals with the advantages and possibilities of rocket mail in general terms. The final paragraph gives the following specific details.

In the event of an emergency, polar expeditions would be able to obtain packages sent by rocket. A two-stage rocket could be launched in Arkhangelsk with an initial speed of 6,500 kilometers per hour, later reaching a speed of 14,000 kilometers per hour and an altitude of 400 kilometers. Here the first stage of the rocket would drop away and the rocket would be automatically guided to the North Pole with the aid of wings that would push themselves out. As the rocket lost speed, it would lose altitude. Near its goal when it would be flying at a speed of 900 kilometers, the mother ship would meet it, pick it up, and carry it to land. (Prague, Obrance Vlasti, 4 Apr 58)

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USCOMM-DC-36491