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INFORMATION ON INTERNATIONAL GEOPHYSICAL COOPERATION PROGRAM --

SOVIET-BLOC ACTIVITIES

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I. GENERAL

Processing the Materials of the IGY and Further International Geophysical Cooperation

The International Geophysical Year (IGY) evoked substantial progress in geophysics and related branches of knowledge, and determined many new forms of rewarding international scientific cooperation.

Ninety Soviet scientific institutes and institutions of higher education and 18 departments participated in the investigations of this program. Of 500 stations conducting observations 170 were newly built or were completely rebuilt. Original equipment was installed in these stations, which in many cases was more advanced than foreign equipment. Industry mastered and produced 30 types of new instruments and equipment. In addition, 400 types of mass-produced instruments and equipment were installed in the stations. Soviet expeditions to the Antarctic, in all the oceans of the world, on the largest glaciers and to many other relatively inaccessible regions were outfitted. The regional Center of announcement of outstanding solar and geophysical phenomena began functioning.

The utilization of such new technical means as rockets and artificial earth satellites for geophysical research was the greatest achievement.

The methods of observation and investigation in all Soviet stations, observatories and expeditions carrying out the program of planetary observations and investigations in coordination with other countries were considerably improved.

Despite the fact that the period of observation ended 31 December 1959, the processing of materials has just begun, and already very important information has been obtained and fundamental discoveries have been made concerning the upper atmosphere, the structure of the magnetic field at great distances from the Earth, magnetic traps around the Earth, connections between various geophysical phenomena of the electromagnetic complex, the peculiarities of the development various geophysical processes simultaneously in the Arctic and Antarctic, the life of the oceans, etc.

Assembled in world centers, one of which is located in Moscow, the observational materials serve as a basis for work in the field of geophysics and related sciences and shall be a major new basis for theoretical research and generalization. These materials will be supplemented by the results of subsequent observations.

The years 1960 and 1961 have been proclaimed by international organizations as the period of analysis and multifaceted study of the data of IGY, and the participant countries are competing with each other in scientific mastery of the results of the observations.

Having heard the report of the Interdepartmental Committee on the Conduct of IGY concerning the organization and ensuring of active participation of the USSR in this undertaking, the Presidium approved its activity and noted that now an especially responsible period is beginning in the activity of the IGY participants. The Interdepartmental Committee must determine the main directions of mastery of the unique materials of the IGY in the USSR for the purpose of successful resolution of the problems connected with the prediction of weather and changes in climate, prediction of the conditions of radio communications, the possibilities of actively influencing geophysical processes, study of the cosmos, determination of the shape and structure of the Earth, exploitation of the resources of the ocean, and many other tasks which at the present time have great significance and which have been resolved according to the results of planetary observations. The Interdepartmental Committee was charged with daily control of fulfillment of the work plans during the basic period of scientific and practical mastery of the IGY results (1960-1962), and with control of providing personnel of the world centers of assembly and distribution of geophysical data materials subject to international exchange.

The committee is required to ensure timely publication in its publications of the IGY results, coordination of the Soviet geophysical investigations with works conducted abroad, and active participation of the USSR in the activity of the appropriate international organizations; to develop and introduce in the international organizations recommendations concerning problems of cooperation and mutual aid to countries in the phases of processing the IGY data.

The most important tasks of the institutions working on the IGY program are to ensure timely assembly, scientific mastery and publication of the results of observations, and to submit to the World Center all materials of observations and publications subject to exchange through the Center.

In 1960 and in the following years the level of observations and investigations achieved in 1959 will be maintained. ("Processing the Materials of the IGY and Further International Geophysical Cooperation," Vestnik Akademii Nauk SSSR, No 2, 1960, p 106-107)

II. ROCKETS AND ARTIFICIAL EARTH SATELLITES

10,000 Turns Around the Earth

As of 0600 hours 3 April the third artificial earth satellite completed 9,982 turns around the Earth.

On 4 April the third Soviet artificial earth satellite will complete its ten-thousandth turn around the earth's sphere. By that time it will have flown 446.6 million kilometers and will have been in flight for 689 days.

The third satellite considerably surpassed its predecessors in time of existence. As is known, the world's first artificial earth satellite, created by Soviet scientists, engineers and laborers, which opened a new era in the development of science and technology, existed for 94 days, making 1,440 turns around the Earth, and the second lasted for 163 days, completing 2,370 turns.

The weight of the third satellite, 1,327 kilograms, is almost sixteen times greater than the weight of the first satellite, and with respect to payload weight the third satellite remains unsurpassed to the present time.

The great weight of the third satellite (enabling complex and varied scientific equipment to be installed in it), the reliability and durability of the functioning of this equipment under the conditions of launching and orbiting, and the high efficiency of the electric power sources on board enabled important and precise investigations to be conducted with the aid of this satellite over the course of a long period of time.

Finally, the substantially large apogee of the third satellite in comparison to those of the first two satellites enabled the acquisition of new data concerning altitudes which previously had not been attained.

When the third satellite first was placed in orbit its greatest distance from the Earth (apogee) was 1,880 kilometers, the minimum distance (perigee) was 226 kilometers, and its period of revolution was 105.95 minutes. By the time it had completed five thousand revolutions, on 8 May 1959, the period of revolution of the third satellite had decreased to 99.51 minutes, and its apogee had been shortened by 605 kilometers, reaching 1,275 kilometers.

Following the second five thousand revolutions the changes in the parameters of its orbit occurred considerably more rapidly, in connection with the motion of the satellite through dense layers of the atmosphere.

By 4 April the period of revolution of the satellite had decreased to 88.60 minutes, and the apogee of its orbit dropped to 230 kilometers.

The perigee of the orbit of the satellite also decreased considerably, dropping to 165 kilometers. The shortening of the orbit and its approximation of a circular path was especially intense during the course of the last month of the existence of the satellite.

A period of sharp braking of the motion of the satellite and its entrance into considerably denser layers of the atmosphere began on 26 March.

On the basis of calculations which have been performed the termination of the existence of the third Soviet satellite is expected on approximately 4-6 April of the current year.

With the aid of the third Soviet artificial earth satellite extensive investigations were conducted on cosmic rays, corpuscular radiation of the Sun, the magnetic field of the Earth, and the structure of the ionosphere, and studies were conducted on the distribution of density and pressure in the upper strata of the atmosphere and on meteorite particles and the propagation of radio waves.

The discovery of the external radiation zone and selective investigation of both the internal and external zones are important scientific results obtained through study of cosmic radiation with the aid of the third satellite. As is known, the first reports of the existence of the external radiation zone of the Earth were obtained through the flight of the second Soviet artificial satellite.

During the flight of the third satellite over a region of 65 degrees of geomagnetic latitude in the northern and southern hemispheres it intersected a zone of increased radiation caused by electrons with energy in the range of tens and hundreds of thousands of electron volts. This radiation was not observed in the lower latitudes nor in the region of the geomagnetic poles, which is possible only in a case in which electrons are closed in a trap created by the magnetic field of the Earth. This conclusion, based upon the observations of the third satellite, were later substantiated by data obtained from the flights of Soviet cosmic rockets.

Intense cosmic radiation above equatorial regions had been discovered prior to the launching of the third satellite. However, the characteristics of this radiation and how it was distributed in space were not known at that time. The instruments of the third Soviet artificial earth satellite gave the first answer to these questions. It was shown that the internal equatorial zone of radiation of the Earth consists of very high energy protons, in the range of tens, and even hundreds, of millions of electron volts. In addition, interesting data were obtained on the distribution of heavy nuclei in primary cosmic radiation.

Equipment for observation of low energy particles was installed on the third satellite, with the aid of which streams of electrons with energy on the order of 10 kiloelectron volts were detected. A considerable portion of these electrons is reflected in proportion to motion toward the Earth as a result of the existence of the geomagnetic barrier. The electrons which are able to reach the ionospheric strata create additional ionization and charging of the upper atmosphere. The discovery of the indicated electron streams throws new light upon the nature of the aurora polaris.

With the aid of the third satellite new data were obtained on the permanent magnetic field of the Earth. Brief and rapid changes in the magnetic field also were detected. Because of this valuable information was obtained on the investigation of the so-called current systems of the upper strata of the atmosphere.

New data were obtained in the measurement of the density of the atmosphere. Observation of the speed of braking of the third earth satellite enabled the discovery that the density of the upper atmosphere at levels higher than 200 kilometers is considerably greater than had been thought previously. In this, the very speed of braking of the satellite was found to be irregular. Fluctuations in the density and temperature of the upper atmosphere were exposed. It was established that its illuminated portion is denser and warmer than the unilluminated portion, and that the density and temperature of the upper atmosphere over the higher latitude regions depend essentially upon the condition of solar activity.

Utilization of improved ionization- and magnetic electrical-discharge manometers enabled direct determination of the distribution of pressure and density of the upper strata of the atmosphere up to an altitude of 500 kilometers.

Mass-spectrometric measurements by the third satellite enabled acquisition of data on the status of ionization of the ionosphere within a wide range of altitudes.

The measurements indicated that during the daytime ions of atomic oxygen predominate in the ionosphere at altitudes from 225-1,000 kilometers. Molecular ions of nitrogen, nitric oxide, oxygen and ions of atomic nitrogen also were detected. The molecular ion content drops rapidly with increased altitude and beginning at 500 kilometers the ionosphere becomes atomic. It was established that the composition of the ionosphere depends upon latitude.

Prior to the launching of the third satellite direct measurements of the concentration of charged particles were conducted only up to an altitude of 470 kilometers (by the high altitude geophysical rocket of the Academy of Sciences USSR, launched 21 February 1958). With the aid of ion traps mounted on the third satellite the magnitude of ionic concentrations up to an altitude of 1,000 kilometers were established for the first time. The concentration of ions, measured at this altitude, was found to be 60,000 ions per cubic centimeter. Data were obtained on the amount of ionospheric irregularities at various altitudes.

Measurements made with the third satellite enabled explanation of the fact that the so-called meteor danger is not great.

Radio observations of the transmitter "Mayak" installed in the third satellite played a significant role in the investigation of the ionosphere, pinpointing its characteristics, and in studying the propagation of radio waves. Many tens of Soviet and foreign scientific measurement stations and points distributed throughout the entire earth's sphere, received and registered its radio signals.

The long and reliable functioning of the "Mayak" transmitter enabled investigation of the propagation of signals broadcast by it at extremely different altitudes, at different times of the day and year, and at various points of the earth's sphere.

These investigations enabled acquisition of new information on the so-called irregular changes in the ionosphere.

The phenomenon of "fading" of the radio signals of the satellite was detected. As a result of the processing of numerous experimental data by Soviet investigators it was explained that this fading is caused

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by heterogeneities in the ionosphere. These heterogeneities form a clearly defined broad zone; a connection was established between fading of the satellite radio signals and other geophysical phenomena. The character of the dependence of fading upon the time of day and altitude was established.

Registration of the radio signals of the "Mayak" transmitter enabled the acquisition of new information on the concentration of electrons in the outer ionosphere. In conformance with the data obtained earlier with the aid of the first satellite it was established that the electron concentration in the outer portion of the ionosphere is considerably denser than had been proposed earlier.

The results of the long use under outer space conditions of the solar batteries installed in the third satellite are very important and interesting, and these appear to have a good outlook in utilization as sources of electric power for space objects. The faultless functioning of the solar batteries from the moment of launching of the satellite substantiated the correctness of the design which had been developed, and of the rationality of the placing of its individual sections in the satellite.

The measurements conducted with the aid of the third satellite may be processed only under the condition of knowledge of the altitude, latitude and longitude at which the satellite is located at every moment of time.

A special land-based automatic measuring complex, equipped with the latest radio technical apparatus, was developed for determination of the components of the motion of the satellite. The elements of the satellite's orbit are determined by high-speed electronic computers. The work of this measuring complex enabled determination of the characteristics of the orbit of the third satellite during the period in which the greatest amount of measurements were conducted with a degree of accuracy greatly surpassing the accuracy of measurement of the parameters of the motion of the first two satellites.

Other radio technical and optical means also are of great importance in the observation of the third satellite. Approximately 90 optical stations and observatories within the Soviet Union, and more than 110 such stations abroad constantly conducted and conduct observations and regularly send the results of the measurements to the address: "Moskva -- Kosmos" /Moscow -- Space/. In addition to this, approximately 400 more foreign stations in 33 countries periodically conduct observations and forward their data to the Astronomical Council, Academy of Sciences USSR.

Tens of thousands of Soviet and foreign radio amateurs and amateur observers regularly conduct observations of the third satellite.

For evaluation of the volume of measurements and observations conducted it is sufficient to indicate that during the existence of the third Soviet artificial earth satellite approximately 56,000 ephemerides (target designations) were submitted to the coordinating computer center by Soviet observation stations and more than 46,000 were forwarded by foreign stations. During this period were received and processed more than 127,000 radio intersections from the "Mayak" transmitter on board the satellite, approximately 28,500 results of optical observations conducted by Soviet observation stations, and approximately 19,800 observational results forwarded by foreign stations.

Observations of the satellite during the final period of its existence, when it enters the denser strata of the earth's atmosphere, are of special significance and interest. Study of the conditions of flight of satellites, especially in the dense layers of the atmosphere, are most essential for the development of space apparatuses which must return to Earth. During this final stage of existence of the satellite, when observation becomes complex in connection with the sharp changes in the parameters of its orbit, an additional large number of radiotechnical, optical, and other means are employed in its observation.

From the moment of its launching to the last days of its existence the third Soviet satellite evoked great interest from the Soviet people and from foreign citizens.

During this period many thousands of letters addressed to "Moscow -- Space" and "Moscow -- Sputnik" were received from Soviet citizens and from abroad, containing the results of observation of various problems, suggestions for the improvement of equipment and methods of observation, and expressions of admiration of the outstanding achievements of Soviet science and technology in space research.

The results of the investigation accomplished with the aid of the third Soviet artificial earth satellite enriched our knowledge of the upper strata of the atmosphere and cosmic space and led to new discoveries of great theoretical importance. ("10,000 Turns Around the Earth," Unsigned, Pravda, 3 April 1960, p 6)

Atomic Rockets

Rocket technology has grown precipitously during recent years. One of the most complex problems in this field is that of producing highly efficient engines. Its solution is connected mainly with the development of various types of high-energy chemical fuels. The launching of artificial earth satellites and of the first space rockets are indicative of the great successes which have been achieved in this field. However, long space flights of rockets with engines using chemical fuel are impractical, mainly because of the power limitations of chemical sources of energy. It is known that the energy which may be obtained through the chemical reaction of one kilogram of high explosive or of any combustible mixture is 10^7-fold less than the energy which may be obtained from one kilogram of fissionable material. The experiences of practical utilization of atomic energy for power purposes which have been accumulated to the present time enable the indication of the way in which atomic sources of energy may be used in rockets.

The basic difference between ordinary rockets and atomic rockets is in the means of obtaining the energy necessary for motion.

The ordinary rocket obtains energy from the combustion or decomposition of chemical fuel. Heated to a high temperature and ejected through the nozzle of the rocket with great speed, the products of combustion or decomposition of the fuel (working body) also ensure the forward motion of the rocket. In an atomic rocket, for example, with an engine of the heat exchange type, the working body is passive. It is heated by the kinetic energy of dissociative fission, forming as a result of the regulated process of fission in the nuclear reactor, and is ejected with great speed from the nozzle of the rocket.

If it would be possible to eject the products of the synthesis of deuterium with tritium, formed during the course of a thermonuclear reaction, in a direction opposite to the direction of motion of the rocket, the effective specific impulse of such a working body (nucleus of the helium atom) would be 10^4-fold greater than the effective specific impulse of contemporary rockets using chemical fuel. Thermonuclear processes provide a sufficient energy output per unit of reacting mass to ensure working characteristics for rockets which are difficult to obtain at the present time.

Therefore let us examine several possible non-chemical engine systems utilizing the atomic energy of the fission of atomic nuclei. In a rocket engine of the heat exchange type (Figure 1) the working body is fed into the active zone of the reactor by centrifugal pumps driven by a power take-off from the turbine. In the reactor the liquid working body vaporizes, is heated to the necessary temperature, and then ejects through the nozzle with supersonic speed. The payload, which in the future will include the crew, may be located in the nose section, in front of the tanks of fuel. This is done for maximum utilization of the working body as protection against radiation from the reactor, and also to place the people as far as possible from the reactor.

The process of fission may be suitably accomplished in a manner in which retardation of fragmentary fission occurs directly in the working body, and not in the structure, which in the beginning heats itself and only afterward heats the working body. This principle is utilized in the engine of the following type rocket (Figure II. /Not reproduced here/). A homogeneous mixture of fissionable material and working body is fed into the chamber, where the working body is heated directly by fragmentary fission, and then is expelled through the nozzle. The reactor of this type actually is gaseous in the zone of heat exchange. The disadvantage of an engine of this type is that along with the working body a considerable portion of unexpended atomic fuel also is expelled. However, the possibility is not excluded that through rapid rotation of the gaseous stream in the active zone, or through the utilization of electric or magnetic fields separation of the fuel and the working body may be achieved, and thus the loss of fissionable material may be considerably decreased. The specific impulse developed by an engine of this type would be 6- or 7-fold greater than of the previous engine.

The third system reviewed by us is based upon utilization of electric or magnetic fields for accelerating ions or charged particles to very high speeds. The accelerator is powered by electricity developed by a reactor and turbogenerator (Figure III).

The engine of the fourth rocket (Figure IV) works on the basis of a special thermomechanical cycle. Part of the energy of the reactor is utilized to drive a pump, which feeds a liquid working body into the active zone, where it is vaporized and heated under high pressure. The hot gas obtained is fed into a separate high-pressure chamber, which communicates with the blast wave tube via valve 11. At the other end of the blast tube is a diffuser, serving to concentrate the energy of the blast wave, and valve 12 which unites the tube with the nozzle of the rocket. The working cycle of the engine is the following: valve 5 takes the working body from the tank and under high pressure drives it through the reactor, where it vaporizes and is heated to approximately 2,500 degrees Centigrade, after which it is fed into the high pressure chamber. The blast tube at this moment still is filled with low pressure gas remaining from the previous cycle. Next, valve 11 opens rapidly, and compressed gas bursts into the tube, suddenly compressing and heating the gas located in the tube, and evokes in it the phenomenon of a strong blast wave. The greatest compression is obtained in the lower portion of the diffuser. Then valve 11 closes and valve 12 opens, and the gas escapes from the nozzle at high velocity. When the temperature of the escaping gas drops 3- or 4-fold in comparison to the maximal temperature attained in the blast tube, valve 12 closes and valve 13 opens, and with the aid of pump 5 the gas remaining in the blast tube enters the radiator, where it is cooled. This cycle is repeated continuously, producing "clots" of the high-temperature gas escaping from the nozzle at high speed.

The last type of rocket engine with high flight characteristics is based upon direct heating of the working body by an electric current.

One of the possible variants of the nuclear-electric engine is a system with arc heating, in which the working body is transformed into plasma in the arc and is expelled through the nozzle located in the cathode of the arc (Figure V). In distinction from the system reviewed above, the method of direct electrical heating in an arc is uninterrupted and may provide constant thrust with specific impulse of the working body 15-fold greater than the specific impulse of contemporary chemical rockets.

Computations have shown that the weight of rockets with nuclear engine systems will be 10- to 15-fold greater than that of ordinary chemical rockets, and 3- to 5-fold greater than that of high-power chemical rockets with the new types of fuel. If it is remembered that each kilogram of payload of a rocket requires from 10 to 100 kilograms blast-off weight, then it is clear that the development of non-chemical engine systems is of extreme importance to interplanetary flight and to flights with great payload weights. In the event of the successful solution of the problem of developing highly efficient atomic rocket engines, they will supplant presently existing rockets, at least in cases in which great load-lifting ability and long range are needed. There is no doubt that the future of rocket motion is connected with the utilization of atomic energy.

To those who wish to become acquainted in greater detail with the various problems connected with the utilization of atomic energy for creating reactive thrust we recommend the book by R. Bassard and R. De Lauer: Raketa c atomnym dvigatelem /Rocket with Atomic Engine/, Foreign Literature Publishing House, Moscow, 1960. ("Atomic Rockets," by M. Vishkova, Tekhnika Molodezhi, No 1, 1960, p 37-38)

Step by Step

"Launching was accomplished with the aid of a multistage rocket!" We already have read these words many times in reports of the launchings of the world's first artificial satellites, of the creation of the satellite of the Sun, and of the launching of the space rocket to the Moon. Although this is a short sentence, how much inspired work of scientists, engineers and laborers of our country is hidden by these six words!

What constitutes the contemporary multistage rocket? Why did the necessity arise for the use of rockets consisting of a large quantity of stages for space flight? What is the technical effect of increasing the number of the stages of a rocket? We shall attempt briefly to answer these questions.

The accomplishment of space flights requires enormous fuel supplies. These supplies are so great that they cannot be stored in the tanks of a single-stage rocket. At the present level of engineering science it is possible to build a rocket in which the fuel would account for 80 or 90 percent of the total weight. Flight to other planets would require fuel reserves hundreds, even thousands of times greater than the weight of the rocket itself and the useful payload contained within it. With the fuel reserves which may be stored in the tanks of a single-stage rocket a flight speed of up to 3-4 km/sec. may be achieved. Improvement of rocket engines, research on the most suitable types of fuel, the use of better quality structural materials and further improvement of rocket design undoubtedly will enable a slight increase in the speed of a single-stage rocket. However, for space flight all this is greatly inadequate.

K. E. Tsiolkovskiy recommended the use of multistage rockets for the attainment of space speeds. The scientist himself figuratively called them "rocket trains." According to the concept of Tsiolkovskiy the rocket train or, as we say at present, multistage rockets, must consist of several rockets, fastened to each other. The lowest rocket usually is the largest. It carries the weight of the "train." The succeeding stages are of increasingly smaller dimensions.

In the take-off from the surface of the Earth the engines of the lowest rocket are functioning. They function until they have expended all the fuel contained in its tanks. When the tanks of the first stage are empty it separates from the upper rockets in order not to burden their further flight with dead weight. The first stage with the empty tanks continues to fly upward for a short time by virtue of inertia, but then falls to earth. To enable reuse of the first stage it may be provided with a parachute to ensure its safe fall.

After the first stage has separated the engines of the second stage start functioning. They begin functioning when the rocket rises to a certain altitude and has considerable flight speed. The engines of the second stage accelerate the rocket further, increasing its speed by several kilometers per second. After all the fuel contained in its tanks is expended, the second stage also is discarded. The further flight of the composite rocket is ensured by the functioning of the engines of the third stage. Then the third stage also is discarded. This succession leads to the engines of the fourth stage. Fulfilling the work assigned to them, they increase the speed of the rocket by a certain additional amount, after which the engines of the fifth stage begin functioning. After the fifth stage is discarded the engines of the sixth stage begin.

Thus each stage of the rocket in turn increases the speed of flight and the last, highest stage attains the necessary space speed in airless space. If the task is set for landing on another planet and return to Earth, then the rocket which flies out into space also must consist of several stages, which are fired in sequence in landing on the planet, and in taking off from it.

It is interesting to examine the effect produced by the use of a large number of stages in a rocket.

Let us take a single-stage rocket with a launching weight of 500 tons. Let us assume that this weight is distributed in the following manner: payload 1 ton, dry weight of the stage 99.8 tons, and fuel 399.2 tons. Thus the design perfection of this rocket is such that the weight of the fuel is 4-fold greater than the dry weight of the stage, or the weight of the rocket itself, without fuel and payload. The Tsiolkovskiy number, or the ratio of the launching weight of the rocket to its weight after expenditure of all its fuel, will be 4.96 for the given rocket. This number and the magnitude of the speed of escapement of the gas from the nozzle of the engine determine the speed which may be attained by the rocket. Now let us attempt to replace the single-stage rocket with a two-stage rocket. Let us again take the payload as 1 ton, and assume that the design perfection of the stage and the speed of escapement of gas shall remain the same as in the single-stage rocket. Then, as indicated by the calculations, for attainment of the same speed of flight as in the first case a two-stage rocket with a total weight of only 10.32 tons will be needed, or almost 50-fold lighter than the single-stage rocket. The dry weight of the two-stage rocket is 1.86 tons, and the weight of the fuel stored in both stages is 7.46 tons. Thus we see that in the case considered the replacement of a single-stage rocket with a two-stage rocket enables a 54-fold reduction in expenditure of metal and fuel for launching the same payload.

Let us take as an example a space rocket with a payload of 1 ton. Let this rocket penetrate the dense layers of the atmosphere and, flying out into airless space, develop the second space speed of 11.2 km/sec. Our diagrams show the changes in weight of this space rocket as a function of the weight charge of fuel in each stage, and of the number of stages (see page 22 /of the original source/).

It is not difficult to calculate that if a rocket is built whose engines discharge gases at a speed of 2,400 m/sec. and if the fuel charge of each of the stages accounts for only 75 percent of the weight, then in the construction of six stages the take-off weight of the rocket is very high, almost 5.5 thousand tons. The launching weight may be considerably reduced through improvement of the design characteristics of the rocket stages. Thus, for example, if the fuel charge accounts for 90 percent of the weight of the stage, then the six-stage rocket may weigh 400 tons.

The use of high-calory fuel and increasing the efficiency of the engines of the rockets have an extremely great effect. If by increasing the speed of discharge of gases from the nozzle of the engine by 300 m/sec it may be brought up to the magnitude indicated on the graph, 2,700 m/sec., then the launching weight of the rocket may be reduced several times. A six-stage rocket in which the weight of the fuel is only 3-fold greater than the weight of the stage structure, may have a launching weight of approximately 1.5 thousand tons. However, by reducing the structural weight by an amount equal to ten percent of the total weight of each stage, we may reduce the launching weight of a rocket with the same number of stages to 200 tons.

If the speed of discharge of gases is increased another 300 m/sec, or taking the gas escape speed at 3,000 m/sec., this leads to still another reduction in weight. For example, a six-stage rocket with a fuel weight ratio of 75 percent may have a launching weight of 600 tons. By increasing the fuel weight ratio to 90 percent we may build a cosmic rocket with only two stages. Its weight proves to be approximately 850 tons. By increasing the number of stages two-fold we may reduce the weight of the rocket to 140 tons. For a six-stage rocket the take-off weight may be reduced to 116 tons.

Thus we have the effect of the number of stages, their design perfection and speed of discharge of gas upon the weight of the rocket.

Why do the necessary fuel reserves and the over-all weight of the rocket decrease with an increase in the number of stages? This derives from the fact that the greater the number of stages the more frequently may empty tanks be discarded, and the rocket may rid itself more rapidly of useless weight. At the same time, the take-off weight of the rocket prior to launching decreases very rapidly with an increase in the number of stages, but after that the effect of the increase in number of stages becomes less significant. It may be noted also, as is quite evident on the appended graphs /not reproduced here/, that for a rocket with relatively poor design characteristics an increase in the number of stages produces a greater effect than for a rocket with a high-percentage fuel content in each stage. This is completely understandable. If the body of each stage is very heavy, then they must be discarded as soon as possible. However, if the body is very light it does not burden the rocket excessively, and rapid discarding of the empty bodies does not produce such a great effect.

In a flight to another planet the necessary expenditure of fuel is not limited to the amount necessary for acceleration in taking off from the Earth. Flying up to another planet, a space ship falls into the sphere of its gravity and begins to approach its surface with increasing velocity. If the planet is lacking an atmosphere capable of diminishing part of its speed, then in falling to the surface of the planet the rocket wastes that speed necessary for taking off from that planet, or the second space speed. The magnitude of the second space speed, as is known, is different for each planet. For example, for Mars it is 5.1 km/sec., for Venus 10.4 km/sec., and for the Moon 2.4 km/sec. In the case in which the rocket approaches the sphere of gravity of a planet, having a certain speed relative to the latter, the speed of fall of the rocket already is great. For example, the second Soviet space rocket reached the surface of the Moon with a velocity of 3.3 km/sec. If the task is set to ensure a gradual landing of the rocket on the surface of the Moon, then supplementary fuel reserves must be on board the rocket. In order to extinguish any particular speed it is necessary to expend only the amount of fuel necessary for the rocket to develop that speed. Consequently a space rocket assigned to accomplish a safe landing on the Moon surface of any particular load, must carry considerable reserves of fuel. A single-stage rocket with a payload of 1 ton must have a weight of 3 to 4.5 tons, depending upon its design perfection.

We have indicated in the above the great weight which a rocket must have to carry a load of 1 ton into cosmic space. Now we see that only one third or one fourth of this load may be safely landed upon the surface of the Moon. The remainder must be devoted to fuel, tanks for storing it, an engine and the control system.

What must be the sum total of the launching weight of a space rocket intended for safe landing on the surface of the Moon of scientific equipment or of any useful load weighing 1 ton?

To give a representation of the ships of this type, on our drawing is a conventional cross-section of a five-stage rocket intended for delivering on the surface of the Moon a container with scientific equipment and weighing one ton. Technical data cited in a large number of books were included in the basic calculation of this rocket (for example, in the books: V. Feodos'yev and G. Sinyarev: Vvedeniye v raketnuyu tekhniku /Introduction to Rocket Technology/, and Satton: Raketnye dvigateli /Rocket Engines/.

Rocket engines using liquid fuel were taken. Turbopump units, placed in action by the products of decomposition of hydrogen peroxide, are provided for feeding the fuel. The average velocity of gas discharge for the first stage engines is taken at 2,400 m/sec. The engines of the second stage function in the extremely rarified layers of the atmosphere and in airless space, and because of this their efficiency is somewhat greater, and the velocity of their gas discharge is taken as equal to 2,700 m/sec. The design characteristics of the stages also are based on values which may be found in rockets described in the technical literature.

At the selected original data the following weight characteristics of the space rocket were obtained: take-off weight 3,348 tons, including 2,892 tons of fuel, 455 tons structural weight, and a one-ton payload. The weight distribution among the individual stages is the following: first stage 2,760 tons, second stage 495 tons, third stage 75.5 tons, fourth stage 13.78 tons, and fifth stage 2.72 tons. The length of the rocket is 60 m, and the diameter of the lowest stage is 10 m.

In the first stage are installed 19 engines with 350-tons thrust each. The second stage contains three engines of the same thrust, and the third stage contains three engines of 60-tons thrust each. The fourth stage contains one engine of 35-tons thrust, and the last stage contains an engine of 10-tons thrust.

In take-off from the surface of the Earth the engines of the first stage accelerate the rocket to a speed of 2 km/sec. After the empty body of the first stage is discarded the engines of the following three stages are started, and the rocket attains the second space speed.

Farther on the rocket flies to the Moon by inertia. Approaching its surface, the rocket turns with its nozzle downward. The engine of the fifth stage is started. It brakes the speed of fall, and the rocket gradually lands on the surface of the Moon.

Finally, the appended drawings and the related computations do not represent an actual plan of a Moon rocket. They are included only to give an initial impression of the scale of multistage space rockets. It is completely clear that the design of a rocket, its dimensions and weight, depend upon the level of development of science and technology, upon the materials at the disposal of the designers, upon the fuel used and the quality of the rocket engines, and upon the skill of its builders. The creation of space rockets represent unlimited scope for the creativity of scientists, engineers and technicians. Much discovery and invention still remains to be done in this field. With each new achievement the characteristics of rockets will change.

Just as the contemporary aircraft of types IL-18, TU-104 and TU-114 are not similar to the airplanes which were flying at the beginning of this century, space rockets will be continuously improved. By the time space flights are being made rocket engines will be using not only chemical reactions, but other sources of energy, such as the energy of nuclear processes. With changes in the types of rocket engines the design of the rockets themselves also will change. However, the remarkable idea of K. E. Tsiolkovskiy concerning making "rocket trains" always will have an honorary role in the investigation of the limitless expanses of space. ("Step By Step," by I. Merkulov, Tekhnika Molodezhi, No 1, 1960, p 18-21)

East Germans Pick October 1960 as Ideal Time for Firing Mars Probe

An article by Heinz Mielke in Volksstimme, 19 March, discusses the problems inherent in firing space probes, particularly to Mars and Venus, as announced by the Soviet Union. The author covers, in general terms, the difficulties which anyone has to overcome in firing such a probe, including selection of vehicle, angle of flight, time of firing, etc. In discussing the best time for the proposed space flight, the author states that "taking into consideration the Earth-Moon mass, the relative position of the Moon, the position of the Sun, and the orbit of Mars, the choice of ideal firing time for probe intercepting the orbit of Mars within 50,000 kilometers would be 14-15 October 1960." Turning to a proposed Venus probe, the author states that Venus would not be in favorable position until January 1961.

Although the author does not claim that these dates are those chosen by Soviet space experts, he does state that the "USSR needed only two test firings /into the Pacific Ocean/ to successfully conclude that series of experiments, and... Soviet scientists have long since proven that they can put the undesirable geographic position of the USSR, with respect to achieving optimum results in interplanetary trajectories, to good use by simply taking the conditions dictated by nature into consideration in making their calculations."

In another part of this article, Mielke recalls that the major difficulty in past space flights has been the element of inaccuracy presented by the absence of accurate knowledge regarding the "Astronomical Unit," defined as the mean distance between Earth and Sun (149,500,000 kilometers). He does imply, however, that possibilities exist for solving this problem, in that space probes can now continuously measure the distance between themselves and the earth as well as between themselves and the target planet and transmit this information to earth by radio. Thus, comparison between these actual distance measurements and those based on computations, could result in a more accurate determination of the "astronomical unit," than heretofore. According to Mielke, the known "Astronomic Unit" is accurate only to within about 70,000 kilometers, a factor which could lead to considerable errors in planning interplanetary trajectories. ("Progress Toward Mars," by Heinz Mielke, Magdeburg, Volksstimme, 19 Mar 60, p 4)

Satellites Serve Peace

1. Outer-Space Observatory

The atmosphere of the Earth is a very serious hindrance to astronomic observations. It refracts and partially absorbs the light coming to us from heavenly bodies. Starlight, passing through the continually moving layer of air, is partially refracted and weakened. This decreases the visible clarity of stars, causes their twinkling and, as a consequence, flickering and diffuseness of the images of heavenly bodies in telescopes.

An outer-space observatory will enable observation of the world of heavenly bodies in unaltered form. In photographing heavenly bodies from here, considerable magnification and great lengthening of exposure time may be permitted. This will become possible because due to the lack of gravitational force the structure of telescopes may be considerably simplified and lightened, and its dimensions may be much greater. Calculations indicate that a mirror 2.5 m in diameter, with a focal length of 27.5 m may yield an image of the Moon 25 cm in diameter, and an image of Mars 3.7 mm in diameter.

From a space observatory the sky will appear absolutely black upon observation. The brightness of heavenly bodies will increase considerably on this background. This will enable photographs to be made of stars and star clusters which are unattainable with terrestrial telescopes. With the aid of radio telescopes the investigation of radio emanations of heavenly bodies in the entire range of electromagnetic waves known to us will be possible.

2. Space Land Surveyors

To the present time we still do not know the precise shape of our planet. However, this is of extremely great importance in the composition of geographic maps. At the present time only part of the Earth's dry land has been mapped predisely.

It is known that the speed of motion of a satellite is not constant. It is greater above the poles, and less above the equatorial belt of the Earth. The Soviet scientist F. Krasovskiy calculates that the distance from the center of the Earth to the equator must be 21,382 m greater than at the pole. Because the force of gravitational attraction is inversely proportional to the square of the distance from the center of the Earth, to counterbalance this force a satellite must move with greater velocity over the poles than over the equator. By observing the changes in velocity of the flight of a satellite the shape of our planet may be defined more precisely, and the distance between continents may be measured with greater accuracy. At present this distance has been determined with an accuracy on the order of 100 m! Great perspectives also are opened by photography of the surface of the Earth.

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3. Satellite Prospectors of Terrestrial Mineral Resources

The main force determining the motion of an earth satellite after it has been placed in orbit is the force of gravitational attraction of the Earth.

Moving in the field of gravity, it reacts very sensitively to all changes in this field caused by changes in the composition of the crust and in the character of terrestrial mineral deposits.

It is as though a satellite senses what lies beneath it: whether deposits of heavy iron ore, massive mountain crests, or relatively light ocean waters. The greater the mass in a given area, the more the satellite is attracted at that point.

Depending upon the extent to which the mass of the Earth is distributed unevenly the satellite, experiencing definite perturbations, moves in a wavy trajectory.

Through observation of the motion of satellites with the aid of optical and radio technical means the structure of the Earth and the distribution of large-scale heterogeneities in the mass of the earth crust may be studied. This will enable not only more precise determination of the configuration of our planet, but also will enable discovery of new areas in which deposits of various mineral resources lie.

Especially numerous deposits of mineral resources may be found in regions of large expanses of water, which at the present time are completely uninvestigated in this respect.

4. The Secret of Time and the Satellites

The theory of relativity asserts that there is no single time for the entire universe. The proper time of the crew of an astral flight, moving at a velocity nearly equal to the speed of light, is substantially shortened with respect to time on the Earth. A clock located on a satellite moving at a speed of 8 km/sec. will lose one hundred seconds with respect to clocks on the ground. The insignificance of this lag is explained by the fact that the speed of the satellite is very small in comparison to the speed of light.

For experimental testing of the effect of slowing of the "course" of time, Corresponding Member of the Academy of Sciences USSR V. L. Ginzburg states that a special, highly precise atomic-molecular clock must be installed on a satellite. By comparison of its indications, transmitted from the satellite by radio, with the indications of the same type clock located on the Earth appears to offer the possibility for determination of the lag predicted by the theory of relativity.

The realization of such an experiment will have decisive importance in puzzling out the secret of time, which is very important both in investigation of the character of the development of the universe in time, and for interstellar travel. It may be that this negligible rate of seconds also will solve the problem of how far man will penetrate into the universe.

5. Satellite Fireflies

Observations of the flight of artificial earth satellites are conducted with the aid of radio technical equipment, such as radar and radio telescopes, and with optical means, such as telescopes, and binoculars. However, the radio methods are relatively low in precision, and with the use of optical instruments the satellites may be seen mainly in the morning and evening, when it is already dark on the Earth, but the satellite very well reflects the rays of the sun. Put how is the satellite to be seen at night? For this it would be sufficient to have a source of light on the satellite, which periodically would give off a brilliant burst of light, readily visible against the dark background of the night sky.

To increase the accuracy of determination of the coordinates of the satellite in space, it would be advantageous to transmit radio impulses simultaneously with the burst of light. The data on the position of the satellite, measured with an accuracy of up to 2 or 3 seconds of arc, would enable determination of the distance between various points on the Earth and the shape of the terrestrial sphere with an accuracy of up to tens of meters.

6. Space Radio Beacons

In marine navigation and aviation radio beacons transmitting powerful signals are used extensively for determination of the location of ships or aircraft. These radio signals are received with the aid of radio receiving equipment on board the ship or aircraft, and the instrument indicates the direction to the radio beacon. Through the intersection of the direction to several radio beacons, plotted on a navigational map, the navigator finds the position of the ship or aircraft at the given moment.

For interplanetary travellers to steer their space ships accurately it is necessary for them also to have radio orientation. These may be satellites orbiting around heavenly bodies and equipped with power radio transmitters. The possibility is not excluded of setting them up on the surface of satellites of other planets, or on the planets themselves.

Knowing the trajectory of motion of the space radio beacons and their location at definite moments of time, it appears possible to determine the position of the space ship in space which is receiving their signals.

7. Bio-Satellites

The time is approaching when man will rush into cosmic space. To accomplish this extremely great step Soviet scientists are conducting multifaceted research on the conditions of the existence of a living organism under these circumstances which are unusual for it.

The launching of the second Soviet satellite, carrying the dog Layka, was a great accomplishment in this direction. An important factor in this case was the sufficiently long stay of an animal in space. The materials obtained indicated that its condition was satisfactory both during the process of the ascent and during the entry of the satellite into orbit, and also during the further movement of the satellite until consummation of this unique experiment. It is thought that the first flight of an animal in a satellite did not solve enough of the problems connected with ensuring the safety of people from cosmic rays. New experiments will be indisputably provided.

The basic problems connected with the stay of man in space may be divided into three groups. The first group includes the problems of the influence upon man of the acceleration and weightlessness which arise in placing the satellite in orbit and during its movement through cosmic space. The second group includes problems such as the creation of hermetically sealed cabins, equipment, providing members of the crew with food, and providing the necessary supply of air, its temperature and humidity. Finally, the third group consists of the problems of protection from cosmic rays, ultraviolet and X-rays of the Sun, from meteors, etc.

Artificial earth satellites, used as space medicine laboratories, will play a prime role in the solution of these problems. With their aid it will become possible to conduct experimental studies of the influence upon the living organism of the conditions of prolonged space flight, which cannot be conducted on the Earth.

8. Space Solar Electric Power Stations

The solar batteries placed in the third Soviet artificial earth satellite and in the third Soviet space rocket, have performed very well (for an explanation of the functioning of solar batteries, see No. 10, 1959, of the present periodical).

The solar batteries, having freed the world from the subjugation of solar light, transformed solar power of the Earth in space. The space solar electric power stations, transforming the hot radiation of the sun into electric power with the aid of photo- and thermoelectric generators, thermal machines and other means, will satisfy the needs of consumers located in space. When man will learn to transmit electric power from space to the Earth without wires, similarly to the manner in which radio communication is accomplished at present, the creative mind of man will devote its forces to the creation of space solar electric power stations, supplying the inhabitants of the Earth with electric power in unlimited amounts. This will enable considerable savings in all types of fuel and will most completely satisfy power demands.

9. Space Projector

This is how a space projector may look. It may be a solar electric power station equipped with a special light reflector. By concentrating the power light stream with the aid of an optical system, artificial lighting of individual regions of our planet during the hours of darkness may be possible. Calculations show that a projector located on a satellite, with a mirror diameter of several hundred meters is sufficient to produce an illumination of the surface of the Earth equal to that of the full moon on a cloudless night. Illumination may be increased by focusing the rays from two or more space projectors upon the same illuminated area.

10. Meteorological Stations in Space

The activity of man is closely connected with the weather. Its caprices -- destructive downpours and floods, parching drought and bitter cold, brutal storms and hurricanes -- cause man collossal losses and untold disasters. It is very important to be able to predict them in order to take the necessary protective measures. However, at present the world meteorological service has very limited resources for this. Only one third of the surface of the Earth has a network of meteorological stations, the remaining two thirds, covered by oceans and seas and where weather also is formed, have no such stations. The artificial earth satellites will be of significant assistance to the world meteorological service.

Equipped with the necessary instruments for observation of the processes taking place in the forge of weather, the atmosphere, during the course of one-and-one-half to two hours they may fix the distribution and character of the cloud cover, the presence of regions of bad and good weather, and the movement of warm and cold air masses.

As a result of the rotation of the Earth about its axis, with every successive rotation the satellite is able to observe the meteorological picture of new regions contiguous with the preceding regions. This enables determination of the movement and speed of movement of visible storms, determination of which cyclones and anticyclones die out and which are becoming stronger, and the movement of warm and cold air masses. Through observation from satellites of the processes taking place in the atmosphere of the Earth we do not simply obtain a picture of the weather during any given moment and in a limited region, but we detect the basic tendencies of its development on an entire planetary scale.

With the development of earth satellites and of electronic computation technology a new era was begun not only in the improvement of methods of long-range prediction of weather, but also of the emergence of a new science, the science of space meteorology. ("Satellites Serve Peace," by N. A. Varvarov, Tekhnika Molodezhi, No. 1, 1960, pp 3-38)

The Earth's "Corona"

Three articles in a recent issue of Znaniye-Sila discuss the "corona" of the Earth. The first article is devoted to drawing similarities between the Van Allen belts of the Earth and the corona of the Sun, the second discusses the "hot" electrons in the earth's atmosphere, and the third attempts an alternate explanation of the radiation zones surrounding the Earth.

Following the US announcement in February 1958 of the existence of a "deadly" radiation zone surrounding the Earth the third Soviet artificial satellite was launched on 15 May 1958, carrying special instrumentation for investigation of the unknown radiation, and the results were reported at the September 1958 meeting of the IGY at Moscow by Corresponding Member of the Academy of Sciences USSR S. N. Vernov and Professor V. I. Krasovskiy. Working independently of the Soviets, US Scientist Van Allen calculated the existence of a zone of electrons of considerably less power than cosmic rays at approximately 150 km above the polar regions of the Earth. Van Allen's cosmic ray counters, carried in equatorial orbits by the US satellites Explorer I, II and III were "choked up" by excessive radiation at an altitude of 1,000 km. A cosmic ray counter of revised design aboard Explorer IV confirmed Van Allen's theory and revealed that despite its heavy concentration, this radiation is of low penetrating power and was almost completely absorbed by the shell of the satellite. The problem of the origin of this radiation was solved by a radiation counter carried by the third Soviet satellite, sensitive only to electrons with energy of at least ten kiloelectron volts, and S. N. Vernov's X-ray-detecting instrument. In a polar orbit, the satellite showed that at an altitude of 250 to 500 km the radiation consisted of electrons unable to penetrate the alloy shell of the satellite, but producing heavy X-ray radiation through collision with the satellite shell, and thus also through collision with atmospheric molecules at that altitude. The stream of electrons was so dense that an instrument outside the satellite was "choked up." This phenomenon was called the "corona" of the Earth.

According to the views of S. N. Vernov, the boundaries of the two zones of radiation which surround the Earth coincide with the magnetic lines of force of the Earth. The inner zone is at an altitude of 600 kilometers in the region of the US, and 1,600 kilometers in the region of the USSR. Thus the Earth changes the cosmic space surrounding it, and the "corona" of the Earth actually should be called the zone of the Earth's corpuscular radiation. According to Yu. I. Gal'perin the power of this aureole of rapid, charged particles surrounding the Earth has been found to exceed all expectations, and these particles have a very great role in the most important processes of the upper layers of the atmosphere.

Just as the corona of the Sun, consisting of a plasma of hydrogen nuclei and free electrons emitting heat, light, radio- and higher-frequency radiation, may extend to the Earth in the form of corpuscular radiation, the atmosphere of the Earth, once thought to be a close-fitting "scarf" extends farther into space than previously thought, and at the boundary between the atmosphere and interplanetary gas consists of ions and electrons, forming a shield which protects the Earth from all forms of solar radiation and from radiation from outer space. Ultraviolet rays cause ionization of the upper atmosphere, but the strongest ultraviolet rays come to within only 80 or 100 km of the earth before dying out. The ultraviolet rays which succeed in approaching closer to the Earth are stopped at an altitude of 30 to 50 km by ozone molecules. X-rays and gamma rays, which strip electrons from atoms, do not penetrate below 60 kilometers. Similarly to the corona of the Sun, the ionized layer of the earth's atmosphere at an altitude of 1,000 km, or 7- or 8-times the earth's diameter, is influenced more by the magnetic field of the Earth than by its gravity, is the region of the X-ray radiation peculiar to the Earth, and the plasma of the earth's atmosphere at this altitude is heated to temperatures of thousands of degrees.

Yu. I. Gal'perin states that solar wave- and corpuscular radiation generally is absorbed below an altitude of 300 kilometers. The atmosphere above this level is practically transparent for all forms of solar radiation. The temperature of several thousand degrees Centigrade at this altitude cannot be caused by absorption of short-wave solar radiation, and one of the hypotheses for the explanation of this temperature is that the Earth passes through very hot interplanetary gas in its revolution around the Sun. The real cause of this phenomenon is not yet known. Another phenomenon which has not yet been explained satisfactorily is the ionization of the upper atmosphere at night and during a solar eclipse. A suggested explanation is that only the "leading ranks" of a stream of solar corpuscles make contact with the uppermost and most rarified regions of the atmosphere.

The Earth's corona consists of two layers: the inner, relatively stable layer at an altitude of 500 to 1,000 km, consisting of charged particles and located mainly over the Equator, and the outer, relatively variable layer located at an altitude of 40,000 to 50,000 km, consisting of electrons, covering almost the entire Earth, and having a much denser concentration of charged particles. Associates of the Department of the Upper Atmosphere of the Institute of Atmospheric Physics, Academy of Sciences USSR, headed by Professor Valerian Ivanovich Krasovskiy, maintain that the Sun is responsible for the formation of the Earth's corona.

S. N. Vernov offers another possible explanation of the origin of the Earth's "corona," or the Earth's corpuscular radiation. According to this theory the collision of cosmic ray particles with atoms of the earth's atmosphere may result in the formation of neutrons. Because the neutron has no charge it may continue in a straight line into outer space. However, because the average life of the proton is 15 minutes, some of the neutrons decompose into a proton, electron and neutrino, which are caught in the trap of the earth's magnetic field and oscillate between the Earth's poles because as they approach a pole, where the magnetic lines of force of the Earth emerge, a magnetic "bottleneck" is formed and the protons and electrons reverse their direction. Because of the rarefaction of the upper atmosphere this oscillation continues for a long period of time. Because of recent studies of cosmic rays in the stratosphere the amount of neutrons formed by the earth's atmosphere under the action of cosmic rays now is known. Although this theory may explain the origin of the inner band of radiation around the Earth, no satisfactory explanation yet has been found for the fact that the concentration of matter between the two radiation zones is at least one-thousand-fold less than within the radiation zones. A new science, the physics of plasmas, may provide the answer to the question of how the two radiation zones become filled with matter. The relatively great temporary changes in the outer radiation zone indicate this may be due to the action of corpuscular radiation from the Sun. The question of whether the Moon also has a corona was answered by the launching of the Moon rocket: no marked magnetic field, and hence no corona was detected near the Moon.

The rockets launched from the Earth to the Moon passed radially through the electron layer and enabled precise determination of the extent of the Earth's "corona." The earth radiation zone reaches its highest level at 25,000 km above the Earth, after which it drops off rapidly. At a distance of 10 earth radii the radiation has dropped 100-fold and is practically equal to the general cosmic level. This defines the boundary of the Earth's "corona." At this altitude the magnetic field of the Earth has no marked effect, the magnetic trap disintegrates, and electrons cannot be held by it. If this were not the case, charged particles would be observed there because, based upon computation, each charged particle would live no less than one week.

Yu. I. Gal'perin explains the formation of the magnetic trap around the Earth as follows. Because of the rarified atmosphere at an altitude of 500 to 1,000 km, collisions between atoms or molecules of the air are less frequent than in the lower, denser atmosphere, and thus the velocity of these atoms and molecules toward outer space is so high that they begin to move in an elliptical orbit around the center of the Earth. The outer atmosphere contains a large number of these "satellite" particles. The charged particles moving within the magnetic field of the Earth are subjected to a force in conformance with the Right Hand Rule. The action of this force in the magnetic field of the Earth will bend the trajectory of solar corpuscles in a complex manner so that a considerable portion of these corpuscles will go toward the opposite, or night side of the Earth, mainly in the vicinity of the magnetic poles. The charged particles of the upper atmosphere and within the magnetic field of the Earth describe a complex, spiral path, and while they move around the Earth the electrons move toward the east and the positively charged particles move toward the west. This movement of charged particles must create a ring current around the Earth, which weakens its magnetic field. This current may exist only if its magnetic field is weaker than the magnetic field of the Earth at the given altitude. In addition to revolution around the Earth, the charged particles revolve around the magnetic lines of force, and also vacillate around the latter. Because of fewer collisions between particles in the rarified altitudes of the atmosphere the particles maintain this complex motion for long periods of time. If great energy is imparted to these particles, which is equivalent to the great heating of the upper atmosphere, the increased temperature also will be maintained for a long period of time because of little interaction between this portion of the atmosphere with the denser layers. Thus we have the magnetic trap for charged particles around the Earth. In this trap the ions and electrons of the hot plasma which is formed at extreme altitudes above the Earth are held in endless motion around the Earth, just as scientists at present are attempting to create a sun-like plasma and confine it within a "magnetic bottle." If, under certain conditions the amplitude of vacillation of particles around the magnetic lines of force is increased, a small portion of the particles are deflected from their usual orbit, and especially in the polar regions, collide with atoms and molecules of the denser layers of the atmosphere at altitudes of 100 to 500 kilometers, imparting great energy to these atoms and molecules and resulting in the phenomenon of the aurora polaris.

At the annual meeting of the Department of Mathematical Physics of the Academy of Sciences USSR Sergey Nikolayevich Vernov reported that sounding balloons released during the IGY from Murmansk and from the Moscow suburb of Dolgoprudnaya indicated that perhaps once a year relatively high energy particles from outer space are recorded, although they have not been recorded at latitudes to the south of Moscow. As to whether these particles originate in the Sun, it is noted that although a powerful solar eruption occurred on 23 February 1956, charged particles were not observed in the vicinity of the Earth until twenty hours later. Vernov states that this suggests the existence of "travelling" traps, which may be "pieces" of the magnetic field of the Sun which have broken off from the latter and are travelling in space. It is known that in a stream of solar corpuscles, or a shred of rarified plasma, the magnetic field generated by the movement of its component charged particles may continue to exist for an unlimited period of time. Entering the earth's magnetic field, these shreds of the solar magnetic field disintegrate the continuity of the earth's magnetic trap and penetrate the trap.

According to V. I. Krasovskiy and his associates the cloud of electrons surrounding the Earth consists of a stream of solar corpuscles caught in the earth's magnetic field. External corpuscles cannot enter the region of regulated movement of charged particles described above, and this region is "prohibited" to them. Investigations conducted with the third Soviet artificial earth satellite unexpectedly revealed the presence of fast, charged particles, especially electrons, in the outer atmosphere and in the "prohibited" regions. V. I. Krasovskiy and his associates determined that the temperature of these electrons attains tens of millions of degrees. Other investigation led to the discovery of even hotter particles, though in much less quantity. According to the view of Yu. I. Gal'perin, the origin of these "superheated" particles results from the transformation of the kinetic energy of clots of ionized gas ejected from the Sun into heat upon the collision of these clots, having magnetic fields of their own, with the outer atmosphere of the Earth, which also constitutes a closed magnetic field. The hot particles generated in the outer atmosphere in this manner have a velocity approximately equal to that of electrons in a television picture tube.

Because of the presence of high energy particles in the lower zone of the earth's "corona" it is suggested by Ye. Saparina that the formation of this zone may have been caused by the explosion by the US of thermonuclear bombs high above Johnston Island in the Pacific Ocean late in 1957. At the same time an unusual aurora polaris was observed 3,500 kilometers away. The explosion and the aurora occurred along the same magnetic line of force, and it is known that charged particles travel most easily along magnetic lines of force. Computations of Soviet scientists show that an atomic explosion above the state of Nevada, for example, may result in electrons rising as high as 10,000 km, and may directly enter the lower zone of the earth's "corona." Although it may be argued that the charged particles produced by an atomic explosion are insufficient to produce a noticeable result, calculations show that only a few high-altitude atomic explosions would be sufficient to "fill" the lower zone with charged particles. To test this theory the US conducted "Project Argus" in 1958, with three nuclear explosions at an altitude of several hundred kilometers, with the result that a considerable portion of the Earth was encircled by a supplementary zone of radiation for several days. Thus atomic tests are considered objectionable not only because of the direct danger from radiation, but also because of their possible meteorological effect. The Johnston Island test, for example, apparently caused great magnetic storms and the extraordinary appearance of an aurora polaris over the tropical islands of Samoa, the Canary Islands, and others. ("Corona of the Earth" by Ye. Saparina, Znaniye-Sila, No 3, 1960, p 34-39, "'Hot' Electrons in the Earth's Atmosphere," by Yu. I. Gal'perin, Znaniye-Sila, No 3, 1960, p 36-37, Article by S. N. Vernov, Znaniye-Sila, No 3, 1960, p 37-38)

III. UPPER ATMOSPHERE

Giant Telescope

Soviet astronomical science soon will be enriched by a new telescope, the most powerful in the world. The planned building at Pulkovo of a telescope with a mirror diameter of six meters has been developed under the direction of Corresponding Member of the Academy of Sciences USSR D. D. Maksutov.

At the present time there is a reflecting telescope with an aperture of five meters at the Palomar Observatory in California. The new Soviet reflector, the plan of which includes the creation of a great mirror and the introduction of many design and technological innovations, will enable the realization of research unknown to scientific practice. This is primarily related to the study of extragalactic space outside the limits of the Milky Way, and which to the present time has been little accessible to Soviet astronomers because of the lack of sufficient powerful telescopes.

The telescope will enable realization of extensive investigation of the physical properties and structure of stars through the use of spectral analysis and modern electronic technology.

During the current year the Pulkovo Observatory is continuing work started earlier in expeditionary searching prior to selection of a site for the new telescope. In the immediate future special expeditions are being sent to the mountainous regions of the Caucasus, Central Asia, the Pamirs, and the Far East for study of astroclimatic conditions. ("Telescope-Giant," Izvestiya, 6 April 1960, p 2)

IV. ARCTIC AND ANTARCTIC

Climatic Zones of East Antarctica and the Southern Ocean

During the International Geophysical Year meteorological and aerological observations were conducted not only on the shore of Antarctica, but also within the sixth continent. Because of this, data were obtained on the circulation of the atmosphere and the course of weather at various distances from the shore, all the way to the South Pole. Valuable observational data were accumulated during the movement of sled-tractor trains into the interior regions of Antarctica. Much was accomplished by air weather surveys, with the aid of which distances of 2,000-4,000 km were covered in one day. To this must be added the systematic study of the relief of Eastern Antarctica, conducted by the Third Soviet Antarctic expedition in 1958. Analysis of all this observational data enables us now to indicate the basic climatic zones of Eastern Antarctica and its surrounding Antarctic Ocean (Figure 1). /Note: Reproduced figures are appended following the last page of this report./

Five climatic zones are differentiated: (1) the high Antarctic plateau, (2) the Antarctic slope, (3) the Antarctic shore, (4) drift ice, and (5) open Antarctic waters.

All five zones are described briefly in the following.

The Zone of the High Antarctic Plateau

As is indicated by the surface profile of the ice cover of Eastern Antarctica, which extends in various directions, a structural contour of approximately 2,800 m limits that internal region of Eastern Antarctica which best may be called the high Antarctic plateau. It is true that this is not a plateau in the sense that the surface is completely horizontal. On the contrary, on a relief map a domed section stands out clearly, located to the southwest of camp Sovetskaya and outlined by a 4,000-m structural contour. However, the slope of the snowy surface on all sides of the dome is small, on the order of 10^{-3}, and produces only weak slope winds.

The climate of the Antarctic plateau is unusually bleak and is not duplicated anywhere on the earth's sphere. The main characteristics of the climate are: low negative temperatures of the air during the entire year, predominance of clear weather with little wind, small amount of precipitation, and dryness of the air.

The Vostok, Sovetskaya and Komsomol'skaya stations characterize this climatic zone with their observations.

The warmest months, December and January, are distinguished by a great regularity of temperature throughout the entire Antarctic plateau. At the ground surface the mean diurnal temperature in two thirds of the cases is between -30 and -35 degrees. The maximum temperature reaches -22 to -24 degrees.

During summer the troposphere above the plateau also is characterized by horizontal regularity of temperature.

During February and March the temperature drops sharply; afterward, the period of the Antarctic cold winter begins, lasting until the middle of October, with July and August the coldest months. The lowest temperatures recorded in 1958 were during the month of August: -87.4 degrees at station Vostok, -86.8 degrees at station Sovetskaya, and -80.7 degrees at station Komsomol'skaya. During winter the mean diurnal temperatures of all days were below -40 degrees. In the second half of October and in November the temperature rises rapidly.

The daily fluctuations in temperature are interesting. In the summer a considerable range of temperatures is observed during a 24-hour period. In April the temperatures begin to level out. During the polar night the regular diurnal change is lacking, but is clearly expressed again with the rising of the sun. However, the diurnal variation in temperature during the course of the year remains great, with the greatest fluctuation from day to day observed during the winter period, which is well illustrated by the data of station Vostok (Figure 2). The explanation is that in winter a meridional exchange of air masses arises, and on the Antarctic dome, together with cyclonic outbursts air currents from temperate, and even from tropical latitudes arise. On the other hand, sharp diurnal fluctuations in temperature may be observed even during periods of regular, very frosty weather, when there is absolutely no exchange of air masses. In this case an especially sharp temperature inversion occurs near the surface, with a rise in temperature of 3-5 degrees at 100 m in a thin, low layer. Naturally, with rising winds and increasing mixture the fluctuation in temperatures at the surface of the plateau may become great.

Clear weather predominates on the Antarctic plateau both in winter and in summer. However, this does not mean that a lasting anticyclone is located here during the winter. On the contrary, the lowest temperatures always are observed during the periods of lowest pressure, approximately 600-610 mb. Thus, during the winter a cold, cloudless cyclone dominates above the Antarctic plateau, the circulation of which extends upward, also occupying the stratosphere. During the period of this closed circulation, when no warmer air masses penetrate the Antarctic from the outside, as a result of loss of heat through radiation the lowest temperatures are produced. In the surface inversion layer, extending several hundred meters high, a frosty mist is formed almost continuously, from which icy crystals precipitate. This produces a small amount of precipitation because the absolute humidity of the air fluctuates within the range of 0.001-0.1 mb. In the case when cyclones of the oceanic region enter the system of the Antarctic cyclone and bring in warmer air, clouds are formed and precipitation increases somewhat.

The predominant cloud form is cirrus and the condensed cirrostratus which is peculiar to the Antarctic; altostratus formations are rare. The sun always shines through this cloud cover, and precipitation falls in the form of ice bars or plates, rarely in the form of snowflakes. All this cannot greatly increase the snow cover. Precipitation is increased with the appearance of dense altostratus clouds, reminiscent of nimbostratus, but this occurs only in isolated cases.

One third to one half of the monthly total precipitation is deposited by hoarfrost. The total annual precipitation at station Komsomol'skaya is approximately 20-25 mm. The total precipitation at the Sovetskaya and Vostok stations may be taken as 25-35 mm. Close to the outer border of the high Antarctic plateau the annual total increases, apparently to 50-60 mm.

Despite the fact that the general features of the climate of the entire area of the Antarctic plateau are similar there is no complete climatic homogeneity, which is caused by variations in altitude, location inland within the continent, and by peculiarities of the relief of East Antarctica. Thus the climatic character in the region of station Sovetskaya is determined by a depression in the relief in a northwesterly direction, alongside the mid-continental valley, opening on the Olaf-Pryuds Bay. This depression determines the direction of the predominant ESE wind. The wind is of a slope-wind character, and has a low velocity of 2.5-4.6 m/sec. At the same time a west-southwest wind, also of low velocity and of a slope-wind character, predominates at the geomagnetic pole, located on the eastern slope of the spur separating the Sovetskaya and Vostok stations. These peculiarities of inland slope winds, determined by the relief, are encountered everywhere.

Turning to the region of station Sovetskaya, on the other hand, it must be mentioned that it is located on the upper portion of the wide valley mentioned above, which leads to the following results. In the event that warm air masses invade the Antarctic through the shore of Olaf-Pryuds Bay, they penetrate relatively easily to the region of station Sovetskaya, and in any case no less frequently than the intrusion of warm air as far as station Komsomol'skaya, located at a much shorter distance from the shore.

The existence of the crest of the icy dome of the Antarctic southwest of station Sovetskaya and of the spur which extends in a northeasterly direction to a known degree screens the region of the station from loss of warm air masses from the region of Ross Sea; the latter fairly frequently reach station Vostok, which lies on the opposite slope of the spur.

The trip to the relatively inaccessible pole, which was made in December 1958, revealed that more abundant deposit of frost and precipitation is observed on the opposite, western and southwestern sides of the dome than on the slopes on which station Sovetskaya is located. This indicates that relatively more humid and warm air currents from the west and the Weddels Sea release their reserve of moisture on the western and southwestern slopes of the Antarctic dome, and arrive at the opposite slope in a much drier state.

There are several differences in the course of temperature variations, also, which is apparent at least from comparison of the data of station Komsomol'skaya with the data of stations Sovetskaya and Vostok. This difference is explained not by the altitude or geographic latitude of the locale alone, but also by the distance from the shore, from where advection of heat, diminishing with distance, occurs.

Figure 3 contains annual isotherms assembled by Kh. Ya. Zakiyev on the basis of results of measurements of the temperature of subsurface firn taken during trips into the interior continent. As is known, the temperature at a depth of approximately 15 m (where annual variation in temperature is absent) is equal to the average annual temperature of the aid at the given point. The map shows marked differences in the temperature characteristics of the Antarctic plateau. The region of rise in temperature between station Sovetskaya and the station at the relatively inaccessible Pole is noteworthy.

The conditions of deposit of precipitation in various sections of the Antarctic plateau have not been studied very thoroughly, and in this connection valuable results may be afforded by analysis of the reserve of firn-snow thickness through boring holes. At present this work has been only at a small number of points.

The Zone of the Antarctic Slope

The basic distinguishing characteristic of the climate of this zone is the existence of constant, strong slope winds which create a drifting movement of snow from the interior regions of the Antarctic to the shore. We take the upper boundary of the Antarctic slope as a structural contour of approximately 2,800 m, and the lower boundary is taken close to the shore, at a distance of several tens of kilometers from the shoreline. The width of the zone is 600 to 800 km.

The Antarctic slope is rather steep. For the first hundred kilometers from the shore the slope is 0.014 or 0.015, but higher up the slope factor decreases to 0.004 or 0.005. The conditions for establishing a downflow of air, cooled by passing over a snowy slope, are unique in their proportions.

At present the climate of the slope is characterized by the observations of three inland stations: Vostok-1 ($\varphi = 72^\circ 08'$, $\lambda = 96^\circ 35'$, $h = 3,140$ m), Pionerskaya ($\varphi = 69^\circ 41'$, $\lambda = 95^\circ 30'$, $h = 2,700$ m), and Sharko ($\varphi = 69^\circ 30'$, $\lambda = 139^\circ 02'$, $h = 2,400$ m).

Station Vostok-1 was functioning during the winter of 1957. It is located to the south of the upper boundary of this climatic zone, where the drainage slope winds are born. The winter temperature characteristics are indicated by the following average values:

April	May	June	July	August	September	October
-48.0	-52.7	-51.7	-58.0	-53.0	-48.7	-48.3

According to the observations of station Vostok-1 the monthly average wind velocity is 6 to 7 m/sec, and that of the Antarctic plateau is 3 or 4 m/sec.

The observations of the Pionerskaya and Sharko stations are most typical of the slope. The annual maximum temperature at station Pionerskaya is -13 degrees, and minimum is -67 degrees. The distribution of annual average temperatures on the slope is shown on the map of Zakiyev (Figure 3). As far as the monthly average wind velocity is concerned, it varies in the range of 8 to 13 m/sec. In general the wind on the slope is weaker than on the shore. However, the character of the wind in the slope zone is different. On the shore periods of storms and hurricanes alternate with days of weak wind, but on the slope the wind is distinguished by great constancy, although it does not reach hurricane force.

The down-slope wind lifts many small crystals of snow from the Antarctic surface, creating an almost constant down-grade drift, covering the Antarctic slope with a cloud of drifting snow mist. From afar or from above this cloud has a very characteristic lavender shade. Its upper edge rises to 50-100 m above the snowy surface. According to aerial observations, during ordinary "calm" weather the cloud of drifting mist begins 100-150 km from the shore and gradually dissipates, transforming into drifting snow at a distance of 500-600 km from the shore. The density of the cloud of snowy mist depends upon the force of the wind and the condition of the snowy surface. The cloud grows with a fresh fall of snow.

The influence of oceanic cyclones passing close to the shore or penetrating the interior of the continent extends to the Antarctic slope with considerably greater frequency than to the Antarctic plateau. Because of this snow fall is frequently observed here, increasing the recurrence of drifting. Downgrade and general drifting is observed a total of 25-29 days per month during the winter, and 15-20 days per month during the short summer. Because of this the Antarctic slope sometimes is called the climatic zone of constant drifting.

The Antarctic Shore Zone

The climate of the shore of East Antarctica has been studied by many stations both prior to the International Geophysical Year and, especially, during the IGY. In general the climate of the Antarctic shore at the latitude of the Antarctic Circle may be termed dry, and relatively warm with a large number of clear or sunny days. The latter circumstance essentially distinguishes the shore from the drifting ice zone, with its misty, damp weather. The stormy slope winds are the climatic scourge of the shore zone, but they are also its own peculiar blessing. It is well known that winds which have a slope-wind, or foehn-wind character bring with them dry and warmed air, mix with formations of extremely cooled terrestrial layers of air (which occurs in the deep regions of the Antarctic) and enable the breaking up of low cloud formations. Its boundary constantly is visible on the horizon from the sea to the north. Because of the slope wind the most frequent temperatures on the shore are within the range of -10 to -25 degrees, even during the winter. During the coldest periods the minimal temperature drops to -30 to -35 degrees, and the minimal limit is approximately -40 degrees.

Fairly intense melting of snow is observed on the shore in the summer, and the maximum temperatures sometimes rise above zero.

Four climatic zones may be distinguished within the extent of all shore zones: (a) icy shore with barrier, (b) external shelf-glaciers, (c) inland shelf-glaciers, and (d) Antarctic oases.

The first climatic region, icy shore with barrier, includes the most extended sections which constitute the ends of the slope of the Antarctic shield, with a perpendicular barrier at the boundary with the sea. The icy surface rises sharply upward toward the south, and at several tens of kilometers from the shore the absolute altitude is greater than 1,000 m. Naturally, this sharp rise of the surface rapidly changes the climatic conditions, especially with respect to temperature and precipitation. As a result of this the observations of stations located on the icy shore characterize the climate as a narrow coastal belt. The area of location of the Mirnyy observatory, in particular, belongs to this climatic region.

On the shore of Antarctica oases also are observed, as well as shelf-glaciers abutting on the shore line. Their climates are distinguished by peculiarities connected with great areas of open rocky surface in the first case, and with an almost horizontal icy or snowy surface in the second case.

The shelf glaciers may be divided into two categories: external and inland glaciers. Examples of the first are the Western and Shackleton shelf glaciers, and of the second the Aymor and Ross glaciers.

The external shelf glaciers move far to the north in the sea. Because of the quasi-horizontal surface the slope winds of the Antarctic die down over the shelf glaciers at a small distance from the shore. Under the conditions of anticyclonic weather during the summer this leads to much greater cooling of the air than at the shore. On the other hand the constant stratus and stratocumulus cloud cover observed above the sea frequently expands over sections of glaciers which have moved out to sea, increasing the number of cloudy and hazy days per year. Winds of storm and hurricane force dominate here during the passage of deep cyclones. Precipitation must be greater than on the shore.

The inland shelf glaciers cut deeply into the continent and are located at very high latitudes. Because of this the temperature conditions of these glaciers must be bleak. It is known that the average monthly temperatures at the Little America station during the coldest months are considerably below -30 degrees (down to -38 degrees). At the same time the average wind velocities are approximately the same as those on the high Antarctic plateau. Strengthening of the wind as a result of stormy cyclones occurs more frequently than on the Antarctic plateau. The amount of precipitation is approximately the same as at the shore.

The basic climatic characteristics of the Antarctic oases are such that their areas may be included in the climatic zone of the shore, despite the sharp difference between the underlying surface in comparison to the surrounding geographic medium. However, they also have their own characteristic distinctions, which may be readily seen in the example of the Banger oasis ($\varphi = 66^{\circ}16'$, $\lambda = 100^{\circ}44'$, $h = 20$ m). First of all, slope winds are lacking at the oases. These die down at the approaches to the oases, meeting an intersecting surface of low grade having a considerably horizontal expanse. The existence of slope winds on the nearest Antarctic slope is detected by a bluish shroud of drifting ground snow, while winds are calm or of low velocity at the oases. On the other hand, during the passage of stormy cyclones hurricane winds flare up, lasting from one or two days to several days. These hurricanes remove the snow cover, which is maintained only in the form of air drifts on the leeward side of obstacles, and because of this during the entire year, including winter, the rocky surface of the oasis remains uncovered. This has only a slight reflection in the course of temperatures during the cold periods of the year from the point of view of comparison with other climatic fields of the shore. During the summer, however, and during the transitional seasons, the uncovered surface of granite, detritus and soil change the radiation and heat balance of the active surface in comparison with a snowy surface. During the prevalence of gentle winds this leads to a perceptible warming of the air.

The climatic region of the mountain chains of the Antarctic remain to be delineated. At the present time, however, an extremely small amount of data is available pertaining to the characteristics of these regions.

The Drift Ice Zone

The zone of drift ice and icebergs exists as though it were a continuation of the Antarctic continent to the north on the ocean side. Its climate is particular: the sky is covered almost constantly with low clouds, fog is formed above the ice, and supercooled rain falls frequently. The character of precipitation is both frontal and convective, within unstable air masses. Convection precipitation falls from Antarctic Cb /cumulonimbus/, distinguished by a small vertical development of approximately 1.5 to 2 km. The total annual precipitation here is greater than on the shore.

The climatic conditions of the drift ice zone during the summer season have been studied on the basis of the data of various naval expeditions, and the first climatic maps have been drawn up. In particular, the temperature of the air here remains constantly at approximately zero.

The amount of data which has been accumulated on the characteristics of the cold period still is small. Because of this, ice surveys have been conducted monthly during both the winter and summer by aircraft flying from the shore to the edge of the ice within the area of the Davis Sea, and meteorological observations have been made during these air surveys.

The slope winds extend from the shore for a distance of a few kilometers, at the most, over the sea. Because of this, in the event of calm weather it is colder on the drifting ice fields than on the shore. However, as the edge of the ice is approached we meet a zone of sharp rise in temperature, dense, low clouds, occasionally blending with low fog, snowfall or supercooled rain. Cutting through this zone, which is approximately 100 km thick, we enter another, warmer air mass with temperatures above -10 degrees, with a temperature of approximately -20 degrees on the shore. This zone is the Antarctic front. It may be contrasting or diffuse, depending upon the general synoptic condition. Toward the end of winter the edge of the ice moves up to 800 km from the shore.

The Zone of Open Antarctic Waters

In the preceding climatic zone the annual changes in the course of weather depends to a great extent upon the seasonal movement of the edge of the ice toward the north or back toward the south. Because of this the northern boundary of the drift ice climate may be taken as the extreme (farthest removed from the shore) position of the edge of the ice in winter.

The water of the ocean, nowhere covered by ice, goes even farther north. The climatic characteristics of this zone, lying south of the end of the subtropic anticyclones, are determined primarily by the fact that the underlying surface here is the water of the open ocean. Furthermore, as it is known, these are the stormy latitudes of the southern hemisphere, with their misty and bad weather. The line of Antarctic convergence, constituting a remarkable physico-geographical border, must serve also as the northern boundary of the climatic zone of the open Antarctic waters. ("Climatic Zones of East Antarctica and the Southern Ocean" by V. A. Bugayev, Meteorologiya i Gidrologiya, No 3, 1960, p 3-10)

Figure Appendix for Chapter IV Arctic and Antarctic

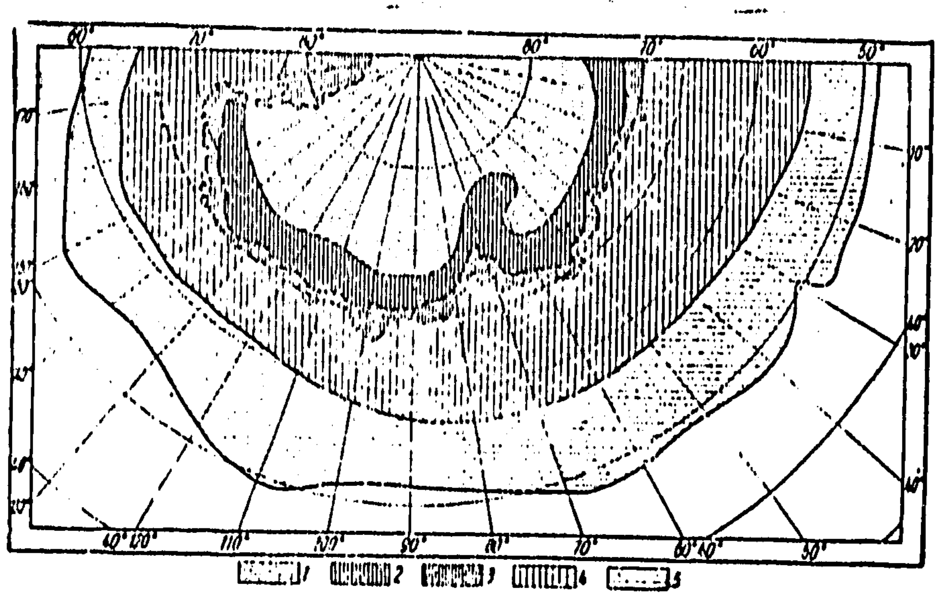

Figure 1. Climatic Zones of East Antarctica and the Southern Ocean; 1 -- Antarctic Plateau; 2 -- Antarctic slope; 3 -- Antarctic shore; 4 -- drift-ice zone; and 5 -- zone of open Antarctic waters.

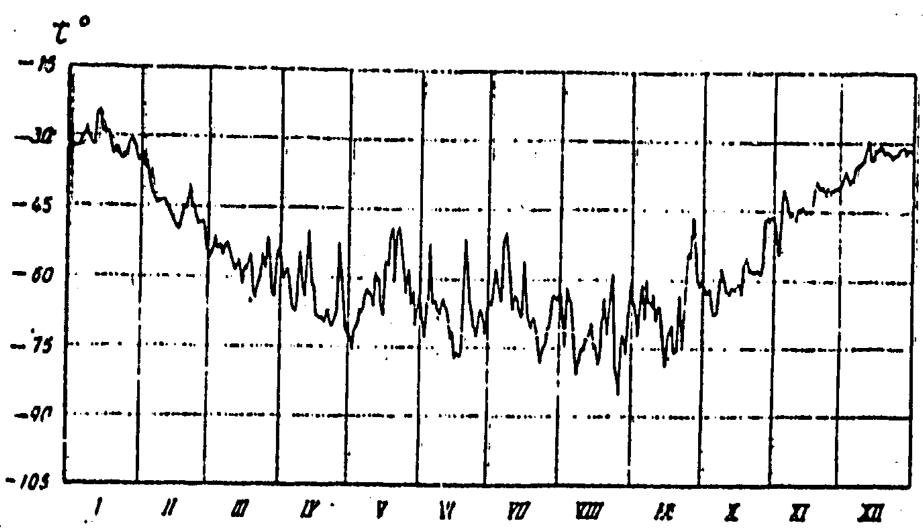

Figure 2. Annual range of mean diurnal air temperatures at Station Vostok.

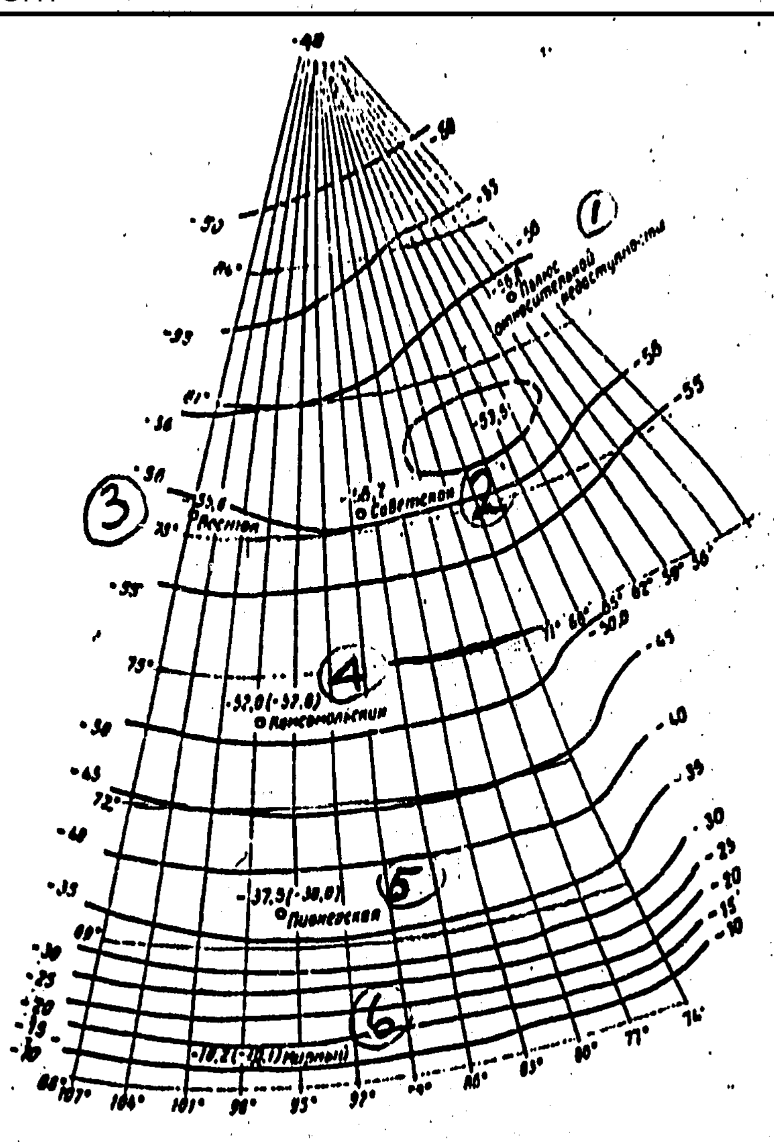

Figure 3. Mean annual air temperatures (after Kh. Ya. Zakiyev). Legend: 1 -- Pole of relative inaccessibility; 2 -- Sovetskaya; 3 -- Vostok; 4 -- Komsomolskaya; 5 -- Pionerskaya; 6 -- Mirnyy

V. METEOROLOGY

Fog Dissipation by CO_2 Seeding

A brief article in Ogonek describes a demonstration of CO_2 seeding of a fog bank to clear an airport. The CO_2 apparatus, mounted in a large aircraft, was made by associates of the GVF Scientific Research Institute under the direction of A. V. Tarasov, and consisted of a meteorograph, recording air temperature, atmospheric pressure and humidity, and an apparatus including liquid-CO_2 bottles.

The fog, described as a menace to the regular operation of air lines, in this case apparently was a supercooled fog. The seeding from an aircraft took 30 or 40 minutes, during which time the aircraft flew a great "S-" shaped course within an area of 100 square kilometers. Precipitation occurred rapidly in a zone 1-1/2 kilometers wide on each side of the line of flight, cutting a swath out of the fog where the aircraft had passed. A "lower sun" is seen shining from beneath the fog. This is explained as a reflection of the sun by snow crystals formed from droplets of water comprising the supercooled fog. The aircraft landed at the same airfield, which now had been cleared of fog. ("Sun in the Fog," by A. Golikov, Ogonek, No 6, 1960, p 31)

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