JPRS 81552

17 August 1982

USSR Report

SPACE

No. 17

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service (NTIS), Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semimonthly by the NTIS, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service (NTIS), Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semimonthly by the NTIS, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

JPRS 81552

17 August 1982

USSR REPORT

SPACE

No. 17

CONTENTS

MANNED MISSION HIGHLIGHTS

Chronology of 'Salyut-7' Flight..... 1

New Features of 'Salyut-7' Station..... 6

SPACE SCIENCES

Achievements of 'Cosmos' Satellites..... 9

Further Commentary on Accomplishments of 'Cosmos' Satellites.... 13

Effect of Fluctuations in Atmospheric Density on Accuracy of Determination and Prediction of Artificial Earth Satellite Orbits..... 17

Attainability of Asteroid Belt During Pulsed Flights From Artificial Earth Satellite Orbits With Maneuvers Near Mars or Jupiter..... 18

Features of Electron Spillage at Magnetically Conjugate Points..... 18

Energy Electron Pulsations in Earth's Magnetosphere..... 19

Modulation of Cosmic Rays by High-Speed Solar Wind Flows, Based on Measurements Made by 'Prognoz-3' Satellite and 'Mars-7' Automatic Interplanetary Station in January 1974..... 19

Three-Dimensional Beam Trajectories of Low-Frequency Electromagnetic Waves in Earth's Magnetosphere..... 20

Observation of Electrons With $E \geq 10^{12}$ eV in Primary Cosmic Radiation..... 20

Possible Mechanism of Transverse Acceleration of Ions in Auroral Region..... 21

Solar Wind Flows Arising Because of Planetary Gravitation..... 21

Runge-Kutta Process of High Orders and Stabilizing Transformations in Artificial Earth Satellite Motion Prediction Problems..... 22

Measurement of Electrostatic Fields and Pulsed Electromagnetic Noise on 'Raduga' Satellite..... 22

Perturbed Satellite Motion Relative to Its Center of Mass Located at a Triangular Libration Point..... 23

Evolution of Ensemble of Gas Bubbles in Fluid Under Weightlessness Conditions..... 23

Inner Zodiacal Light From Photographs Taken on Board 'Salyut-6' Orbital Station..... 24

INTERPLANETARY SCIENCES

Commentary on First Results From 'Venera-13' and 'Venera-14'.... 25

'Venera' Mass Spectrometer Data on Atmospheric Composition..... 30

Iron in Venusian Clouds..... 34

Optical Properties of Venusian Atmosphere and Radiative Heat Exchange..... 35

Spectroscopic Evaluation of Carbon Monoxide Content in Upper Atmosphere of Mars..... 36

Change With Solar Activity of Photoionization Rate Coefficients of Neutral Components in Upper Atmospheres of Planets..... 36

Megarelief on Visible Side of Moon..... 37

LIFE SCIENCES

Cybernetic Analysis of Cardiac Rhythm of 'Salyut-6' Orbital Station Crew During Graded Exercise Test..... 38

Combined Rehabilitation and Therapeutic Measures in Space Medicine..... 45

Cooperative Effort Suggested for Research on Extraterrestrial Life..... 52

SPACE ENGINEERING

Notes on 'Cosmos' and 'Proton' Launchers..... 55

Low-Thrust Engines for Spacecraft..... 58

Prospects for Power Engineering in Space..... 62

Space Antennas..... 71

Lunar Radiointerferometer..... 75

Multiple Gyropower Systems..... 75

Optimum Braking of Initial Rotation of Satellite-Gyrostat With Flywheel Motors..... 76

Optimum Stabilization of Steady-State Motions of Spacecraft, Located at Triangular Libration Point, Relative to Its Center of Mass..... 76

Detecting Systematic Error in Range Measurements When Controlling Spacecraft Rendezvous..... 77

Gyrohorizon Compass Type Systems on Board Spacecraft..... 77

One Problem of Pulse Stabilization With Time Lag..... 77

Calculating Characteristics of Gamma-Ray Telescopes With Aperture Coding..... 78

SPACE APPLICATIONS

Satellite Systems for Marine Rescue..... 79

Possibility of Using Results of Remote Sensing From Space To Interpret Spatial Distribution of Seismicity (on Example of Anatolia-Armenia-Iran Region)..... 81

Danube Delta Dynamics Study Using Satellite Photographs..... 81

Development of Shore Relief of Gulf of Riga From Results of Analyzing Satellite Images..... 83

Study and Mapping of Agricultural Land Use From Satellite Images..... 84

Mapping of Forest Vegetation by Means of Satellite Images..... 85

Study of Anthropogenic Influence on Natural Environment From Multiband Scanner Image Data..... 86

Study and Mapping of Erosion Relief of Kalach Upland From Multiband Scanner Images..... 87

Satellite Images Obtained by Means of 'Fragment' System as Basis of Landscape Mapping and Physical Geographical Zoning of Arid Lands..... 88

Regularizing Solution of Problem of Determining Coordinates of an Object From Satellite Doppler Observations..... 89

Investigation of Small Deformations of Moving Objects According to Stroboscopic Surveying Images..... 89

Modeling and Analysis of 'Optical Instrument + Natural Medium' Physical System During Aerospace Surveying of World Ocean Water Areas..... 90

SPACE POLICY AND ADMINISTRATION

Militarization of U.S. Space Program Alleged..... 91

Commentary on U.S. Space Policy and Programs..... 94

LAUNCH TABLE

List of Recent Soviet Space Launches..... 104

MANNED MISSION HIGHLIGHTS

CHRONOLOGY OF 'SALYUT-7' FLIGHT

[Editorial Report] The Soviet News Agency TASS reports the following information on activities connected with the flight of the "Salyut-7" space station:

11 Jun

The first month in orbit for cosmonauts Berezovoy and Lebedev is ending. Over the past four weeks the crew have performed a large amount of planned work to bring the "Salyut-7" station into manned flight regime and they have unloaded the "Progress-13" transport ship. One of the important stages in the planned program has been work with the improved autonomous navigation system "Del'ta". This system makes it possible to determine automatically and with high accuracy the trajectory parameters of the orbital complex and to issue commands for performance of necessary dynamic operations. The system also has regimes connected with display of results of observations and photo surveys according to time and location. The autonomous navigation system significantly improves the crew's work productivity and makes possible more efficient use of fuel, electrical energy and the service life of the station's on-board equipment. Today the crew will use the "Del'ta" system to perform a number of astrophysical studies requiring highly accurate orientation and stabilization. Experiments on cultivation of higher plants are continuing. The cosmonauts are observing plant development, orientation, leaf, color and other features. Tommorrow the crew will have a day of rest. (Moscow PRAVDA in Russian 12 Jun 82 p 1)

15 Jun

Today's schedule includes astrophysical studies using the "Del'ta" autonomous navigation system, biological experiments, visual observations of the ocean and physical exercises. Along with this, the cosmonauts are stowing and checking the scientific equipment which will be used for joint research with the visiting international crew which will include a French cosmonaut. In order to evaluate atmospheric parameters in the immediate vicinity of the station and to study earth's atmosphere and ionosphere the "Astra-1" mass spectrometry apparatus was activated yesterday. Measurements are made with sensors installed at different levels on the external surface of the "Salyut-7" station. (Moscow PRAVDA in Russian 16 Jun 82 p 1)

18 Jun

In preparation for upcoming work with the Soviet-French crew the cosmonauts have installed and checked apparatus for physico-technical and biological experiments. Today they are installing and checking a new technological unit. As compared to the earlier unit the new one has larger dimensions for the electro-thermal chamber and it is equipped with devices for recording temperatures in different zones of the furnace. In the course of the day the cosmonauts will perform a number of stipulated maintenance operations and will do physical exercises. An orbital correction maneuver is planned for tomorrow. (Moscow PRAVDA in Russian 19 Jun 82 p 1)

22 Jun

Cosmonauts Berezovoy and Lebedev are in the 41st day of their flight. They are finishing up preparations for joint work with the Soviet-French crew. Tomorrow will be devoted to medical exams. In particular, there will be studies of the cosmonauts' cardiovascular systems under physical loads and a series of experiments to evaluate the sanitary and hygienic conditions on the station. (Moscow PRAVDA in Russian 23 Jun 82 p 1)

24 Jun

At 2030 hours Moscow time on 24 June the "Soyuz T-6" spacecraft was launched in the Soviet Union. The international crew consists of USSR Pilot-Cosmonaut Vladimir Dzhanibekov, Flight-Engineer USSR Pilot-Cosmonaut Aleksandr Ivanchenkov and Cosmonaut-Researcher citizen of the Republic of France Jean-Loup Chretien. The flight program calls for docking with the "Salyut-7"--"Soyuz T-5" complex and performance of joint studies and experiments with cosmonauts Berezovoy and Lebedev who have been in orbital flight since 13 May. (Moscow PRAVDA 25 Jun 82 p 1)

25 Jun

By 1300 hours Moscow time "Soyuz T-6" had completed eleven revolutions of the earth. The working day for the crew began at 1100 hours. After an orbital correction the orbital parametes of "Soyuz T-6" are: apogee, 277 km; perigee, 248 km; period of revolution, 89.6 minutes; inclination, 51.6 degrees. (Moscow PRAVDA in Russian 26 Jun 82 p 1)

At 2146 hours Moscow time on 25 June the "Soyuz T-6" spacecraft docked with the "Salyut-7"--"Soyuz T-5" complex. The on-board systems of "Soyuz T-6" "Salyut-7" carried out the mutual search, rendezvous and docking. Both crews worked smoothly and with complete mutual understanding. (Moscow PRAVDA in Russian 26 Jun 82 p 1)

26 Jun

At 0100 hours Moscow time on 26 June after checking the docking seal the crew of "Soyuz T-6" transferred to the "Salyut-7" orbital station. Over

the next seven days the cosmonauts will carry out a wide-ranging scientific program prepared by scientists of the Soviet Union and France. Plans include medico-biological, technological, and astrophysical experiments as well as studies of the earth's atmosphere and photography of individual regions of earth's surface and the oceans. (Moscow PRAVDA in Russian 27 Jun 82 p 1)

The working day aboard the orbital complex began today at 1300 hours and will last until 2400 hours Moscow time. During the joint flight the visiting crew will conduct the planned Soviet-French experiments. Cosmonauts Berezovoy and Lebedev will assist them and perform the required operations to orient and stabilize the orbital complex. Today the visiting crew will perform medical studies. In particular, evaluations will be made of changes in the cosmonauts' cardiovascular systems during adaptation to weightlessness. The French-made "Echograph" apparatus will determine indices of heart function, rate of blood flow in the vessels and their geometric dimensions. These studies will be performed a number of times during the joint flight. The "Poza" (Posture) experiment will study the interaction of sense organs and the motor system of the organism providing for spatial orientation and movement. In the course of this study the bioelectric activity of the muscles maintaining body stability will be recorded. Today's schedule also includes a material processing experiment in the "Kristall" unit, determination of parameters of the atmosphere near the orbital complex and a television report. (Moscow PRAVDA in Russian 27 Jun 82 p 1)

27 Jun

Today the crew members are continuing medical studies on the state of the human organism in weightlessness. Another cycle in the "Echograph" and "poza" experiments will be performed. Acuity, depth of vision and sensitivity of the visual analyzer will be checked. To study possibilities for normalization of blood circulation in weightlessness the visiting crew is using the specially developed "Braslet" (Bracelet) prophylactic device. In the program of space materials processing the "Kalibrovka" (Calibration) experiment will be performed today. This experiment determines the temperature field of the electric heating furnace in various work modes with simultaneous recording of the micro-accelerations acting along the axis of the station. Today's schedule also includes motion picture and still photography of the joint activity and a television report on the work being performed. (Moscow PRAVDA in Russian 28 Jun 82 p 1)

28 Jun

The visiting crew of Dzhanibekov, Ivanchenkov and Chretien are in their third day aboard the orbital complex. Today the cosmonauts began the "Piramig" and "PCN" experiments the aim of which is to study the earth's atmosphere, the interplanetary medium and galactic and extra-galactic sources of radiation. These joint experiments are being conducted with the use of photo equipment developed by French specialists. The visiting crew has completed another cycle of studies on the cardiovascular system and vision during adaptation to spaceflight conditions. In the program of space materials studies the "Kristall" unit will be used for an experiment to determine diffusion coefficients of copper and lead in weightlessness.

Ampules with the initial substances were prepared by French scientists. In the evening two television sessions will be devoted to a press conference with the international crew for Soviet and foreign correspondents. (Moscow TASS in English 1016 GMT 28 Jun 82)

29 Jun

In one of the first radio communication sessions today the cosmonauts reported that they had completed the latest cycle of studies to evaluate changes in the human system of control of movement in weightlessness and that they had started the "Cytos-2" biological experiment which was prepared by Soviet and French specialists. The aim of this experiment is to study the activity of microorganisms in spaceflight conditions and the effect of various antibiotics on them. A large part of the flight program is devoted to experiments with the "Piramig" and "PCN" apparatus. Here there are two main areas of study: study of earth's atmosphere and interplanetary space and astrophysical study. Today, in particular, radiation of weak galactic and extragalactic sources will be recorded on highly sensitive film. Observation of such sources from earth is difficult because of atmospheric interference. The "Kristall" unit will be used for a technological experiment called "Likvatsiya" (Liquation) to study the effect of capillary forces on the structural formation of an alloy of aluminum and indium, two metals which do not mix in normal terrestrial conditions. The experiment is of practical interest for obtaining new composition materials composed of elements with substantially different densities and melting temperatures. (Moscow IZVESTIYA in Russian 30 Jun 82 p 1)

1 Jul

During the visiting crew's fifth day aboard the orbital complex the cosmonauts performed a scheduled cycle of astrophysical research with the "Piramig" and "PCN" apparatus. The apparatus was calibrated by the sun before beginning photography in the shadow section of an orbit. The "Del'ta" autonomous navigation system was used to orient and stabilize the complex. Medical and biological experiments are also continuing. The "Echograph" apparatus was used to examine the cosmonauts' cardiovascular systems with ultrasound. Sensitivity of microorganisms to various antibiotics was evaluated in the "Cytos-2" experiment. In the "Microbe Exchange" experiment features of microflora formation were studied during the occupancy of the station by the two crews. In the evening another melt is planned in the "Kristall" unit as part of the "Likvatsiya" experiment. At present the parameters of the orbital complex are: apogee, 307 km; perigee, 281 km; period of revolution, 90.3 minutes; inclination, 51.6 degrees. (Moscow PRAVDA in Russian 1 Jul 82 p 1)

2 Jul

At 1821 hours Moscow time on 2 July after successfully completing the program of joint studies and research aboard the orbital complex, the international crew of cosmonauts Dzhanibekov, Ivanchenkov and Chretien returned to earth. Cosmonauts Berezovoy and Lebedev are continuing work

aboard "Salyut-7". The "Soyuz T-6" descent craft landed in the scheduled area 65 kilometers northeast of the city of Arkalyk. The cosmonauts felt well after the landing. The cosmonauts completely fulfilled the scientific and technical program prepared by specialists of the Soviet Union and France. In the medical and biological program new information was obtained on adaptation of the human organism to weightlessness. In the continuing flight of "Salyut-7", cosmonauts Berezovoy and Lebedev will continue the experiments developed by Soviet and French scientists. The successful completion of the flight of this international crew with the participation of a French cosmonaut is an important step in the fruitful cooperation of the Soviet Union and France for the peaceful conquest of space in the interests of both countries. (Moscow PRAVDA in Russian 3 Jul 82 p 1)

CSO: 1866/124-P

NEW FEATURES OF 'SALYUT-7' STATION

Moscow IZVESTIYA in Russian 18 May 82 p 3

[Article by B. Konovalov, special correspondent, Flight Control Center: "A Trip Through the 'Salyut-7'"]

[Text] These are busy days right now for Anatoliy Berezovoy and Valentin Lebedev. They have things to do, just like anyone else who has moved into a new home. However, their new home is in space and has "built-in furniture," but, in the first place, keeping house is a little more complicated than on Earth and, in the second, at the cosmodrome all the station's "furnishing" were placed in a special travel position so they could withstand the overloads and vibrations that are inevitable during injection into orbit. Now the crew has to put everything in its proper working position. It takes a lot of time to "revive" a station's systems and check their fitness for operation. The station is new and this is the first crew to work in it. It is on them, naturally, that the main load falls as far as making this home in space livable is concerned.

In Zvezdnyy Gorodok not long before the launch, Anatoliy Berezovoy spend half an hour after a training session to acquaint me with the terrestrial twin of the new "Salyut" station so that the readers of IZVESTIYA could take a mental trip around the new orbital "house."

"From the outside our station looks just like its predecessor," says Anatoliy Nikolayevich, "but on the inside many of the systems have been improved and the observations of all the crews that worked in 'Salyut-6' have been taken into consideration. Let's begin our inspection with the station's transfer compartment. After the hatches are opened, Valentin Lebedev will immediately float in here with a light and our watch on board the 'Salyut' will begin. For the crew the transfer compartment is the best place for making both instrument and visual observations. When the space complex is flying under so-called gravitational stabilization--vertically to the Earth--a cosmonaut has almost a full 360° view through the compartment's seven windows. Instruments can be 'stuck onto' the windows and investigations can be carried out. There are several working places with small portable tables where we can put documents, navigational maps, replaceable lenses, pencils--in short, everything needed to carry out experiments. There are facilities for holding all these things down, as well as the cosmonaut himself. There are two control knobs: on the left side, in case we are looking toward the bow of the station (from now on, we will use 'left' when we mean this side), and one on the ceiling. They enable a cosmonaut who is conducting an investigation to control the station himself, without any help from his comrade, and orient it in any way necessary to carry out an experiment."

As was the case with the preceding station, from the transfer compartment the crew can venture out into open space. Pressure suits for this purpose are stored here, and there is also a system for testing them.

In contrast to the "Salyut-6," however, the crew can now take advantage of some of the features of outer space without leaving the station. Two of the windows in the "Salyut-7" are transparent to ultraviolet light; this enlarges the station's investigative arsenal, protects against the possibility of the development of pathogenic bacteria carried along from Earth and--which is most pleasant for the crew--enables the cosmonauts to get a tan in space as if they were on a Black Sea beach. As experience has shown, on a spaceflight no comfort is ever excessive.

One of these ultraviolet-transparent windows is in the transfer compartment, while the other is in the main working compartment. All of the station's other "ports" also differ from those in the "Salyut-6." As the experience gained during the course of the long expeditions demonstrated, the windows on that station gradually lost their transparency. Scratches appeared, along with tiny craters caused by the impacts of micrometeorites. Dust accumulated on the inside, while products from the combustion of fuel in the engines gathered on the outside. In order to eliminate this flaw, the insides of the windows are now covered with very thin removable pieces of glass. When accurate instrument observations are needed, they are taken off and the work begins. Several of the windows are fitted with transparent outer covers that are driven electrically. When needed for an experiment, the covers retract at the simple push of a button; the covers remain in place the rest of the time in order to prevent contamination of the actual window glass.

"And now let's go into our main working compartment," Berezovoy suggests. "The entire station consists of three cylinders of increasing diameter. The smallest is the transfer compartment, while the other two are working compartments that are joined together by a conical connector. In front of the stern docking unit there is also a small 'transfer lock,' but in contrast to the longer bow compartment it is used primarily for housekeeping purposes."

As before, immediately behind the transfer compartment we find the station's main control point. To the left is the commander's seat and to the right--the flight engineer's. However, these are not large, strong couches. They are light and removable seats of the bicycle type that are set up in the working position only after the crew enters the station.

To the right of the flight engineer's seat is the control panel for the "Del'ta" cybernetic system. On the "Salyut-6" it was used experimentally, but now it is the standard station control system; it enables the crew to do much more work in the automatic mode, according to assigned programs.

All of the panels are now covered with gratings so the crew will not brush against them when floating around inside the station. Around the bottom of the main panel's entire perimeter there is a rubber cord under which a cosmonaut can place his legs so as not to float around in weightlessness. Generally speaking, everywhere along the walls there are many rubber tapes, pouches and shelves for the convenient storage of all the documents needed. There are many "sockets" for portable working tables and lights. On the whole, the station has become more comfortable and convenient as far as the crew is concerned.

A glance around the working compartment tells us that the main apparent change from the "Salyut-6" is the replacement of the "hero" cloth that was used to trim all the panels and walls with washable leather. The left wall is painted apple green and the right one beige, while the ceiling is white. All the panels covering the station's service systems and life support units are easily removed. The fans are less noisy and are equipped with dust collectors. In addition to these, there are also special replaceable dust collectors.

As before, the center of the main part of the working compartment is occupied by a cone-shaped block of scientific equipment. In contrast to the "Salyut-6," however, instead of a submillimeter telescope it contains a complex of X-ray equipment for extra-atmospheric investigations.

The two airlocks that were located in the stern, behind the X-ray telescope, have now been standardized. Each of them can be used either for dumping garbage or for conducting experiments requiring a vacuum.

"As before, we will have at our disposal a veloergometer and a complex physical training unit. Every day we will run and pump the pedals so as not to yield to the lure of the 'easy life' in weightlessness," says Anatoliy Berezovoy with a smile as our quick tour comes to an end.

Now, however, weightlessness has become a permanent, invisible companion for both him and Valentin Lebedev, and it will not leave them until the very end of their orbital flight. They are testing "Salyut-7" and weightlessness will be testing them.

Soon after "Soyuz T-5" docked with "Salyut-7," we met one of the station's creators in the Flight Control Center. We asked Professor K.P. Feoktistov, Hero of the Soviet Union, to tell us a little about it.

"It is a natural continuation of the 'Salyut-6," said Konstantin Petrovich, "a further development and improvement of it. The experience of the unprecedentedly long operation of the 'Salyut-6,' the flight of which has last for more than four and one-half years, gave much to cosmonautics. And I should mention here that even now it is still in working condition. 'Kosmos-1267' is now docked with it and tests of the complex that are very important for the future of cosmonautics are being conducted. We will continue to work with "Salyut-6," and at the end we intend to test it in modes we wouldn't dare to use under normal conditions. But, of course, our basic attention will now be focused on 'Salyut-7.'"

"If I were to attempt to describe all the improvements made in this station, the word would be 'modernization.' It applies to very many of the station's systems. Given the same dimensions and station configuration, we tried to improve its basic technical parameters, make it more comfortable for cosmonauts to live and work in, enlarge the amount and capabilities of the scientific equipment, and plan a series of important technical investigations that will be needed for the creation of future equipment for use in space. The flight program is a full and interesting one. We hope that 'Salyut-7' will serve Soviet cosmonautics and science throughout the world quite well."

11746
CSO: 1866/106

ACHIEVEMENTS OF 'COSMOS' SATELLITES

Moscow PRAVDA in Russian 23 Mar 82 p 3

[Article by A. Maksimov and B. Pokrovskiy, scientific workers, command and measurement complex: "The 'Cosmos' Satellites Do Work"]

[Text] Many specialists remember the time when we began to prepare a space program involving the launching of a whole series of satellites. The program was impressive for the depth and extensiveness of the research it encompassed, the novelty and diversity of the scientific equipment carried by the satellites, and the number of satellites that were launched. In 2 years it was planned to launch into near-Earth orbits twice as many spacecraft in the new series alone as had been launched during the preceding 5 years. In addition to everything else, this required command and measurement systems with a large traffic capacity, high accuracy and a high information content. By the beginning of 1962, such systems had been created and installed at the measuring points.

The launching of the first tens and then hundreds of satellites in the "Cosmos" series confirmed the scientific validity of the technical decisions realized in these command and measurement systems, the techniques for using them and the prospects for their further utilization. Put into operation more than 20 years ago, after modernization these systems have served faithfully and correctly up until the present.

Another important step was the development and organization of the series production of the two-stage "Cosmos-RN" launch vehicle, which has been used to launch many hundreds of scientific satellites, and the standardization of the satellites' on-board equipment and design. Just as bodies for different purposes are mounted on monotypical motor vehicle chassis, scientific instruments for widely differing types of investigations are mounted in these "space chassis."

However, the diversity of this research does not, of course, make it possible to have total standardization of the "space chassis." At the present time there are a number of types of designs: a nonorientable satellite with chemical power sources for projects of short duration and solar batteries for long-term functioning in orbit, and satellites that can be oriented on the Sun or the Earth. When the conditions of experiments require that biological objects, scientific materials, instruments, test samples and so forth return to Earth, a "chassis" with a descent vehicle (or capsules), a braking engine and a parachute system ("Cosmos-110, -782, 936" and others) is used.

Most of the satellites in this series are launched by separate launch vehicles. In a number of cases, however, a single rocket lifted into orbit two, three, five and even seven satellites. The satellites do not always operate for the same length of time, either. For example, "Cosmos-27" required only 1 day to carry out its program, whereas its colleague No 80 will, according to ballistics, fly "silently" around our planet for 100 centuries. The inclinations of the planes of the "Cosmos" satellites' orbits to the equator also differ, ranging from 48.4° to 83°. The space "field" worked by these tillers of science is a large one: "Cosmos-918," for example, plowed it at distances of 131-265 km from the Earth's surface, Nos 1030 and 1261 flew at altitudes of 600-40,000 km and No 159 entered a virgin area of space at a distance of 60,600 km above our planet.

During each revolution the satellites "absorb" a mass of extremely interesting "impressions" from what is seen and heard by their on-board instruments. In order to share this information, in some cases a "Cosmos" initiates a "conversation" with Earth on command from its on-board temporally programmed devices, while in other cases the conversation is begun by a request from Earth. It goes without saying that all of these "talks" are conducted when the satellites pass into the zones of radio visibility of ground stations in the command and measurement complex. However, if scientists need to obtain operational information from a "Cosmos" flying over regions of the USSR where there are no stationary tracking facilities, airborne measuring points are sent into these areas. They can receive information both when they are on the ground and in the air. When needed, as specified by the flight program, expedition ships belonging to the USSR Academy of Sciences can also communicate with "Cosmos" satellites.

What are the fields and results of the investigations and experiments carried out over the last two decades with the help of "Cosmos" satellites? They are so variegated and grand in scope that to answer this question briefly is practically impossible. We will present only a few illustrations. The study of processes occurring in near-Earth space and their dependence on solar activity, the time of the year and even the time of day made it possible to draw some important conclusions. For instance, measurements made by the "Cosmos-7" made it possible to evaluate the radiation situation before the flights of the third and fourth "Vostok" ships, in which A.G. Nikolayev and P.R. Popovich made the first group flight in history. "Cosmos-4, -5 and -17" registered additional radiation that appeared after the nuclear explosion of the American atomic "Sea Star."

The study of processes taking place on the Sun and the possibility of using the information as a basis for predicting the safety of manned flight beyond the Earth's atmosphere was a matter of considerable practical importance. For this purpose, "Cosmos" satellites have been sent on solar patrol more than once (Nos 166 and 230, for example). Their colleagues, Nos 135 and 163, disproved once and for all the old hypothesis of the existence of some sort of dust cloud around our planet.

So-called ionospheric disturbances have a great effect on radio wave propagation. In order to make the correct selection of radio frequencies insuring reliable communication, it is necessary to make a thorough study of the ionosphere's "habits." Here, also, the "Cosmos" satellites were of assistance, particularly those set up as ionosphere probes ("Cosmos-381" and others).

Seasonal variations in the ionosphere were investigated with satellites launched at different times of the year: "Cosmos-261" flew in the winter and "Cosmos-348" in

summer. It is possible to adapt somehow to seasonal variations in the ionosphere, but to adapt to flares (particularly strong ones) on the Sun it is more difficult. Communications people have obviously not forgotten 2 September 1967, when radio communication on our planet was disrupted almost totally for 2 hours because of a powerful flare on the Sun.

"Cosmos" satellites have also served astronomers quite well, particularly those in the youngest branch of one of the most ancient sciences: extra-atmospheric astronomy. The main objects it investigates are the medium between the planets, stars, galaxies, hot and neutron stars and quasistellar and other cosmic objects. They radiate most intensively in the ultraviolet and X-ray bands. These waves cannot overcome the thickness of the Earth's atmosphere, so the lifting beyond its boundaries of astronomical instruments and tools became one of the most effective and promising achievements of astronomy.

Various optical and electronic instruments functioned on board many "Cosmos" satellites (Nos 215, 262, 264, 461). With their help it was possible to observe the emissions of hot stars and gamma-ray bursts (mysterious echoes of gigantic flares of as yet unexplained origin) and to "feel around" for proposed places of accumulations of intergalactic gas, which--in the opinion of some scientists--may contain the main part of the matter in the Universe.

With the help of "Cosmos" satellites, scientists learned much about the effect of spaceflight factors on biological objects, ranging from single-celled algae, plants and seeds ("Cosmos-92" and others) to dogs and other animals ("Cosmos-110, -605, -690, -782, -936").

Satellites in the "Cosmos" series also became a unique scientific testing ground for the development of space technology elements and entire systems. In this respect, the most memorable events were the completely automatic docking, undocking and landing on Earth that were performed brilliantly by two pairs of satellites (Nos 186 and 188 and Nos 212 and 213).

An important step in the improvement of space technology was the experimental flight of the "Cosmos-1267," which was injected into a near-Earth orbit on 25 April 1981. It docked with the "Salyut-6" station on 19 June. This was the 35th docking at the station during its unprecedented flight, which has now lasted for nearly 4 1/2 years. During the voyage of this new modification of the satellite, the designers and testers received essential information that will assist them in their future work on space technology.

Tests of new technological elements on board "Cosmos" satellites have also had a direct effect on the development of ground command and measurement facilities. For instance, the results of tests of a laser on "Cosmos-97" contributed to an improvement in the accuracy of common-time equipment, the sensitivity of receivers and the radio wave frequency stability of transmitters. A substantial improvement in the reliability of both ground and space equipment was facilitated by experiments conducted on board "Cosmos-140 and -213" with instruments utilizing the phenomenon of superconductivity. On-board equipment elements that were tested on "Cosmos-47" were used successfully in the "Molniya" satellite-repeaters. The experience amassed during work done with "Cosmos-23, -122, -144, -156, -184, -206" also proved to be extremely valuable during the creation of the "Meteor" satellites and the Soviet space weather service as a whole.

The reception by the "Cosmos-243" of the thermal radio-frequency emissions of our planet and its atmosphere gave us information on the distribution of moisture in the atmosphere and the temperatures in the world ocean, and also made it possible to draw up a map of the Antarctic ice, regardless of whether its boundaries were covered by clouds or not. Temperature and optical irregularities on the water's surface, along with wave action and storms--a very important matter for meteorology and navigational safety--were investigated with the help of oceanographic satellites (Nos 1076 and 1151).

In a word, it is impossible to enumerate all the experiments conducted with the help of those scientific laborers known as the satellites of the "Cosmos" series. They are standing their peaceful watch to study the Universe. "Cosmos" satellites recently began their third decade of service, and they are oriented on the future.

11746
CSO: 1866/63

FURTHER COMMENTARY ON ACCOMPLISHMENTS OF 'COSMOS' SATELLITES

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 82 pp 43-44

[Article by V. Lyndin: "The 'Cosmos' Satellites Serve People"]

[Text] Artificial Earth satellites of the "Cosmos" series are the most numerous family of all spacecraft built by man. Twenty years ago, on 16 March 1962, the day of the launching of the first "Cosmos," a scientific research program utilizing these satellites was announced. Its range was quite broad. For the purpose of economy of resources, the creators of this space technology were forced to achieve maximum standardization of the designs and service systems of this series of ISZ [artificial Earth satellite]. This made it possible to use unified hulls, service systems and systems for controlling the on-board equipment and to change over to series production of the satellites and the completing elements.

The advantages of series-produced spacecraft are obvious. However, it is difficult to create a unified, general-purpose, series-produced satellite, since--depending on the specific program--contradictory demands are frequently made on it. Therefore, there appeared several modifications of the "Cosmos" ISZ's. Two-, three- and four-stage launch vehicles lift the satellites into orbits that are varied in altitude and inclination; this makes it possible to investigate almost every region of near-Earth space. It is also the case that a single launch vehicle can lift up to eight ISZ's at the same time. The time of their active functioning depends on the scientific program for the launch and the resources of the on-board systems. Some "Cosmos" satellites complete only a single orbit around the Earth, while others may last for tens of thousands of years. Some satellites have a descent capsule with a sealed container, which makes it possible to return scientific equipment and objects of investigations to Earth.

"Cosmos" satellites are widely used for the solution of national economic problems. They laid the foundation for the space meteorological service. From ancient times people have striven to find out ahead of time about upcoming natural calamities (hurricanes, typhoons, floods, droughts and so on) so as to be able to take the necessary measures on a timely basis. These efforts are now facilitated by the "Meteor" space meteorology system. Just two of these satellites gather and transmit to Earth in the period of 1 day the same amount of information that all the meteorological stations on Earth produce in half a year.

The first experiment in the television tracking of clouds was carried out with the help of "Cosmos-4" (launched on 26 April 1962). In order that this surveying be

conducted on a 24-hour basis, "Cosmos-45" and other ISZ's had equipment operating in the infrared band. Tests of meteorological satellite equipment were also conducted. In particular, electromechanical devices for orienting and stabilizing equipment while moving in orbit were developed, along with the assemblies and units of a power supply system with solar batteries and chemical power sources. "Cosmos-122" was used to test a system for obtaining satellite meteorological information and using it in the operational weather service. "Cosmos-122" transmitted to Earth images of the cloud, snow and ice cover, parameters concerning the state of the atmosphere and data on the thermal flows emitted into space by our planet.

All of this enabled us to create the "Meteor" experimental space system. It included the specialized "Cosmos-144" and "Cosmos-156" satellites. Since 1969 the meteorological satellites have been recognized as an independent class of spacecraft and have received the name "Meteor."

The weather "kitchen" on our planet is its oceans, over the expanses of which powerful atmospheric vortices, hurricanes and typhoons are born. Soviet scientists were pioneers in the integrated study of the ocean with the help of space technology. The oceanographic satellites "Cosmos-1076" and "Cosmos-1151" were launched for this purpose.

The investigation of the ocean from satellites has its own special features. It differs substantially from the same investigations of the surfaces of the continents. The diversity of colors and shadings on land is incomparably greater than in the ocean plains. As a rule, different natural formations on the continents contrast with each other and have rather clearcut boundaries. Space information about these objects is easily interpreted and correlated geographically. The situation is more complicated in the open ocean, where the contrasts and boundaries are dozens of times more weakly expressed and geographical correlation of the obtained data is more difficult. Therefore, the sensitivity and spectral selectivity of the equipment on oceanographic satellites must be much greater, even though the resolution is lower. Maps of the temperature field of the North Atlantic's tropical zone, obtained by oceanographic satellites, are an important element in long-term weather prediction for the European part of our country.

The readers of this magazine are familiar with the system of long-range space television and telegraph and telephone communication with the remote areas of the Soviet Union, the industrial regions of Siberia, the Far North, the Far East and Central Asia. There, too, the "Cosmos" satellites participated directly. Even the first satellites produced important information about the Earth's ionosphere and its effect on the nature of radio wave propagation in near-Earth space, which enabled us to conclude that an Earth-space-Earth radio link is stable and to select the optimum equipment operation modes. Data obtained by subsequent satellites made it possible to evaluate the effectiveness of different facilities for long-range radio and television communication and determine the most suitable parameters for the orbits of ISZ's with which it was proposed to realize the idea of a Union-wide space communication system. "Cosmos-41" (22 August 1964) became the prototype of the future "Molniya-1" series-produced communication satellite.

A constant object of study for the "Cosmos" satellites was the Earth's magnetic field. They made it possible to carry out a global survey of our planet's entire neighborhood that, moreover, was practically simultaneous, which in principle

cannot be done with ground facilities. Data on variations in the magnetic field are used extensively in prospecting for useful minerals, aviation and marine navigation.

Today, cosmonautics is being used effectively in the fields of investigating and utilizing natural resources rationally and in conserving the environment. The space patrol, which is capable of collecting information about huge areas on an operational basis, is extremely important for forestry and agriculture, the seagoing fishing fleet and geological investigations. Regular flights of specialized satellites, the first of which was the "Cosmos-912" (26 May 1977) are contributing actively to the solution of these problems, along with manned spacecraft and orbital stations. Information from ISZ's arrives at the "Priroda" State Scientific Research and Production Center, where it is processed for practical use. The results obtained during the investigation of the Earth's natural resources from space are used in different branches of the national economies of the USSR and the fraternal countries of the socialist concord.

The anniversary "Cosmos-1000" (31 March 1978) was the first unit in the Soviet-created "Tsikada" space system, which is meant to improve the reliability and safety of marine navigation. The existing navigation systems are not entirely satisfactory as far as the seafarers are concerned. Their operation depends on the weather conditions and, in addition, the information does not always have the necessary accuracy, which for oceangoing ships with a draft of 15-20 m can mean running aground on a shoal.

The first test of the "Cosmos-1000" was the voyage of the atomic icebreaker "Sibir'," which sailed from Murmansk to the Bering Strait together with the diesel-electric ship "Kapitan Myshevskiy." The navigational transmitter in the satellite continuously emitted signals containing information on the parameters of the satellite's motion. They were received and decoded by receiving and computing equipment installed in the icebreaker "Sibir'." The computer then printed out the ship's accurate geographic coordinates.

The "Cosmos" satellites have also played a role in the area of international cooperation. The first satellite in the "Intercosmos" program was "Cosmos-261" (29 December 1968). It was used for an integrated investigation of the Earth's upper atmosphere and the nature of the polar auroras. Scientists from Bulgaria, Hungary, the GDR, Poland, Romania, the Soviet Union and Czechoslovakia took part in these investigations. The experiments were then continued with the "Cosmos-321," "Cosmos-348" and "Cosmos-381" satellites, which were launched in 1970.

"Cosmos" satellites have been and continue to be of assistance to manned cosmonautics. As the duration of manned flights increases, the problems of counteracting the negative factors of the conditions encountered in space acquire more and more importance. In order to solve them, it is necessary to study the mechanism of their effects on the human body in more detail and improve the existing and create new life support systems. "Cosmos" satellites have been used to solve many medicobiological problems. In the first stage, micro-organisms, single-celled plants and the seeds of higher plants were studied. The experiments then became more complicated. The dogs Veterok and Ugolek made a 27-day flight--a record for living matter at that time--on board the "Cosmos-110."

A number of the medicobiological experiments had an international aspect. For instance, the "Cosmos-782" carried biological objects consisting of rats, fish and

roe, plant seeds and fungi. Specialists from Hungary, Poland and Romania also participated in similar experiments. Biological objects were placed in a centrifuge at different distances from the center of rotation, which made it possible to simulate the action of an artificial gravitational field on organisms. In addition to this, the "Cosmos-782" was used to test a system for electrostatic protection against the effect of cosmic radiation that used a high-voltage power source. The program of international biological research using specialized Soviet satellites was further developed with the "Cosmos-936" and "Cosmos-1129" satellites.

The multiplan program for studying space with the help of the "Cosmos" satellites is making it possible to solve extremely important problems related to scientific and technical progress, as mentioned in the documents of the 26th CPSU Congress.

11746
CSO: 1866/65

UDC 521.2

EFFECT OF FLUCTUATIONS IN ATMOSPHERIC DENSITY ON ACCURACY OF DETERMINATION AND PREDICTION OF ARTIFICIAL EARTH SATELLITE ORBITS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 19 Dec 80) pp 803-812

EL'YASBERG, P. Ye.

[Abstract] The author discusses the effect of secular perturbations (which is much greater than that of periodic ones) in the density of the Earth's atmosphere on the orbital period and time of arrival at a given point of artificial Earth satellites in comparatively low orbits (up to 800-1,000 km). Assuming the shape of the orbit and the position of its plane are known with sufficient accuracy, he formulates the problem and then determines the optimum strategy that insures the minimum guaranteed error in the results. Solar activity is one of the most influential factors as far as determination and prediction accuracy are concerned. The optimum duration of the orbital parameter measurement interval depends largely on orbital altitude and solar activity. The author concludes that concentrating the measurements at a limited number of points increases the guaranteed accuracy of the determination of the orbital period by about 30 percent in comparison with a uniform distribution of the measurements. Figures 4; references 7: 6 Russian, 1 Western.
[45-11746]

UDC 629.197.2

ATTAINABILITY OF ASTEROID BELT DURING PULSED FLIGHTS FROM ARTIFICIAL EARTH SATELLITE ORBITS WITH MANEUVERS NEAR MARS OR JUPITER

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 14 Jul 80) pp 835-844

LIVANOV, L. B.

[Abstract] The author discuss the problem of evaluating the energy required for a spacecraft to reach any asteriod having a low-eccentricity orbit from a low artificial Earth satellite orbit, with maneuvers near Mars or Jupiter that can possibly save energy. The acceleration gain achievable by a perturbation maneuver near Mars ranges from 0.4 to 1.5 km/s, while for Jupiter the range in 1.8-4.55 km/s. The author then calculates the energy required to visit certain asteroids during the period 1970-2000, assuming that maneuvers are made near one of the two planets. Figures 3; references 9: 7 Russian, 2 Western.
[45-11746]

UDC 581.521.6

FEATURES OF ELECTRON SPILLAGE AT MAGNETICALLY CONJUGATE POINTS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 3 Feb 81) pp 855-859

GRIGORYAN, O. R. and KUZNETSOV, S. N.

[Abstract] The authors use data gathered by gas-discharge detectors on the "Cosmos-484" artificial Earth satellite, which was in a low (about 220 km), circular polar orbit in April 1972, to study the pitch-angle diffusion that arises because of the interaction of electrons with very-low-frequency radiation from both natural and artificial sources. They find that studying the intensity of electron distribution in the loss cone makes it possible not only to evaluate the particles' lifetimes, but also to determine the effect of various sources on their pitch-angle distribution. For particles with a long lifetime, the effect of back scattering caused by elastic collisions with atmospheric components must be allowed for. The authors conclude that the theoretical constructs that have been formulated for the distribution of intensity in the loss cone are too simplified and do not correspond to the actual conditions. Figures 3; references 10: 5 Russian, 5 Western.
[45-11746]

UDC 551.521.8

ENERGY ELECTRON PULSATIONS IN EARTH'S MAGNETOSPHERE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 17 Apr 80) pp 860-868

KUZNETSOV, S. N., LOPATINA, G. B. and STOLPOVSKIY, V. G.

[Abstract] The authors use data gathered by the "Cosmos-484" (on incident electrons with E_e > 30 and > 300 keV) and "Cosmos-721" (on quasitrapped electrons with E_e > 1.4 MeV) artificial Earth satellites to study pulsations in energy electron intensity. For electrons with E_e > 30 keV, there is a maximum pulsation probability at all hours at latitudes of 64-76°, while for latitudes of 52-58° there are morning and evening maximums. For electrons with E_e > 1.4 MeV, the morning and evening maximums correspond approximately with those for electrons with E_e > 30 keV, while the diurnal and nocturnal maximums occur at lower than auroral latitudes. The authors conclude that none of the hypotheses so far advanced can fully explain all the features of electron pulsation from the viewpoint of both intra- and extramagnetospheric sources, although the plasmopause undoubtedly plays a leading role. Some properties of these pulsations are: an increase in the average pulsation periods as the electrons' energy increases; an increase in the amplitude of the pulsations as the period increases. Figures 9; references 21: 18 Russian, 3 Western.
[45-11746]

UDC 523.165

MODULATION OF COSMIC RAYS BY HIGH-SPEED SOLAR WIND FLOWS, BASED ON MEASUREMENTS MADE BY 'PROGNOZ-3' SATELLITE AND 'MARS-7' AUTOMATIC INTERPLANETARY STATION IN JANUARY 1974

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 3 Nov 80) pp 869-875

VAKULOV, P. V., VOLOGDIN, N. I., KUZHEVSKIY, B. M., SPIR'KOVA, Ye. S. and SHESTOPALOV, I. P.

[Abstract] The authors use data gathered by the "Prognoz-3" satellite and "Mars-7" automatic interplanetary station on electrons with $E \geq 40$ keV and protons with E_p = 1-5 MeV to study changes in galactic cosmic ray intensity. On 14 January 1974, the interplanetary magnetic field's sign changed from negative to positive, whereupon there was an increase in solar wind velocity and the intensity of electron and proton flows, while the intensities of galactic cosmic rays, electrons with $E \geq 40$ MeV and the neutron component decreased. On 24 January the interplanetary magnetic field's sign changed again and the phenomena mentioned above repeated themselves, with the

exception that the intensity of electrons with $E \geq 40$ MeV increased. After a further discussion of the measurement data, the authors conclude that even in a single event, the protons and electrons encountered can have different origins: the Sun, the Earth's magnetosphere, or interplanetary space. Figures 3; references 14: 7 Russian, 7 Western. [45-11746]

UDC 550.388.2

THREE-DIMENSIONAL BEAM TRAJECTORIES OF LOW-FREQUENCY ELECTROMAGNETIC WAVES IN EARTH'S MAGNETOSPHERE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 5 Aug 80) pp 876-883

AKSENOV, V. I. and MOSHKOV, A. V.

[Abstract] The authors present an algorithm for the numerical integration (using a computer) of the system of differential equations describing the three-dimensional beam trajectories of low-frequency electromagnetic waves in the spherically heterogeneous, multicomponent magnetospheric plasma. They then discuss the propagation of low-frequency signals in three-dimensional geomagnetic waveguides in the magnetosphere. They reach the following conclusions: the program based on their algorithm does not impose limitations on the model of the distribution of the concentration of electrons and ions in the magnetosphere and allows the use of both dipole and nondipole models of the geomagnetic field; the effect of departure of a beam from the plane of the magnetic meridian on the characteristics of a low-frequency signal at the point of the wave's arrival is not very great, although longitudinal divergence can lead to signal attenuation in the vicinity of the point of arrival; the form of a beam in a three-dimensional waveguide depends essentially on the waveguide's longitudinal dimension. Figures 4; references 18: 6 Russian, 12 Western. [45-11746]

UDC 537.591

OBSERVATION OF ELECTRONS WITH $E \geq 10^{12}$ eV IN PRIMARY COSMIC RADIATION

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 24 Nov 80) pp 884-888

NYMMIK, R. A.

[Abstract] The author attempts to determine the flow of electrons with $E \geq 1$ TeV in primary cosmic radiation on the basis of information gathered

by a large emulsion stack exposed outside the Earth's atmosphere by the "Intercosmos-16" artificial earth satellite. In addition to the monitorable nuclear photoemulsion stack, the equipment used also included spark chambers, scintillation counters and an ionization calorimeter. After describing the techniques used to determine the nature of the primary particles that were registered and the results of the experiment, the author concludes that the lifetime of a registered electron with E = 3 TeV was about 10^5 years and that its source was less than 1 kps away from the Solar System.
Figures 2; references 6: 3 Russian, 3 Western.
[45-11746]

UDC 537.525.1

POSSIBLE MECHANISM OF TRANSVERSE ACCELERATION OF IONS IN AURORAL REGION

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 18 Aug 80) pp 889-895

ZAKHAROV, A. V., LIPEROVSKIY, V. A. and SHALIMOV, S. L.

[Abstract] Mass spectrometer studies from satellites have revealed the existence in the auroral magnetosphere of significant flows of positive hydorgen and oxygen ions moving upward from the Earth. From the data available, it appears that they are accelerated upward, in a direction transverse to the external magnetic field, at altitudes of 400-500 and 5,000-6,000 km. After discussing the possible mechanisms behind this acceleration, the authors conclude that above the areas of observation of the auroral electrons there probably exist areas of wave electrostatic turbulence with anomalous resistance and a longitudinal electrical field.
References 9: 3 Russian, 6 Western.
[45-11746]

UDC 523.165

SOLAR WIND FLOWS ARISING BECAUSE OF PLANETARY GRAVITATION

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 15 Apr 80) pp 896-901

RESHETOV, V. D.

[Abstract] The author uses published data on the main geomagnetic disturbances observed over a period of 42 years (750 events with intensities greater than 40 A_p units) in an attempt to determine the gravitational effect of the planets on the solar wind. After categorizing the disturbances by factors such as time before and after opposition and degree of solar activity,

he concludes that the planets' gravitational effect in the interplanetary plasma causes the dynamically unstable solar wind to develop a convection sector or arm of rising and falling movements oriented according to the planets' phases and its own magnetic spiral structure. High-speed solar wind flows develop in these sectors because of the plasma's magnetic-hydrodynamic instability. Figures 4; references 5: 4 Russian, 1 Western. [45-11746]

UDC 517.11

RUNGE-KUTTA PROCESS OF HIGH ORDERS AND STABILIZING TRANSFORMATIONS IN ARTIFICIAL EARTH SATELLITE MOTION PREDICTION PROBLEMS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 8 Sep 80) pp 941-944

BORDOVITSYNA, T. V.

[Abstract] The author discusses the results of the application of Runge-Kutta processes of high orders to problems of the numerical prediction of satellite motion, allowing for perturbations, and the effectiveness of these methods for integrating a satellite's classical Newtonian equations of motion and equations of motion stabilized with the help of a Kustaankheymo-Shtifel' transform. Relying heavily on the work of E. Fehlberg on Runge-Kutta processes, she applies that mathematician's algorithms to several model problems of the perturbed motion of a satellite. She finds that the use of Runge-Kutta processes of high order makes it possible to double or triple the accuracy of prediction of the spatial location of a satellite and increase the operational nature of the computations by the same factor in comparison with the fourth-order Runge-Kutta process. Figures 2; references 11: 3 Russian, 8 Western.
[45-11746]

UDC 538.56

MEASUREMENT OF ELECTROSTATIC FIELDS AND PULSED ELECTROMAGNETIC NOISE ON 'RADUGA' SATELLITE

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 23 Oct 80) pp 944-946

GRAFODATSKIY, O. S., DOVGIY, V. I., IGNATENKO, A. G., KNYAZEV, B. N., KOZLOV, A. G., KOCHEYEV, A. A., SOKOLOV, V. S. and OSIPOV, N. K.

[Abstract] The authors describe the results of an experiment conducted on a "Raduga" geostationary satellite, using electrical field sensors and pulsed

electromagnetic noise recorders, to study satellite electrification processes and their relationship to changes in geomagnetic activity. They find that on both quiet and active days there is an increase in the electrical field's intensity in the midnight-morning sector and that an increase in magnetic activity results in an increase in electrical field intensity. As far as pulsed electromagnetic noise is concerned, there is an increase in the midday sector in both quiet and active periods. Figures 3; references 3 (Western).
[45-11746]

UDC 521.401

PERTURBED SATELLITE MOTION RELATIVE TO ITS CENTER OF MASS LOCATED AT A TRIANGULAR LIBRATION POINT

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 58, No 6, Nov-Dec 81 (manuscript received 14 Jan 80) pp 1306-1313

MARKOV, Yu. G., Moscow Aviation Institute imeni Sergo Ordzhonikidze

[Abstract] The author develops a theory of motion of a satellite relative to its center of mass, which is located at triangular libration point L_4 in a limited, elliptical three-body problem. He formulates the problem and sets up the equations of motion and then discusses the perturbing function, the satellite's intermediate motion relative to its center of mass, and the effect of first-order perturbations in the satellite's rotary motion. Figure 1; references 11.
[53-11746]

UDC 532.73-1;532.529.6;533.13

EVOLUTION OF ENSEMBLE OF GAS BUBBLES IN FLUID UNDER WEIGHTLESSNESS CONDITIONS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 260, No 4, 1981 (manuscript received 20 Mar 81) pp 876-880

GEGUZIN, Ya. Ye., DZYUBA, A. S. and KAGANOVSKIY, Yu. S., Khar'kov State University imeni A. M. Gor'kiy

[Abstract] A feature of the behavior of gas bubbles in a fluid under weightlessness conditions is that the rapid "terrestrial" mechanism of the release of excess free energy, the floating up of bubbles to the surface, is precluded. Accordingly, slower mechanisms, especially coalescence, should be operative. This article discusses the thermodynamics and kinetics of this process. This matter is of interest in connection with the observation of an ensemble of gas bubbles in water aboard the "Salyut-5" space

station by the cosmonauts B. V. Volynov and V. M. Zholobov. The following problem is examined. Bubbles of the radius R, within which there are N_{gas} gas molecules, are stabilized (in equilibrium) if the internal pressure of the gas is compensated by the sum of Laplacian pressure and the pressure imparted to the fluid from the outside. It is postulated that the process of coalescence of bubbles occurs with a constant total number of gas molecules within them, which is correct if the volume of gas dissolved in the fluid is substantially less than the volume included in the bubbles. Then it is possible to discuss two different situations arising in an ensemble of "small" bubbles and in an ensemble of "large" bubbles. In this formulation it is possible to describe the kinetics of coalescence of an ensemble of motionless gas bubbles in a weightless fluid. It is clear that the flow of gas into a bubble or from it is determined by two processes: emission (or assimilation) of gas molecules by the surface of the bubble and diffusional transport. However, instead of the bubbles being motionless, forces can be operative which cause the bubbles to move. The possible nature of such forces is considered. The force operative on the bubbles may be a consequence of the temperature gradient, either constant or periodical. The diffusional kinetics of coalescence in pure form may be observable only in exceptional cases. Coalescence becomes possible in a regime of collision of moving particles. The circumstance that in the "Salyut-5" experiment the single resultant bubble formed at the center of a spherical flask makes it entirely likely that the radial temperature gradient was of fundamental importance. Figures 1; tables 1; references 7 (Russian).
[27-5303]

UDC 523.6

INNER ZODIACAL LIGHT FROM PHOTOGRAPHS TAKEN ON BOARD 'SALYUT-6' ORBITAL STATION

Moscow PIS'MA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 8, No 1, Jan 82 (manuscript received 6 Aug 81) pp 52-56

GRECHKO, G. M., DIVARI, N. B., NIKOL'SKIY, G. M. and ROMANENKO, Yu. V., Institute of Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation, USSR Academy of Sciences, Troitsk, Moscow Oblast

[Abstract] The authors discuss photographs of the inner zodiacal light taken from "Salyut-6" with 35-mm black-and-white film on 10 March 1978 using an exposure time of 30 seconds. The zodiacal light brightness values that were obtained were used to construct isophotes that were free from the enlargement seen in isophotes constructed on the basis of ground observations, indicating that this enlargement is the result of distortion in the lower layers of the atmosphere. The authors then compare their brightness values with those found by other investigators and conclude that the absence of differential absorption of light in the Earth's atmosphere and the spatial separation of twilight illumination and the zodiacal light makes studies of the night sky from space more accurate and reliable. Figures 4; references 17: 6 Russian, 11 Western.
[54-11746]

COMMENTARY ON FIRST RESULTS FROM 'VENERA-13' AND 'VENERA-14'

Moscow PRAVDA in Russian 12 Mar 82 p 3

[Article by Academician R. Sagdeyev, director, Institute of Space Research, USSR Academy of Sciences, and V. Moroz, doctor of physical-mathematical sciences, chief, Department of Planetary Physics: "Research--Integrated"]

> [Text] It has been almost 15 years since "Venera-4" first transmitted to Earth telemetric information about measurements made directly in the atmosphere of another planet. At that time there were so many controversies and contradictions and so much vagueness related to Venus! Since then, several space expeditions have visited the Morning Star. The complex of automatic instruments carried on each flight have become ever more intelligent, sharp-sighted and versatile. Even at that, the breadth and quality of the "Venera-13" and "Venera-14" interplanetary stations' scientific program outstrips all the preceding ones by a substantial margin.
>
> The purpose of this article is to discuss some of the first impressions from the realization of this program. Let us emphasize that our main focus is impressions and not qualitative results, since it is now necessary to process a literal mountain of telemetric information that has been received, and the first scientific publications will not be ready for several months.

The study of the planets by spacecraft is a laborious and expensive proposition. However, there is no doubt of the need for it. Only by this method can we learn about the general rules governing the structure and evolution of the planets, including the one on which we live.

It is a well-known fact that Venus and the Earth are almost identical in mass, size and amount of heat received from the Sun and, on the contrary, differ sharply as far as atmospheric and climatic characteristics are concerned. How can this difference be explained? On our planet, can the atmosphere and climate not change in the same direction in the course of some foreseeable period? On what does this depend: a change in external conditions, pollution of the environment? Finally, in the distant future will it not be possible to change the atmosphere and climate of other planets artificially and make them suitable for colonization? This makes it clear why many specialists on the planets consider the study of Venus to be a problem of

primary importance. At the same time, it is extremely important to carry out integrated and comprehensive investigations. That requirement is met by the scientific equipment on board the "Venera-13" and "Venera-14," which consists of 14 instruments.

Almost all the instruments for studying the atmosphere began to operate as early as during the time of the descent, at an altitude of about 60 kilometers, when the parachute opened and the descent vehicle was released from the upper and lower hemispheres, in which it had been carried until then like a nut in a shell. The television equipment and the instruments for investigating the surface went to work immediately after the landing. The descent took about an hour, and after landing the "Venera-13" continued to function for 2 hours 7 minutes, while the "Venera-14" ceased functioning after about an hour.

The investigations of the structure and dynamics of the atmosphere (the scientific leader for this work was Academician V.S. Avduyevskiy) were conducted by several methods. Even before the parachute opened, information about the vertical distribution of pressure and temperature, as encountered during braking of the spacecraft in the atmosphere, was produced by (no matter how strange this may seem at first glance) an overload detector. These overloads exceeded terrestrial gravitational acceleration by a factor of 140-150. When the dependence of the overloads on time is known, it is possible, by using equations from aerodynamics, to find the dependence of the temperature and pressure on the altitude in the altitude interval from approximately 100 to 65 kilometers. Measurements were then made by special thermometers and barometric sensors.

A very interesting method was used to measure the wind speed and the characteristics of turbulent motion: radio signal frequency changes caused by the Doppler effect. Both of these original methods--studying Venus's atmosphere on the basis of overloads and the Doppler effect--were proposed by Soviet scientists and were first realized in stations of the "Venera" type many years ago. The purpose of the new measurements was to accumulate statistical data on Venus's atmosphere. The vertical temperature and pressure profile obtained during the course of the new experiment was close to those obtained earlier, as was apparently also the case with the vertical wind and turbulence profile, although here we must be careful because the data require protracted processing.

The main feature of the dynamics of Venus's atmosphere is the high and--in the first approximation--constant velocity of the wind (about 100 meters per second) at altitudes of 50-70 kilometers. The wind blows in the direction of the planet's rotation, but moves much faster. As a result, the atmosphere's period of rotation at altitudes of 50-70 kilometers is about 4 terrestrial days, although the planet itself revolves with a period of about 243 days. A result that is important for the explanation of this phenomenon was obtained by the "Venera-13" and "Venera-14" with the help of an optical spectrophotometer. It showed that a considerable part of the solar radiation is absorbed precisely at these altitudes. It probably also is subjected to intensive convective and turbulent motions, as well as the 4-day period of rotation of the atmosphere.

Its chemical composition was investigated by four different instruments. One of them was a mass spectrometer (this experiment's scientific leader was Doctor of Physical and Mathematical Sciences V.G. Istomin, of the USSR Academy of Sciences'

Institute of Space Research). This instrument "sorts" atoms and molecules according to their weights, after which mass spectrums--curves with peaks--are transmitted to Earth. In all, both stations obtained a total of about 250 of them. The nature of the information is very graphic: the craft had still not landed on the surface when the experimenters were already saying that they saw an isotope of neon that they had previously not succeeded in registering. (The instruments' sensitivity is now 10-30 times greater than that of the instruments carried by "Venera-11" and "Venera-12.") After a short amount of further processing, xenon was found; this is a gas, the presence of which had not been previously noted.

We now have available data on the content of isotopes of four inert gasses: neon, argon, krypton and xenon. Their relative concentration is very low, ranging from hundredths of thousandths to hundredths of a percent, but the scientific value of these data is extremely high. The fact of the matter is that most isotopes of inert gasses are relict isotopes; that is, they have been preserved without change since the formation of the atmosphere. Their relative and absolute amounts serve as an important control factor when "sorting out" different "scenarios" according to which formation of an atmosphere can occur.

Another instrument that supported the chemical part of the program was a gas chromatograph (the scientific leader was Doctor of Physical and Mathematical Sciences L.M. Mukhin, of the USSR Academy of Sciences' Institute of Space Research). Its "hobby" was the measurement of small molecular components such as carbon monoxide, sulfur dioxide and other compounds containing sulfur. The results obtained by this instrument will help to reveal the secrets of the complicated chemical transformations taking place when different gasses interact with each other, the soil and cloud particles. During the descent, this instrument analyzed the atmosphere's composition eight times.

A third instrument that gave us valuable information about the atmosphere's chemical composition was an optical spectrophotometer (the scientific leader was Doctor of Physical and Mathematical Sciences V.I. Moroz). The optical spectrometer registered the spectrum of the solar radiation that was scattered by the clouds; that is, the dependence of its brightness on wavelength. The spectrum was cut by valleys, which were the absorption bands of carbon dioxide and water vapor. The amount of these compounds present can be judged by the depth of the valleys. In the case of carbon dioxide this is not very interesting: we already know that it amounts to 96 percent of the atmosphere. However, the results of previous measurements of the water vapor content, which were made by different methods, were contradictory. Now, several thousand spectrums were received from each station. The measurements of the scattered radiation were made in several directions (upward, downward and so on), which gives us information on the amount of radiation absorbed.

It will be very interesting to compare the evaluations of the water content according to the absorption bands with the results of the measurements made by a hydrometer, the operating principle of which is based on the change in electric conductivity of a moisture-absorbing material (the scientific leader was Doctor of Physical and Mathematical Sciences Yu.A. Surkov, of the USSR Academy of Sciences' Institute of Geochemistry and Analytical Chemistry). The problem of water in Venus's atmosphere as a whole presents us with a number of mysteries. For example, we do not understand why there is so little of it in comparison with Earth's atmosphere. Earlier measurements gave us grounds for assuming that the relative concentration of

water vapor in Venus's atmosphere is minimal at the surface and maximal at altitudes of 50-60 kilometers. This hypothesis will be tested on the basis of data gathered by the optical spectrophotometer and hydrometer carried by the "Venera-13" and "Venera-14."

Information about the physical characteristics of particles in the atmosphere can be extracted by an analysis of the measurements made by the optical spectrophotometer, the nephelometer and the "Groza" instrument. The nephelometric experiment was carried out under the leadership of Doctor of Physical and Mathematical Sciences M.Ya. Marov (Institute of Applied Mathematics, USSR Academy of Sciences). Layers of clouds were registered clearly by the nephelometer's signal. The lower boundary of the clouds, which is located at an altitude of about 48 kilometers, has a complex (and still not understood) structure. Joint processing of the results of the measurements made by the nephelometer and the optical spectrophotometer may yield some information on the particles' size and refractive index. One of the "Groza" instrument's channels (the scientific leader was Doctor of Physical and Mathematical Sciences L.V. Ksanfomaliti, of the USSR Academy of Sciences' Institute of Space Research) "trapped" particles and registered their appearance by electric conductivity. Other channels recorded thunderstorm discharges, which were first detected during an analogous experiment conducted by "Venera-11" and "Venera-12." The level of thunderstorm activity recorded by "Venera-13" and "Venera-14" was lower.

The stations carried two X-ray fluorescence spectrometers (the scientific leader was Doctor of Physical and Mathematical Sciences Yu.A. Surkov). One of them analyzed the composition of particles in the cloud layer that were collected by special fine-mesh nets, while the other analyzed the composition of the soil. Its intake process was the most complicated (in the technical sense) operation in the entire program.

Both stations picked up soil successfully and analyzed its spectrum. These spectra will make it possible to determine the percentage content of different elements and this, in turn, will enable us to determine the nature of the minerals in Venus's soil. Interesting additional information may be obtained from measurements of the soil's strength and electric conductivity (scientific leader--Doctor of Technical Sciences A.K. Leonovich). The optical spectrophotometer made it possible to obtain about 100 reflection spectra for several areas of the surface after landing.

The first attempt was made to record seismic vibrations on Venus, using one of the "Groza" instrument's channels. Nothing can be said about the results until the signals are processed.

The television experiment on Venus's surface (scientific leader--Doctor of Technical Sciences A.S. Selivanov) was both brilliant and extremely difficult. When this experiment was first conducted, with more limited characteristics, with "Venera-9" and "Venera-10" in 1975, we knew so little about our heavenly neighbor that on the descent vehicle there were powerful illuminators (what if it will be dark!), although the landing took place at noon on the equator. Such precautions are now unnecessary, and the equipment's technical parameters are much better. The results are available: the new panoramas offer us great opportunities for geological interpretation.

The analysis of the surface's characteristics--the panoramas and the data gathered by the X-ray fluorescence spectrometer, the optical spectrometer and

physicomechanical measurements--will be both interesting and complicated. Moreover, we may be able to say something about the atmosphere: the horizon and a small piece of sky above it can be seen in the panoramic views. This is sufficient to determine how the temperature changes with height in the first few meters above the surface (here there are some peculiarities that cannot be "caught" with temperature sensors).

From what has been said it is obvious how complicated the complex of scientific instruments was and how variegated were the connections between different experiments. Even more complicated, however, were the technology of the actual flight to Venus, space communications, control during the flight and the landing, and the development and production of the automatic interplanetary stations themselves. Large collectives took part in the different stages of this work. We would like to express our gratitude to everyone who helped set "Venera-13" and "Venera-14" on their way into space and who accompanied them solicitously until the very end of their lives.

11746
CSO: 1866/64

'VENERA' MASS SPECTROMETER DATA ON ATMOSPHERIC COMPOSITION

Moscow PRAVDA in Russian 21 Apr 82 p 3

[Article by V. Istomin, doctor of physical and mathematical sciences, Lenin Prize laureate: "Witnesses of the Birth of Planets"]

> [Text] The rare gasses--helium, neon, argon, krypton and xenon--are also called noble or inert, since they (as a rule) do not form chemical compounds with other elements. These gasses are present in Earth's atmosphere in extremely small concentrations. For example, detecting xenon in the air is no easier than finding one certain individual among all the inhabitants of Moscow. As far as Venus's atmosphere is concerned, the problem of searching for rare gasses there proved to be even more complicated.

The first of these investigations, using spacecraft of an earlier generation ("Venera-4"-"Venera-8") were carried out with the help of simple instruments: gas analyzers, each of which was set for a certain component. These instruments could give only a comparatively rough estimate of the presence of impurities in concentrations of only a few or even tenths of a percent. However, even these evaluations, which were obtained with the help of different spacecraft, differed from each other, with the causes of the differences not always being clear.

There was a cardinal change in the situation with the appearance of a new generation of stations (beginning with "Venera-12") that carried precision analytical instruments, including mass spectrometers.

This instrument is no newcomer in space research. Its most important property, which has been thoroughly tested during studies of our planet's upper atmosphere, is its total "lack of bias" with respect to the object of investigation. The instrument is not preprogrammed to detect any definite chemical elements or compounds of them, but registers everything that is within the spectrometer's band of mass numbers.

Mass spectrometry is capable of giving information not only on the chemical, but also on the isotope composition of substances being investigated. Its other notable features and a gigantic dynamic range. Finally, in our country we have amassed a large amount of experience in the development and utilization of automatic mass spectrometers for space research. All of this, taken together, determined the choice of these instruments as the analytical instruments needed for the new generation of "Venera" stations.

However, mass spectrometry in general and space mass spectrometry in particular had never before been faced with a problem of the complexity of the one posed us by our nearest neighbor. It involved up to a hundred atmospheres of pressure and temperatures on the order of 500°C! And the mass spectrometer is not only a quite delicate instrument, but one that operates with a vacuum. For it to function normally; the pressure in the mass analyzer must be lower than the pressure on Venus's surface by a factor of 1 billion!

There was yet another great difficulty. It was necessary to find a method and invent a device to realize this method, in connection with which a precisely metered amount of gas would be introduced into the instrument. The amount of gas needed would be hundredths of a cubic millimeter.

These two problems were solved successfully by the USSR Academy of Sciences' Institute of Space Research, in collaboration with specialists from the USSR Academy of Science's Scientific and Technical Department's Special Design Office of Analytical Instrument Making and the Special Design Office of the USSR Ministry of Instrument Making, Automation Equipment and Control Systems' Sumy Electron Microscope Plant.

The solution was found on the leading edge of the capabilities of modern vacuum technology: a spectrometer vacuum system was created that had the smallest possible gas separation and an insignificant inleakage of gas from without. Because of this, the vacuum in the instrument could be maintained by one single pump. The mass spectrometer's analyzer "communicated" with the external medium by means of a pulsed micrometering valve, which let the required amount of gas into the instrument in just thousandths of a second. The operation of the valve, pump and mass analyzer was controlled electronically, by commands received from the "Venera" station's onboard systems.

The basic characteristics of mass spectrometers are such that upon beginning to operate, it is as if the instrument searches for the needed amount of gas: search cycles take place. When the appropriate amount is found, for about 5 minutes the instrument processes several gas samples, analyzing each one several times with a high degree of sensitivity. The instrument's sensitivity level enabled it to make a quantitative analysis of xenon, the rarest of the rare gasses. The instruments functioned as the descent vehicles were in the bottom 20 kilometers of the atmosphere, right up until the moment the Morning Star's surface was reached.

Just what place in planetary research do these experiments occupy?

On Venus, in December 1978, five mass spectrometers investigated the composition of its atmosphere. Three of them were installed in American "Pioneer-Venus" craft and two in "Venera-11" and "Venera-12." The two mass spectrometers on "Venera-13" and "Venera-14" have now been added to this roster.

In the development of mass spectrometers, scientists and designers in the USSR and the United States worked independently of each other, but along quite similar paths. The United States' equipment was extraordinarily complex; in our opinion, this was not always justified. For example, some of the mass spectrometers had five vacuum pumps, whereas ours had only one. A comparison of the results obtained showed that the Soviet instruments turned out to be more nearly perfect in the area of preflight preparation. For example, U.S. scientists, using isotope-enriched xenon-136, had at

their disposal a gas consisting of about 95 percent basic isotope. Thanks to the support of Academician I.K. Kikoin, we succeeded in having at our disposal isotope-enriched gas of 99.99 percent purity, which had a cardinal effect on the quality of the instruments' preflight preparation.

What can be said about the results? The unexpectedly large amounts of argon-36 and argon-38 isotopes on Venus (in comparison with the Earth) was a sensation. This fundamental, unpredictable conclusion, the value of which is difficult to overestimate, was reached practically simultaneously, from measurements made both by the American "Pioneer-Venus" and the "Venera-11" and "Venera-12" craft. In the first publications of the results of the American measurements, the abundance of argon-40 was not mentioned, but in subsequent ones it was stated with a large degree of error.

The importance of this discovery becomes obvious when we recall that almost all the argon in the Earth's atmosphere consists of radiogenic (that is, it has appeared as the result of the decay of radioactive potassium-40 in the Earth's crust) argon-40 isotope. On Venus, however, radiogenic argon-40 and nonradiogenic argon-36 and argon-38 exist in equal quantities. Thus, it turned out to be the case that the relative content of nonradiogenic ("primary") argon isotopes exceeded their content in the Earth's atmosphere by a factor of 300.

At first, the other results of the mass spectrometric measurements of rare and other gasses by "Pioneer" and "Venera" were strongly divergent. The noncoincidence was especially noticeable in the first publications of the results by U.S. scientists. For some important components (nitrogen, argon-40) there were no figures at all, whereas in later works the differences between their and our measurements became less substantial. All the remaining differences and the comparatively large size of the errors produced by the "Pioneer" experiments forced us to place on the agenda the question of collating the readings of the Soviet and American gas-analyzing instruments.

During meetings in Moscow in 1979 and 1980, a program for the calibration of these instruments was formulated. Unfortunately, it is still being implemented very slowly, and none of this is our fault.

But what is the reason for investigating rare gasses in the atmospheres of the planets?

For example, the discovery of an abundance of primary argon isotopes on Venus immediately enabled us to draw a number of conclusions of a fundamental nature. It became obvious that the history and conditions of the formation of the atmosphere on Venus and on Earth differed significantly. Because of the fact that the noble gasses, by not participating in any chemical transformations, are preserved on a planet throughout the entire time of its existence, they serve as reliable witnesses of the birth of the planet's atmosphere. Therefore, Doctor of Physical and Mathematical Sciences M.N. Izakov, of the USSR Academy of Sciences' Institute of Space Research, used the results of the analysis of the content of rare gasses in Venus's atmosphere as a basis for suggesting that a large part of the noble gasses' primary isotopes entered the atmospheres of the terrestrial group of planets (Venus, Earth, Mars) because of accretion (capture) of gas from the preplanetary nebula by the growing planets in the early stages of their formation. This and other hypotheses about the

origin of atmospheres are subject to testing and refinement as new data are obtained.

Among the results that would have been difficult to predict ahead of time, it is also possible to mention the precise values of the isotopic state of neon that were obtained by "Venera-13" and "Venera-14." This can shed additional light on the problem of the evolution of Venus's atmosphere and narrow the framework for acceptable hypotheses on the origin of the atmospheres of the terrestrial group of planets. An examination of the telemetric measurements showed that because of the high sensitivity of the instruments', neon-22 and neon-20 isotopes were registered reliably in almost all of the mass spectra that were obtained. This means that yet another of the goals placed in front of the "Venera" craft has been reached.

11746
CSO: 1866/84

UDC 523.042

IRON IN VENUSIAN CLOUDS

Moscow DOKLADY AKADEMII NAUK SSR in Russian Vol 260, No 4, 1981
(manuscript received 1 Jun 81) pp 834-836

PETRYANOV, I. V., academician, ANDREYCHIKOV, B. M., KORCHUGANOV, B. N., OVSYANKIN, Ye. I., OGORODNIKOV, B. I., SKITOVICH, V. I. and KHRISTIANOV, V. K., Scientific Research Physicochemical Institute imeni L. Ya. Karpov, Moscow, and Space Research Institute, USSR Academy of Sciences

[Abstract] Additional modeling and processing of data from an x-ray - radiometric experiment, described earlier in the literature (Yu. A. Surkov, et al., GEOKHIMIYA, No 1, p 3, 1981; I. V. Petryanov, et al., DAN, Vol 258, No 1, p 57, 1981), have made it possible to obtain new information on the composition of the aerosol in Venusian clouds. The experiment was carried out in such a way that there was simultaneous recording of the characteristic x-radiation of chemical elements in the gas and aerosol phases of the clouds in two spectral ranges. The characteristic radiation of light chemical elements was excited by a radioisotopic source ^{55}Fe (first channel of instrument) and that of heavy chemical elements was excited by a radioisotopic source ^{109}Cd (second channel). However, due to the need for identifying the phase state of chemical elements and ensuring an adequate sensitivity of measurements of chemical elements in the gas phase a ^{55}Fe radioisotopic source was also included in the second instrument channel. The spectral measurements reported and analyzed in this experiment revealed the presence of iron in Venusian clouds, which is not unexpected, since it was suggested earlier that Fe ions are present and account for the yellowish hue of the clouds. It was concluded that the iron discovered in Venusian clouds is primarily in the aerosol phase. The iron is evidently associated with chlorine and probably is present in the form of $FeCl_3$. If it is postulated that the concentration and composition of aerosol did not change within the limits of the cloud layer along the path of descent of the "Venera-12," the volumetric concentration of iron in the aerosol of Venusian clouds is 0.21 ± 0.06 mg/m^3. The discovery of water vapor in the Venusian clouds in this same range of altitudes makes it possible to assume that $FeCl_3$ is present in clouds in the form of hydrates and solutions. Figures 2; references 6: 4 Russian, 2 Western.
[27-5303]

UDC 535.24;523.42

OPTICAL PROPERTIES OF VENUSIAN ATMOSPHERE AND RADIATIVE HEAT EXCHANGE

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 15, No 4, Oct-Dec 81
(manuscript received 14 May 80) pp 196-209

KONDRAT'YEV, K. Ya. and MOSKALENKO, N. I., Main Geophysical Observatory imeni A. I. Voyeykov

[Abstract] This review, based on 44 recently published sources, is devoted to a reassessment and updating of information available on the optical properties of the Venusian atmosphere and their influence on radiative heat exchange. The materials pertain to measurements of structure and chemical composition, laboratory investigations and numerical modeling of the optical properties of different gas and aerosol components. Since data on chemical composition and structural parameters have been given in many books, articles and reviews, only new information is presented. For example, the authors determined the optimum vertical profile of the volumetric concentration of water vapor on the basis of measurements of the effective flux of thermal radiation, spectral intensities of scattered radiation and spectral intensities of outgoing short-wave and long-wave planetary radiation; the pertinent data are summarized in Table 1. The text relating to molecular absorption by gaseous components in the Venusian atmosphere contains a discussion tied-in to a series of figures: Fig. 1 -- spectral absorption coefficients in vibrational-rotational CO_2 bands at different temperatures; Fig. 2 -- transmission spectra of Venusian CO_2 atmosphere in spectral region 5700-7300 cm^{-1}; Fig. 3 -- transmission spectra of Venusian CO_2 atmosphere in transparency window 3500-5000 cm^{-1}; Fig. 4 -- transmission spectra of CO_2 atmosphere in region of transparency window 2500-3500 cm^{-1}; Fig. 5 -- spectral absorption coefficients for water vapor at different temperatures; Fig. 6 -- absorption spectra of some gaseous components (CO_2, CO, NO, SO_2); Fig. 7 -- absorption spectra for other gaseous components (NH_3, C_2H_2, C_2H_4 and others). The modeling of optical properties of Venusian clouds is then reviewed with an evaluation and integration of different sources; Table 2 summarizes the microstructural parameters for different fractions of Venusian cloud cover particles. Radiative heat exchange in the Venusian atmosphere is examined in the final section and different sources are compared with Fig. 8.presenting profiles of the effective flux of long- and short-wave radiation computed on the basis of data from different authors. Figures 8; tables 2; references 44: 28 Russian, 16 Western.
[59-5303]

UDC 523.042:523.43

SPECTROSCOPIC EVALUATION OF CARBON MONOXIDE CONTENT IN UPPER ATMOSPHERE OF MARS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 24 Nov 80) pp 902-906

KRASNOPOL'SKIY, V. A.

[Abstract] Using data from measurements of the illumination of the fourth-positive CO system on board the "Mariner-6" and "Mariner-7" spacecraft, the author attempts to determine the CO content of Mars's upper atmosphere. After taking into consideration such previously unconsidered factors as continuity of the radiation and CO absorption along the optical axis, illumination absorption by CO_2 molecules, and CO fluorescence and self-absorption, he constructs formulas for determining the CO concentration at altitudes up to 150 km. Figures 3; references 17 (Western).
[45-11746]

UDC 551.510.53+350.388.8

CHANGE WITH SOLAR ACTIVITY OF PHOTOIONIZATION RATE COEFFICIENTS OF NEUTRAL COMPONENTS IN UPPER ATMOSPHERES OF PLANETS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 18 Jun 80) pp 907-912

PAVLOV, A. V.

[Abstract] The basic source of the ionization responsible for the formation of planetary ionospheres is solar ultraviolet and X-ray radiation. Because of the complicated nature of the temporal variability in this flow, various figures have been used in the numerous investigations of photoionization that have been made. Using newly available data on periods of both high and low solar activity, the author constructs formulas that enable photoionization reactions to be described by two variables that characterize the dependence of the photoionization rate coefficient on solar activity, and gives the values of these variables for 20 different reactions. Figures 4; references 26: 4 Russian, 22 Western.
[45-11746]

UDC - 523.34

MEGARELIEF ON VISIBLE SIDE OF MOON

Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 15, No 4, Oct-Dec 81
(manuscript received 13 Jul 79, after revision 20 Jul 81) pp 211-215

GAVRILOV, I. V., KISLYUK, V. S. and KARASEV, L. A., Main Astronomical Observatory, Ukrainian Academy of Sciences

[Abstract] Specialists at the Main Astronomical Observatory, Ukrainian Academy of Sciences, in collaboration with specialists in the Geodesy and Cartography Department, Kiev State University, have compiled a new hypsometric map of megarelief on the visible side of the moon. Use was made of the selenodetic coordinates of 2390 base points already published. Their absolute elevations above a barycentric sphere with a radius of 1738.0 km were computed. These data were supplemented by the absolute elevations of 960 points in the limb zone of the moon, as well as selected elevations of peaks of lunar ranges and walls of major craters. The surface was divided into sectors measuring 10° x 10°, in most of which 10-30 base points were plotted. Hypsometric levels were determined in 215 sectors. After smoothing, isohypses with a contour interval of 0.5 km were sketched and spot elevations were plotted. Figure 1 is a foldout of the final map. The accuracy was evaluated and the map was compared with other variants. The results agree well with laser altimetry data and the map of lunar topography published in ICARUS by Bills and Ferrari. The new map is superior because the hypsometric information is barycentric and quite uniform. Figures 2; tables 1; references 10: 7 Russian, 3 Western.
[59-5303]

UDC: 612.171:613.693]:007

CYBERNETIC ANALYSIS OF CARDIAC RHYTHM OF 'SALYUT-6' ORBITAL STATION CREW DURING GRADED EXERCISE TEST

Moscow KARDIOLOGIYA in Russian Vol 21, No 11, Nov 81 (manuscript received 11 Nov 80) pp 100-104

[Article by R. M. Bayevskiy, Zh. V. Barsukova and I. G. Tazetdinov, Institute of Biomedical Problems (director--Academician O. G. Gazenko), USSR Ministry of Health, Moscow]

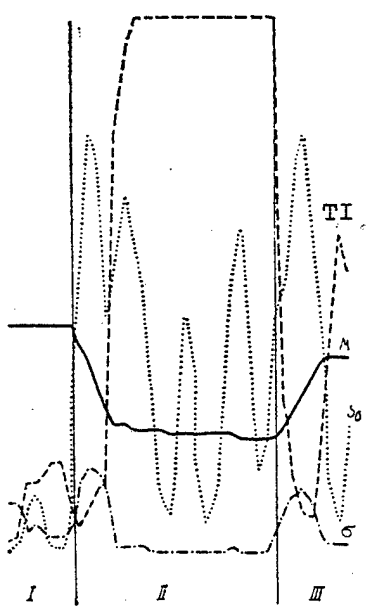
[Text] Tests using graded exercise have gained wide use in clinical practice and applied physiology for evaluation of the functional state of the cardiovascular system. However, taking the pulse rate, arterial pressure and EKG are still the traditional methods used by almost everyone to assess the body's reactions to exercise. These parameters characterize essentially the functional level of different elements of the cardiovascular system, and they do not furnish a complete enough idea about the function of regulatory mechanisms, changes in which are manifested at the very earliest stages of diseases or in their preclinical phase [2, 15]. Cybernetic analysis of cardiac rhythm is one of the available methods of examining control and regulation systems in the living organism, and it is gaining increasing popularity. Z. I. Yanushkevichus was the first clinician to use this method during tests with graded exercise, and he developed some recommendations on its use [17, 18]. He believes that one can predict appearance of serious disturbances in cardiac rhythm and assess the work capacity of patients, as well as describe the functional state of the heart under the influence of different factors in sick and healthy subjects on the basis of the results of cybernetic analysis of cardiac rhythm.

Cybernetic analysis of heart rhythm has been used in space medicine starting with the first flights of animals and man [2, 15]. We submit here the results of our use of this method for evaluation and forecasting of the functional state of cosmonauts' cardiovascular system during exercise and conditioning.

Monitoring and forecasting the functional capabilities of each crew member present a serious problem during long-term space flights, where exercise is one of the most important means of preventing the adverse effects of weightlessness [10]. To solve this problem, inflight tests with graded exercise on a bicycle ergometer are conducted regularly [6]. On the basis of using cybernetic analysis of cardiac rhythm, an effort was made to enlarge the existing diagnostic approach to assessing changes in functional level of the cardiovascular system during tests with graded exercise, which makes it possible to determine the "price" of adaptation of the body to exercise loads according to degree of strain on the regulatory systems [2].

Material and Methods

The studies were conducted in the course of long-term missions performed by four crews aboard the Salyut-6 orbital station. The cosmonauts performed the exercise test on the onboard bicycle ergometer (750 kg-m/min at a rate of 60 r/min for 5 min). The test was conducted about once a month. For cybernetic analysis of cardiac rhythm, we used the EKG, which was recorded continuously in the DS lead or anterior Neb lead. The data were transmitted to the ground via telemetry channels or recorded on magnetic tape aboard the station. The EKG was processed by means of a YeS-1030 computer. The program included determination of statistic parameters of a dynamic series of cardiac intervals, plotting histograms, autocorrelation and spectral analysis (the program was elaborated together with V. V. Aksenov). Cardiac rhythm was analyzed by the continuously sliding method, where each successive sample included part of the preceding one [9]. The size of the sample constituted 100 cardiac intervals and the spacing of shifts along the dynamic series constituted 20 cardiac intervals. The program provided for output in graph form of up to 10 selected mathematical and statistical parameters. The Figure illustrates a typical example of a plot of changes in mean duration of cardiac intervals (M), standard deviation (σ), power of slow waves of cardiac rhythm (S_0) and tension index (TI) of regulatory mechanisms calculated from the histogram parameters [1]. Mean duration of cardiac intervals (the reciprocal of pulse rate) characterizes the functional level of the cardiovascular system and makes it possible to assess the body's reaction to the exercise load according to the difference between the values of this parameter before and during the test. The standard deviation of duration of the cardiac cycle reflects the overall activity of regulatory mechanisms: it increases during the period of warming up and recovery (process of readjustment of regulatory system) and decreases during the exercise period. The tension index characterizes the degree of activation of the sympathetic branch of the autonomic nervous system, while the power of slow waves of cardiac rhythm enables us to assess the degree of activation of central regulatory mechanisms responsible for energetic and metabolic processes in the body. Our physiological interpretation of the mathematical and statistical parameters ensues from a number of experimental and applied studies pursued by Soviet and foreign authors [1, 2, 5, 7, 13, 18, 19]. We submit below data on the values of parameters M, TI and S_0 before the flight and at different stages of flight before and during the exercise test on eight cosmonauts. For comparative evaluation of the reaction of each crew



Graph of changes in mathematical-statistical parameters of cardiac rhythm during graded exercise test

M) mean duration of cardiac cycles
σ) standard deviation
TI) tension index of regulator mechanisms
S_0) power of slow waves of heart rhythm
I) background
II) exercise
III) recovery period

member, we calculated the average inflight parameters for period of rest and exercise.

Results

Table 1 lists data on the dynamics of M, TI and S_0 among crews of the four long-term missions aboard Salyut-6 orbital station. The crew of the first mission had the least favorable reaction to exercise on the 24th day of flight (most significant shortening of cardiac intervals). Improvement of the reaction on the 42d day of the mission in the commander [CDR] was associated with significant increase in TI during the exercise test. The crew of the second mission adjusted to the tests at different times: the CDR presented the most marked reaction on the 40th and 62d flight days and the flight engineer [FLE] on the 29th day. The crew of the third mission adapted to exercise more uniformly, and we can only mention some relative deterioration of pulse rate reaction to exercise at the end of the mission in the CDR, which was associated with an increase in TI and decrease in power of slow waves of cardiac rhythm. The adaptation process proceeded differently in the crew of the fourth mission. In the CDR, the reaction to the exercise test was the most marked on the 97th flight day. It was associated with marked shortening of cardiac intervals (to 0.39 s) and considerable increase in TI during the test. In the FLE, the most marked reaction to exercise was noted on the 139th flight day (according to tension index). He presented similar dynamics of mean values of duration of the cardiac cycle before exercise during the third and fourth missions. In both missions, cosmonaut V. V. Ryumin presented relative increase in heart rate in the 3d-4th month of flight. In the 2d month of flight, this was associated with some increase in TI and appreciable increase in power of slow waves of cardiac rhythm.

Table 2 lists the mean flight values of M, TI and S_0 at rest and during exercise. Mean duration of cardiac intervals at rest was shortest for the crew of the second mission and in the CDR of the fourth. The same cosmonauts presented the highest inflight mean values for tension index and power of slow waves of resting heart rhythm. According to pulse rate and TI, the reaction to the graded exercise test was the most marked in the crew of the first mission and CDR of the fourth one. Changes in power of slow waves of cardiac rhythm were the most significant in the crew of the third mission and CDR of the fourth.

Discussion

As we know, physical work capacity refers to the magnitude of mechanical work that a man can perform at a high intensity [8]. The prerequisite for high physical work capacity is high physical conditioning, i.e., the potential capacity of the body to adjust effectively to the loads put to it. N. N. Yakovlev [16] considers conditioning as an adaptation process aimed at adjusting the body to changes in chemistry of muscles, organs and the endogenous environment when performing muscular activity of different types. During muscular activity there is a specific adaptation mechanism aimed at increasing the amount of mitochondria and, accordingly, power of aerobic resynthesis of ATP per unit muscle mass [12]. Activation of nucleic acid and protein synthesis is found to be quite intense, and it is indicative of expenditure of structural resources of the body. For this reason, we should discuss the "price" of adaptation to loads, which depends on the magnitude of functional reserves and is determined by the degree of

strain on regulatory mechanisms [2]. In weightlessness, less energy is expended, the functional capabilities of the cardiovascular system diminish, there is a decrease in volume of structural elements of muscles, diminished effective impulsation and change in reactivity of the body [10, 14]. All this cannot fail to affect the process of adaptation to physical loads.

Table 1. Results of cybernetic analysis of cardiac rhythm with use of graded exercise test on crews of 1st-4th missions aboard Salyut-6

Mission	Inflight days	Commander						Flight engineer					
		background			exercise			background			exercise		
		M	TI	S_0	M	TI	S_0	M	TI	S_0	M	TI	S_0
1	Preflight	0,79	59	0,13	—	—	—	0,75	210	0,18	—	—	—
	24	1,02	183	0,05	0,37	1594	0,02	0,99	46	0,06	0,40	2357	0,08
	42	0,87	57	0,03	0,44	5476	0,06	0,94	350	0,14	0,55	1719	0,07
	70	0,74	48	0,01	0,45	2106	0,03	0,85	42	0,02	0,43	2106	0,06
	82	0,80	79	0,07	0,45	1595	0,04	0,91	78	0,01	0,45	2106	0,07
2	Preflight	0,96	42	0,38	—	—	—	0,86	130	0,05	—	—	—
	29	0,88	132	0,11	0,57	1170	0,39	0,60	456	0,67	0,56	1145	0,25
	40	0,73	254	0,40	0,50	1580	0,61	0,92	119	0,14	0,68	410	0,38
	62	0,69	400	0,15	0,48	2278	0,22	0,43	91	0,14	0,62	1021	0,27
	96	0,88	211	0,26	0,53	2140	0,01	0,88	148	0,11	0,56	1799	0,33
3	Preflight	0,92	58	0,12	—	—	—	0,97	111	0,03	—	—	—
	30	0,97	59	0,14	0,57	405	0,39	1,23	33	0,10	0,72	220	0,28
	55	1,13	85	0,15	0,60	804	0,30	1,13	50	0,09	0,67	351	0,19
	75	0,97	70	0,14	0,53	1756	0,38	0,90	41	0,09	0,65	308	0,27
	114	1,01	81	0,05	0,53	1750	0,34	0,95	66	0,14	0,63	775	0,21
	139	0,96	125	0,11	0,49	723	0,18	1,07	53	0,09	0,67	295	0,23
	158	0,98	66	0,13	0,48	1831	0,15	1,04	25	0,29	0,63	493	0,25
4	Preflight	0,92	68	0,03	—	—	—	0,88	228	0,04	—	—	—
	27	0,88	235	0,36	0,49	3605	0,37	1,07	103	0,04	0,69	562	0,30
	64	0,82	143	0,67	0,47	1200	0,68	1,15	31	0,17	0,69	555	0,10
	70	0,70	215	0,13	0,45	2085	1,07	0,94	144	0,28	0,53	807	0,12
	97	0,78	129	0,06	0,39	5952	0,62	0,98	102	0,43	0,64	870	0,28
	106	0,85	178	0,11	0,43	5319	0,60	1,12	39	0,19	0,61	1059	0,44
	139	0,72	287	0,25	0,45	5319	0,60	1,05	52	0,22	0,62	1276	0,16
	175	0,77	186	0,61	0,46	2579	0,59	1,01	40	0,18	0,72	254	0,27

The above data indicate that, in spite of individual distinctions of reactions to exercise tests at different stages of flight in each crew as a whole (with the exception of the fourth), there are distinct adaptation features in common with regard to flight conditions, in particular to physical loads. Thus, the crew of the third mission stood out as having the highest physical conditioning. They presented the least change in M and TI during exercise and the most significant increase of S_0. This means that the "price" of adaptation to the load, i.e., degree of strain on regulatory mechanisms, was lower for the crew of the third mission. The increase in power of slow waves in response to exercise is indicative of significant activation of nerve centers responsible for energetic and metabolic support of muscular activity; this may indicate that the body reacts adequately to change in chemistry of muscles, organs and the endogenous environment. The crew of the first mission must be considered the least conditioned (perhaps, this is due to the fact that this mission was the shortest), and they presented the most marked reaction of cardiac rhythm to the exercise test (according to mean duration of cardiac intervals and TI). In the members of this crew, there was little change in power of slow waves of cardiac rhythm in response to exercise, and it remained on the same low level as before the test.

Table 2. Mean inflight parameters of cybernetic analysis of cardiac rhythm before and during exercise in crews of four missions aboard Salyut-6 orbital station

Parameter	Crew 1 CDR	Crew 1 FLE	Crew 2 CDR	Crew 2 FLE	Crew 3 CDR	Crew 3 FLE	Crew 4 CDR	Crew 4 FLE
Duration of cardiac intervals:								
at rest	0,86±0,060	0,92±0,029	0,80±0,050	0,83±0,078	1,00±0,026	1,05±0,049	0,81±0,021	1,03±0,022
during exercise	0,43±0,019	0,46±0,035	0,52±0,020	0,61±0,029	0,53±0,019	0,66±0,014	0,45±0,010	0,64±0,018
TI, arbitrary units								
at rest	92±31	129±74	249±56	203±85	81±10	45±6	172±10	83±15
during exercise	2693±935	2072±132	1792±136	1094±285	1221±265	407±82	3167±512	770±100
Slow wave power, arbitrary units:								
at rest	0,04±0,013	0,05±0,033	0,23±0,065	0,26±0,135	0,12±0,015	0,13±0,032	0,30±0,058	0,21±0,036
during exercise	0,04±0,009	0,070±0,0061	0,30±0,120	0,30±0,029	0,29±0,041	0,23±0,014	0,52±0,075	0,26±0,056

The crew on the second mission was notable for relatively high mean inflight values of M, TI and S_0 at rest, which was indicative of sympathotonic level of function of the cardiovascular system and high activity of central regulatory mechanisms, including subcortical nerve centers. Such changes in mathematical-statistical parameters of cardiac rhythm are indicative of diminished physical conditioning [4] and mental fatigue [11]. There was relatively minimal reaction to exercise, as well as little change in power of slow waves of cardiac rhythm. All these findings may be indicative of development of tension and even stress of regulatory systems. A. V. Beregovkin et al. [3], who studied on the same crew the reactions of the cardiorespiratory system to exercise immediately after the mission, reported that the difference between resting pulse rate after 96-day (1st mission) and 140-day (2d mission) flights constituted 5-10 and 13-17/min, respectively. The cardiac tension [load] index was close to preflight values in the crew of the first mission, whereas in the crew of the second one it increased by 44-75%.

During the third mission, the work program aboard the station was less intensive, in spite of the fact that its duration was increased to 175 days; the amount of physical conditioning was greater than for preceding crews, and this provided for a high level of cosmonaut adaptation to long-term weightlessness.

During the fourth, longest mission aboard Salyut-6, we observed substantially different reactions in the CDR and FLE. The flight program was quite heavy, and perhaps this was one of the reasons that the state of the CDR at rest was similar to that of the crew of the second mission. The CDR of the fourth mission presented significant increase in pulse rate, drastic increase in TI and substantial increase in slow wave power of cardiac rhythm. This reaction can be evaluated as a manifestation of a high "price" of adaptation, with adequate functional

reserve. As for the FLE, who participated in the second long-term space flight, the differences between his parameters in the preceding mission (third mission), could be attributed to both the fuller flight program and accumulation of fatigue, which was manifested by a higher tension index during exercise, increase in power of slow waves at rest and rather significant increase thereof during exercise. Thus, the second mission of V. V. Ryumin was characterized by a higher "price" of adaptation to exercise and some decrease in the functional reserve.

The above data indicate that adaptation to the conditions of long-term flights is associated with certain changes in regulatory systems. These changes are of prognostic value, since they are indicative of certain tendencies in development of adaptation processes. Thus, the following changes should be considered prognostically unfavorable: significant increase in tension index during exericse, which reflects an increase in "price" of adaptation to it; decreased difference between power of slow waves of cardiac rhythm before and during exercise, which is indicative of adequate activation of subcortical nerve centers necessary to mobilize energy and metabolic resources. The "price" of adaptation depends on many factors: duration of flight, difficulty of its program, level of physical conditioning of crew members and intensity of conditioning exercises, individual distinctions. It should be noted that all of the changes in regulatory mechanisms during long-term space flights were nonspecific, they were well-compensated and did not lead to impairment of homeostasis. The results of these studies and the proposed criteria may be used in clinical practice and different branches of applied physiology.

BIBLIOGRAPHY

1. Bayevskiy, R. M., in "Funktsional'nyye osobennosti serdtsa pri fizicheskikh nagruzkakh v vozrastnom aspekte" [Age-Related Aspect of Functional Distinctions of the Heart During Exercise], Stavropol', Vyp 1, 1975, pp 27-50.

2. Idem, "Forecasting Borderline States Between Normal and Pathology," Moscow, 1979.

3. Beregovkin, A. V., Vodolazov, A. S., Georgiyevskiy, V. S. et al., KOSMICHESKAYA BIOL., No 4, 1980, pp 8-11.

4. Vorob'yev, V. I., "Investigation of Mathematical and Statistical Characteristics of Cardiac Rhythm as a Method for Evaluating the Functional State of the Body During Muscular Activity of Subjects of Different Ages," author abstract of candidatorial dissertation, Moscow, 1978.

5. Voskresenskiy, A. D. and Venttsel', M. D., "Statistical Analysis of Cardiac Rhythm and Hemodynamic Parameters in Physiological Studies," Moscow, 1974.

6. Georgiyevskiy, V. S., Lapshina, N. A., Andriyako, L. Ya. et al., KOSMICHESKAYA BIOL., No 3, 1980, pp 15-18.

7. Zatsiorskiy, V. M. and Sarsaniya, S. K., in "Matematicheskiye metody analiza serdechnogo ritma" [Mathematical Methods for Analysis of Cardiac Rhythm], Moscow, 1968, pp 31-50.

8. Karpman, V. L., Belotserkovskiy, Z. B. and Gudkov, I. A., "Investigation of Physical Work Capacity of Athletes," Moscow, 1974.

9. Kletskin, S. Z. and Khamitov, A. S., in "Teoriya i praktika avtomatizatsii elektrokardiologicheskikh i klinicheskikh issledovaniy" [Theory and Practice of Automation of Electrocardiographic and Clinical Tests], Kaunas, 1977, pp 112-115.

10. Kovalenko, Ye. A. and Gurovskiy, N. N., "Hypokinesia," Moscow, 1980.

11. Kudryavtseva, V. I., "The Question of Predicting Mental Fatigue During Prolonged Monotonous Work," author abstract of candidatorial dissertation, Moscow, 1974.

12. Meyerson, F. Z., "Cardiac Adaptation to Heavy Loads and Cardiac Function," Moscow, 1975.

13. Navakatikyan, A. O., KARDIOLOGIYA, No 3, 1973, pp 103-109.

14. Panferova, N. Ye., "Hypodynamia and the Cardiovascular System," Moscow, 1977.

15. Sidorenko, G. I., editor, "Early Instrumentation Diagnostics of Essential Hypertension and Atherosclerosis," Minsk, 1973.

16. Yakovlev, N. N., TEOR. I PRAKT. FIZ. KUL'TURA, No 9, 1974, pp 21-26.

17. Yanushkevichus, Z. I. and Zhemaytite, D. I., VESTN. AMN SSSR, No 5, 1966, pp 41-43.

18. Yanushkevichus, Z. I., Zhemaytite, D. I. and Grabauskas, V. I., in "Biofizika membran" [Membrane Biophysics], Moscow--Kaunas, 1969, pp 382-388.

19. Sayers, B. M., ERGONOMICS, Vol 16, 1973, pp 17-32.

10,657
CSO: 1840/73

UDC: 613.693+629.78:616-092-08-036.8

COMBINED REHABILITATION AND THERAPEUTIC MEASURES IN SPACE MEDICINE

Moscow SOVETSKAYA MEDITSINA In Russian No 12, Dec 81 (manuscript received 25 May 81) pp 3-8

[Article* by T. N. Krupina, A. V. Beregovkin, V. M. Bogolyubov, B. M. Fedorov, A. D. Yegorov, A. Ya. Tizul, V. V. Bogomolov, V. V. Kalinichenko, A. P. Ragulin and V. A. Stepin (Moscow)]

[Text] Numerous studies pursued during long-term space flights and in the after-effect period indicate that cosmonauts develop polymorphic functional deviations which create some difficulties in returning to earth's gravity. Various disorders have been described in the form of a group of symptoms [syndrome] outwardly similar to seasickness, changes in motor function and fluid-electrolyte metabolism, deconditioning of the cardiovascular system for exercise and orthostatic factors, diminished mineralization of bone tissue, the anemic syndrome, pain in the muscles and ligaments. Similar changes were induced with simulation of space flight factors on earth with use of antiorthostatic [head down] hypokinesia (AOH) and immersion (T. N. Krupina and A. Ya. Tizul). The obtained data made it necessary to develop preventive measures in flight and rehabilitation methods for the readaptation period. Studies and observations made on the ground and following space flights revealed that hemodynamic disorders, dysregulation of vascular tonus, change in activity of the adrenosympathetic system and diminished functional reserve of the cardiorespiratory system are the most probable pathophysiological basis for the developing deviations. Combined rehabilitation and therapeutic measures for the postflight period were developed in ground-based studies using the model of 49- and 182-day AOH, and they were based on the experience of clinical medicine (M. M. Kabanov; Yu. Ye. Danilov et al.; Ye. I. Sorokina et al.) with consideration of the main etiopathogenetic mechanisms of the disorders.

The chief condition for hypokinesia was bed rest in AOH position at an angle of -4° during 49-day AOH and -4.5° during 182-day AOH. All procedures, tests and hygienic measures were performed without disrupting bed rest. During the 182-day AOH, 12 out of 18 subjects performed preventive exercise during hypokinesia without disrupting the test conditions and 6 did not exercise, serving as the control.

*Questions of rehabilitation therapy were worked on with consideration of the results of ground-based studies, in which Prof N. A. Belaya, V. T. Olefirenko (TsNIIKF [Central Scientific Research Institute of Space Physiology?], USSR Ministry of Health), Prof Z. M. Atayev and A. P. Golikov (Scientific Research Institute of Emergency Medicine imeni N. V. Sklifosovskiy) participated.

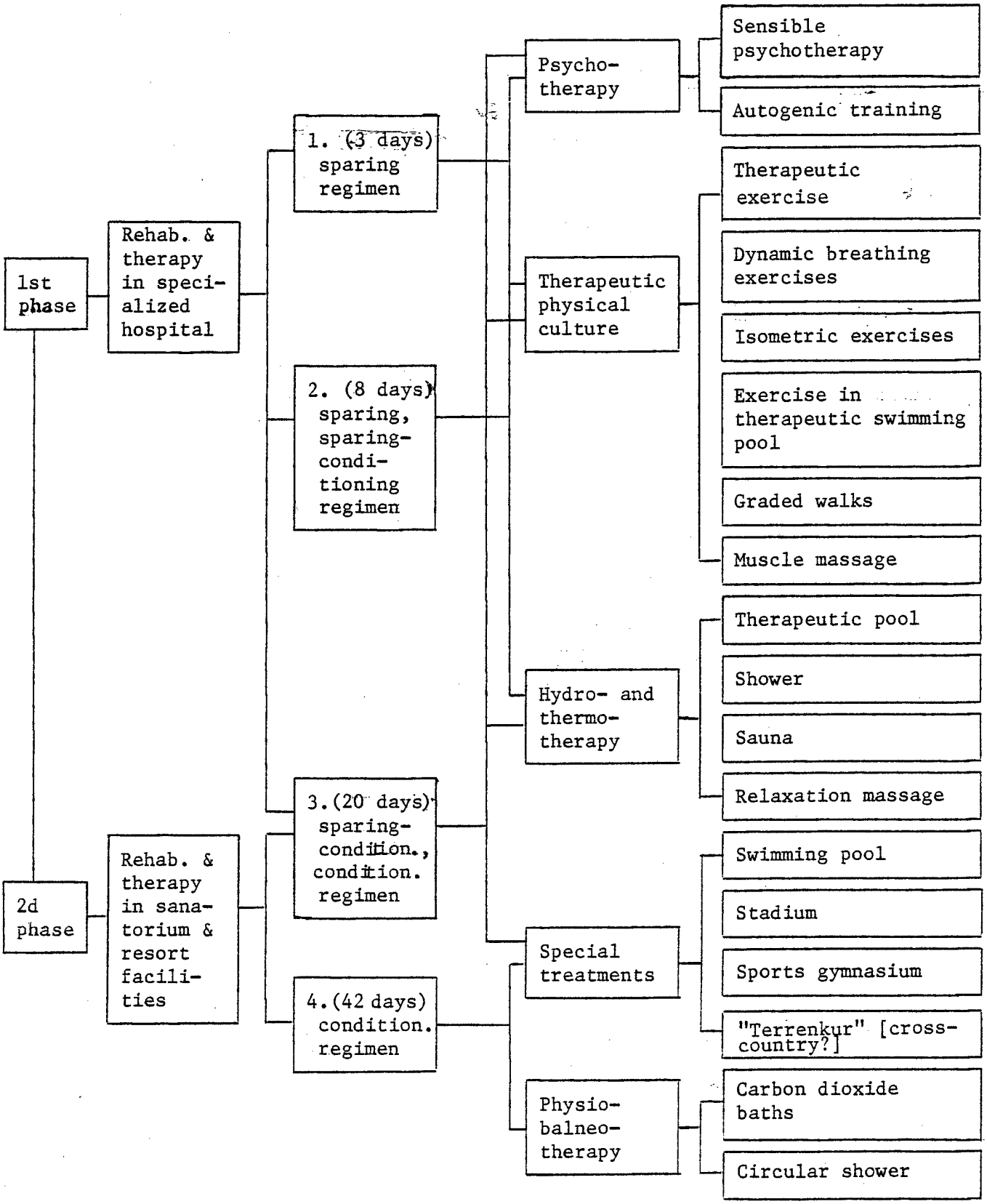


Figure 1. Chart and names of main rehabilitation and therapeutic measures used at different phases and stages of the readaptation period

The presence of changes in most tested systems (cardiovascular, nervous, muscular, adrenosympathetic, cardiorespiratory) made it necessary to use a strictly regulated exercise regimen in the early readaptation period. The rehabilitation and therapeutic measures were arbitrarily divided into three regimens based on the distinctions of symptomatology and course of readaptation period (Figure 1): 1) sparing, whose purpose was adaptation and conditioning for erect position and light exercise, prevention of muscular and ligament pain; 2) sparing and conditioning, aimed at adapting the body to moderate exercise, creating favorable conditions to increase the reserves of the cardiorespiratory and other systems; 3) conditioning, whose purpose was to obtain as complete as possible a recovery of impaired functions.

Of therapeutic physical culture and physical exercise methods, we used morning toning exercise, hand massage of muscles, therapeutic exercise in a pool and gym (court), graded [measured] walking, running, etc. Depending on clinical manifestations, course and individual distinctions of the subjects, we used various rehabilitation and therapeutic measures, which included exercise using specially equipped rehabilitation facilities. When indicated, drug therapy was used at the early phase of recovery and, as a rule, functional therapy methods were limited at this time: orthostatic loads diminished and there was strict regulation of motor activity. Therapeutic physical culture was the most beneficial when practiced in a therapeutic pool. Therapeutic physical culture was performed in a water environment (at temperatures of 31-32°C), which reduced axial loads and hydrostatic pressure that aided in prevention of orthostatic disturbances and normalization of circulation and muscle tone. Therapeutic massage of leg and back muscles, which was prescribed from the first day of the recovery period, had the same effect. Classical methods of hand massage were used, and it was given before and after completion of maximum exericse for a given day. Much attention was given to graded walking. In view of its universal conditioning effect on the cardiorespiratory system, coordination and statokinetic functions, as well as possibility of grading and controlling intensity and duration of walking, it occupies one of the prominent places in the set of rehabilitation measures. At first the subjects walk at a strolling pace, then the speed and duration are increased, the routes including ascents and descents ("terrenkur") [cross-country?] up to 1 km at the sparing stage and 10-14 km/day at the conditioning stage.

Therapeutic exercise was performed in a differentiated manner: exercises for small and medium muscle groups, with limited amplitude and intensity of motion, in the sparing regimen. We gradually changed to a sparing-conditioning regimen adding special conditioning exercises aimed at restoring muscle tone, coordination and statokinetic functions, speed and force qualities, with more exercises for medium and large muscle groups, increasing the intensity and speed of exercises, and added games. We held to a "single-peak" physiological curve of exercise, with an increase in pulse rate not exceeding 120/min and 3-min "plateau" on the tolerance level. In the sparing-training and training regimens, therapeutic physical culture and exercise were performed with a "two-peak" and then "three-peak" physiological curve, the pulse increasing to 132/min, with gradual increase in the "plateau" (Figure 2). The intensity and duration of exercise were calculated from the parameters of tolerable physical load, determined by the method of intermittent bicycle ergometry with staggered [in steps] increases (Z. M. Atayev et al.). The effectiveness of recovery was evaluated on the basis of combined clinical and physiological data (testing hemodynamics during graded exercise, orthostatic test), biochemical tests, etc.

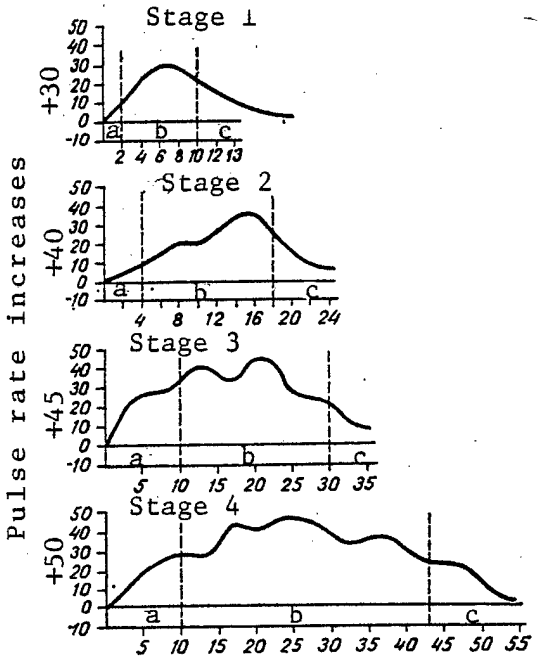


Figure 2.
Duration of physical conditioning, nature of physiological load curves and dynamics of increase in heart rate at different stages of readaptation period

a) introductory part
b) main part
c) final part of physical conditioning

X-axis, time (min); y-axis, heart rate

The results revealed that the efficacy of rehabilitation measures increased with proper scheduling of daily regimen, optimum alternation of exercise and rest, combined with positive psychoemotional factors in the form of special auto-training sessions, psychotherapy and appropriate musical accompaniment to exercises. After 49-day AOH, we observed normalization of functional state of the cardiovascular system, neuromuscular system (restoration of most parameters characterizing the state of hemodynamics, endurance and speed-force qualities of muscles) and significant reduction of asthenization syndrome at the end of the 3d week.

The principles of rehabilitation measures developed after 49-day AOH served as the foundation for working out systems of combined rehabilitation and therapy for 182-day hypokinesia. After 182-day AOH, particularly in the first group who did not use preventive measures, the recovery period lasted up to 2 months, 30 days of which were spent in the hospital and the same number of days as outpatients. During the first 5 days, the rehabilitation measures were used in a sparing regimen against a background of a large volume of functional load tests, and they were limited to relaxation massage, intramuscular injection of 100 mg cocarboxylase, intake of multiple vitamins. The sparing conditioning phase lasted 10 days for the group where preventive measures were used during AOH and 17 days in the control group (without preventive measures). The conditioning phase at the hospital consisted of the same methods of functional therapy using two- and three-peak physiological curve, exercise and gradual increase in duration of "plateau" and intensity of load. Special clinical and physiological examinations were made every 2 weeks, on the basis of which we evaluated the dynamics of recovery of functions and efficacy of therapeutic measures, corrected and optimized conditioning regimens. Once a week there was a day of rest from exercise, during which the rehabilitation measures were limited to toning exercises in the morning. Exercises in the swimming pool and gym, where physical training and athletic games were pursued, continued under ambulatory conditions under the supervision of experienced methodologists. This period was characterized by processes of social readaptation to the individual life stereotype, family and working conditions.

We observed differentiated normalization of functional state of the cardio-respiratory and neuromuscular systems, statokinetic disturbances in the different groups, and this occurred 7-10 days sooner in the groups where preventive measures

were used during AOH. Somewhat later there was disappearance of the asthenic syndrome and vegetovascular dysfunction, as well as normalization of adrenosympathetic system function.

Combined ways and means of rehabilitation therapy of posthypokinetic states, which were developed, served as the basis for rehabilitation and therapy following 140- and 175-day space flights. A differentiated approach was used to implement rehabilitation measures, the chief principle of which was combination, including functional therapy successively in sparing, sparing-conditioning and conditioning regimens.

The rehabilitation measures used after 140- and 175-day space flights were performed in two phases: first at the spaceport for 2 weeks, starting with the sparing regimen, followed by sparing-conditioning and conditioning. After this, rehabilitation was continued in sanatoriums of Crimea or the Caucasus for 1 month, depending on weather and season.

The early phase is the most important period of rehabilitation therapy, and proper implementation thereof determines subsequent dynamics of recovery of functions. For the first 4 days of readaptation, it is of special importance to wear a preventive postflight suit, which maintains circulating blood volume when body position is changed.

During these days, the main element of rehabilitation and therapeutic measures is to prevent orthostatic disturbances and gradually adapt to light exercise.

During the first days of readaptation after space flights, the cosmonauts presented changes in the myocardium (demonstrated by EKG), reduced mass of muscle in the left chambers of the heart, enlargement of chambers and muscle mass in the right heart (echocardiographic examination) and signs of moderate hypertension in the pulmonary circulatory system.

Some cosmonauts had vestibulovegetative disturbances and orthostatic instability, which worsened sharply with forced head movements and in erect position, which determines to some extent the tactics and nature of rehabilitation and therapy.

At the first phase, the chief means of rehabilitation therapy of cosmonauts consist of optimizing the regimen of motor activity, therapeutic massage of muscles, graded walking, hydrotherapy and thermotherapy, autogenic conditioning, as well as diet, vitamins and drug therapy (inoziye-F [typo for inosine?], retabolil, dedalon and others).

Toning exercise in the mornings, with breathing exercises and exercises for small and medium muscle groups were performed in bed for the first 2-3 days. Independent walking was limited to moving in the room, rehabilitation-therapeutic massage was given several times a day, before and after functional tests or exercise. On these days, the massage was selective: relaxing, toning and pneumatic ["pumping"?], depending on the initial condition of muscles and circulation. In the evenings, graded hydrotherapy and thermotherapy, combined with relaxing massage and autotraining, were used to remove fatigue and emotional tension. These procedures were determined by the subjective sensations of cosmonauts and no more than a 50% increase in pulse rate.

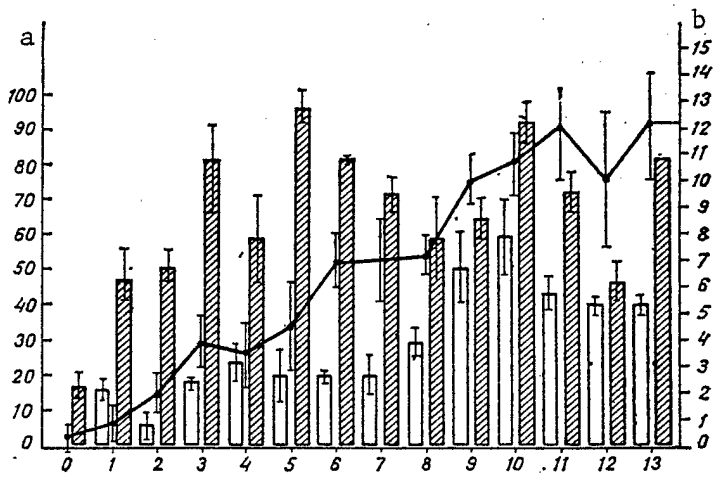


Figure 3. Duration of massage (striped columns), physical conditioning (white columns), walking (curve) at first phase following 140- and 175-day space flights.

X-axis, days of readaptation; y-axis: a) duration of massage and exercise (min); b) walking (km)

The considerable amount of clinical and physiological tests and work with methodologists during this period exact much physical and nervous-emotional tension of the cosmonauts, so that questions of psychological protection and giving them a day off once a week acquire particular importance in the set of rehabilitation measures. The sparing-conditioning regimen is followed from the 5th-8th day, during which the amount of physical exercises, particularly walking, was gradually increased (Figure 3). Rehabilitation massage included elements of rubbing and "kneading" with coverage of deeper groups of muscles of the back, buttocks and legs, and increasing duration. With the change to the conditioning regimen, the amount of all forms of exercise was increased, with addition of athletic walking, riding a bicycle and sports (volleyball, table and court tennis). The amount of walking at a strolling pace speeding up toward the end of the first phase of readaptation at the spaceport constituted 10-14 km/day. In order to condition vascular and muscle tone at this time, thermotherapy (sauna) combined with temperature contrasts was used.

The cosmonauts reacted favorably to the first phase of rehabilitation at the "Cosmonaut" preventorium, and there was gradual restoration of impaired functions. At the second (sanatorium-resort) phase of recovery, combined measures were used after 2-4 days of acclimatization to resort conditions, with the use of climatic, resort, balenological and physiotherapeutic elements. Physical training and sports were performed in the conditioning regimen, with the use of the "three-peaked" physiological curve of physical load. As compared to the first phase, the cosmonauts had much more free time and there was more individualization of rehabilitation measures.

The combined rehabilitation and therapeutic measures were instrumental in normalizing the functional state of different systems of the body and adequate course of readaptation processes following long-term space flights, and they can be used under analogous conditions.

BIBLIOGRAPHY

1. Beregovkin, A. V., Vodolazov, A. S. and Georgiyevskiy, V. S., KOSMICHESKAYA BIOL., No 5, 1976, pp 24-30.

2. Vorob'yev, Ye. I., Gazenko, O. G., Nefedov, Yu. G. et al., Ibid, No 5, 1976, pp 3-18.

3. Gazenko, O. G., Kakurin, L. I. and Kuznetsov, A. G., "Space Flights Aboard Soyuz Series Craft. Biomedical Research," Moscow, 1976.

4. Gazenko, O. G. and Yegorov, A. D., VESTN. AN SSSR, No 4, 1976, pp 25-36.

5. Gazenko, O. G., in "Nauchno-tekhnicheskaya revolyutsiya i chelovek" [The Scientific and Technological Revolution and Man], Moscow, 1977, pp 84-90.

6. Gurovskiy, N. N. and Yegorov, A. D., KOSMICHESKAYA BIOL., No 6, 1976, pp 5-14.

7. Gurovskiy, N. N., Yeremin, A. V., Gazenko, O. G. et al., Ibid, No 9, 1975, pp 48-54.

8. Danilov, Yu. Ye, Gazenko, O. G., Fedorov, B. M. et al., VOPR. KURORTOL., No 6, 1976, pp 39-44.

9. Kabanov, M. M., VESTN. AMN SSSR, No 4, 1978, pp 52-58.

10. Krupina, T. N. and Tizul, A. Ya., SOV. MED., No 7, 1978, pp 30-34.

11. Molchanov, N. S., Krupina, T. N., Balandin, V. A. et al., KOSMICHESKAYA BIOL., No 6, 1970, pp 26-31.

12. Rudnyy, N. M., Gazenko, O. G., Gazulov, S. A. et al., Ibid, No 5, 1977, pp 33-41.

13. Sorokina, Ye. I., Kanevich, N. A. and Daninov, B. I., SOV. MED., No 1, 1978, pp 73-77.

10,657
CSO: 1840/108

COOPERATIVE EFFORT SUGGESTED FOR RESEARCH ON EXTRATERRESTRIAL LIFE

Leningrad LENINGRADSKAYA PRAVDA in Russian 16 Feb 82 p 3

[Article by Yu. Zaytsev, head of department of Institute of Space Research of USSR Academy of Sciences: "This Enigmatic Mars"]

[Text] Probably no plane of the solar system has so many hypotheses—fantastic, audacious and wonderful--connected with it as does Mars. Only quite recently, the imagination of earthlings was excited by the fascinating possibilities of finding a world similar to their own at a distance of only several tens of millions of kilometers, which is quite insignificant on the scale of the universe. Moreover, certain data, or more precisely the interpretation of these data, seemingly confirmed the existence of such a world.

A great deal of noise was made at one time by the discovery on Mars by the Italian astronomer Schiaparelli of a network of straight dark lines, which he called canals. This name, which was mechanically applied to another planet from earthly conditions, instantaneously acquired the rights of citizenship. Everyone here believed that these canals were built by thinking beings. They believed what they wanted to believe.

The regular spread in each hemisphere of the planet from pole to equator of "waves of darkening" with the onset of spring was attributed to the awakening of vegetation because of increasing warmth and moisture. A discovered anomaly in the movement of Mars's satellites--Phobos and Deimos--brought up an original supposition about their possible artificial origin.

Researches of the last ten years and flights of Soviet "Mars" and American "Mariners" and "Vikings" have made it possible to obtain more reliable data on the natural features of Mars. But to the question "Is there life on Mars?" contemporary science cannot as yet answer definitively. The importance of the solution of this problem is tremendous. Of course, it would be tempting to establish a connection with intelligent beings from another planet. But even an encounter with most elementary forms of life or authentic traces of their past existence would be of undoubted interest.

The problem of the origin of life is one of the greatest philosophical problems of natural science. Without its solution, an understanding of the very nature of life would remain inaccessible to our intelligence. But no matter how deeply and completely we cognize substances, structures and processes lying at the

basis of organization of contemporary living bodies, we are not in a position to answer the question as to why this organization is as it is.

According to the hypothesis of Academician Alekxandr Ivanovich Oparin on the origin of life accepted today by the majority of natural scientists, the emergence of the most elementary ancestral forms of microorganisms was preceded by a long period of chemical and biochemical evolution. At first simple and later increasingly complex molecules of organic substances were formed from atoms and molecules of carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur and certain other elements as a result of so-called abiotic synthesis. They then became those "bricks" from which predecessors of contemporary microorganisms could be formed in a special confluence of circumstances.

It should be said that in recent years a large number of varieties of such molecules has been discovered, particularly in certain meteorites. But an agglomeration of molecules is still not a living system. And even with a very successful development of laboratory research in the immediate years ago, it would hardly be possible to produce artificially even a most elementary microorganism. At the same time, it would be extraordinarily interesting to understand how it came to be formed. It is therefore necessary to take another, very difficult, route--to look for living microorganisms on celestial bodies, first of all the planets of the solar system. In this sense Mars provides much hope.

In recent years, a series of researches was conducted for the purpose of elucidating whether live organisms could exist under Martian conditions. Here curious results were obtained. Rats lived in a simulated Martian environment for only a few seconds, tortoises--more than six hours, frogs--25 hours, spiders and beetles--for several weeks.

On a "Martian farm," oats, beans, rye and rice turned green. But their growth was retarded, and analysis showed that chemical changes had taken place in the plants. Most of the plants were found incapable of reproducing in the new conditions, but mushrooms, lichens, moss and algae fully adopted themselves to them. Bacteria also do not experience any difficulties in a "Martian atmosphere."

It is true that automatic interplanetary stations have provided certain corrections to our understanding of what the real conditions on the surface of Mars are--they have been found to be more severe than had been surmised. These stations, after making a soft landing on the surface of Mars, carried out a search for microorganisms on the surface layers of martian soil. They did not succeed in finding any microorganisms. But a consideration of the results of the accomplished work has caused the majority of investigators to be of the opinion that it is too early to reach any conclusions. The negative result could have been due to the absence of those types of microorganisms whose discovery had been the objective of the program and also because of many other circumstances: selection of landing sites, equipment for conducting the experiments and so on.

At the present time, plans are under discussion of further long-range programs aimed at a search for microorganisms on different celestial bodies, first of all

on the planet Mars. These plans entail in particular sending improved automatic laboratories to Mars not only for the purpose of conducting research on the site but also taking specimens of soil from the surface of the planet and bringing them to earth for further study.

It is understandable that the accomplishment of these programs will require big outlays of material resources. In this connection, it would be difficult for individual countries to carry out such programs independently. The greatest success would be achieved under conditions of strengthening of international cooperation and joint activities of scientists of different countries.

7697
CSO: 1866/50

NOTES ON 'COSMOS' AND 'PROTON' LAUNCHERS

Moscow KRYL'YA RODINY in Russian No 12, Dec 81 p 26

[Article by I. Merkulov, design engineer: "The Space Fleet of the Nation of the Soviets"

[Text] "Cosmos"

In the history of Soviet cosmonautics, March 1962 saw the beginning of various investigations of near-Earth space and the upper atmosphere and the solution of other problems with the help of artificial Earth satellites of the "Cosmos" series. By 4 October 1967, the end of the first decade of the space age, 180 satellites in this series had been launched. In the book "Successful Achievements of the USSR in the Investigation of Space," it is emphasized that the creation of the ISZ's [artificial Earth satellite] in this series "is a most important stage in studying the physics of space....Investigations conducted with satellites in the 'Cosmos' series also helped answer many technical questions."

In the course of the next 10 years (1967-1977), another 777 "Cosmos" satellites were launched. By 1 September 1981, the number of "Cosmos" satellites launched into orbit exceeded 1,300.

The realization of the program of space research using "Cosmos"-series satellites became possible because of the use of a new, quite powerful--and, at the same time, economical--launch vehicle bearing the same name. It was created by a collective led by Chief Designer M.K. Yangel'. In October of this year, the nation's scientific community celebrated extensively the 70th birthday of this outstanding communist designer, who is also a two-time Hero of Socialist Labor.

The "Cosmos" rocket is a two-stage one. It is 30 m long and 1.65 m in diameter. An ISZ is placed in the second stage, under the nose cone, and ejected after the rocket has passed through the dense layers of the atmosphere.

The rocket's first stage contains an RD-214 engine with a thrust of 74 t. This liquid-fuel rocket operates on a nitric acid oxidizer and a hydrocarbon combustible. In the second stage of the rocket there is an RD-119 engine, which has 11 t of thrust and a specific impulse of 352 seconds. It operates on oxygen and nonsymmetrical dimethylhydrazine.

The "Cosmos" launch vehicles and the ISZ's placed in near-Earth orbits by them are rightfully called tireless toilers in space. They have provided the basic volume of

information on the structure and properties on the upper layers of the atmosphere and near space, the electromagnetic radiation of the Sun and so on that have been obtained by Soviet scientists with the help of ISZ's.

The creative collective led by M.K. Yangel' carried out successfully its extremely complicated task of creating an economic and efficient rocket complex that was to be used to launch a large number of artificial Earth satellites. In the same way, this collective also solved another problem: the development of the new, improved and even more powerful "Intercosmos" launch vehicle for the placement of artificial Earth satellites of the "Intercosmos" series in orbits beyond the clouds.

The satellites in this series are the result of a fundamental agreement among the heads of the governments of nine socialist countries: Bulgaria, Hungary, the GDR, Cuba, the Mongolian People's Republic, Poland, Rumania, Czechoslovakia and the Soviet Union. This agreement covered the questions of collaboration in the field of the investigation and utilization of space for peaceful purposes. At a meeting of representatives of these countries, a program consisting of four basic sections was agreed upon and adopted. These sections are: the investigation of the physical properties of space; the development of space communications; work having to do with space meteorology; research in the field of space biology and medicine. The first "Intercosmos" ISZ was launched in the Soviet Union on 14 October 1969. After this, in accordance with the program, the second and succeeding "Intercosmos" satellites flew into space.

The technical parameters of the "Intercosmos" launch vehicles made it possible to lift large, automatic, general-purpose scientific orbital stations into orbit. In July 1976 an "Intercosmos" launch vehicle injected into a near-Earth orbit the first satellite of a new series, the "Intercosmos-15," which is an automatic, general-purpose orbital station (AUOS). The satellites in this family are capable of carrying a large complex of scientific instruments. Tests of the systems, design elements, assemblies and equipment making up this prototype confirmed the calculations of scientists and designers, and 24 September 1977 saw the launching of the "Intercosmos-17" AUOS for the execution of a multifaceted program of scientific research. A relatively short time later, the "Intercosmos" rocket lifted the "Intercosmos-18" and "Intercosmos-19" craft into orbit.

"Proton"

The multifaceted scientific program for the investigation and utilization of space for peaceful purposes that has been developed in our country provides for the simultaneous creation of spacecraft for different purposes and the appropriate launch vehicles to lift them into orbit. The years during which this program has been realized have shown that Soviet scientists, designers, engineers, technicians and workers are successfully carrying out that section of it that stipulates the development and constant improvement of launch vehicles. In particular, the creation in 1965 of the "Proton" launch vehicle was a huge success for the rocket builders. The lifting capacity of this rocket is several times greater than that of the well-known "Vostok" rocket. The first stage of the "Proton" launch vehicle contains an RD-253 engine that was developed by the collective of the GDL's [Gas Dynamics Laboratory] OKB [Special Design Office]. The rocket's other stages contain liquid-fuel rockets created in the OKB headed by S.A. Kosberg.

In remarking on the great value of this rocket in the investigation of space, Academician V.P. Glushko emphasized that "...the birth of the 'Proton' launch vehicle system marked the beginning of a new stage in the study and conquest of space. New opportunities have been opened for the investigation of the planets and other heavenly bodies that make up our Solar System."

Thanks to the excellent operating and power characteristics of this launch vehicle, many new and shining pages have been written in the history of the study of space. In July 1965 launched the "Proton-1" scientific station into a near-Earth orbit. It was followed by the "Proton-2," "-3" and "-4" stations, in which the scientific equipment complex alone weighed 12.5 tons.

The "Proton" launch vehicle also lifted into orbit the "Zond-5"-"Zond-8" craft, which circled the Moon and returned to Earth, as well as the "Luna-16," "Luna-20" and "Luna-24" automatic stations, which delivered lunar soil to the Earth. The "Proton" rocket started automatic stations of the "Mars" type on their interplanetary voyages to circle Mars and land on its surface, as well as other spacecraft.

The Soviet people can be proud of the space fleet that has been created by its talented sons. It enables this country to achieve ever newer successes in the conquest and utilization of space for progress in science, culture and the national economy.

This story of the "Cosmos" and "Proton" launch vehicles completes the publication of the section entitled "The Space Fleet of the Nation of the Soviets."

11746
CSO: 1866/46

LOW-THRUST ENGINES FOR SPACECRAFT

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 2, Feb 82 pp 42-43

[Article by V. Ivanov, doctor of technical sciences]

[Text] One of the decisive directions in practical space research and improving space vehicles is the development of engine systems. If an analysis is made of the development of space equipment, particularly space vehicles, the variety of types, not only in designs and layout decisions but also in engine or power systems, is obvious. And, as is known, any diversity requires classification. According to present views, in terms of the method by which they derive energy, engine systems can be divided into three categories. The first includes thermal propulsion engines (thermochemical, nuclear, heliothermal, laser), whose characteristic feature is restricted exhaust velocity. The second category is made up of engine systems of limited power. These include various modifications of the electric jet engines (electric-arc, ion, magnetic-plasma). They usually consist of a source, a converter and a power extraction system, an engine with a fuel feed system and a housing with a propulsive mass. The availability of a separate limited power source determines the basic properties of designation of engine systems in this category. Engine systems of the third category are characterized by low thrust. These systems include solar and isotope sail engines.

Thermal propulsion engines are called high-thrust engines. The acceleration (a) that they produce in a vehicle usually reaches values substantially greater than acceleration of gravitational force on the Earth's surface (g). Others belong to the low-thrust category, since they always have an inequality where $a < g$. The possible classes of space flight using various kinds of engines is shown in Figure 1 below. The ordinate $\frac{a}{g} = 1$ corresponds to the boundary that separates high- and low-thrust engines.

The possibility of developing the electric jet engine was proved theoretically and experimentally by academician V. Glushko as long ago as the early Thirties. However, the low-thrust engine did not find practical application until 1964 when the Voskhod and Zond-2 space vehicles with ion-drive and plasma-drive electric jet engines aboard were launched from the Soviet Union. Thus, the Zond-2, which was launched toward Mars, had an orientation system of six electric jet plasma engines. Later, in 1970, the Sert-2 vehicle was launched into a polar orbit. It completed a 5-month spiraling climb to almost 100 kilometers, and then descended over a 3-month period with the aid of two ion engines. In 1971 the Meteor satellite was launched with two static plasma engines that took it into a planned nominally synchronous orbit.

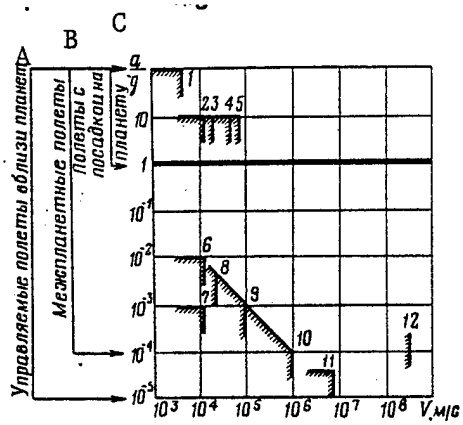


Figure 1. Range of Possible Accelerations $\frac{a}{g}$ and Exhaust Velocities V for Engines of Various Types.

Key: 1-5 High-thrust engines:

1. Chemical combustion chamber
2. Reactor heating with solid nuclear fuel
3. Reactor heating with liquid nuclear fuel
4. Reactor heating combined with chemical combustion chamber
5. Reactor heating with gaseous nuclear fuel

6-12 Low-thrust engines

6. With solar heater
7. With isotope heater
8. Electric-arc
9. Electrodynamic
10. Electrostatic
11. Isotope sail
12. Solar sail

A. Controlled flights near planets
B. Interplanetary flights
C. Flights with a planet landing

Low-thrust engines are considered very promising for long-duration space flights and significantly increasing payload. The fact is that thrust in a jet engine is determined by the values for mass rates and exhaust velocities for the propulsive mass. When chemical fuel with a large amount of energy is used (hydrogen-oxygen or hydrogen-fluorine), exhaust velocities can reach 4-5 km/sec. But an engine with a nuclear reactor is twice as good as a chemical reactor for this characteristic, an electrothermal engine is four or five times as good, and ion and plasma engines are 10 to 100 times better. At the same

time, however, the design of the low-thrust engine places constraints on the mass rate for the propulsive mass. As a result, the thrust and acceleration developed are relatively small. In particular, for satellites with electric jet engines, maximum controlled acceleration is no greater than 0.04 m/sec^2.

In additon to this basic difference, low-thrust engines have a number of other features. Thus, they can operate continuously for many weeks and months, which as a result makes it possible to impart a quite significant terminal velocity to a satellite. This property makes it possible to develop extremely sophisticated controlled vehicles from the standpoint of accuracy in executing the complex schemes for space flights. For of course, under these conditions, it is possible to exercise active guidance throughout the entire flight. Measurement errors and error in working out control actions have less effect on fulfillment of the required flight pattern compared with using a high-thrust engine. But they also have disadvantages. The most significant is that they can be used only under conditions of the high vacuum of the space medium. Thus, it is not possible to launch a space vehicle from the Earth's surface using a low-thrust engine. For this, a high-thrust engine is required.

The trajectory along which a satellite moves using a low-thrust engine is characterized by long active sections, sometimes measured in millions of kilometers, and short passive sections (and sometimes there is no passive section at all). This affects the flight pattern for a space vehicle. Thus, for orbit transfer between circular coplanar (located in the same plane) orbits, from the viewpoint of energetics, the high-thrust engines are optimal for the two-impulse Hohmann tranfer. The flight trajectory is a half-ellipse that touches that boundary orbits at the points of perigee and apogee. The first impulse is to remove the satellite from the initial orbit and place it in the Hohmann half-ellipse, and the second is to transfer it into the final orbit. The same flight maneuver using a low-thrust engine will be done differently. Its trajectory is an unwinding or tightening spiral that touches the initial and final orbits. To make the transfer from a low orbit to a higher one, thrust must coincide with the direction of the space vehicle's orbital movement; otherwise it is changed to the opposite direction. Whereas, a low transverse or tangential thrust is adequate for departure from the initial circular orbit, in order to transfer from a spiral trajectory to a final circular orbit a special transfer section is required in the flight, using radial thrust.

By using a combination of sequential transfers for a satellite between coplanar circular orbits it is possible to consider a more complex pattern for a space flight associated with transfers to several planned orbits and return to an intital orbit. Depending on the specific missions for a flight, the sequence used in orbit departure can be either planned ahead or determined according to conditions for optimizing controlled movement according to given criteria. In the former case, the general flight pattern is determined in the form of the total sequential transfers between each pair of planned orbits, while in the latter it is determined during the course of resolving inflight tasks that establish the sequence required for removing the satellite from a given set of orbits.

Let us consider transfer during a flight from Earth to Mars that starts from a low geocentric orbit and ends with injection of the satellite into a low orbit around Mars. The general pattern can be divided into three sections.

During the first section of the flight, using a spiral trajectory the vehicle transfers from circular geocentric orbit to a flight trajectory for Mars. Flight duration will depend on the magntidue of control acceleration and the gravitational effects of the Moon. In order to simplify guidance conditions it is expedient to continue the acceleration trajectory far beyond our natural satellite. In this section of the flight (transfer between the planets) flight duration is about 280 days. At this stage the fact that the orbits of Mars and Earth are not coplanar is of less significance than Mars' eccentricity.

During the final section of the flight the vehicle transfers along a spiral trajetory to an orbit that makes it a satellite of Mars. The duration of this section is determined by the values for control acceleration available.

Thus, given a = 0.0001 m/sec^2, total duration of the entire flight from Earth Mars is about 430 days. If the passive part of the flight is excluded, it can be reduced to 320 days. If control acceleration is doubled, total flight time is less than in high-thrust engines (260 days).

If the required trajectory is made using only a low-thrust engine then flight duration can be quite long. It is therefore expedient to use this scheme only when there are no firm constraints on flight duration or in order to eliminate various kinds of disturbance factors (gravitational, aerodynamic). Otherwise, both low-thrust and high-thrust engines are used. This kind of combined control makes it possible to utilize the advantages of both kinds. It will be possible to expand significantly the classes of schemes used for a space flight, including a landing on a planet.

In space flight, the use of low-thrust electric jet engines is most frequently proposed. Here, the following circumstance must be borne in mind. The large-dimension payloads for which they are intended should be equipped with powerful sources of electric power. They can also be used to supply power to the electric jet engine. In addition, in long-duration flights it is possible to use solar panels as sources of electric power.

In an ideal situation it is advisable to start on a satellite design by determining the goal-oriented tasks and the size of the payload. After this, the flight duration and the essential typical velocity are determined. With regard to parameters such as initial weight, exhaust velocity for the propulsive mass, acceleration stress, current, full power, mass of the electric power source and fuel, they are determined as a result of decisions made in the general problem of optimization according to given criteria.

The characteristics of a satellite with an electric jet engine will be limited by the possibilities of the carrier vehicle and the electric power source available. The factor imposing greatest constraint is the latter. Notwithstanding, the appearance of similar installations rated at 5 to 50 kilovolts can be expected in the near future. This makes it possible to speak realistically of making space flights with low-thrust engines in a quite extensive range of orbits.

9642
CSO: 1866/56

PROSPECTS FOR POWER ENGINEERING IN SPACE

Moscow ZEMLYA I VSELENNAYA in Russian No 6, Nov-Dec 81 pp 2-6

[Article by V. S. Avduyevskiy, academician, S. D. Grishin, doctor of technical sciences, L. V. Leskov, doctor of physical and mathematical sciences, V. K. Ablekov, candidate of technical sciences, and A. F. Yevich, candidate of technical sciences]

[Text] Today man is producing so much energy that it is necessary to think about the "thermal contamination" of the earth. This can evidently be avoided by use of power engineering in space.

***

There are various specific ways in which solar energy can be used: direct use by means of concentrators of solar energy or conversion into electrical or mechanical energy for use for productive purposes. During recent years these ideas have led to specific projects.

The objective of these projects is man's intensive exploitation of solar energy with the maintenance of ecological equilibrium on the planet. Without examining the attempts of certain western scientists to find new possibilities for solving the social problems caused by the general crisis in capitalism by such "expansion into space," we will note the purely technical aspect of the problem.

At the present time the world consumption of energy is about $3 \cdot 10^{20}$ J annually, that is, approximately 0.01% of the energy which the earth receives from the sun. If all mankind used as much energy per capita as is consumed in the well-developed countries, this figure would increase to 0.03%. And this is already in the immediate neighborhood of the threshold beyond which irreversible effects on planetary climate (earth's "thermal contamination") occur. If in the computations an allowance is made for the continuing growth of the earth's population and the increase in energy consumption in the well-developed countries (doubling each 10-15 years), the situation becomes still more serious.

In the opinion of specialists, in order to prevent crisis consequences of an ecological character and maintain global ecological equilibrium up to 40% of all the expenditures of society will be required.

One of the radical means for overcoming these difficulties is a changeover from a "two-dimensional" industry at the planet's surface to "three-dimensional" industry -- a transfer of a considerable part of power production, and also some energy-intensive and dangerous forms of production into circumterrestrial space. K. E. Tsiolkovskiy visualized the future of mankind in precisely such a way.

Pluses and Minuses of Space Electric Power Stations

The following scheme of space electric power stations is usually considered: apparatus whose main component is solar cells is deployed in a geostationary orbit, 36 000 km distant from the earth's surface. The produced electric current is transformed into superhigh-frequency (SHF) radiation, transmitted to the earth. On earth the SHF radiation is transformed back into an electric current of the required parameters.

The planned investigations indicated that a single space electric power station is characterized by the following figures: electric power about 10 GW, mass about 10^5 tons, areas of solar cells about 100 km^2 and approximately the same area of the antenna receiving SHF radiation at the earth.

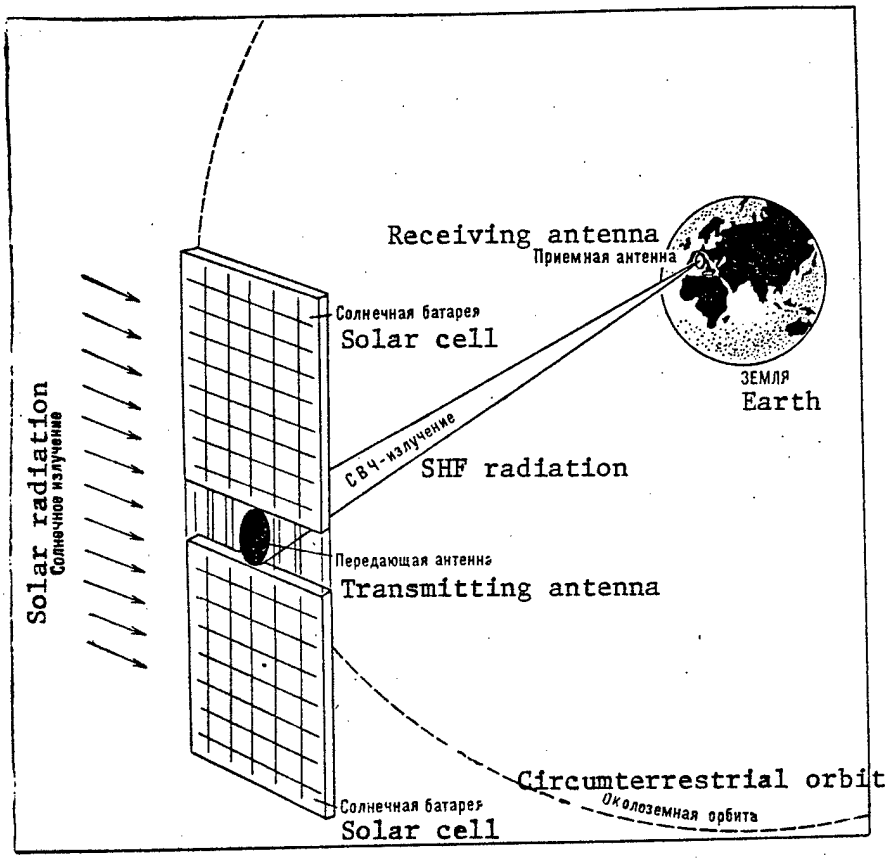
In the United States there are projects which examine the possibility that in the first third of the 21st century about 60 such stations will be created, and in Western Europe -- 50. These stations could supply up to 40-50% of the needs for electric power. The cost of building one space electric power station is estimated (very approximately) at from 15 to 40 billion dollars. This, to be sure, is a large sum. But we will attempt, glancing at the table, to compare the expenditures on the implementation of different long-range projects for producing electric power on the basis of nuclear breeder-reactors, thermonuclear reactors and space electric power stations.

Cost of Different Methods for Producing Electric Power in Space

Proposals - Expenditures	Construction cost, dollars/KW	Energy cost, cents KWhr
Nuclear breeder-reactors	400-560	1.2-1.7
Thermonuclear reactors	1500-2500	3.4-5.7
Space electric power stations	1500-4000	3.2-8.6

We see that at the present time breeder reactors are the most economical. But they have serious shortcomings: nuclear reactors give a great quantity of potentially dangerous radioactive wastes and in addition as the primary raw material they use uranium and thorium, whose reserves are limited.

With respect to space solar electric power stations, taking into account the approximate character of the estimates which have been made it must be admitted that their economic effectiveness differs little from the efficiency of



Space solar electric power station (P. Glazer scheme).

promising thermonuclear reactors. Thus, even today there is a quite serious basis for regarding space solar electric power stations as one of the promising sources of energy.

At the same time these investigations have indicated: in order to create space electric power stations it is necessary to overcome more than a few difficulties, one of them being the truly enormous size of the construction. For example, if the delivery of station elements with a mass of 10^5 tons into a geostationary orbit is accomplished by means of liquid-fuel rocket engines, a considerable quantity of fuel must be put into a reference circumterrestrial orbit. As a result, the total mass will be not less than $3 \cdot 10^5$ tons. In order to launch such a quantity of freight into space from the earth's surface it would be necessary to create carrier-rockets of an almost fantastic load-lifting capacity. The launching of such rockets from the earth's surface involves another difficulty: it is necessary to burn an exceedingly great volume of fuel in the earth's atmosphere -- about 8 million tons for only one electric power station.

If it is assumed that the admissible quantity of power consumption on the earth is about 1% of the solar constant and it is assumed that space electric power stations will supply 10% of this quantity, with a power of one station of 10

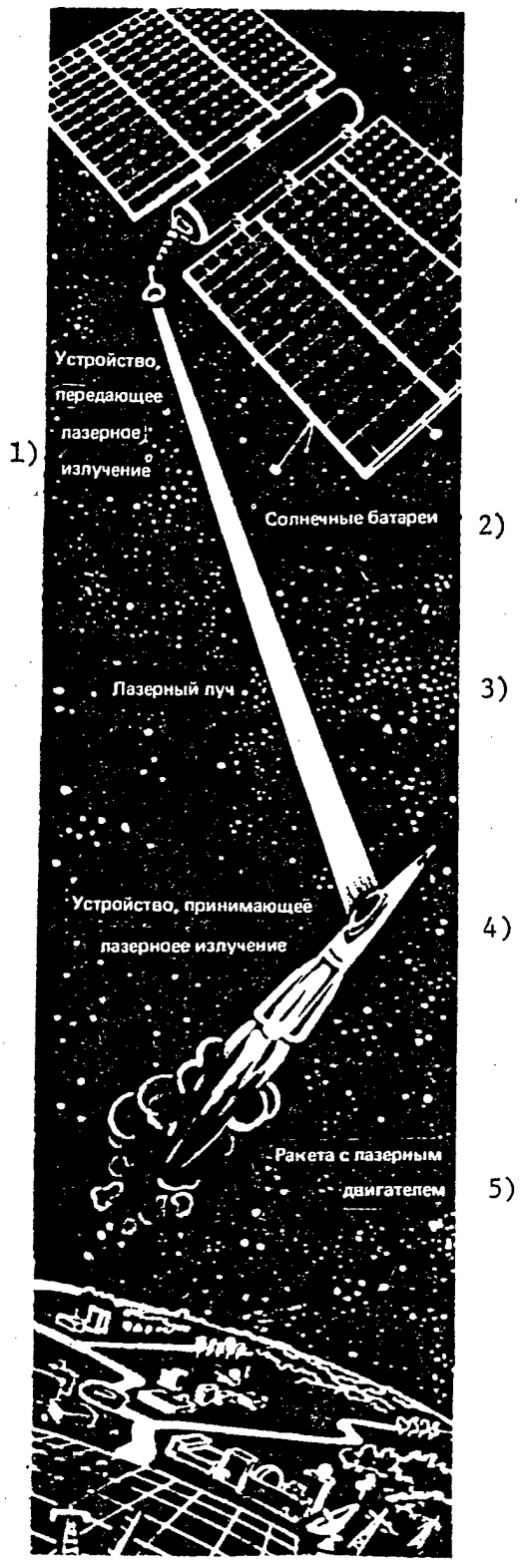
GW the number should be 10^4. It is easy to compute that for launching the payload for 1000 stations into a geostationary orbit by means of carrier-rockets with hydrocarbon chemical fuels it is necessary to expend almost 10^{11} tons of fuel. As a comparison we point out that the mass of carbon dioxide gas in the earth's atmosphere is of the same order of magnitude -- about $2 \cdot 10^{11}$ tons. It is clear that the entry of such a quantity of combustion products into the atmosphere can exert an appreciable influence on the climate of the planet and is inadmissible from the ecological point of view.

New Ideas in Space Power Production

Thus, for a rational solution of the problem of power supply to the earth from space there must be a fundamentally different approach. First of all, on qualitatively new principles it is necessary to contend with three tasks: find methods for a substantial decrease in the mass of the space electric power station with retention of the same useful power; organization of the delivery of freight into the circumterrestrial reference orbit with minimum losses for the environment; assurance of optimum placement of this cargo into a geostationary orbit.

The last task is the creation of an interorbital freight "tug": it is best to solve this problem by means of electric rocket engines. The working medium in the engines should be plasma or a beam of ions accelerated by an electromagnetic field.

The use of electric rocket engines for the delivery of payloads to a geostationary orbit has a number of important advantages. First, in these engines use can be made of solar energy produced by elements of the space electric power station itself. Second, they are most economical. Third, electric rocket engines ensure the possibility of transporting



KEY:
1) Unit transmitting laser radiation
2) Solar cells
3) Laser beam
4) Unit receiving laser radiation
5) Rocket with laser engine

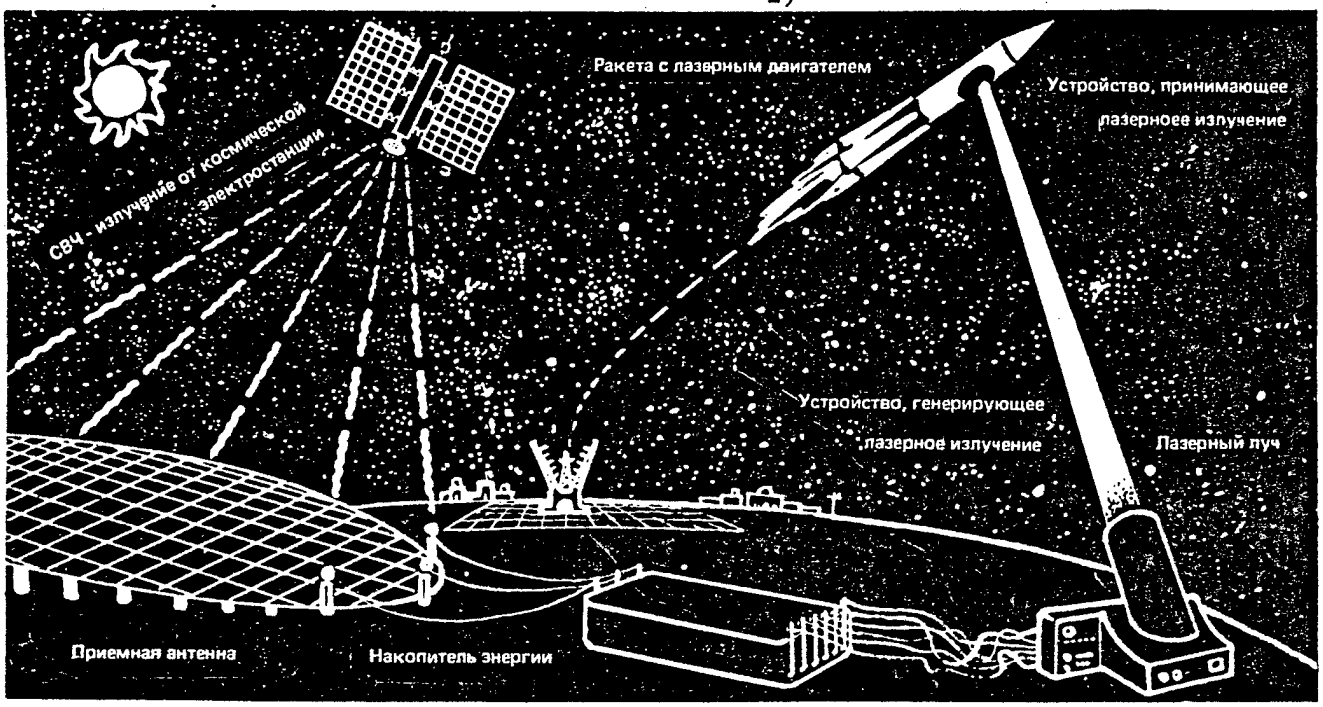
Launching of rocket with laser engine in a regime of energy transfer directly by space electric power station.

freight with small accelerations acting on the space vehicle -- not more than 10^{-3}-10^{-4} g. This lessens the requirements on the strength of large station components installed initially in the circumterrestrial reference orbits and accordingly reduces their mass.

It is more complex to create fundamentally new engines for the launching of rockets from the earth's surface. We will consider how it is possible to solve this problem using the attainments made in the field of laser technology.

Laser Technology and Cosmonautics

Laser engines ensuring the launching of rockets from the earth's surface are known. Their basis is the same principle as in electric rocket engines. In contrast to ordinary rockets with chemical fuel, the working medium used in the engine and the energy source are separated. However, whereas in an electric engine the power source (solar power plant, nuclear reactor) is aboard the rocket, in a laser engine it remains on the earth and the energy is sent to the vehicle by a beam of well-focused laser radiation.



Launching of rocket with laser engine in regime with preliminary accumulation of energy.

KEY:

1) SHF radiation from space electric power station
2) Rocket with laser engine
3) Apparatus receiving laser radiation
4) Apparatus generating laser radiation
5) Laser beam
6) Receiving antenna
7) Energy storage unit

Characteristics of Three Different Schemes for Putting Rocket Into Circumterrestrial Orbit

Schemes - Characteristics	Exhaust velocity of working medium, km/sec	Payload, tons	Rocket launching mass, tons	Mass of surface apparatus, tons
Launching of rocket with liquid-fuel engines	3.5	100	3000	--
Energy conveyed to rocket by laser beam from earth	20	100	200	10^5-$3 \cdot 10^5$
Energy conveyed to rocket from space electric power station	20	5-10	15-20	--
	20	5-10	15-20	--

Aboard the rocket the working medium by means of the energy of laser radiation is heated to high temperatures and then is ejected through a supersonic nozzle with high escape velocities. Since the energy source remains on earth and the escape velocities of the working medium (specific momenta) are great, the laser engines are capable of ensuring the output of quite high accelerations -- up to 1-2 g. Accordingly, engines of such a class, in contrast to electric engines, can be used as sustainer engines during the launching of a rocket from the planetary surface.

As the primary energy source for the sustainer laser engines it is desirable to use the energy produced by the space electric power station itself. There are two methods which can be employed for using this energy. In the first the well-focused laser beam conveys the energy produced by the space electric power station installed directly aboard the rocket at the launching point. The advantage of this method is evident: it does not require any intermediate energy converters and storage units. However, with a standard power of the station of 10 GW using such a method it is possible to put only relatively small payloads (1-10 tons) into circumterrestrial orbit.

Therefore another, although more complex method, merits attention. The energy transmitted from the space electric power station is first sent to a storage unit and only then is used for the rocket launching. In order to apply this method it is necessary to build a storage unit on the earth (on the basis of superconducting elements, hydroaccumulators), converters and a group of lasers of increased power for transmitting power to the rocket.

If the exhaust velocity of the working medium is 20 km/sec and the payload is 100 tons, the launching mass of the rocket will be about 200 tons. As the working medium (due to economic considerations) it is convenient to select such a medium as water. Then the ecological problems will be less acute than when using hydrocarbon fuels. It is true that the problem of the influence of water vapor escaping from the engine on the protective ozone layer in the earth's atmosphere requires special study.

It is necessary to impart a power of about 10^8 KW to the working medium (water) for its evaporation and acceleration to a velocity of 20 km/sec and the total power which must be imparted to the flying rocket is 10^{14} J (assuming the efficiency of energy conversion of radiation to be 10%). We will assume that the specific mass of the surface laser apparatus sending this energy to the rocket is 1 kg/KW. Then the mass of the apparatus will be 10^8 tons. It goes without saying that such a surface installation for the launching of rockets by means of laser emitters will be technically complex and expensive. However, its cost will scarcely exceed the expenditures on the creation of the first space electric power station (about 40 billion dollars) and the advantages of such an apparatus are obvious -- the possibility of repeated use with minimum harmful and lasting consequences which will be inflicted on the earth's environment. Progress in the development of laser technology can also facilitate solution of another problem in the space industry -- a significant decrease in the mass of the space electric power station. In particular, there is a possibility of creating high-power lasers with direct pumping due to solar radiation for sending to the earth laser radiation energy in the form of a well-focused beam.

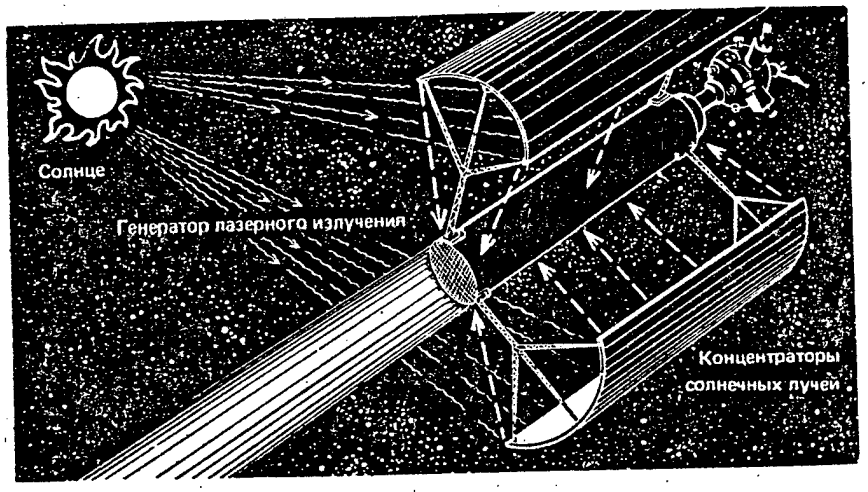
The use of lasers for space electric power stations will make possible a sharp decrease in the size of the receiving antenna and the use of artificial earth satellites as relay stations.

Lasers and Thermonuclear Energy in Space

Even now it is possible to think about creating a photon machine, in other words, a system for the effective transformation of the energy of laser radiation, for example, into electric energy. Whereas a laser is an analogue of an electric generator, a photon machine is an analogue of an electric motor. After the creation of such a machine the efficiency of the system for conversion of the energy of laser radiation on the earth will increase to 70%. The solution of this problem will lead to a new decrease in the mass of the space electric power station and an increase in station efficiency.

There are also other possibilities for a further decrease in the mass of space electric power stations and prevention of undesirable effects on the environment. One of these involves the use of power plants on the basis of controllable thermonuclear reactions as a primary source of energy for a space electric power station.

We will examine a thermonuclear power plant as an example. A deuterium-tritium reaction will occur in the thermonuclear reactor.This reaction is initiated by laser radiation. The mass of the propulsion stage with such an engine is 300 tons; the total thermal power of the reactor with a pulse frequency of 500 Hz is 63 GW. With an efficiency of conversion of thermal energy into electric energy of 15% (for example, using a thermoemission converter) the reactor power will be 10 GW -- the same as for a "standard" space electric power station. If a relativistic electron beam is used in place of a laser in a thermonuclear power plant, the efficiency of this electron beam being much greater, we obtain an additional decrease in station mass.



Space electric power station with direct conversion of thermal energy into the energy of laser radiation.

The heat received from the sun or which is produced in space by a thermonuclear reactor can be used for direct conversion into the energy of laser radiation and then the energy can be transmitted to the earth. Assuming that the specific mass of such a laser apparatus is about 2-3 kg/KW, for the total mass of a laser-thermonuclear space electric power station with a power of 10 GW we obtain $(2-3)\cdot 10^4$ tons. This is less than in the case of ordinary space electric power stations.

The expenditure of thermonuclear fuel at such a station is small -- 10^{-14} kg/J or about 3 tons per year with a power of 10 GW. The transfer of thermonuclear power production into circumterrestrial space will make possible a substantial increase in the threshold quantity of energy beginning with which the "thermal contamination" of the earth will become substantial. Precisely for this reason it is desirable to develop thermonuclear electric power stations.

The gain with respect to mass will be still more significant if it is taken into account that a spaceship, created on the basis of a thermonuclear reactor, is capable of transfer from a reference orbit into a geostationary orbit by means of the very same thermonuclear power plant.

Power plants based on thermonuclear reactors are now in the research stage. According to evaluations of specialists, the appearance of the first experimental-industrial models can be expected in 10-15 years. But precisely at this time it is expected that we will see the initial period of development of work on space electric power stations for supplying the earth with electricity.

The first experiments related to the transmission of energy from space to the earth in principle can be carried out in the next 10-15 years. After this it will be possible to proceed to the construction of experimental space electric power stations. In the first decades of the next century such stations will be

capable of satisfying a considerable part of the energy requirements of mankind.

In evaluating the prospects for space electric power stations, we once again emphasize a thought of fundamental importance for further progress in this field: the engineering development of the problems of power production in space must rest on the attainments in related fields of science and technology -- electronics and electrical engineering, nuclear and thermonuclear power, plasma physics, quantum electronics and laser technology (ZEMLYA I VSELENNAYA, No 2, pp 27-31, 1979 -- Editor's Note).

5303
CSO: 1866/61

SPACE ANTENNAS

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 82 pp 40-41

[Article by V. Andreyev and V. Shagov, candidates of technical sciences: title as above]

[Text] Many objects in space, including those that cannot be seen with the most powerful optical telescopes, can be detected by their radio frequency emissions. At the same time, the radio background carries millions of times less energy than the light flow. As it turns out, this striking contast between visible and radio frequency emissions is caused not so much by the difference in their powers as by the special features of the absorption and scattering of electromagnetic waves along the path from the source to the receivers, as well as the reception capability.

Space radio facilities use ultrashort waves almost exclusively. The reason for this is that the gaseous layer adjacent to the surface of our planet (the troposphere) contains increased concentrations of water vapor and oxygen, which absorb waves in the millimeter and optical bands. In addition to this, in the ionosphere (at altitudes of 50-280 km) there are several layers with increased concentrations of free electrons, which block the passage of long radio waves. After being reflected as if from a mirror, they return to Earth. This property, which is both necessary and sufficient for terrestrial radio communication, is the basic interference for space radio communication. Ultrashort waves (in the centimeter, decimeter and meter bands) pass through these obstacles. Therefore, they are used for communications with satellites.

As far as the reception capability is concerned, it is related primarily to the area of the antennas. The diameter of the mirror of the largest optical telescope in the world is 6 m, while that of the largest rotatable radiotelescope is 100 m. This increase in antenna area made it possible to enlarge the framework of our observations of the Universe significantly, to distances of 10 billion light-years from Earth. In cosmonautics there is not yet any need to communicate over such distances. However, this example illustrates graphically not only the possibilities of radio instruments, but also the direction for the development of space radio links. Actually, the installation of powerful emitters on satellites is difficult. Overcoming the force of the Earth's attraction requires large expenditures of energy. This, in turn, places limitations on the size and weight of equipment installed on satellites that consumes electricity. It can be compensated for, obviously, only by setting up more powerful radio equipment on Earth.

Bilateral communication with satellites is achieved by means of radio links. They enable us to control spacecraft motion, monitor flight trajectories, receive and transmit telemetric and scientific information, communicate with cosmonauts, and control the functioning of on-board equipment. If we add to this the differences in satellite distance and flight speed and their orientation and stabilization methods, it becomes clear just how diversified the radio links must be. This shows up most noticeably in the antennas. Right now there are several dozen of them, differing from each other in size, shape and other parameters.

The parabolic antenna, which is utilized in the decimeter and centimeter wave bands, is the most widely used one. It consists of a metal mirror in the shape of a paraboloid of rotation and an irradiator located at the focus. Its operating principle is based on phenomena common to radio engineering and optics. For instance, light rays emanating from a source located at the focus of such a mirror become parallel after being reflected from it. Each element of the paraboloid's surface can be regarded as a source of reradiation of electromagnetic energy. From the definition of a parabola as a locus of points located equidistantly from focus F and directrix bb' (see figure [omitted]), we find that distances FK = KM and FN = NP. From this there follows an important conclusion: the electromagnetic field in plane aa', which is at any distance away from the directrix, will be cophasal. This means that within the limits of the paraboloid's opening, the value of the electromagnetic field at any point in this plane will be the same at any given moment. Incidentally, let us mention here that the electromagnetic field's cophasality also predetermines the narrowly directional emission of energy in the direction of the Z axis.

How does the radiation's intensity change beyond the limits of the paraboloid's opening? It is characterized by the antenna's radiation pattern, which is the electromagnetic energy's density as a function of angle θ. The radiation pattern is usually given in two cross-sections, in the vertical and horizontal planes. For antennas with axial symmetry, the radiation pattern is practically the same in both cross-sections. The proximate value of angle θ, at the boundary of which the electromagnetic radiation's density becomes zero, determines the pattern's main lobe. The greater the diameter of the paraboloid's surface with respect to the wavelength, the narrower the radiation pattern becomes and the more intense is the beam of electromagnetic energy emitted into space. For instance, for the antenna with a 25-m mirror that is installed on the ship "Kosmonavt Yuriy Gagarin," the width of the radiation pattern's main lobe is 8 angular minutes for a wavelength of 5 cm.

One of the characteristics of an antenna is the width of its radiation pattern. It is determined by the angle, within the limits of which the power emitted is no less than half its maximum value. A real parabolic antenna emits energy in all directions and, because of the finite dimensions of the mirror, even backward. However, the maximum energy is emitted in the direction of the axis. The so-called side lobes of the radiation pattern characterize the change in the electromagnetic energy's density outside the main lobe. This is quite obvious from the figure, in which the pattern is given for one cross-section. Because of the antenna's axial symmetry it determines the radiation pattern completely in all space.

For a short wavelength (units and tens of centimeters), any deviation of the mirror's shape from the given shape causes a change in the radiation pattern, distorts and expands the main lobe and enlarges the side lobes. Therefore, the mirror of a

parabolic antenna several meters in diameter is manufactured with an accuracy of several millimeters. In addition to this, its structure must be sufficiently rigid in order to eliminate distortion when affected by wind, its own weight and dynamic loads. Snow, rain and icing of the mirror also affect the radiation pattern. In order to reduce their effect, as well as to protect the antenna from the wind, it is usually covered with a dome made of a special radio-transparent material.

From the principle of reciprocity it follows that the radiation patterns of any antenna coincide during reception and transmission. Therefore, the same antenna can be used in both cases. During pulsed emission, it alternately turns on the transmitter or the receiver because of the temporal separation of the transmitted and received signals. In order to use the same antenna during continuous emission, the transmitted and received signals must have frequency separation. Electromagnetic energy is sent from the transmitter to the irradiator and from the irradiator to the receiver by means of a waveguide-feeder channel.

Providing the required parabolic antenna radiation pattern when a satellite is moving under conditions of the Earth's daily rotation is not so simple. The antenna must track a rather complicated trajectory. This can be done manually, according to a program, or automatically. In the first case, the operator uses electromechanical devices to move the antenna in the horizontal and vertical planes separately. When program control is used, the antenna is linked with a computer. The computer calculates the change in angles as a function of time and controls the antenna. For automatic tracking, the irradiator in the mirror's opening receives a signal and sends it into a closed control system that, finally, insures the tracking of the incoming radio waves by the radiation pattern.

Spiral and director antennas are used in space radio links in the meter and lower part of the decimeter bands. The former is a coil that is attached to a metal disk and powered through a coaxial cable. Its inner conductor is connected to the coil, while its outer shell is connected to the disk, which is perpendicular to the coil's axis. In connection with this, there can be several conical or cylindrical spirals on one disk. The directional properties of a spiral antenna depend essentially on the ratio of the spiral's diameter and the wavelength, which is usually 0.25-0.45. The maximum radiation of such an antenna is directed along its axis. The radiation pattern's width is several tens of degrees and depends on the wavelength, the length and number of loops and the winding pitch. The antenna is moved manually or according to a program. The disk of a spiral antenna is used to weaken emissions in the rear hemisphere. The range of working frequencies is broader for conical spiral antennas than for cylindrical ones. Spiral antennas are easy to operate and cheap to produce.

A director antenna has a linear, active oscillator. Behind it there is a reflector, and in front of it there are several deflectors placed at identical distances apart in the same plane. The oscillator's length is usually close to half the wavelength. Only the active oscillator is connected to the transmitter and the receiver. The presence of the reflector and the several directors improves the directional nature of the antenna's emissions on the side where the directors are located. The width of the direction pattern's main lobe for a given wavelength depends on the sizes of the active oscillator, the reflector and the directors, as well as the number of the latter and the distance between them. The power feed, control and directivity of the emissions of this antenna are similar to those of a spiral one.

In recent years more and more interest has been manifested in antennas of a new type, the so-called phased antenna arrays (FAR). They consist of a set (hundreds, thousands and even tens of thousands) of elementary emitters. They are powered in sequence or parallel through special elements: splitters, amplifiers, phase shifters and commutators. In each elementary emitter, the required electromagnetic field magnitude and phase are obtained. All the elements are controlled by a computer. By changing the magnitude and phase of the electromagnetic field for each element according to a given rule, it is possible to change, without almost any time lag, the shape of the FAR's radiation pattern and the number and relative position of the main emission lobes, as well as to move the main lobe in space in any manner.

The possibility of forming the required electromagnetic field distribution electrically makes it possible to make an FAR in practically any shape that best conforms to that of the object on which it is to be mounted. The future belongs to phased antenna arrays.

11746
CSO: 1866/65

UDC 523.164.83

LUNAR RADIOINTERFEROMETER

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 59, No 1, Jan-Feb 82
(manuscript received 21 Nov 80) pp 155-159

ARTYUKH, V. S. and SHISHOV, V. I., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The author proposes a super-long base lunar interferometer with an operating principle similar to a marine interferometer. Observations would be made with a single antenna with a multiray diagram or with two antennas, one directed at the source and another at the moon. The coherent component of two signals would be recorded, one directly from the source and the other reflected from the moon. The authors describe a lunar model in the form of a mirror sphere and discuss random variations of lunar surface relief as affecting radiointerferometer operation. The factors influencing signal phase stability are analyzed and the sensitivity of the proposed instrument is compared with the parameters of the 300-m Arecibo antenna. The project is feasible on the basis of the Arecibo radiotelescope, but an even larger antenna would be desirable. The method would be effective in the decimeter-decameter wavelength range, the principal inadequacy being weak response. The larger antenna needed should have a multiray diagram controllable in two coordinates. Figures 2; references 10: 6 Russian, 4 Western.
[76-5303]

UDC 531.28

MULTIPLE GYROPOWER SYSTEMS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81
(manuscript received 3 Nov 80) pp 813-822

TOKAR', Ye. N., LEGOSTAYEV, V. P., PLATONOV, V. N. and SEDYKH, D. A.

[Abstract] The authors discuss systems of single-axis power gyroscopes (gyrodynes) that break down into colinear groups, with the axes of suspension

of the members of each group being parallel to the same straight line. They list the common properties that such multiple groups have, then examine the special properties of systems with different numbers and sizes of groups. Figures 5; references 5.
[45-11746]

UDC 62.50

OPTIMUM BRAKING OF INITIAL ROTATION OF SATELLITE-GYROSTAT WITH FLYWHEEL MOTORS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 1 Jul 80) pp 823-828

ZLOCHEVSKIY, S. I. and KHALENKOV, M. A.

[Abstract] After making a number of initial assumptions about a satellite-gyrostat, the authors discuss the problem of the optimum braking of its initial rotation in orbit with the help of three flywheel motors, the axes of relative rotation of which are parallel to the satellite's main central axes of inertia. They conclude that there does exist a solution to the optimum control problem, but it must be approached in different ways, depending on whether the solution of the two-point problem encountered is a monotonic or nonmonotonic function. References 10: 8 Russian, 2 Western.
[45-11746]

UDC 629.7

OPTIMUM STABILIZATION OF STEADY-STATE MOTIONS OF SPACECRAFT, LOCATED AT TRIANGULAR LIBRATION POINT, RELATIVE TO ITS CENTER OF MASS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 17 Apr 80) pp 829-834

BLINOV, A. P. and MARKOV, Yu. G.

[Abstract] The authors discuss two methods for the optimum stabilization of the steady-state motions of a dynamically symmetrical satellite, located at triangular libration point L_4 of the Earth-Moon system, relative to its center of mass: by applying a control moment with respect to a cyclic coordinate or by changing the moment of inertia. They conclude that the first method is practicable, but the second is not. References 4.
[45-11746]

UDC 629.782

DETECTING SYSTEMATIC ERROR IN RANGE MEASUREMENTS WHEN CONTROLLING SPACECRAFT RENDEZVOUS

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 9 Apr 80) pp 930-933

POLISHCHUK, Ye. P.

[Abstract] The author discusses the possibility of detecting systematic errors in range measurements with the help of invariants of relative motion. He sets up equations for two invariants that relate the current range between spacecraft, the angular velocity of the sighting line and the cosines of the angles formed by the local vertical with the sighting line and the vector of the normal component of the relative velocity. These two invariants have different degrees of sensitivity to systematic errors and should be used under different conditions. References 5.
[45-11746]

GYROHORIZON COMPASS TYPE SYSTEMS ON BOARD SPACECRAFT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 20 Mar 80) pp 933-937

ZAVOZIN, Zh. G.

[Abstract] The author discusses a system consisting of two paris of identical gyrocameras mounted in a gyrosphere in such a manner that they revolve in opposite directions at the same rate. The system is actually a form of gyrohorizon compass when certain conditions are met. The author determines the conditions under which it is stable in a spacecraft in a circular orbit or making arbitrary movements in a Newtonian gravitational field. Figures 1; references 7.
[45-11746]

UDC 629

ONE PROBLEM OF PULSE STABILIZATION WITH TIME LAG

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 25 Dec 79) pp 937-940

PRASOLOV, A. V.

[Abstract] The author discusses a spacecraft stabilization system consisting of three reaction engines located on the ship's three principal central axes

of inertia that are turned on by relay starting devices. Since the problem of pulsed stabilization without a time lag has been solved, he turns to the one involving a lag. After writing the equations of motion for triaxial spacecraft stabilization in Rodrig-Hamilton parameters, he uses a Lyapunov function in his solution to the problem. References 2.
[45-11746]

UDC 537.531

CALCULATING CHARACTERISTICS OF GAMMA-RAY TELESCOPES WITH APERTURE CODING

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 19, No 6, Nov-Dec 81 (manuscript received 25 Sep 80) pp 947-951

GAL'PER, A. M., LAZAREV, S. A., LUCHKOV, B. I., OZEROV, Yu. V. and PRILUTSKIY, O. F.

[Abstract] The authors discuss the use of the aperture coding method to improve the resolution of gamma-ray telescopes, taking into consideration such features as the presence of several converters at different distances from the coding screen, the screen's finite thickness, measurement error, and so on. They use the Monte-Carlo method to calculate the characteristics and find that aperture coding enables angular resolution to be improved by a factor of at least six, although the ability to distinguish weak, discrete sources against an isotropic background deteriorates noticeably. They also conclude that the possibilities of the aperture coding method need to be developed further, with optimum matching of telescope parameters. Figures 5; references 7: 3 Russian, 4 Western.
[45-11746]

SATELLITE SYSTEMS FOR MARINE RESCUE

Moscow IZVESTIYA in Russian 5 Feb 82 p 3

[Article by B. Konovalov]

[Text] Sailors from all nations have long awaited this event. In 1976, a conference of representatives of the governments of 52 countries met in London and decided to form INMARSAT, a new international organization for the creation of a satellite communication system. This organization concludes contracts for the production and launching of satellites for marine communications. It has already ordered 6 satellites that will cover the entire world from 70° North to 70° South Latitude with reliable communication zones.

The first of these six satellites, the "Marex-A" (manufactured by the European Space Agency), began to operate on the night of 31 January-1 February. It more or less hangs suspended at an altitude of 36,000 kilometers over the equatorial zone of the Atlantic Ocean, at 26° West Longitude.

In time, every ship will have automated telegraph equipment that will enable it to tap an international telex line. It will be possible to communicate with any telegraph and telephone subscriber on the planet directly from the captain's bridge. There are already about 1,000 ships--including Soviet ones--that carry equipment for communication via satellites.

In the USSR the special All-Union "Morsvyaz'sputnik" Association, under the USSR Ministry of the Maritime Fleet, has been created for the purpose of organizing reliable round-the-clock communication between ships and land and each other via satellites. It is the USSR's plenipotentiary representative at INMARSAT and, in addition, is creating a national system for communication via satellites.

"We have conducted trial communication sessions with the INMARSAT system," says Yuriy Sergeyevich Atserov, chairman of the All-Union "Morsvyaz'sputnik" Association. "In particular, there were conversations with the container ship 'Magnitogorsk' in the Caribbean Sea and the passenger liner 'Lensovet,' which is going to New Orleans. The connection was good and we are happy about that."

Communications are of special importance to the maritime fleet. However, the existing system of short-wave communication does not satisfy sailors. Although it also is of the global type, breaks in communication lasting 7-8 hours occur because of ionospheric interference, while in regions remote from the USSR they can even last

for days. Moreover, because of the continuous increase in the number of ships operating in the world ocean, the existing marine communication channels are extremely overloaded. All of this reduces the efficiency of maritime fleet control and is a hazard to navigation. Therefore, the sailors are relying heavily on the assistance of satellites.

We are already using navigational satellites, such as the "Cosmos-100." They make it possible to determine a ship's location at any moment with a high degree of accuracy, regardless of the weather conditions. This is of great importance. Even now, the yearly maritime cargo fleet's losses because of navigational errors average about a million tons of total ship tonnage. Accidents occur most frequently because of running aground. Satellite navigation also plays an extremely important role in saving sailing time.

The Soviet geostationary "Gorizont" satellites have special communication channels for the maritime fleet. Our industry is developing Soviet-made marine equipment that will make it possible to provide ships with telephone, telegraph and photo-telegraph communication via satellites.

This year, near Odessa there will go into operation a shore station that will receive signals retransmitted by satellites and direct them into ground communication channels and, on the other hand, assist in shore communication with ships. An analogous station will begin operation in Nakhodka in 1983.

According to the calculations of specialists, the use of satellite communications will mean ships of an average cargo capacity (about 20,000 tons) can produce additional income of 35,000-40,000 rubles per year. The total savings for our country, with its huge fleet, will be extremely tangible. Besides this, we will obtain additional profits because of the savings in sailing time and fuel consumption.

We are happy that the INMARSAT system began operating commercially during the period when the Sixth Congress of the USSR Trade Union of Maritime and River Fleet Workers was meeting in Moscow. The facilities given birth to by the scientific and technical revolution should make the sailor's work easier and safer.

In this respect we should mention yet another international project that the USSR, the United States, Canada and France will begin to realize in 1982. Two Soviet and two American satellites in 1,000-kilometer circular orbits will be used to set up a search and rescue system for ships that have suffered accidents. Throughout the world about 350 ships are still lost every year.

Special radiobuoys will be placed on the ships participating in the experiment. In case of an accident they will be thrown overboard and will begin to transmit a distress signal. The emergency buoy's signals will be intercepted by a satellite and the coordinates computed either by an on-board microprocessor or ground computers, in which case the satellite will simply be used as a relay unit. After obtaining the coordinates of the ship in trouble with an accuracy of several kilometers, it will be possible to direct the nearest ships or airships toward it on an operational basis.

Thus, satellites will be not only guiding and communication stars for sailors, but will also come to their assistance in times of danger.

11746
CSO: 1866/42

UDC 550.34:550.814(479.25)

POSSIBILITY OF USING RESULTS OF REMOTE SENSING FROM SPACE TO INTERPRET SPATIAL DISTRIBUTION OF SEISMICITY (ON EXAMPLE OF ANATOLIA-ARMENIA-IRAN REGION)

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: NAUKI O ZEMLE in Russian Vol 34, No 6, Nov-Dec 81 (manuscript received 19 Jun 81) pp 3-11

ASLANYAN, A. T., DEBABOV, A. S., KARAKHANYAN, A. S., KOROVINA, T. L. and USIKOV, D. A., Institute of Geological Sciences, Armenian SSR Academy of Sciences; Institute of Space Research, USSR Academy of Sciences

[Abstract] The authors attempt to use space photographs to establish a cohesive theory of the distribution of seismicity in the Anatolia-Armenia-Iran region. Using lineament maps compiled from space photographs and data on earthquake epicenters and severity, they find a significant correlation between the concentrations of severe earthquake epicenters and intersections of seismically active lineament zones and extended faults. They also give a detailed explanation of the application of computer technology to the problem of the geological interpretation of images from space. Finally, there is a discussion of the possible history of this region where the Eurasian and Gondwanaland platforms came into contact. Figures 1; references 8.
[78-11746]

UDC 551.435.126+629.78(282.243.76)

DANUBE DELTA DYNAMICS STUDY USING SATELLITE PHOTOGRAPHS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 81 (manuscript received 28 Apr 81) pp 90-96

YEFREMOVA, O. N. and KRAVTSOVA, V. I., Geography Department, Moscow State University imeni M. V. Lomonosov

[Abstract] Results are given of a comparison of photographs of the Danube Delta taken from the American Landsat satellite on 4 Sep 72 by means of a

multiband scanning system in four regions of the visible spectrum and near infrared region with photographs taken by the "Fragment" multiband scanning system from the "Meteor" satellite on 26 Sep 80 in the same four regions of the visible spectrum. The purpose of the comparison is to study the dynamics of changes in the Danube Delta region over the 8-year period. The satellite images have a resolution of 80 m in the first case and 85 m in the second. Prints were made on a scale of 1 : 500,000 for the purpose of comparison. The photographs were purposely taken in the same month for better comparison. Photographs taken with the "Fragment" apparatus do not have an identical longitudinal and horizontal scale, while those taken from the Landsat satellite do. This made it impossible to give precise quantitative evaluations of changes. The photographs show part of the water area of the Black Sea along its western shores and the greater portion of the Danube Delta with the exception of its upper Tulcea-Izmail section. The Kiliya section of the delta in the north is actively growing because 70 percent of the solid and liquid discharge of the Danube is drained through its northern branch. The section from the Kiliya Delta to the Gheorghe branch in Rumania is under the influence of sea factors and is characterized by the development of abrasion and aggradation processes. There is a third lagoon - drowned estuary section in the sourth where spits and bars have cut off drowned estuaries and inlets from the sea. Lake Razelm is the largest formation of this sort. A great portion of the delta is occupied by flood plains, some of which have been drained and are used as rice fields. The comparison of photographs revealed changes in the position of the coast line, drainage, inundation and the state of agricultural development of the delta. Notable changes occurred in the shore line of the delta's sea boundary. The Kiliya Delta grew about 10 km^2 over the 8-year period. Sea drifts are gradually filling in the inlet between the sea shore and the Kiliya Delta. South of the mouth of the Gheorghe Delta accretion is occurring in some sections of the shore and erosion in others. The Portitsy Delta is being sealed in more and more by drifts, which threaten to close off Lake Razelm from the sea, so a channel will probably have to be dug in the future. Drainage within the area of the Danube Delta remained practically unchanged during the 8-year period. Substantial changes have taken place in the system of lakes in the flood plain region of the delta, some of them associated with drainage and irrigation work undertaken for agricultural purposes. About 30 percent of the flood plain area, representing about 30,000 hectares, has been developed at the present time for agricultural purposes. A large canal about 10 km long had been built over the 8-year period, connecting the Kiliya Delta and the lake area in the region of the village of Primorskoye. New rice fields have been created, occupying an area of about 15,000 hectares. About 85,000 hectares of new rice fields have been created in the Rumanian territory of the delta. On the terraces of the Danube north of Lake Razelm various crops are being grown on a total area of about 50,000 hectares. Figures 3.
[19-8831]

UDC 551.417

DEVELOPMENT OF SHORE RELIEF OF GULF OF RIGA FROM RESULTS OF ANALYZING SATELLITE IMAGES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 81 (manuscript received 28 Apr 81) pp 97-102

SAF'YANOV, G. A. and KRAVTSOVA, V. I., Geography Department, Moscow State University imeni M. V. Lomonosov

[Abstract] The results are given of an analysis of satellite images of the Gulf of Riga obtained by the "Fragment" multiband scanning equipment from the "Meteor" satellite on 24 Jul 80. It is demonstrated that by analyzing an aerial image taken by satellite it is possible not only to single out several stages in the development of the relief of the coast line of the Gulf of Riga, but also to observe the trend of dynamic processes of the coastal zone over recent millenia. The most important trend has been disintegration of the single East Riga coastal drift flow into a number of relatively small systems of coastal drift. This phenomenon is a result of changed external conditions for drift. Forms of the relief make it possible to interpret the processes which they reflect. The results of analyzing the images indicate that the region of the development of a fluvial-glacial relief on the eastern shores of the gulf indicated on the 1 : 2,500,000 geomorphological chart of the European sector of the USSR (1966, 1970) should come under the heading of a region of the development of marine accretion forms. The images obtained by satellite also show that charts of the USSR's forests must also be refined. The information obtained will also make it possible to refine charts of vegetation, such as the 1 : 4,000,000 geobotanical chart of the USSR (1954). Images in three regions of the spectrum--the orange (0.6 to 0.7 μ), red (0.7 to 0,8 μ) and near infrared (0.8 to 1.1 μ)--on a scale of 1 : 500,000 were used to study the development of the relief of the shore line of the eastern half of the Gulf of Riga in the Baltic Sea, including the Gulf of Parnu in the north and the eastern and southern shores of the Gulf of Riga. Several geomorphological regions were singled out from direct geomorphological traits represented on the images and from the indicating role of the vegetation cover. Several stages in the development of the area's relief are detailed, beginning with the most ancient stage--the development of the glacial accretion relief of the last continental glaciation of the Russian Plain. Figures 2; references 3 (Russian).
[19-8831]

UDC 528.946

STUDY AND MAPPING OF AGRICULTURAL LAND USE FROM SATELLITE IMAGES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 81
(manuscript received 28 Apr 81) pp 103-110

YANVAREVA, L. F., Geography Department, Moscow State University imeni M. V. Lomonosov

[Abstract] Satellite images provide a rather detailed picture of extensive land areas and facilitate considerably the study of the confinement of individual kinds of agricultural use to natural land types and they can be interpreted simultaneously from the viewpoint of landscape, geomorphology, soil and geobotanical features. An analysis is made here of the feasibility of using for these purposes satellite multiband scanning images obtained by means of the "Fragment" system on a scale of 1 : 500,000. These regions cover the area bounded by forest-steppe and steppe zones, which alternate with one another from north to south. The greater part of the area studied is occupied by the southern half of the Kalach Upland, which is heavily broken up by a ravine and gully system. In the northwest lies part of the Khoper-Buzuluk accretion plain and in the extreme south the Donetsk Ridge, which is heavily broken up by an erosion system. It is shown that the analysis of satellite images can make a great contribution to studying forms of agriculture as methods which have been created for agricultural land use. The territory studied is a typical grain farming region with a high percentage of grain crops for the production of commodity grain. Grain farming is combined with dairy and meat animal husbandry. The fodder base for animal husbandry relies on field fodder production, for the land does not provide natural fodder resources. Water meadows are of agricultural importance only in the floodlands of the Don and Khoper valleys. The analysis of satellite images recorded at different times makes it possible to determine the proportion of crops in crop areas, the proportion of fallow land and to obtain information on the use of arable land and types of crop rotation. In the territory studied the grain-sowing - fallow-intertilling method of crop rotation is used chiefly with a high percentage of winter and spring non-intertilled grain crops. Analysis of the satellite images from the "Fragment" system demonstrated their suitability for making and revising small-scale charts of land use, types of territorial organization and forms of agriculture in steppe and forest-steppe regions. Figures 5; references 2 (Russian).
[19-8831]

UDC 528.946

MAPPING OF FOREST VEGETATION BY MEANS OF SATELLITE IMAGES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 81
(manuscript receivdd 28 Apr 81) pp 111-116

KOTOVA, T. V., KRAVTSOVA, V. I. and MAKAREVICH, A. K., Geography Department, Moscow State University imeni M. V. Lomonosov

[Abstract] Results are given of a study of the feasibility of studying and mapping forest vegetation from satellite images obtained by means of the "Fragment" experimental system. An analysis is made of a satellite image of one of the northern regions of the European sector of the USSR, covering the northern reaches of the North Dvina River in the area where its right tributary--the Vychegda River--merges with the Little North Dvina River. This region lies at the junction of the boundaries of Arkhangel'skaya, Vologodskaya and Kirovskaya oblasts. The region is a slightly hilly plain broken up by river valleys. Satellite images were obtained on 30 Jul 80 in the orange, red and near infrared regions of the spectrum and prints on a scale of 1 : 500,000 were analyzed. The majority of the territory is covered with forests. Spectral curves demonstrate that in the orange region non-forested areas have the greatest image brightness as compared with other objects. Images taken in the orange region best delineate the boundaries of forests but it is impossible to distinguish types of forests on them. On images taken in the red region it is possible to delineate the outlines of deciduous, coniferous and hybrid forests. On images in the near infrared region coniferous forests are indicated by a dark grey or almost black tone, hybrid forests by a gray tone and deciduous forests by a light gray. It is possible to differentiate these types of forests reliably. However, unforested areas are depicted by the same light gray tone as are deciduous forests. By the combined use of spectrum band images it is possible to identify the entire required set of objects. The recommended procedure is to use images taken in the orange band at the first stage to distinguish the boundaries of forests and to separate forests and non-forested areas and then to differentiate from images in the near infrared band coniferous, hybrid and deciduous forests and finally to correct their outlines from images in the red band, which has the best resolution. Satellite images are not as good as geobotanical charts of approximately the same scale with regard to differentiating spruce and pine forests, for example. But details of boundaries are more precisely localized on satellite images and are distinguishable from those of other natural elements such as river valleys. Satellite images can be used to improve the detail of medium-scale charts of forests. They are best used in combination with data from other sources. Figures 3; references 4: 3 Russian, 1 Western.
[19-8831]

UDC 528.946

STUDY OF ANTHROPOGENIC INFLUENCE ON NATURAL ENVIRONMENT FROM MULTIBAND SCANNER IMAGE DATA

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 81 (manuscript received 28 Apr 81) pp 117-123

KRAVTSOVA, V. I. and NIZKAYA, I. S., Geography Department, Moscow State University imeni M. V. Lomonosov

[Abstract] An analysis is made of the feasibility of using satellite images obtained by "Fragment" equipment for studying anthropogenic influence on the natural environment. Regions were selected which lie outside of the main agricultural zone and which differ markedly both in terms of natural conditions and the nature of commercial utilization. The areas studied were the taiga regions of the north of the European sector of the USSR and desert regions of Central Asia, the central area of the Ustyurt Plateau. An analysis was made of anthropogenic influence on forests and desert landscapes. Human influence on forests was studied in a region rich in forest resources which are processed at enterprises in Kotlas, Sol'vychegodsk, Koryazhma, Velikiy Ustyug and Luza. Evidence of man's negative influence on the natural environment is expressed by destruction of forests and by disturbance of or alteration of their type composition. Changes in soil cover are deduced from evidence of swamp formaiton in deforestation areas. Images were taken in three regions of the spectrum: the orange, red and near infrared. Images in the orange band were optimum for revealing regions in which man's influence is most strongly pronounced, for they most clearly show forest-free areas of different origin. Deforestation is evidenced chiefly in areas of coniferous trees, the spruce being most highly valued in the cellulose and paper industry. Images in the red band are used to differentiate forests in terms of type of tree. Coniferous forests are indicated by a dark tone in this region. Man's influence on the soil and vegetation cover of the deserts of the Ustyurt Plateau was evaluated from a satellite image depicting the central portion of the plateau bounded by the western half of the Uzbek SSR and the eastern half of Mangyshlakskaya Oblast in the Kazakh SSR. Environmental changes in this region have occurred because of the exploitation in recent years of gas and oil fields and the construction of the Bukhara-Center gas pipeline, the Kungrad-Chardzhou railroad, highways and new settlements. Satellite images show erosion of the top-soil, which is no more than 15 to 20 cm deep. This erosion is taking place in the direction of prevailing winds, i.e., from northeast to southwest. The damage is maximum near population centers and transportation routes and gradually decreases the farther one gets from them. The analysis made demonstrates that satellite images make it possible to reveal certain influences of man on the natural landscapes of a desert, largely on the soil and vegetation cover, and to establish their origin, nature and degree. These images can be used to make charts which can be used for making recommendations on the intelligent utilization of the land and on protection of the environment. The range of man's influence on the

landscape in various natural regions which can be revealed by means of these images is rather extensive. Figures 4; references 4 (Russian).
[19-8831]

UDC 551.436.11

STUDY AND MAPPING OF EROSION RELIEF OF KALACH UPLAND FROM MULTIBAND SCANNER IMAGES

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Sep-Oct 81 (manuscript received 28 Apr 81) pp 124-129

LAPTEVA, N. I. and TAL'SKAYA, N. N., Geography Department, Moscow State University imeni M. V. Lomonosov

[Abstract] Geodynamic processes exhibit the greatest activity in uplands in level areas, which is evidenced most clearly in erosion processes. Evidence is presented to demonstrate that satellite images offer new opportunities to study and map erosion forms of topography and the contemporary processes creating them. Results are given of an analysis of multiband scanner satellite images obtained by means of the "Fragment" system of the area of the Don-Khoper interfluve. Images were obtained in the summer and fall (July and October) of 1980 in the orange, red and near infrared regions of the spectrum. Cartographic and published data were used to supplement geomorphological interpretation of the images. The area studied consisted mainly of the southern half of the Kalach Upland which is strongly divided by river valleys and a system of ravines and gorges. In the east there is an alluvial frontal apron plain representing part of the Oksko-Donskaya Lowland, the so-called Khoper-Buzuluk interfluve; in the south the Donskaya Ridge extends along the right bank of the Don. The data of satellite images made in different years and seasons make it possible to obtain information on the state and development of erosion forms of the relief at various points of time, which is important in view of the intense economic development of the territory. The ravine system in the area is the result of presentday progressive erosion caused by a combination of natural and historical conditions for the development of the area's topography. It was found that the structure of the erosion system in the area studied is of a complex nature. An important feature of the structure of the erosion system is the asymmetry of river valleys. On one bank of a river in same valley the development of active erosion forms of the ravine or gully type is observed while the other more gently sloping bank is complicated by extended gorge formations reflecting a less active stage of development. From an image taken in the 0.8 to 1.1 μ band it was possible to distinguish a number of outlines representing different lithological structures of surface deposits. It is concluded that the satellite images with a resolution of 85 m obtained by means of the "Fragment" system are totally suitable for purposes of geomorphological mapping. Images obtained in the red or near infrared bands are the most useful. The degree of detail of images

of natural objects obtained by satellite considerably surpasses the informativeness of medium-scale charts. Figures 4; references 5 (Russian). [19-8831]

UDC 551.451.8

SATELLITE IMAGES OBTAINED BY MEANS OF 'FRAGMENT' SYSTEM AS BASIS OF LANDSCAPE MAPPING AND PHYSICAL GEOGRAPHICAL ZONING OF ARID LANDS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 5, Spe-Oct 81 (manuscript received 28 Apr 81) pp 130-138

IVASHUTINA, L. I. and NIKOLAYEV, V. A., Geography Department, Moscow State University imeni M. V. Lomonosov

[Abstract] Results are given of an analysis of satellite images obtained by the "Fragment" experimental system from a "Meteor" satellite at the end of August 1980, of the steppe-desert regions of the Southern Mugodzhary Mountains region and the typical deserts of North Ustyurt in the territory of the Kazakh SSR. Black-and-white photographs were analyzed taken in the orange and red bands of the spectrum and enlarged to a scale of approximately 1 : 500,000. The purpose of the study was to make landscape maps from the photographs and to use them for the purpose of physical geographical zoning on a medium and small scale. No special field studies were made and sole use was made of the satellite images and various published data and topological, geological and soil maps. It was found that the satellite photographs characterize both the landscape structure of the region as a whole and the internal morphological structure of landscapes. The photographs show in detail natural boundaries of the morphological structure of landscapes. On divided desert denudation plateaus, the natural boundaries of monadnocks and mesas and the sub-boundaries of their clad flat peaks, arid denudation slopes and the trails of their pediments are clearly shown. Desert-steppe ravines and landslides are clearly visible on the chinked slopes of North Ustyurt. It is possible to distinguish without difficulty individual eolian hillocks and ridges, deflation basins and exposed barchans in eolian sand desert areas. The photographs obtained by means of the "Fragment" system can serve as a good basis for landscape mapping on a medium and small scale and they can be used for physical geographical zoning and are better for the latter purpose when they cover a fairly extensive area as opposed to narrow strips of land. Figures 5; references 9 (Russian). [19-8831]

UDC 528.2:629.78

REGULARIZING SOLUTION OF PROBLEM OF DETERMINING COORDINATES OF AN OBJECT FROM SATELLITE DOPPLER OBSERVATIONS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEODEZIYA I AEROFOTOS"YEMKA in Russian No 6, Nov-Dec 81 (manuscript received 28 Mar 80) pp 74-81

KARPUSHIN, Yu. G., candidate of technical sciences, docent, and FOKIN, A. P., engineer, Moscow Order-of-Lenin Institute of Engineers of Geodesy, Aerial Surveying and Cartography

[Abstract] The authors examine the problem of the effect of the relative positions of an artificial earth satellite and on object on the Earth's surface (the geometrical factor) on the determination of the object's coordinates on the basis of Doppler changes in the frequency of radio signals transmitted by the satellite. They give a mathematical description of the problem, obtain both normal and regularized solutions to it, and set up a mathematical model to make calculations in order to determine the comparative accuracy of the two solution methods. They conclude that the regularized method makes it possible to expand the area of application of the Doppler method from satellite angles (above the horizon) of 15-70° to 5-80° and that the gain in accuracy in comparison with the normal solution is 91-98 %. Figures 8; references 7: 6 Russian, 1 Western. [55-11746]

UDC 528.711.114:531.3

INVESTIGATION OF SMALL DEFORMATIONS OF MOVING OBJECTS ACCORDING TO STROBOSCOPIC SURVEYING IMAGES

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEODEZIYA I AEROFOTOS"YEMKA in Russian No 6, Nov-Dec 81 (manuscript received 10 Jul 80) pp 91-98

PANKRUSHIN, V. I., professor, doctor of technical sciences, AMROMIN, P. D., docent, candidate of technical sciences, and GINIYATOV, I. A., lecturer, Novosibirsk Institute of Engineers of Geodesy, Aerial Surveying and Cartography

[Abstract] In order to detect small deformations of moving objects, the authors use two networks of reference points, one of which is potentially deformable while the other is potentially nondeformable (the reference network). Each of the networks must contain at least 20 points for the determination of the statistical characteristics to be reliable. The authors give the theoretical substantiation for their correlation method and explain the technique used to detect small deformations. They state that

their method makes it possible to: 1) detect small deformations, commensurate with the accuracy of the observations, at the same time as the kinematic parameters of an object are being determined; 2) make a more accurate judgment about the accuracy of kinematic parameters determined from the results of geodesic and photogrammetric observations; 3) improve the reliability of the determination of kinematic parameters, either by increasing an object's rigidity or allowing for the presence of small deformations. Figures 3; references 7.
[55-11746]

UDC 528.475

MODELING AND ANALYSIS OF 'OPTICAL INSTRUMENT + NATURAL MEDIUM' PHYSICAL SYSTEM DURING AEROSPACE SURVEYING OF WORLD OCEAN WATER AREAS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEODEZIYA I AEROFOTOS"YEMKA in Russian No 6, Nov-Dec 81 (manuscript received 12 Feb 80) pp 98-104

POLOVINKO, V. V., candidate of technical sciences, Moscow Order-of-Lenin Institute of Engineers of Geodesy, Aerial Surveying and Cartography

[Abstract] The author's model of the "optical instrument + natural medium" physical system is based on a variant of the model with an output function in the form of the distribution of illumination in an image, in which variant the function at the input describes the optical characteristics of the receiving optical system. He then discusses the frequency characteristics of the system's elements in the visible, near-infrared and thermal bands of the spectrum, and concludes that his model can be used to develop methods for determining the characteristics of natural waters when studying the world ocean's natural resources. Figures 2; references 3.
[55-11746]

SPACE POLICY AND ADMINISTRATION

MILITARIZATION OF U.S. SPACE PROGRAM ALLEGED

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, Mar 82 pp 42-43

[Article by Col A. Timofeyev: "Two Approaches to a Single Problem"]

[Text] In October 1982 mankind will mark the 25th year since the beginning of the conquest of space, one of the greatest achievements of science and technology in our time. The utilization of space is even now benefiting man: superlong-range radio communications, television, navigation, the global collection of meteorological information, the study of the Earth's natural resources, the solution of many fundamental scientific problems.

Soviet scientists and specialists are generously sharing the results of their achievements in space with scientists and scientific establishments in other countries. In recent years, important research was carried out on the Soviet "Salyut" space stations and "Soyuz" ships by international crews. Envoys from Czechoslovakia, Poland, the GDR, Bulgaria, Hungary, Viet Nam, Cuba, Mongolia and Romania participated in flights along with the USSR's pilot-cosmonauts. The results of each flight became the property of all the participants in the "Intercosmos" program.

The cooperation of nations in conquering space contributes to a further rapprochement among peoples and the successful joint solution of the problems facing them. It is precisely for this reason that our country attaches a great deal of importance to this cooperation and to the business of attempting to preserve and strengthen its foundation, which is to insure the peaceful direction of the efforts of different nations in the field of conquering and utilizing space. "I would like to emphasize," declared Comrade L.I. Brezhnev, general secretary of the CC CPSU and chairman of the USSR Supreme Soviet's Presidium, in presenting awards to cosmonauts from the USSR and the Mongolian People's Republic, "that the Soviet Union has been and will remain a staunch supporter of the development of businesslike international cooperation in space. Let the boundless ocean of space be pure and free from weapons of any kind. We support the idea that the our joint efforts should arrive at a great and humane goal: the elimination of the militarization of space."

Unfortunately, not all the consequences of the accomplishments of the 20th Century were a blessing to mankind. There were even those that cut short the lives of hundreds of thousands of people (let us remember the tragedy of Hiroshima and Nagasaki). Under present conditions, when the United States' administration is accelerating the arms race and trying to spread it into space, this sad truth is

becoming particularly obvious. Pentagon specialists are considering projects for using reusable ships to establish military bases in space, place mines in space for the purpose of destroying artificial Earth satellites (ISZ), and create space-based antimissile systems. They are also discussing the possibility of using these ships to carry nuclear and ray weapons. The Pentagon's strategists would like to have a space policeman for the "inspection" of foreign satellites in orbit who could change their flight trajectories and, when desired, return them to Earth in the ship's cargo section.

From the very beginning of the development of the reusable ship program, the Pentagon--as is well known--attempted to pretend to be only a "silent partner." of the National Aeronautics and Space Administration (NASA). Now, however, when the time for the immediate operation of the new ships is approaching, the United States' military arm has imperiously occupied the place it paid for without any sentimentality whatsoever. It has reserved for itself the lion's share (one-third) of the more than 400 flights planned for the next decade. The others will be financed primarily by telecommunications companies in the United States and foreign customers, since the present administration is not willing to give NASA the money for scientific research. "NASA is only an insignificant 'passenger' in these ships and is not even the 'driver'," declared Hans Mark, the United States' former Secretary of the Air Force, with blunt sarcasm.

American scientists have not only been pushed to the rear in questions of the utilization of the reusable ships, but have also been removed from leadership of the flights themselves, while the scientific programs have been either curtailed or shut down in general. As a result, NASA was forced to notify the European Space Agency of its refusal to launch a European automatic station to the Sun from on board the ship, despite the agreement it had made and the money spent by the European Agency for the building of the station (more than 300 million francs).

The military arm of the United States is devoting a great deal of attention to the placement of laser weapons in space. In order to speed up the work in this area, the Pentagon was allocated about 5 billion dollars at the end of last year. According to evidence published in the newspaper WASHINGTON POST, representatives of the new U.S. administration showed so much interest in laser weaponry that, even though they had not yet taken up their posts in the Department of Defense, they immediately gave a group of Republican congressmen on Capitol Hill the task of increasing expenditures for its development by a significant amount.

Abundant financial injections are also being given to the United States' antimissile program, which consists of rockets with small ISZ interceptors that are launched from F-15 fighters. According to a report in DEFENSE AND SPACE BUSINESS DAILY, the expenditures for this program's realization in fiscal years 1981 and 1982 alone will be 500 and 700 million dollars, respectively. Intensified work is also being done on other new systems: charged particle beams, "magnetic cannons."

The Pentagon's efforts to spread militarization into space is also indicated by such facts, which have become the property of the press, as the preparations for the construction of a joint space center in Colorado that will control all future flights of shuttle ships and satellites for military purposes, as well as the construction at Vandenberg Air Force Base (California) of a military cosmodrome that will go into operation in 1984.

Thus, the United States' approach to the investigation and utilization of space is entirely the result of the present American administration's policy of unleashing a feverish arms race under the fictitious pretext of catching up with the Soviet Union. The only thing that is not understandable is how Washington intends to eliminate the "space gap" by opposing peaceful Soviet space programs with its adventuristic course of militarization in space. It is obvious that the political figures in the United States still do not understand that scientific and technical development in our time is following parallel courses in different countries and that each of their actions in the definitely military sphere cannot help but be taken into consideration by the other side and cannot help but result in a counteraction.

Nevertheless, the Soviet Union believes that neither one power nor the other will dominate in space, but that this will be the lot of all mankind, based on rigorous law and order that has been worked out in detail. True to its peace-loving policy, as far back as 1958--the dawn of the space age--the nation of the Soviets introduced at the United Nations a proposal providing for the prohibition of the use of space for military purposes. Throughout all the subsequent years the Soviet government has invariably spoken for space being a sphere of exclusively peaceful collaboration. And, a great deal has been done in this direction. A whole series of international agreements on space have been concluded. Among them there are those that prohibit the placement in space of nuclear or other types of mass-destruction weapons.

However, the problem of eliminating the militarization of space remains an extremely urgent one. Considering this fact, the Soviet Union proposed an intelligent alternative to military rivalry in space: an international treaty prohibiting the placement in space of weapons of any type. Most nations supported this initiative and the United Nations' General Assembly approved it during its 36th session, recommending that the Committee on Disarmament begin discussions for the purpose of agreeing on the text of a draft of this treaty proposed by the Soviet Union.

The realization of the Soviet proposal is in the interest of all nations, both those that are participating directly in space research and those who are utilizing the scientific and technical achievements in this field. The numerous positive responses to the Soviet initiative are instilling hope that the Committee on Disarmament will devote the necessary attention to this question.

11746
CSO: 1866/65

COMMENTARY ON U.S. SPACE POLICY AND PROGRAMS

Novosibirsk EKONOMIKA I ORGANIZATSIYA PROMYSHLENNOGO PROIZVODSTVA in Russian No 1, Jan 82 (signed to press 14 Dec 81) pp 171-186

[Article by I.I. Isachenko, candidate of economic sciences, Moscow: "U.S. Space Projects: Experience in Realization"]

[Text] "Adventurism and readiness to put the vital interests of mankind at stake in the name of its own narrow, self-interested motives--this is what is manifested particularly blatantly in the policies of the most aggressive circles of imperialism," said L.I. Brezhnev in his report to the 26th CPSU Congress. These words have been confirmed, to the shock of the world community, by the U.S. administration's course toward the military utilization of new types of space technology.

The space projects of the United States are long-term scientific, technical and production programs. Their structure has taken shape over the course of decades. Their experience in realizing space projects is extremely educational. Being aware of the increasing militarization of the United States' economy in general and the space branches in particular, we must study this experience intently from the viewpoint of the efficient functioning of the organizational structures.

An Integrated Space Project: The Mechanism of Its Realization

Among the number of notable phenomena in the area of the organization of industrial production in the capitalist countries, those related to the creation of space technology occupy a rightful place. Their role is even more significant since they are related to the realization of large-scale projects. For instance, the cost of the American "Apollo" program for landing a man on the moon (1962-1972) was more than 25 billion dollars, while the expenditures merely for the development of the not yet completed "Space Shuttle" program for the creation of reusable space transport facilities, work on which began in 1972, is approaching 10 billion dollars.

The special features of space technology as a production object are determined by the extremely limited (usually not exceeding several units) use of monotypical spacecraft for the execution of scientific or applied assignments. The basic content of the work done by industiral firms for the space programs is applied

scientific research and experimental design work (NIOKR), whereas series production itself is essentially not performed. This gives us grounds for assuming that an important part of the results of industrial activity for the creation of space technology is of a nonessential nature and is related to the acquisition of scientific and technical knowledge over an extraordinarily broad range of fundamental and applied sciences. Although for the aerospace industry (ARKP) as a whole the ratio of the volume of NIOKR to production work is 1:1.9, in the space technology sector it is 1:2.6.

The creation of modern space systems requires the conduct of a broad circle of research work in the newest and most promising fields of scientific and technical progress. The necessity of carrying out a large volume of unique investigations in short periods of time and introducing on an accelerated basis the results of scientific and experimental design developments in concrete samples of the newest technology could not help but require significant improvements in the organizational structure for controlling industrial production and the broadspread introduction into control practices of elements of prospective planning and systems and cost analysis.

The typical form of the enlistment of U.S. industrial firms in the realization of space programs is the conclusion by government agencies--the National Aeronautics and Space Administration (NASA), in particular--of multistage contracts for the performance of work on the successive stages of the creation of space technology.

In accordance with the practice of stage-by-stage planning, the realization of integrated programs for the creation of space systems is divided into four stages or phases.

Stage A--preliminary research and determination of possible paths for the solution of problems. This stage assumes the development of a predraft plan, its coordination with the entire complex of already existing and newly created technical assets that can be used in the solution of the formulated problem, and preliminary evaluation of the cost of realizing the project. At this stage, several (up to 10) contractors are drawn into the work on a competitive basis. On the basis of the realization of this phase, a decision is made about developing the program.

Stage B--conduct of detailed investigations and preliminary planning for the purpose of selecting the most substantiated version for further development. In this stage the order for further development is issued by one or (in the case of particular complexity and novelty of the project) several firms. In addition to this, the number of contractors working in parallel is also determined by the cost of the work being done.

Stage C--detailed definition of all points in the program, final evaluation and selection of the system's design, determination of critical subsystems for the purpose of making the appropriate distribution of forces and facilities that would insure the completion of the program's stated goals in accordance with the planned periods and within the framework of the preliminary evaluation of the program's cost. In this stage all the work is usually assigned to one company that, as a rule, subsequently figures as the basic executor of the program's final phase.

Stage D--detailed development, production and testing of prototypes, accomplishment of the program's final goal.

The beginning of each new phase of the program is preceded by a careful dissection and analysis of the results of the stage just completed. The possibility and advisability of moving on to the next stage or the necessity of reviewing and correcting the program is determined.

A special role in the analysis of the results of completed work is played by so-called extradepartmental expert evaluation, which is done by scientific organizations and firms not engaged in the given developmental work. For example, the decision on the financing of the "Space Shuttle" program that was made by the U.S. Congress was preceded by a careful, expert analysis of the economic effectiveness of the proposed expenditures that was made independently by the "Mathematics," "Aerospace" and "Lockheed" companies under contract to NASA.

The extensive development of scientific and production cooperation, the scale of space projects and the extended period required to implement them forces the customer to pay special attention to the question of organizing the work. Therefore, when examining competing proposals, in addition to the scientific, technical and financial aspects of projects, a most careful analysis is made of the proposed variant for organizing the work: the times for letting the basic subcontracts, the list of proposed subcontractors and their financial position and business reputation, the nature of the temporal distribution of the labor outlays, the need for and scales of enlistment of the state scientific research and production base and so on. The important role of organizational factors can be testified to, in particular, by the fact of the selection of the "Rockwell International" firm as the general contractor on the project for the creation of a transport spacecraft. According to NASA's original explanation, the plan submitted by "Rockwell International" was adopted basically because of its better solution to work organization and control problems. In connection with this, a competing plan submitted by "Grumman Aerospace" was recognized as being better from the technical viewpoint, while that submitted by "Lockheed Aircraft" was evaluated as less capital intensive.

At the same time, in the practice of the development of civil space technology in the United States, which is done--as a rule--under conditions of strict budget limitations, there are many examples where the choice of the cheapest project to the detriment of the quality of the technical decisions and ignoring the principle of stage-by-stage development has resulted in considerable lengthening of the work completion periods and cost overruns. For instance, the concept of "orientation on success," which was adopted in the final stage of the creation of the "Space Shuttle" spacecraft, assumed that all of the technical decisions being realized are the most effective ones. As a result of this, alternative solutions were not worked out, the number of tests was reduced to a minimum, and many ship assembly processes were carried out in parallel without sufficient substantiation. As G. Greer, the chairman of NASA's Consultative Committee on Flight Safety, noted, "The strenuous work schedule resulted in a situation where the technical difficulties that arose were simply 'eliminated' without attempting to understand them from the engineering viewpoint." The unavoidable result of this approach was the appearance of serious technical problems during the final stage and a number of serious accidents during the tests. As a result, the date of the first experimental flight was postponed by 2 years, while the cost overrun (without allowing for the effect of inflation) was 26 percent.

One of the main features of the space programs is their integrated nature. For instance, the "Apollo" program combined in a unified system technical decisions

worked out on the basis of 76 general and 21,000 subcontracting contracts that were coordinated both temporally and thematically.

It is obvious that such large-scale projects are far beyond the limits of the capabilities of individual--even the largest--industrial companies. Although a limited number of the largest companies usually participate in the preliminary research and development work along with state scientific research centers, most of the companies in the aerospace and radioelectronics branches of U.S. industry are used as subcontractors at the stage of the creation of experimental and operational models for space technology. Thus, the system of contracts turns out to encompass tens of thousands of enterprises in different areas of industry.

The practice of the participation of private-corporation industry in the United States in the realization of space programs led to the formation of three basic levels of industrial firm activity in the "space business." On the highest level are the largest firms--the state departments' general contractors, who bear the full responsibility for the development, planning and coordination of all NIOKR for integrated space projects; on the second there is the first circle of subcontracting firms, which carry out the planning and creation of the most important structural elements or complete subsystems under contract to the main contractors; on the third level we find the "providing" subcontracting companies, which are usually engaged in the production of individual (so-called completing) elements or the provision of appropriate types of commercial services. Individual firms frequently appear on several levels at the same time. This type of organization for the implementation of a program requires precise planning and coordination of the work of the general contractors, and also makes it necessary for them to do their own research in areas where the basic part of the work is done by subcontractors. A high level of standardization and unification of the separate elements of the technology being created has been achieved.

By the beginning of the 1970's in the United States, around NASA there had grown up a stable complex of permanent contractors that included about 100 general and 1,100 subcontractors of the first and second orders and more than 7,000 subcontractors in other categories. The total list of suppliers of different rocket and space products and corresponding services numbers (according to the estimates of American economists) more than 80,000 different firms, it being the case that this list is growing constantly as space technology becomes more complex. According to NASA data, 100,000 people, representing 12,500 industrial companies in 47 states, took part in the creation of the "Saturn" launch vehicle for the "Apollo" program.

As NASA's annual reports indicate, over the last 20 years it has been large capital that has been the basic executor of the orders made by its departments. As a rule, more than 90 percent of the total amount of NASA's primary contracts goes to the 100 largest companies every year, it being the case that the 10 largest contractors receive at least 60-70 percent of the total amount.

The permanent composition of NASA's main contractors is typical. A comparison of the appropriate data on the contracts let in the years of the maximum scope of activity on the "Apollo" and "Space Shuttle" programs (the 1966 and 1976 fiscal years, respectively) shows that NASA's basic orders are given most stably to the companies that are this agency's first 12 contractors; that is, whose share of the total volume of work is up to 80 percent every year.

The practice of the realization of the largest NASA projects indicates that the amount of work done by the actual general contractor is rarely more than 50 percent. The rest of it is subcontracted to the general contractor's junior "partners." For instance, for its part of the "Apollo" project "North American Rockwell" enlisted more than 1,500 subcontractors, who did 58 percent of the work for the sum of 2.26 billion dollars. On the project for the creation of the TKK (space shuttle) orbital system, the Space Division of the "Rockwell International" company distributed among its subcontractors at least 53 percent of the total cost of the contract, with the cost of the subcontracted work on the electronic systems alone being estimated at about 0.5 billion dollars.

The distributed subcontracts frequently call for the construction of large, relatively independent integrated developments. For example, one of NASA's general contractors for the "Space Shuttle" program, "Rockwell International," was given 88 large orders amounting to more than 1 million dollars each, including 19 for more than 10 million dollars.

At the same time, a considerable number of subcontracts are let for research and development (of a limited nature) in individual, narrowly specialized fields. In the number of subcontractors, therefore, a significant number are usually representatives of so-called "small business"[1], the enlistment of which is even obligatory by law when fulfilling contracts worth more than 500,000 dollars. According to data gathered during a study of samples of NASA contracts, "small business" received a little more than one-fourth of the subcontracting work (by cost) done during the first half of the 1970's.

As is known, the present stage of the scientific and technical revolution is characterized by rapid acceleration in the differentiation of industrial research and delopment. Under these conditions it is precisely these small firms, because of their narrow specialization in definite, sometimes unique areas of research and development, that are one of the basic sources of new scientific and technical ideas. The use of these companies as subcontractors during the creation of space technology enables the large corporations to insure a high scientific and technical level of project work.

Thus, in the execution of space projects there is fragmentation and intensification of production specialization with a simultaneous high concentration of production facilities, scientific and technical personnel and an overwhelming proportion of contracts among the few largest aerospace corporations, which are the general leaders and coordinators of space program work.

State Regulation in the Sphere of Space Technology Development

According to the officially approved procedure, the letting of contracts in U.S. industry is accomplished by three basic methods: by open and closed bidding and by direct purchase.

---

[1]According to the classification adopted in U.S. industry, "small business" firms are small, specialized enterprises with 50-100 employees, depending on the type of production output.

"Open" bidding assumes extensive publicity and the free participation of all interested companies in the battle for an advertised contract. This type of order placement is used by federal departments when carrying out the program of civilian NIOKR. When unique or secret projects are to be carried out, the present effective legislation makes it possible to limit the number of competitors to only those companies with the known scientific, technical, production and financial capabilities to do the work; that is, the bidding is closed. Direct purchase assumes direct negotiations between the customer and a selected subcontractor and is used for narrowly specialized work with particularly rigid requirements as to dates of completion.

The primary form of order distribution at NASA is bidding. Contracts are placed with contractors on primarily a competitive basis; that is, by open bids. According to NASA's official report, the proportion of orders distributed in this fashion predominates and has recently been growing: from 55-60 percent in the first half of the 1960's to 70-75 percent in the middle 1970's. However, the practice of the struggle for the placement of orders indicates that the widely advertised free competition among any applicants is more a wish than a fact.

The integrated nature of the space technology projects that are being developed and the necessity of conducting wide-scale scientific research with the help of the newest, sometimes unique scientific research base in different stages of the work--including the initial ones--objectively limits the circle of possible claimants of a contract for the creation of large space systems.

Formally, NASA can let a contract at any subsequent stage of a program to anyone; that is, it is not obligated to the previous contractor. However, the specific nature of "space" NIOKR, where a contractor acquires unique knowledge and experience as he fulfills his contract that provide him with weighty advantages over other claimants for the contract for the next stage, as well as the limited marketplace for space products, create a situation facilitating monopolization of certain areas in the creation of rocket and space technology or important elements of it, with all of the economic consequences that follow from this. As a consequence of this, to a certain degree, one of the main principles for the placement of large contracts by NASA is continuity of development, which is indicated by the stability of the list of leading NASA contractors. For example, "Rockwell International" was NASA's general contractor for the central space programs of the 1960's ("Apollo") and 1970's ("Space Shuttle") and obtained a significant percentage of the order for these two decades.

The integrated, large-scale nature of the projects being carried out creates the prerequisites for the conclusion of temporary alliances among industrial companies in the struggle for contracts and the formation of unique scientific production complexes. The same firms frequently come up with competing proposals on different levels. There is further aggravation of the competitive struggle: along with competition among individual companies, there also arises and develops a rivalry between groups of firms. Upon the conclusion of large contracts, the contractors usually are allowed to lease, on favorable terms, complicated and sometimes unique scientific research equipment and entire state enterprises. For instance, during the period of work on the "Apollo" program, "North American Rockwell"--NASA's general contractor for a number of elements in this program--had at its disposal state property that was valued at 1.6 billion dollars. Such practices were also used widely in the 1970's. Almost half (46 percent) of all the production areas used by the

"Thiokol Chemical" company--one of NASA's general contractors for the "Space Shuttle" program--as well as the military departments for a number of missile-building programs, belong to the government.

One form of the utilization of government equipment by private capital is the widespread practice of working in NASA's scientific research centers. According to the official statistics, 15-20 percent of all the personnel of NASA's contractors worked regularly in these centers in the 1970's.

When concluding contracts, the corporations frequently achieve approval of projects that provide for significant government capital investments for the erection of intrafirm structures and the acquisition of equipment. This practice enables the corporations to modernize their research and production bases at government expense. In particular, such conditions prevailed during the letting of the contract for the development and delivery of the solid-fuel boosters for the "Space Shuttle" program to "Thiokol Chemical," the general contractor. In NASA's budget for 1979 alone, about 2 million dollars was allocated for the modernization of "Thiokol Chemical's" production and assembly shops in Wasatch, Utah. Thus, the government provides its contractors not only with working capital, but also a substantial part of its fixed capital.

It is also necessary to consider the fact that the execution of the research and production parts of programs is done in close collaboration with U.S. government scientific research centers and educational institutions. Such an association enables the contractors to accumulate and realize in their own commercial output the results of large-scale scientific research without charge.

The contract system that has been built up does not mean a single type of financial interrelationship between NASA and its contractors. At the present time NASA basically uses three types of contracts and different modifications of them: fixed price, cost reimbursement and initiative.

The simplest type of agreement is a contract with a firm price or a fixed-cost contract. The customer has an idea of his future costs beforehand, while the contractor takes upon himself all the risks related to fulfilling the contract, providing that he receives the established price for delivered services or products. However, contracts of this type do not stimulate the contractor to use the newest technology and original technical solutions, which inevitable results in an increase in cost. NASA uses them for those types of work for which the results can be evaluated with a sufficient degree of reliability (such as orders for the capital construction of scientific research centers, research and development work of limited volume). In turn, the contractors do not go after contracts of this type for long-term projects very willingly, since numerous technical changes and inflation reduce the assumed profit considerably.

Cost-reimbursement contracts are used for work with a high degree of indeterminacy (in the initial stages of NIOKR, basically) and assume compensation for the contractor's costs and the payment to him of a profit, of a previously agreed-upon size, in the form of a percentage of cost or a fixed sum. The use of contracts of this type requires strict monitoring by the customer of the true value of the contractor's costs and the nature of the expenditures that are related to them. According to the practice of the utilization of this type of agreement by NASA, the average profit

level for contracts of the "cost plus fixed compensation" type varied from 6.5 to 7.5 percent over the last 10 years.

The most complicated type of contract, which stipulates an incentive system for the financing of development and production work, is the initiative contract. The essence of initiative financing of work is that the amount of the profit paid to the contractor depends on the effectiveness of the utilization of the financial resources allocated according to the contract. This contract assumes a bonus for the contractor for development work originality, product manufacturing quality and finishing a project ahead of schedule. The amount of the payments for improving these indicators is agreed upon by the customer and the contractor separately, in each individual case, and can reach 15 percent of the contract's total cost.

A small number of NASA contracts are agreements of a simplified type--"working time plus materials" and "working time"--and are used for the placement of orders for small amounts of research work. The profit from contracts of these types is 5-8 percent. As data on the dynamics of the utilization of these types of contracts in NASA's relationships with its contractors show, in the 1970's the most commonly used type was initiative contracts, with the help of which the customer attempts to stimulate the qualitative indicators of the work being done.

One important tool in the state guidance of programs for the development of space technology is NASA's system for monitoring the activities of its contractors. The basic objects of this monitoring are given technical characteristics of spacecraft that are being built, the order of expenditure of allocated resources, and the work completion schedule. Current monitoring of these indicators of a contractor's activity provides a real basis for NASA's annual budget plans, which also serve as the basis for financial support for projects being realized, whereas prospective planning plays a secondary role in NASA's activities.

The information base for the monitoring of contractor activities is a contractor reporting system that makes it possible to follow the course of realization of a project. An important element of the monitoring system is a periodically repeated evaluation of the volume of completed and planned work and the correspondence of the volumes of planned work with the allocated resources. In order to improve the reliability of its estimates, NASA intensifies the degree of detail in the planning of the work for the upcoming year and makes specific technical and economic calculations of the parameters of the most important elements of a program, which are then compared with the contractor's estimates. At the same time, NASA also intensifies the degree of detail in its monitoring of the contractors' observance of the specified technical and economic parameters of the space systems being constructed, including the development schedules, and when necessary reinforces its monitoring activities by using direct economic sanctions.

The intensification of NASA's monitoring of the activities of its contractors induces them to improve their control over and organization of the work itself, as well as their systems for monitoring their subcontractors' activities. For instance, "Rockwell International"--NASA's general contractor for the "Space Shuttle" project--reorganized the service that was managing its subcontractors' activities, as a result of which the control and monitoring of their activities in the technical and financial spheres were combined. The advantage of this amalgamation was the rapid detection of increases in expenditures caused by technical problems. The same

general contractor improved its system for following changes in subcontractor expenditures and did such monitoring on a monthly basis. This, naturally, improved the substantiation for the planning of resource requirements.

Introduction of Scientific and Technical Achievements Into Practice

The creation of extremely complex rocket and space complexes and the solution of the fundamental scientific and technical problems related to spaceflight involved a large number of new ideas and new technical, technological and organizational principles. In the opinion of the leaders of the American space program, more than 2,500 technical improvements that had been made by the beginning of the 1970's were the result of the development of space technology. They include new alloys, microelectronic components, nonflammable fabrics, biomedical equipment of various types, new methods for processing food products, inorganic paints, flexible lines for the transfer of liquids, improved electrical batteries and so on. New systems for analyzing information were created, computers were improved, and photography and meteorological forecasting techniques were developed further.

The process of introducing the results of "space" NIOKR into traditional production and other spheres of practical activity is carried out in the form of a transfer of technology[1]. This means the directed transmission of scientific and technical achievements into the production branches of commercial civil output.

Two types of technology transfers are usually acknowledged. Direct transmission involves the direct output into the marketplace of a product first created for the space program. However, as the degree of complexity of the requirements for the technical and operating characteristics of modern space systems and their elements increases and, as a result, so do their cost, this type of technology transfer becomes meaningless.

A transfer of technology for utilization in other production processes involves the analogous use of already developed technology. If individual technical solutions (such as sensors, integrated circuits and so forth) are borrowed, the technology transfer can be carried out without changes. However, if what is being transmitted is primarily fundamental solutions (such as the operating principles of equipment for the nondestructive monitoring of production output), the use of the space technology requires some further development work. At the present stage of the development of space technology, this type of technology transfer is the important one.

Technology transfer is an important source of economy of material, scientific and technical resources in the creation of commercial output. It stimulates the development of many branches of the economy. According to research data gathered by the Denver Scientific Research Institute, the total economic effect of the "Apollo" program because of the transmission of technology into civil branches of industry was 70-80 percent of the cost of the entire program. The scale of the economic results of the transfer of technology can be indicated also by the results of an investigation conducted by the "Mathematics" company under a NASA contract. According to the

---

[1]In this case, "technology" means the technical devices, equipment or systems, the complex of scientific knowledge, and the engineering developments or processes involved in the production and consumption of goods and services.

data gathered by that firm's specialists, the economic effect from the use of only four scientific achievements that were the result of the implementation of NASA programs was about 7 billion dollars over two decades. These savings were achieved by:
the use, in all fields, of integrated circuits--about 5.1 billion dollars (1963-1982);
the use of gas turbines in thermal electric power stations--111 million dollars (1969-1982);
the use of "space" thermal insulation in cryogenic technology--1.05 billion dollars (1960-1983);
the use of the NASTRAN computer program for strength analysis in designing the structures of railway cars, motor vehicles, bridges and tall buildings--more than 701 million dollars (1971-1984).

The transfer of space technology is one of NASA's functions. It is accomplished by the realization of a special technology introduction program, for the implementation of which about 9 million dollars is spent every year. The goals of this program are: stimulating the introduction of NASA's scientific and technical achievements in the branches of the United States' economy having a potential capability for utilizing them; reducing the amount of time between the appearance of new proposals and technical discoveries and their effective utilization in industry and other branches of the economy.

Within the framework of this program, an information mass numbering more than 10 million documents and technical descriptions has been created. Access to it is gained through a computer. There are also more than 2,000 computer programs, with corresponding documentation. NASA's information fund is growing constantly, and its volume at the end of the 1970's was estimated to be 10^{11} bits per day.

NASA's practical activity for the transfer of technology is carried out through 9 regional centers and 11 representatives in different parts of the United States who service the requests of industiral firms and individual consumers. The number of clients of the NASA information centers is increasing constantly, and by 1977 they had already processed about 100,000 inquiries.

A significant position in NASA's activities is occupied by the output of various informational publications containing information on potentially useful scientific and technical achievements and the conduct of thematic conferences, symposiums, seminars and exhibitions.

Thus, NASA's technology transfer practices are indicative of the bourgeois government's signficant and sometimes relatively successful efforts to provide an additional economic gain from its investments in the development of science and technology. This, of course, should not hide from us the ever intensifying dependence of the space programs on military clients. In practice, the continuing militarization of space research and development work lessens the effect that the civilian branches of the United States' economy would feel under conditions of detente.

11746
CSO: 1866/47

LIST OF RECENT SOVIET SPACE LAUNCHES

Moscow TASS in English or Russian various dates

[Summary]

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
10 Jun 82	Cosmos-1378	682 km	648 km	97.8 min	82.5
18 Jun 82	Cosmos-1379	1,027 km	552 km	100.3 min	65.8
	(Launch announcement includes statement: "scientific research envisaged by the program has been carried out")				
18 Jun 82	Cosmos-1380	732 km	156 km	93.1 min	82.9
18 Jun 82	Cosmos-1381	395 km	216 km	90.3 min	70.4
25 Jun 82	Cosmos-1382	39,540 km	614 km	11 hrs 49 min	62.8
1 Jul 82	Cosmos-1383	1,041 km	1,004 km	105.4 min	83
	(Carries scientific equipment designed to test systems for determining position of ships and planes in distress)				
1 Jul 82	Cosmos-1384	381 km	181 km	105.4 min	67.1
6 Jul 82	Cosmos-1385	264 km	197 km	88.7 min	82.3
	(For continuing studies of earth resources; data will be processed at the "Priroda" State Scientific Research and Production Center)				
7 Jul 82	Cosmos-1386	1,010 km	965 km	104.6 min	83
14 Jul 82	Cosmos-1387	271 km	219 km	89.1 min	82.3
	(Carries equipment for continuing studies of earth resources; data will be processed at the "Priroda" State Scientific Research and Production Center)				

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
21 Jul 82	Cosmos-1388--Cosmos-1395	1,515 km	1,448 km	115.3 min	74
		(Eight satellites launched by single booster)			
21 Jul 82	Molniya-1	38,901 km	650 km	11 hrs 41 min	63
		(Communications satellite for long-distance telephone and telegraph communications and for relay of Central TV programs to the "Orbita" network in the Far North, Siberia, Far East and Central Asia)			

CSO: 1866/125-P

- END -