IGY Conference in Moscow

Reports on the organizational setup and on the Soviet presentation of their rocket and satellite work.

Work and Meetings of CSAGI

The abbreviation CSAGI stands for Comité Spéciale pour l'Année Géophysique Internationale—or, in English, Special Committee for the International Geophysical Year. The CSAGI was created late in 1951 by the International Council of Scientific Unions (ICSU), to guide the planning, organization, and coordination of research during the International Geophysical Year (IGY). To appreciate this role of CSAGI in the IGY, one should be aware of the place of CSAGI in the organizational scheme of things.

The International Council of Scientific Unions in 1932 succeeded the previous International Research Council. Adherents of ICSU are of two types: (i) 13 international unions such as the International Union of Geodesy and Geophysics, the International Union of Scientific Radio (URSI), and the International Astronomical Union, and (ii) national members, of which the United States is one. Financial support is provided by contributions from the union and national members, with some support by UNESCO. The purpose of ICSU is to provide a central organization for the coordination and encouragement of international science.

Lloyd Berkner's original idea for an international geophysical year was first proposed formally to the Mixed Commission on the Ionosphere, a commission sponsored jointly by the international unions of Scientific Radio, of Geodesy and Geophysics, and of Astronomy. After approval here, the proposal then proceeded to URSI, from which it was referred to the ICSU. Finding considerable interest in and support for the idea, the ICSU established CSAGI. Organizationally, then, the CSAGI is a committee of the ICSU, with responsibilities to the union members of ICSU on the one hand and to the national members on the other.

At the time it created the CSAGI, ICSU also sent out invitations to the national members of ICSU asking them to participate in the IGY program and to establish national committees for the IGY. The purpose of the national committees was (i) to develop in their own countries research programs appropriate to the IGY aims, and (ii) to work with CSAGI to integrate the individual national programs into the total IGY effort. At the same time, CSAGI proceeded to develop its own internal organization. In the course of time, the following over-all organization evolved: (i) the CSAGI itself, including reporters for each of the following IGY disciplines and activities: meteorology, geomagnetism, aurora and airglow, ionosphere, solar activity, cosmic rays, glaciology, oceanography, rockets and satellites, seismology, gravimetry, and nuclear radiation; (ii) the CSAGI Bureau, which consists of the CSAGI officers, plus two appointees-at-large; (iii) the CSAGI Secretariat, which resides at Brussels; (iv) the Advisory Council for IGY, which consists of the principal delegates of the various national delegations to CSAGI assemblies, and which accordingly comes into action only during such assemblies; (v) the various national committees for IGY, of which there are now 67.

As part of its planning and coordination activity, the CSAGI sponsored a number of international meetings; the first and third of these were held in Brussels in 1953 and 1955, the second was held in Rome in the fall of 1954, and the fourth was held in Barcelona in the fall of 1956. At these international meetings, the CSAGI, the bureau, and the advisory council consider the various problems at hand and attempt to work out appropriate solutions. In addition, the CSAGI establishes numerous working groups, which exist for the period of the assembly only. In the scientific disciplines, the working groups are generally chaired by the respective CSAGI reporters and bring to the attention of the CSAGI recommendations pertinent to the needs of the separate disciplines.

The Second General Assembly of CSAGI was of particular note, for at that meeting the planning assumed impressive proportions. An extensive and promising antarctic program had begun to take form; sizable efforts were beginning to shape up in all of the various disciplines; an extensive program of rocket sounding of the upper atmosphere had been introduced; and the CSAGI went on record as being interested in artificial satellite observations should these prove feasible. Also, on the closing day of the assembly, the U.S.S.R. announced its intention of joining the IGY program, thus closing what had hitherto stood out as a serious gap in the geographic coverage of the program.

The Fourth Assembly, in Barcelona, was the last such assembly to be held before the actual start of the IGY, which commenced on 1 July and ended on 31 December 1958. Here the final plans for IGY were firmed up, with considerable attention given to the rocket and satellite part of the program.

The Fifth General Assembly of CSAGI was held in Moscow, from 30 July to 9 August 1958. There were four principal matters for the assembly to take up: (i) a review of the accomplishments of the first two-thirds of the IGY; (ii) the question of the future of international cooperation in geophysics after the end of the IGY; (iii) the problem of the collection, storage, and cataloging of data at the world data centers; and (iv) the question of publication of IGY data and results.

The review of accomplishments during the first year of the IGY was achieved largely through symposia in the various disciplines. The list of accomplishments is impressive. Those reported by the U.S.S.R. in the rockets and satellites area are summarized below.

Extending the IGY

The question of the future of international cooperation in geophysics after the end of IGY received much attention. There was general agreement that international cooperation in this area should continue; the problem was to arrive at a common agreement about the mechanism for accomplishing the continued international cooperation. The Soviet delegation, with the support of Communist China, Poland, and East Germany, proposed and strongly urged that the IGY be extended for another year. There is a twofold need for this, they said: First, many important IGY tasks will not have been completed by the end of 1958, and the additional year would make it possible to finish these tasks; second, there is need for some permanent arrangement for international cooperation in geophysics and solar physics, and the extra year of IGY would extend the present cooperation for a long enough period to permit permanent arrangements to be worked out.

From their position on this question of extending the IGY, and from what individuals said in defense of that position, it appeared that the Soviet scientists need the IGY name and organization to help them maintain their position at home and their outside contacts and the freedom of intercourse that has been achieved so far. Apparently this need is a very urgent and demanding one in the opinion of the Soviet geophysicists and solar physicists.

On the other side in this question of extending the IGY were those countries, including the United States, whose governments had supported the effort with the definite understanding that the program would be achieved in the year and a half from 1 July 1957 to 31 December 1958 and would terminate on the latter date. Even if these governments might be persuaded to lend further support, there was serious doubt as to whether the total IGY program should be continued. It was stated by spokesmen for this position that, while admittedly there were areas in which the cooperative work should go on, nevertheless there were also some research projects that should terminate, either because the point of severely diminishing returns had been reached or because the output had been too poor to warrant further support.

A compromise between the two positions was finally reached in the form of a CSAGI recommendation for "International Geophysical Cooperation—1959" (IGC-1959). Although this may look like simply a change of names, it is not. The intent and expectation is that following the end of the IGY on 31 December 1958, many research projects will terminate, many others will be greatly curtailed and modified, while perhaps a few may even be expanded. In those areas in which research and international cooperation do continue, it is hoped and urged that the data and results will continue to be fed into the world data centers, thus adding in an orderly way to the IGY results. Included among the recommendations for continued cooperative work are recommendations for a world magnetic survey, a limited solar activities program, antarctic research, oceanographic studies, and rocket and satellite observations.

Outlook for the Future

As a result of these and other discussions, the present outlook for the future is as follows: (i) The IGY will terminate as planned on 31 December 1958; (ii) the IGY will be followed by IGC-1959; (iii) the CSAGI will cease to exist on 30 June 1959; (iv) in order to wind up the affairs of IGY, the CSAGI Secretariat will continue to function until October 1959; (v) recognizing that results from the IGY program will continue to evolve through many years following the end of the IGY observing program, the CSAGI recommends to its parent ICSU that the board of reporters for the various disciplines continue to function and direct the publication of IGY results; and (vi) CSAGI recommends to ICSU that an IGY Completion Committee [Comité pour l'Utilisation des Résultats de l'Année Géophysique Internationale (CURAGI)] be established to wind up the affairs of the IGY.

Policies for the operation of the world data centers and the exchange of IGY data developed rather smoothly except in the area of rockets and satellites. Difficulties arose because of the U.S.S.R.'s refusal (i) to provide orbital elements for Soviet satellites during the course of the satellites' life-times; (ii) to provide precision radio tracking data for satellites; (iii) to agree to an automatic dispatch of basic data to the world data centers. On the last point the U.S.S.R. provided no guarantee whatsoever that the rest of the world will ever see any of the desired data; the Soviets say that they intend to negotiate each request for information with the requestor. When it was pointed out that this procedure would not provide a means for scientists to know what data existed, the Soviets had no comment. As acting reporter for rockets and satellites, I felt compelled to state in my report to the full assembly on the last day that the working group for rockets and satellites had failed to achieve a satisfactory solution of the data exchange and world data centers problem.

In discussing this question, it should be made clear what we mean by data. We mean the basic measurements, suitably reduced and calibrated. These data include both radio and optical tracking data; assimilated tracking data, such as orbital elements for a satellite; cosmic ray counts; temperatures; sizes of antennas; sizes, shapes, and weights of satellites; power outputs; frequencies; modulation; antenna patterns; and so on. These are data needed by researchers in other countries, either for evaluating Soviet reports and papers or for carrying out researches of their own.

Such data are to be distinguished from reports on final results, which are in essence interpretations of data. The Soviets presented many interesting papers containing important results. A good scientist will, however, provide enough of the basic data on which his results are based for his critics to judge the validity of his conclusions. It remains to analyze the Soviet papers to see how many of these underlying data they did reveal. Preliminary indications are that they were reasonably open in papers on upper-air rocket results, as the discussion below on the Rocket and Satellite Symposium shows, but that they withheld such information as descriptions of rockets used, of telemetering systems, and of precision tracking data.

With regard to the publication of IGY results and data, it was agreed that the *Annals of the International Geophysical Year* should serve as a complete record of the IGY. To this end, then, all important results and data—or where the data are too extensive, significant and representative portions of the data—will be published in the *Annals*. Such publication will not preclude publication elsewhere and in fact might often involve a republication of previously published material. The reporters for the various disciplines will have the responsibility of seeing that their respective disciplines are properly reported in the *Annals*.

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Soviet Papers Presented at the Rocket and Satellite Symposium

The following sections of this report give, for each discipline, data which the Soviets presented at the 5th General Assembly of CSAGI on the results of their work in rockets and satellites. Due to time limitations some of the papers were only outlined by the speakers, and hence

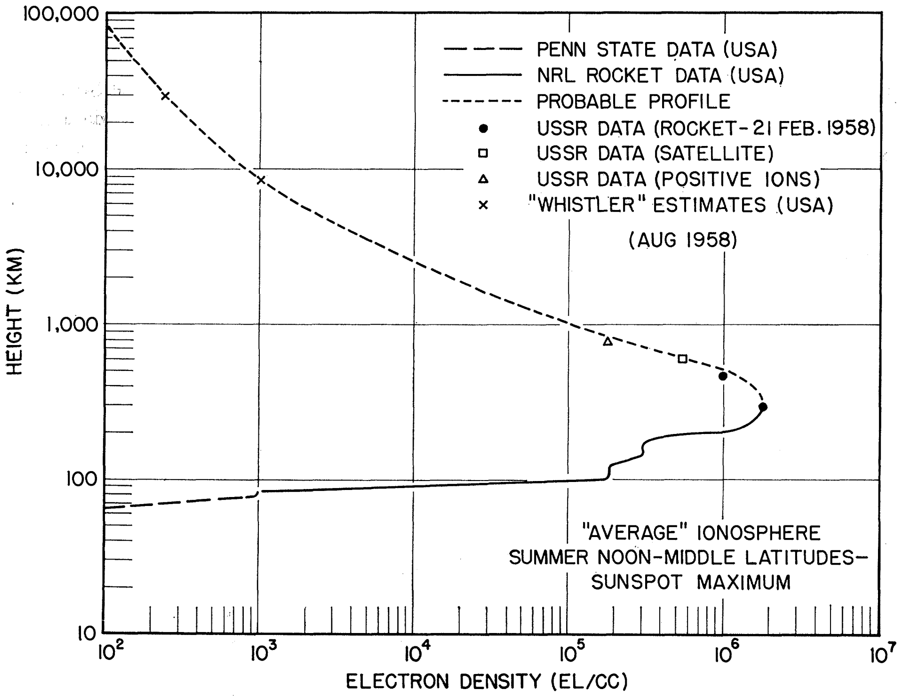

Fig. 1. Data from the United States and the U.S.S.R. summarized and combined to give an "average" ionosphere.

this report is not complete. The full papers are now being translated, and the scientific community can look forward to their publication in the near future.

Ionosphere and Positive Ions

The Soviet papers on the distribution of electron density in the ionosphere and on the nature and number of positive ions were impressive. The Soviet rocket and satellite experiments have apparently provided the first quantitative data on the profile of the ionosphere above the maximum of the F_2 region. The result of this research indicates that the decay of electron density above F_2 maximum is less rapid with altitude than had been expected. This conclusion agrees with recent United States data obtained through the studies of "whistlers," and with English data obtained by observation of the transit of radio signals from the earth to the moon and back. Several techniques were employed by the Soviets to obtain electron density measurements.

First, observations were made on the radio "rise" and "set" of the Sputniks (*1*). Both the 20- and 40-megacycle signals were used. From these observations the Soviets obtained a profile above F_2 maximum. Second, experiments were conducted in rockets (*2*). The experimental technique used was the same as that used at the U.S. Naval Research Laboratory, where two radio signals, harmonically related, are transmitted to ground from the rocket. The lower frequency is chosen so that it is affected by the ionosphere; the upper frequency is chosen so that it is not affected and thus serves as a reference signal. By observations on the two signals it is possible to deduce the electron density profile. The U.S.S.R. scientists presented data below F_2 maximum taken on a number of occasions with rockets. These profiles agree well with U.S. results that show the ionosphere to be a single layer with fine structure. Above F_2 maximum the Soviets gave data from a recent flight of their "Geophysical" rocket. During this flight they found F_2 maximum at 290 kilometers where the electron density was 1.8×10^6 electrons per cubic centimeter. At 470 kilometers they found a density of 10^6 electrons per cubic centimeter. Third, the Soviets presented data obtained on Sputnik III by the use of an ion trap (*2*). This device gave an ion density of 5.2×10^5 ions per cubic centimeter at 242 kilometers and a density of 1.8×10^5 ions per cubic centimeter at 795 kilometers. These results were taken on a single day, 15 May 1958, and at middle latitudes. The time given was during daylight, just before noon. John E. Jackson of the U.S. Naval Research Laboratory has summarized these data, and the results appear in Fig. 1. Here he has combined U.S. ground-based observations (*3*), U.S. rocket observations (*4*), the U.S.S.R. data, and finally whistler data (*5*), to obtain an "average" ionosphere. It must be realized of course that the ionosphere varies, particularly as a function of time of day and of time during the solar cycle, but the curve still can be taken as a good indication of average conditions.

In addition, a mass spectrometer was flown on Sputnik III. This instrument was used to determine the nature and relative abundance of positive ions in the ionosphere in the range from 6 to 50 atomic mass units (*6*). The instrument appears to be identical to the one used by J. W. Townsend and C. Y. Johnson at the U.S. Naval Research Laboratory for the past 8 years on a number of rocket flights. The results given from the first several orbits show that the principal positive ion is that of atomic oxygen, mass 16, in the region from 250 to 950 kilometers. Atomic nitrogen, mass 14, was also found, in amounts that varied with altitude, as shown in Table 1. In addition, two other small peaks were found in the spectra, at masses 18 (water) and 30 (nitric oxide). The Soviets stated in their paper that they felt these were due to contamination, since they disappeared from the spectra as time went on. Besides the flight of Sputnik III, Soviet scientists flew the mass spectrometer in a rocket. Their data agree closely with recent U.S. data that show a predominant ion of mass 30 (nitric oxide) along with mass 32 (molecular oxygen) in the E region. Above the E region and into the F region, masses 30 and 32 give way to mass 16 (atomic oxygen), which in turn becomes the predominant ion above 250 kilometers. An interesting side light on both the ion trap and the mass spectrometer experiments on Sputnik III was that both instruments showed a satellite potential of around −2 volts.

Table 1. Variation of atomic nitrogen with altitude, as shown by mass spectrometer flown on Sputnik III.

Height (km)	Atomic nitrogen/atomic oxygen
230	0.037
250	0.03
255	0.035
285	0.045
385	0.06
460	0.06
650	0.07
705	0.07
820	0.06

Atmospheric Structure

The Soviets have flown a large number of their so-called "Meteorological" rockets during the IGY from launching sites in the Antarctic (Mirny), in the Arctic (Franz Josef Land), and aboard ship at many latitudes. Results on the temperature distribution up to an altitude of 50 kilometers were presented (7). The measurements were made by means of a novel, radiation-shielded, resistance thermometer. The Soviets claim good agreement between data from this instrument and derived temperatures obtained from pressure and density measurements made at the same time. The data show the same over-all temperature distribution with altitude as is shown in U.S. data. However, for the first time, complete curves were presented, apparently from a large number of firings in a complete program, showing the seasonal variation of temperature at each of six 5-kilometer intervals between 25 and 50 kilometers. Below 40 kilometers, the temperature varied in a sinusoidal fashion with an excursion of about 25°C. The temperature maximum came in the late part of June. Above 40 kilometers the variation was also sinusoidal but it was larger, with an excursion of about 35°C. The maximum came earlier (late May) at the higher altitudes. As a function of altitude, the data showed the temperature minimum to be at 26 kilometers, at a value of 200°K (December), and the maximum to be at 50 kilometers, at a value of 290°K (May).

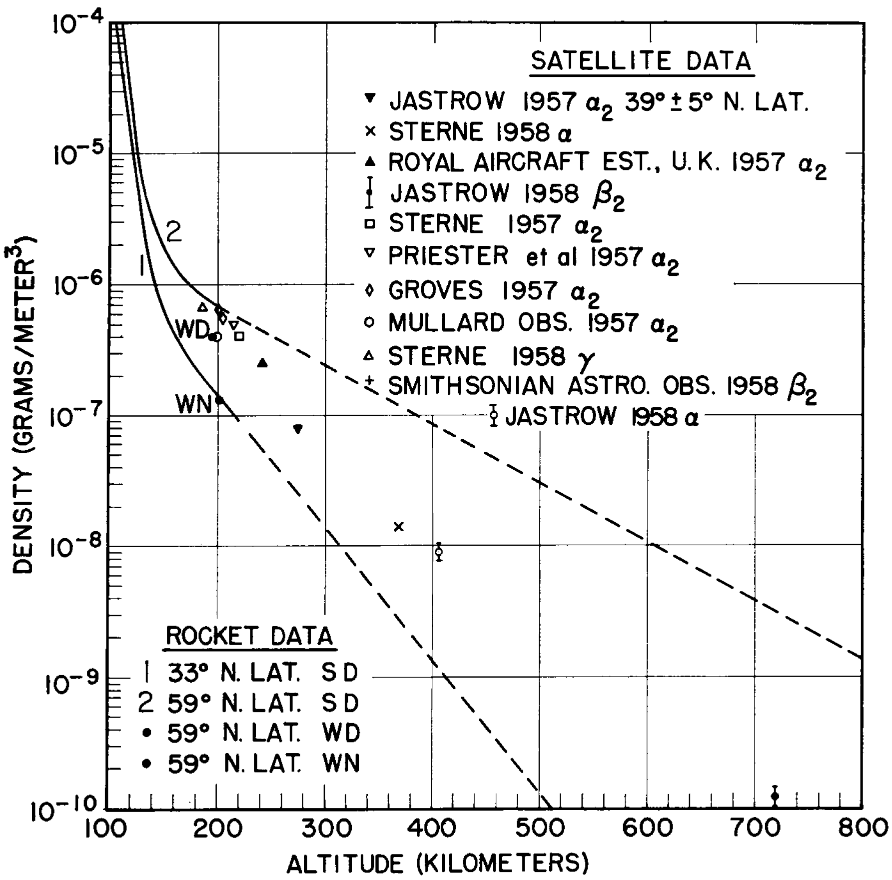

Fig. 2. Recent data from the United States and the U.S.S.R. on atmospheric densities, as determined from rocket and satellite observations.

Fig. 3. Sputnik II. [H. E. LaGow]

From pressure-gage measurements made on rocket flights, one of the U.S.S.R. papers compared high-altitude densities with U.S. data (*8*). The agreement is good, considering the fact that it is now believed that densities in the atmosphere above 100 kilometers are lower at lower latitudes than at higher latitudes. The U.S. rocket was fired at the White Sands Proving Ground, New Mexico; the Soviet rocket, at "middle latitudes" (presumably 45°N). The data are shown in Table 2. Also in Table 2 are shown densities determined by means of satellites. The point at 228 kilometers was obtained by satellite drag measurements (*9*); the points at 260 and 355 kilometers, by pressure gages mounted in Sputnik III. In connection with drag measurements, the Soviet data are in excellent agreement with U.S. results obtained by observations on the same U.S.S.R. satellites. A note of interest should be added. The U.S.S.R. paper on the pressure-gage measurements in Sputnik III mentioned data analysis difficulties caused by motion of the satellite and by outgassing of the object during the early phases of flight. United States observers have had similar difficulties in connection with rocket flights. It was stated that the residual pressure in the gage was 10^{-7} millimeters of mercury on the first day, 10^{-8} on the second, and 10^{-9} on the third day.

All of the recent data from the U.S. and the U.S.S.R. on atmospheric densi-

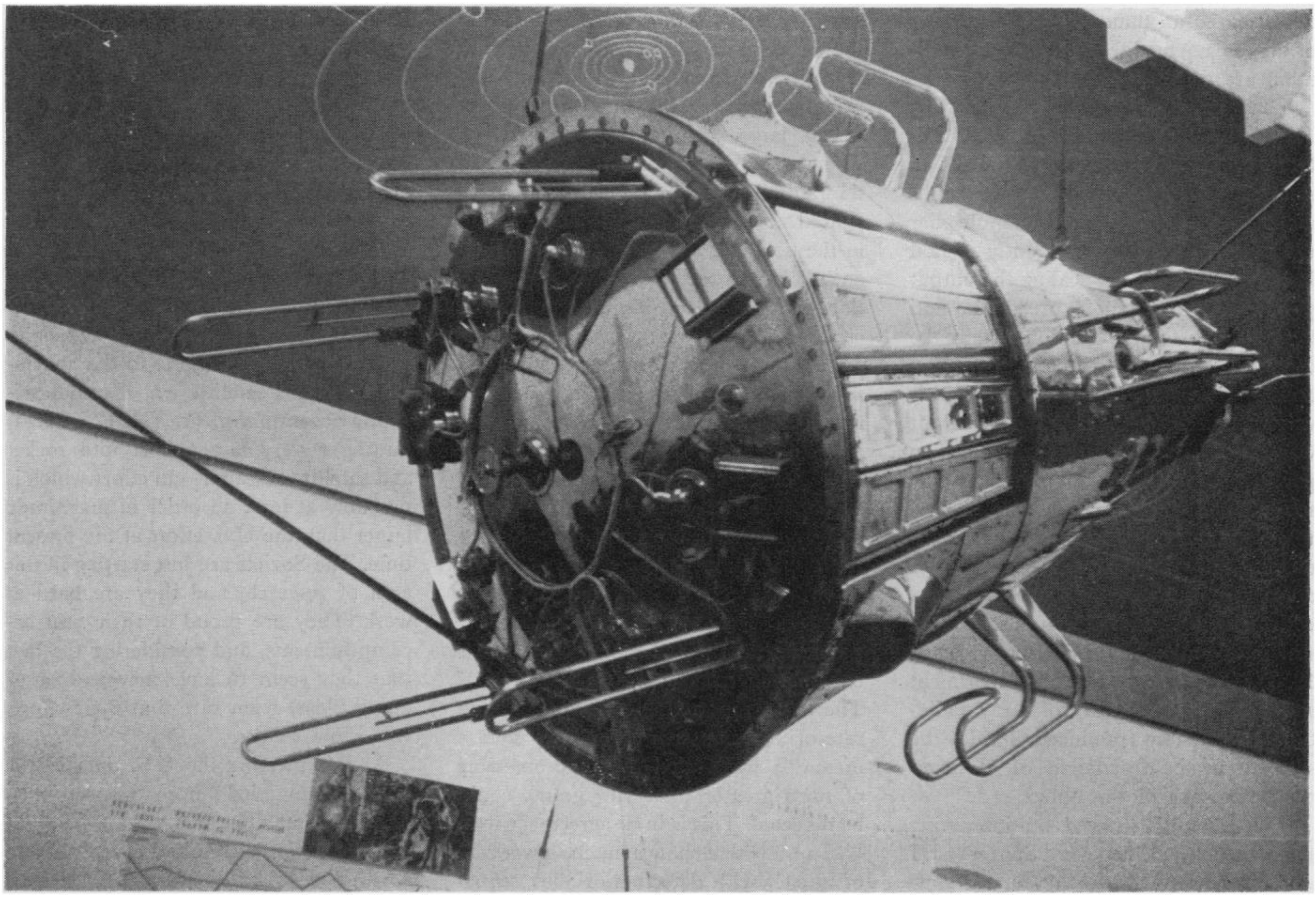

Fig. 4. Sputnik III. [H. E. LaGow]

ties tend to show that there is a strong latitude dependence. Figure 2, prepared by H. E. LaGow of the U.S. Naval Research Laboratory, shows this. The solid curves are rocket data taken at two latitudes. The points are from satellite observations of drag; *W* refers to winter, *S* to summer, *D* to day, and *N* to night. Note that at the higher latitudes the densities are higher. The satellite data bear this out, since the Soviet satellites have a perigee at high latitudes (the drag is much higher at perigee, hence satellite drag data taken by observation of the change in period give rise to density data at perigee) and the U.S. satellites have a perigee at the lower latitudes.

One U.S.S.R. paper suggested that there was a diurnal variation of density at about 225 kilometers, but that more data were needed (*9*).

Cosmic Rays and Photons

The U.S.S.R. effort in the study of cosmic rays and photons was reported on in a number of papers. In Sputnik II a single-shielded Geiger counter (5 g of Al) was flown to measure the cosmic ray counting rate as a function of geomagnetic latitude and as a function of altitude. The results shown revealed that the counting rate increased almost linearly from 30°N to 60°N geomagnetic latitude at a constant altitude. No evidence of a knee showed clearly in the data. As a function of altitude the rate increased gradually from 225 to 700 kilometers. The Soviets attribute the increase primarily to the decrease in magnetic field as a function of altitude and secondarily to the spin of the earth. During the flight of Sputnik II (see Fig. 3), an unusual event occured during which the counting rate increased by 50 percent. There was no correlation with any event noticed on the ground. The Soviets stated that later experience with instrumentation on board Sputnik III (see Fig. 4) leads them to believe that there is an electron flux north of 60°N at relatively low altitudes and that the "event" was probably part of this phenomenon. The U.S.S.R. scientists felt that the electrons are in orbit from pole to pole and that there are three possible sources: (i) particles from the sun, (ii) particles from the stars, and (iii) particles from the decay of neutrons coming back from the earth (the neutrons would be albedo from energetic cosmic rays).

On Sputnik III the U.S.S.R. scientists had three interesting experiments. The first of these involved the use of a Chĕrenkov counter arranged to detect atomic nuclei in the primary cosmic radiation of $Z > 15$ and of $Z > 30$. The apparatus was calibrated with mu mesons. The results were quite straightforward (*10*). Over an interval of ten days the number of nuclei with $Z > 16$ amounted to an average of 1.2 ± 0.1 per minute. Only one single count was observed corresponding to $Z > 30$. The conclusion is that the composition of the primary cosmic radiation is about that expected on the basis of cosmic abundances and that recent reports of the

Table 2. High-altitude densities from pressure-gage measurements made on Soviet rocket flights compared with U.S. data.

Height (km)	Density (g/cm³) U.S.S.R. rocket	Density (g/cm³) Viking VII (U.S.)	Density (g/cm³) Satellite
100	4×10^{-10}	2.5×10^{-10}	
150	1.7×10^{-12}	6.6×10^{-13}	
200	2.7×10^{-13}	1.4×10^{-13}	
220	1.6×10^{-13}	9.0×10^{-14}	
228	1.3×10^{-13}		2.4 to 3.2×10^{-13}
260	6.9×10^{-14}		1×10^{-13}
355			8.8×10^{-15}

detection of an unusually large number of very heavy nuclei in the primary radiation are open to question.

The second experiment on Sputnik III involved the use of a large scintillator. The apparatus consisted of a sodium iodide crystal 40 by 40 millimeters, back by a large photomultiplier (*11*). The device was apparently carried inside the satellite. By scaling the output pulses with a threshold of 35 kev and by obtaining total ionization within the crystal by measuring the anode current, and by noting a dinode current which was nonlinear to the anode current, it was possible to obtain information on particle flux, energy flux, and energy spectrum. All information was telemetered via the 20-megacycle radio transmission (pulse length–pulse space). This device seems to be on separate power, with modest demand, for it is said to be still in operation at this writing (August 1958). The results of this experiment showed a high intensity of x-ray radiation presumably produced inside the satellite by bombardment of electrons on the surface of the object.

The intensity showed an interesting phenomenon: Whenever Sputnik III was north of 60°N, in the auroral zone (its maximum excursion was about 70°), a "sharp" increase in counting rate was systematically observed. The Soviets attribute this to auroral electrons with an energy of the order of 100 kev and more, incident on the satellite shell. Furthermore, they speculate that the current may be "stationary" and semipermanent. In addition, peculiar effects with respect to the total ionization measurements were noted outside of the auroral zone, which they felt were hard to explain on the basis of the normal cosmic ray flux. They mentioned latitude, longitude, and altitude effects. Their present conclusion is that the satellite may be running into corpuscular streams probably composed of electrons with energy of less than 100 kev. They stated that in the auroral zone, in the energy range 200 to 300 kev, a typical flux was 10^4 particles per square centimeter per second; in the range 20 to 60 kev, the corresponding flux was 10^7 particles per square centimeter per second.

The third experiment in this field in Sputnik III involved the use of two photomultipliers with thin phosphor screens (*12*). The screens (2×10^{-3} g/cm^2) were in turn covered by two thicknesses of aluminum foil (4×10^{-4} g/cm^2 and 8×10^{-4} g/cm^2). These detectors were apparently mounted on the outside of the satellite, so that they were exposed to the incident radiation and not only to partially absorbed and bremsstrahlung radiation, as was the case with respect to the large scintillator just described. The results showed strong variations in the radiation detected. The radiation appeared strongest at the high altitudes and in the polar regions (auroral zone). The authors attributed the bulk of the radiation to 10-kev electrons. The maximum energy detected was very large, being 4×10^3 ergs per second per steradian per square centimeter. Again it appears that these are electrons in orbit from pole to pole, with absorption at each end. The Soviet scientists felt that the energy involved was enough to add materially to the heating and ionization of the upper atmosphere.

Miscellaneous

One interesting and controversial paper on micrometeors was presented (*13*). The paper reported an average counting rate of 90 counts per second per square meter. It was stated that micrometeors of mass greater than 10^{-9} grams could be detected. This is in disagreement with U.S. results that show a much slower rate of impact with detectors of about equal sensitivity. The Soviet results, if converted in terms of the mass of meteoritic material falling on the earth per day, appear to lead to impossibly high numbers. It will be interesting to see how the controversy is eventually resolved.

The magnetometer on Sputnik III was described, and full details were given on its construction and calibration (*14*). No data were presented from the flight because of the time element and the data-reduction problem. The U.S.S.R. authors said that a considerable amount of data was obtained and that evidence of discontinuities, particularly at higher altitudes, was found. In connection with the interaction of the satellites with the magnetic field, several Soviet scientists stated that there was no evidence of magnetic damping of the spin rate (although such damping might be small and thus escape observation) and no evidence of "electric drag" due to the presence of a large charge on the objects.

The Soviet biological experiments in rockets and satellites were reviewed (*15*). Most of the work has been done with dogs, both in and out of pressurized chambers and with and without pressure suits. No new information, outside of that which has appeared in the press, was given on the dog in Sputnik II. When asked a direct question, the scientist giving the paper stated that the dog lived during the prescribed program of 7 days.

Conclusion. During our visit to Moscow we saw what was probably one of the "flight spares" units of Sputnik III. The instrumentation installed in the satellite had been taken out and was on display, piece by piece. In most cases the individual units were open for inspection. This was an impressive sight. From what I saw I came to the conclusion that this satellite was a major scientific accomplishment. The U.S.S.R. is putting a very large effort into rocket and satellite research—an effort which is probably at least an order of magnitude larger than the U.S. effort at the present time. The Soviets are just starting in this area of research, and they are hard at work. They are proud of their past accomplishments, and considering the fact that they seem to have new and interesting ideas, I am sure that their efforts will show results.

At this meeting the U.S. data in the field commanded more respect than U.S.S.R. data. The U.S. data were given in more detail, were more complete, and covered a broader effort. At the next international gathering of this type—say, a year or so from now—the Soviet results will be on a par with our results. After that, unless conditions change, the Russians will be ahead.

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