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Tempo, April 28, 1959

By Ceasare Capone

Translated by A. J. Viterbi and J. L. Zygielbaum

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The astronauts will have to learn to predict solar storms in order to avoid deadly shipwrecks in the interplanetary ocean. This was one of the more important conclusions presented in an exclusive interview between the author and four Soviet scientists. These scientists designed and developed the equipment installed on Lunik and also reduced and interpreted the data received.

What is there above the atmosphere? Which radiations, which mysterious forces exist in cosmic space? This is the question that man has set for himself since his first awareness of the earth's place as a tiny globe, moving in an immense universe. For hundreds of years physicists, chained with their instruments to the surface of the earth, attempted to answer these questions with scientific speculation. But now, with the launching of the first artificial satellites and the first space probes, men of science have begun to single out, to measure and to know directly the true nature of interplanetary space—which is not at all empty—but which is crossed in every direction by atoms and energies which have influence on the movement of celestial bodies and perhaps on the very rhythm of life itself. And this is the space across which the space probes directed toward the moon, Venus, and Mars, will have to pass in the near future.

Last year the data transmitted by the Explorer satellites permitted the Americans to be the first to announce the unexpected existence of a radioactive belt encircling the earth at a great height. The three Pioneer space probes have given further confirmation to this discovery.

And the Soviets, how about them? Their Sputnik and Lunik, have they not revealed anything analogous? That was the theme of our interview with the Soviet physicists S. N. Vernov, A. E. Ciudakov, I. S. Slovskij, and V. I. Krasovskij. (Vernov and Ciudakov designed the scientific equipment installed aboard Lunik and interpreted data transmitted by it during its first 450,000 kilometers of flight.)

The Russians have discovered the belt of radiation which surrounds the earth. For the first time they speak openly, but the contradictions with the American data are not lacking, (as we have noted, in passing, in the context of their answers). They revealed, among other things, that the radioactive belt is not at all, as many fear, a deadly obstacle to the exploration of space by man but rather a shield for the inhabitants of earth against the lethal radiations which come from the sun and from the universe.

Question: The artificial Explorer satellites and the Pioneer lunar probes launched by the United States have revealed that extraterrestrial space is crossed by radiations very intense and very dangerous to the future of space travelers. Did Sputnik and Lunik also discover things of this nature?

Vernov: Yes. The multiplicity of the equipment installed aboard the artificial satellite and the cosmic rocket built by the Soviet Union has permitted us to know precisely enough the intensity and the composition of the radiation existing in interplanetary space. And so, today, we are in a position to make known the results of our research on this radiation, which was recorded in the vicinity of our planet at a distance of over 100,000 kilometers from the center of the earth.

One important conclusion is this: at distances greater than nine earth radii, or shall we say 57,000 kilometers, the radiations do not become more intense as the distance from the earth is increased. Rather, they become so weak as to represent almost no danger at all for human beings.

Very different physical conditions exist, however, in the regions of space adjacent to our planet. In these regions the intensity of radiation (*we are not speaking of thermal rays nor of ultraviolet rays*) makes the danger hundreds of times greater than in interplanetary space. The analysis of radiations existing in such zones has revealed the presence of roentgen rays, or X-rays, formed by the bombardment of the metal skin and equipment of the two Soviet space vehicles by nuclear particles.

Question: What are these particles?

Slovskij: Radiation counters located on the satellite and on the Soviet space rocket have revealed, contrary to scientific expectations, that in the upper amosphere—beginning at an approximate height of 500 to 1,000 kilometers—there is an enormous accumulation of fast particles carrying electric charges and possessing an energy varying from several hundred to several thousand electron-volts. (*The electron-volt is the unit of energy used for all the known particles of atomic physics, charged or uncharged.*) The indications of the equipment lead to the conclusion that the greatest portion of the mass of each particle is formed by electrons. (*The electron is the elementary particle of negative charge which gravitates or goes around the atomic nucleus, but which may also be separated from the nucleus. The energy developed by a flux of electrons is that which we know under the name of electricity.*)

Question: Did you have difficulty in discovering the radiation belt which surrounds the earth?

Krasovskij: No. This zone extends for about seven to eight earth radii, that is, up to about 50,000 kilometers. The concentration of particles is so great in some places that the phenomenon has been recorded several times, even by rockets equipped with instruments designed to do other tasks. This particular surprising array of particles which surrounds the upper regions of our planet could be called a corona of the earth, in analogy with the corona of the sun, which also is composed of electrically charged particles. (*The corona is the external stratum or layer of rarified, intensely hot gas which surrounds the sun.*)

Question: American scientists, especially Professor James Van Allen, have spoken recently of not a single, but a double belt of radiation around the earth. Does this coincide with your observations?

Slovskij: In a general way, yes. Also, according to our views, the zone of particles consists of two fields—that is, magnetic fields.

The first field is found relatively near the surface of the earth and is situated in great part in the lower latitudes of the globe, in the space just above the temperate and equatorial zones. The concentration of particles—which in the interior of this field is not uniform—reaches its maximum height at approximately 10,000 kilometers.

The second field has an extension notably greater in distance. It extends from 40,000 to 50,000 kilometers above the earth and surrounds almost all the globe. The concentration of particles is higher here than in the lower field. In the center of this field the number of particles is 100 times greater than in the lower field. However, the research done by the satellite and the Soviet rocket indicate that the energy of the particles in the lower field is notably greater than the energy of the particles in the upper field. (Here the data do not agree with data furnished recently by the American scientists, according to whom the first belt of radiation goes from 2,250 to 5,500 kilometers and the second from 12,800 to 19,300 kilometers from the surface of the earth.)

Question: How does one explain the formation of such fields and whence come the particles that form them?

Ciudakov: It is not quite clear. It seems quite probable that the origin of the particles in question may be found primarily in the action of cosmic rays which bombard atoms of the high atmospheric strata and also, perhaps, from particles formed by solar activity. Since they are charged electrically, the particles are attracted and fall, one might say, into a trap consisting of the earth's magnetic field. (*The earth acts as a gigantic magnet. In fact, it possesses magnetic poles, not coinciding, however, with the geographic poles. The zone of influence, or the magnetic field, produces among other things the phenomenon of the double belt of radioactivity which is nothing other than a collection of captured particles oriented along the lines of force of the earth's magnetic field.*)

Occasionally, however, because of the action of the energy of the sun, this trap opens up with the following results: In the space above the polar regions the

activated electrons branch out toward the inferior regions of the atmosphere, provoking those spectacular luminescent phenomena which are the Aurora Borealis and Aurora Australis. In this way, thanks to the discovery of the "halo" of fast charged particles surrounding the earth, phenomena like the polar aurora and the magnetic storms—whose nature has for a long time been unknown—become comprehensible to us.

Question: Will the double belts of radiation which surround the earth be a serious danger to future astronauts?

Krasovskij: The discovery of the zone crossed by these fast, electrically charged particles is of extraordinary interest not only to geophysicists and astrophysicists, but also because it is across this corona of radiations that the manned space vehicles will have to pass. Therefore, it is indispensable to know what influence these radiations could have on living organisms.

Actually, fear has been expressed from many sources that the zones of maximum concentration of the particles represent a danger to the future explorers of space. (The American physicist, James A. Van Allen, affirmed recently that a human being could not survive if he became exposed for more than five hours without protective shielding from the flux of radiations existing at a height of 1600 kilometers.) In fact, the electrons which migrate in great numbers along these belts around the earth, hitting the walls of the space vehicles with great velocity, produce X-rays which are lethal to human beings when absorbed in abnormal doses (that is, too intensely or for extended periods of time).

The research performed during the flight of the Soviet cosmic rocket has, however, indicated that such danger is less than was at first thought. Nevertheless, it will be necessary to take certain defensive measures in order to protect the equipment of future space vehicles from X-rays. We have calculated that due to the energy of the particles present in these zones, metallic walls of relatively small thickness will be sufficient to effect the shielding against harmful radiation. (*The Americans, however, have foreseen instead another possibility, which is the passage of the space ships across the space above the poles, where the double belt of radioactivity is absent. Furthermore, James A. Van Allen has made known a fact of notable interest—that according to most recent data at around 10,000 meters in height, in the space which separates the two zones, the radioactivity descends to limits which can be tolerated. It seems therefore that a space observatory could orbit about the earth for a long time at that height without danger to its passengers. In view of this, the American project of manned satellites, being studied under the name of Mercury, assumes great significance.*)

Question: This is a subject of great interest, would you give us further clarification?

Vernov: It has been discovered, as we have said, that around the earth up to and beyond a distance of 50,000 kilometers, a great number of electrons are in motion. The equipment placed aboard the Soviet rocket has permitted one to determine that their energy is quite low —from 30,000 to 100,000 electron-volts. (*In fact, expressed as a unit of daily life, such as the kilowatt-hour or the calorie, the energy corresponding to one electron-volt or even to one million electron-volts is infinitesimal. But the number of particles is quite large and these values express a concentration of energy which is considerable.*) However, because the individual energy possessed by these electrons is relatively small, they can become absorbed without danger by small layers of matter. In this way, there is a possibility of defending oneself from the harmful action of X-rays.

But things will become much better once the astronauts have exceeded the first 50,000 miles of distance from the earth. In fact, as I mentioned in the beginning of the interview, in deep interplanetary space the intensity of cosmic radiations is quite small. During its travel toward the sun the equipment aboard the Soviet rocket registered only two particles per second per square centimeter. Therefore, we maintain that there are no particular regions in which to fear disease from radiation for men who will fly in the near future. (*In regard to the probing of the American Pioneer IV, which traveled 650,000 kilometers from the earth during the first 80 hours of its flight, with its transmitter functioning, it should be noted that the Lunik transmitter was also heard past 450,000 kilometers. An official communique was issued, based on data gathered by Pioneer IV, which stated that it was not certain whether belts of radiations existed in addition to those already noted.*)

Question: So under these aspects—will we actually have nothing to fear?

Ciudakov: This is not so simple. One must not forget, for example, that during the eleven-year solar cycle of perturbations, the eleventh year is noted for its colossal explosive processes. During this time the sun scales or flakes into space huge clouds of particles strongly activated and charged with electricity, these particles filling the solar system with deadly radiations. (*We are protected from these radiations by the earth's magnetic field, which in great measure captures and deviates the particles; and by the atmosphere which slows down the velocity—and hence the energy—of those particles which manage to penetrate the magnetic field.*)

The flight of the Soviet rocket occurred during a period of relative solar calm. Only under similar conditions will such a flight by future interplanetary passengers be possible. Actually, as it was in the remote beginnings of sea navigation, the astronauts will not be able to embark during solar storms. On the other hand, they will have to learn to predict ways of avoiding the mortal shipwrecks in the interplanetary ocean.

Question: What do you think, from a strictly scientific point of view, of the Argus project? That is, of the creation on the part of the United States of an artificial radioactive belt produced by the explosion of atomic bombs at great height.

Slovskij: On the Argus project, we had heard of the experiments several months before the American authorities announced them officially. We had gathered out information from several sources, among which was the normal organ of means of information—the press of the West. We knew, for example, that the experimental explosions of two atomic bombs, occurring at great altitude above Johnson Island in the Pacific, during the first days of August, 1958, had produced above the island of Samoa (3,500 kilometers away along the magnetic equator) a polar aurora.

It is very important, according to our way of thinking, that a phenomenon of this kind has occurred on this zone of the terrestrial globe where it is very rarely verified, and that the place of the explosion and the place of the artificial aurora were between two magnetic lines of force. That is, as if they had been connected together across the shortest possible route which could be used by charged particles to transfer themselves from one hemisphere to the other. The phenomenon of the artificial polar aurora observed above the isle of Samoa, and the data furnished by following experiments (accomplished by the three small atomic bombs which were exploded by the Americans in the region above the South Atlantic between the end of August and the first of September, 1958) indicate clearly that immediately after the nuclear explosions at great heights in the southern latitudes there were formed enormous quantities of electrons. Part of these massed themselves in the traps of the earth's magnetic poles up to a distance of approximately 10,000 kilometers, that is, in the middle of the first inferior field of the aurora of natural radiation which surrounds our planet. The calculations performed by us confirm that certain of these explosions have been really sufficient to form temporarily an inferior artificial field of fast particles charged with electricity.

Question: So it is possible to create an artificial radioactive belt by exploding nuclear charges above any region of the earth?

Krasovskij: No, there exist limitations. The regions where this can best be done are the equatorial and subequatorial regions. Those which are least applicable are those situated immediately above the poles and around them. In fact, the product of nuclear explosions effected in this region above the high terrestrial latitudes toward the extreme north or the extreme south could be of a completely different nature. The charged particles would not be trapped in the magnetic field of the earth but would be sucked into interplanetary space. This would be due to the fact that in the polar regions the lines of force produced by the earth's magnetic field lose themselves, so to speak, at a great distance from our planet. (*For this reason the space just above the poles does not contain the two belts of naural radiation which surround all the rest of the space nearest the earth. Therefore, as we have already mentioned, many American experts believe that the best way to travel on space voyages would actually be to pass above the arctic or antarctic regions.*)

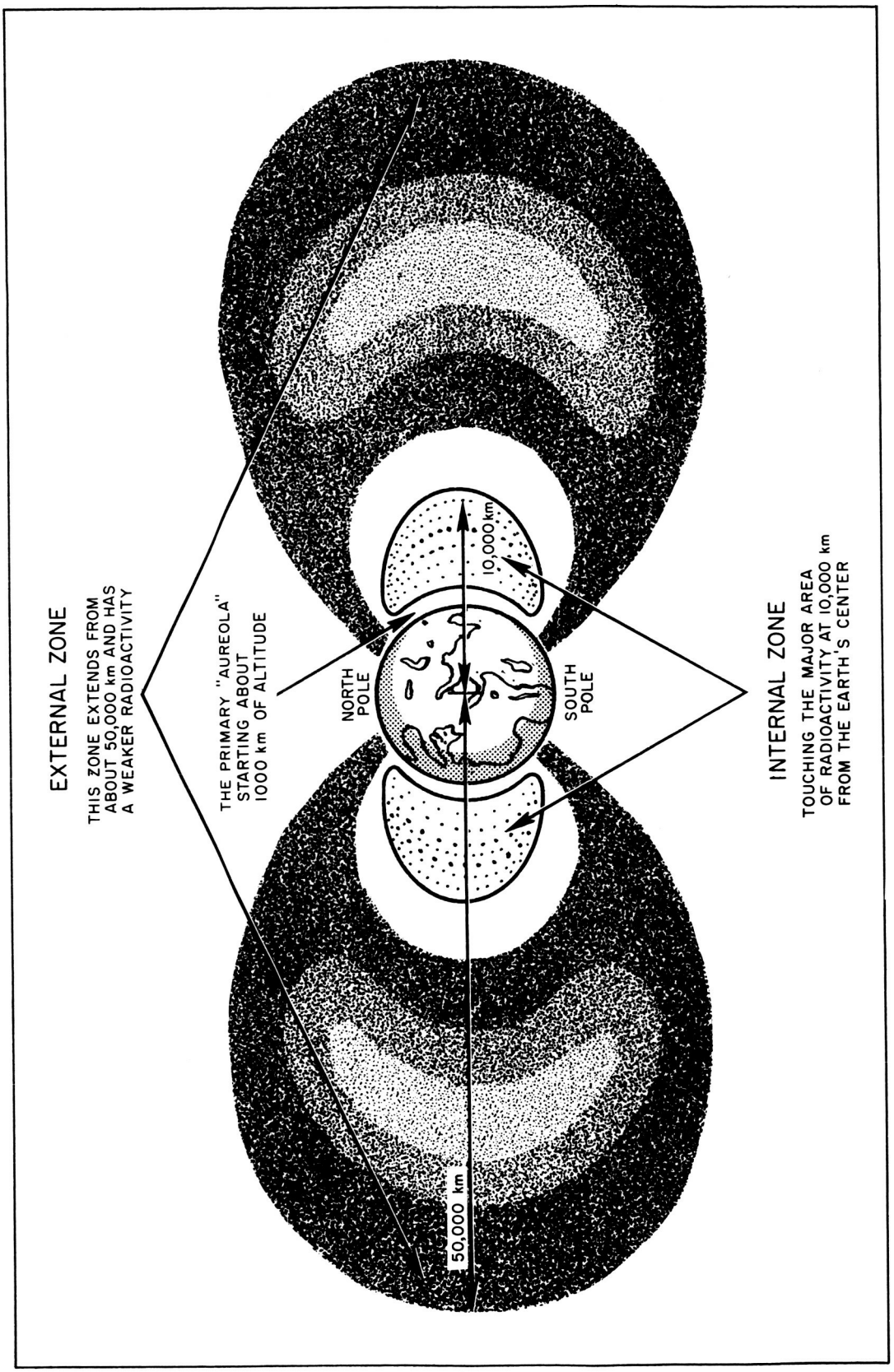
Question: Do you maintain that the artificial polar auroras, the belts of electrons produced by experimental nuclear explosions like that of Project Argus, will disturb the natural order of things and that they might be in some way dangerous?

Slovskij: Actually, it is too early to speak of the influence of the artificial radioactive aurora and the

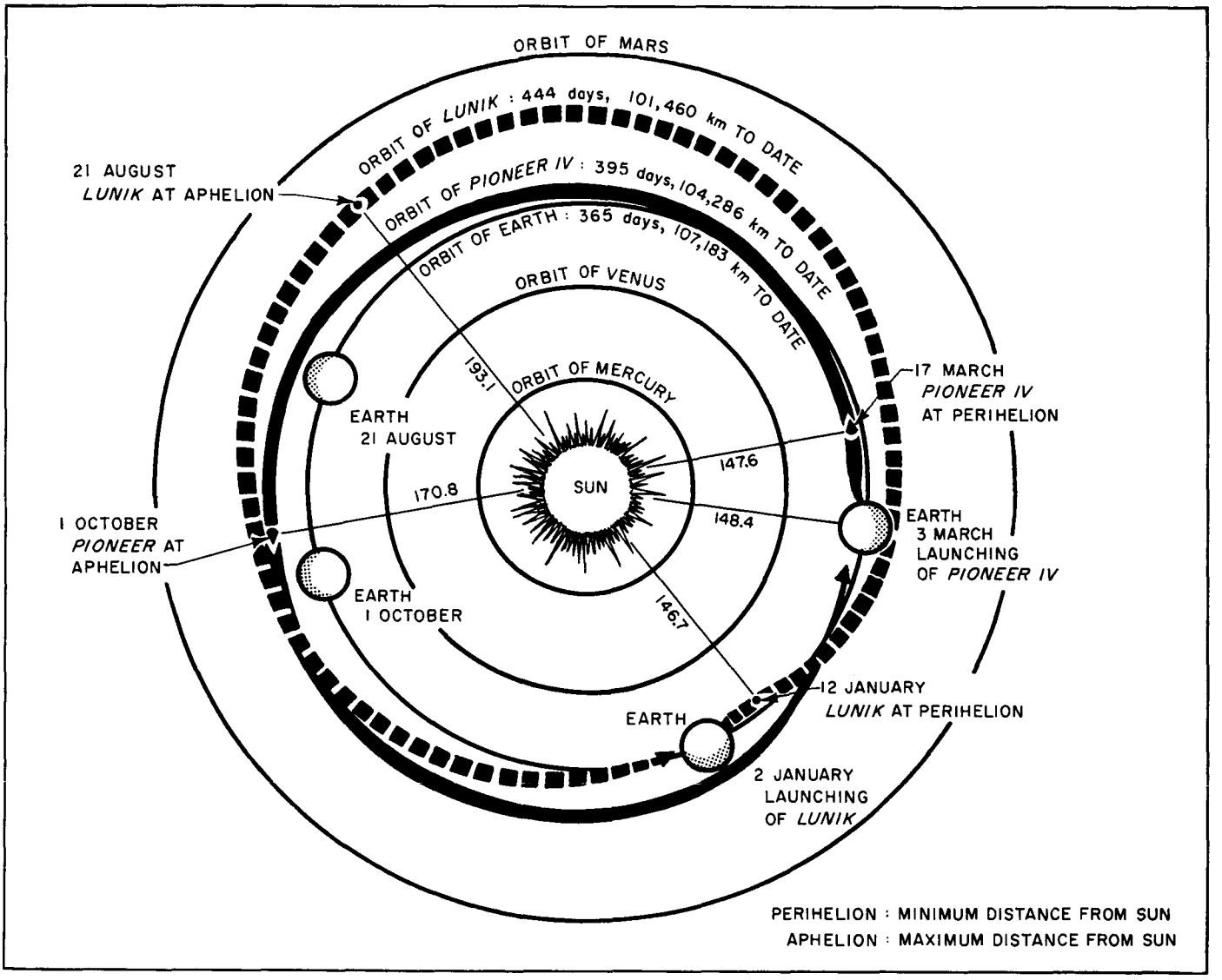
influence which it could have on the physical processes of the earth.

Question: Which researches do you plan for the future launchings?

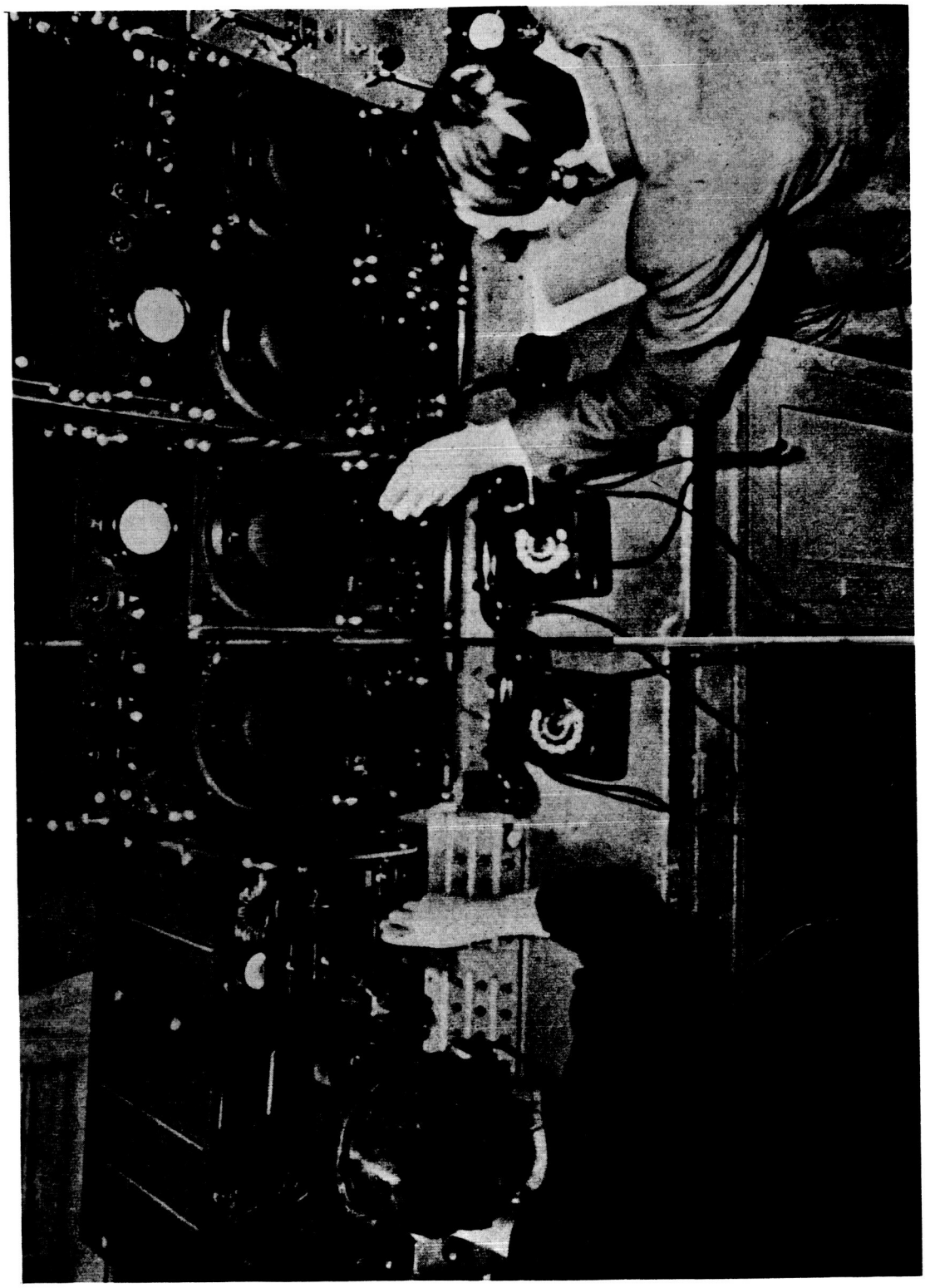
Ciudakov: That is a question which to answer would tie us down, and which would need a long and complex discussion. We can only answer briefly that the purpose of our further researches is to extend to the maximum our knowledge of the phenomena which occur in interplanetary space and in that part near the earth which changes under the action of the magnetic poles. Analogous, or similar auroras of particles exist, probably, around other celestial bodies which possess magnetic poles. Space rockets will give an answer also on this.



The double "aureola" of radiation which surrounds the earth is shown here according to the calculations of the Soviet scientists. It extends farther into space than the American data would indicate. The radioactive belt, which the Russian physicist Krasovskij proposes to call the corona of the earth, is analagous to the solar corona. It is formed primarily by electrons captured in the Earth's magnetic field and placed along its lines of force. The origin of these particles, some of which are probably protons, is not yet well defined. It is very probable that they are produced by cosmic rays or by solar activity. The magnetic field of the earth acts towards cosmic rays as a shield, fortunately capable of deviating these deadly radiations so that humans are protected from them.



This is a diagram of the solar system, most of which is self-explanatory. All distances are given in millions of kilometers. The two man-made planets—Lunik and Pioneer IV—are in good company in interplanetary space, as the diagram shows. Their respective orbits have been determined precisely by electronic computers, which used data from radio signals sent by the two small planets during the first phase of their travel. From these computations their route in space, their present positions, and future positions have been determined.



A historic picture showing technicians at the radio station of the Moscow Planetarium receiving signals from Lunik. The American minitrack system is used in the tracking network of the Soviet Union. The system is very well organized, and utilizes the close collaboration existing between radio amateurs and scientific institutions. This collaboration is not so widely used in the U.S.A. The technique of tracking is being improved constantly, although the Americans are much more advanced in equipment miniaturization. As has been noted, Lunik ceased transmitting after the first 450,000 kilometers of travel while the Pioneer IV continued to signal its presence in outer space up to 660,000 kilometers.

Two astronomers of the Crimea Observatory who participated in the visual observations and photography of the first phase of the launching of Lunik. As has been noted, the Soviet space probe was furnished with equipment which released a burst of sodium in the high regions of the atmosphere, producing a luminescent trail similar to the tail of a small comet. This was recorded by normal optical means and photographs by the observatories. This permitted the precise determination of the initial phase of the trajectory of Lunik.