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TO EDITORS:

The attached speech by Dr. Homer E. Newell, Deputy Director of the NASA's Office of Space Flight Programs, is for your background information and files. It was presented in Japan on May 24, 1960 at the International Symposium on Rockets and Astronautics, sponsored by the Japanese Rocket Society, Tokyo.

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THE U.S. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION'S SPACE RESEARCH PROGRAM*

News Release no. 60-202

NASA, Wash. D.C.

by

Homer E. Newell

May 1960

ABSTRACT

The United States National Aeronautics and Space Administration is developing a broad program of aeronautics and space research. Included in the program are the development of vehicles for space flight, the development of advanced technology, aeronautics research, applications of space research and technology results to practical problems, manned flight and human exploration of space, and scientific investigations of the earth's atmosphere and space. The space program will involve about 100 sounding rocket firings per year for the next few years, plus roughly 9 scientific satellites and near-earth probes per year, plus about 4 deep space probes per year. The development of an international cooperative program is being vigorously pursued, and on the operational side extensive cooperation is already under way in radio and optical tracking of satellites and probes, and in the preparation of the Mercury range. Specific cooperative programs in atmospheric and space science have already been developed, and many others are under discussion. It is the hope of NASA that a truly world-wide international program may be developed including cooperation between the United States and the USSR.

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*~~Prepared for presentation to~~ Presented at the International Symposium on Rocket and Astronautics, sponsored by the Japanese Rocket Society, Tokyo, Japan, May 1960.

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THE U. S. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION'S SPACE RESEARCH PROGRAM*

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INTRODUCTION

The United States National Aeronautics and Space Administration has now been in business for about a year and a half. Created under the Space Act of 1958, which became law on July 28, 1958, the NASA was given the job of continuing and extending the work of the older National Advisory Committee for Aeronautics, and of developing and carrying out a national space program. The Act declared "that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind". The Act further set forth eight objectives of aeronautical and space activities of the United States, including the expansion of human knowledge of atmospheric and space science, and the use of space knowledge and technology for practical applications.

There are many technical activities in NASA. The Administration took over the activities, facilities, and personnel of the 40-year old National Advisory Committee for Aeronautics. Thus, a large part of the NASA program is comprised of aeronautics and related research. This activity includes not just aeronautics in the classical sense, but also advanced research directed toward the space age. The X-15 aircraft is an example of the combination of rocketry and aeronautics. In the laboratory, research is devoted to improved materials and their use, advanced propulsion techniques, and advanced instrumentation.

NASA has a strong program of vehicle development and launching in support of its space activities. About a dozen different types

of sounding rockets are in use or under development. Typical of these are the rockets listed in Table 1.

The NASA vehicle program also includes 12 types of satellite and space probe vehicles. With the exception of the Redstone, these are shown in Figure 1. This relatively large number of launch vehicles resulted from the availability of ballistic missiles systems already developed for military missions. Seven of the vehicles are considered to be of an interim or relatively short term use and will be discontinued by about 1963. Four others, the Scout, Atlas-Agena-B, Atlas-Centaur, and Saturn, -- form the backbone of the long-range satellite and space probe programs. Nova is, at the present time, a vehicle concept included in the very long-range plans.

The vehicles included in the NASA program will provide a build up of payload and mission capabilities during the next ten years, illustrated in the drawing of Figure 2. This capability is expressed in terms of the payload weight that can be placed in a near-earth satellite orbit. Such capability can, however, also be expressed in terms of the capabilities for space probe missions, for example, to the moon or to the planets. As is seen from the figure, there will be a progressive rise from 1960 through 1962, then a substantial jump in payload capability with the coming of the Saturn vehicle. It is anticipated that there will be a continued rise in payload capability through 1969, accompanying the projected Saturn growth.

Table 1

U. S. SOUNDING ROCKETS

Vehicle	Cost (Thousands of dollars)	Capability Altitude (mi./km)	Capability Payload Weight (pounds)
Aerobee 100	20	60/95	100
(Aerobee Jr.)		80/130	40
Arcon	6	45/70	50
		75/120	16
Nike-Asp	9.5	80/130	200
		190/305	20
Aerobee 150, 150A	29	110/175	300
(Aerobee Hi)		180/290	120
Aerobee 300	36	220/355	130
(Spaerobee)		450/725	20
Argo D-4	50	690/1111	90
(Javelin)		1075/1730	10
Argo D-8*	130	1600/2575	100
		2600/4185	20

*Preliminary figures, based on feasibility and design studies.

The Scout is of especial interest in that it is intended to be a relatively inexpensive multi-purpose vehicle. As shown in Figure 3, the Scout is a four-stage solid propellant rocket. Because of its simplicity, the rocket can be launched from inexpensive launching facilities. It can be used to carry a large variety of scientific payloads, such as high altitude probes, re-entry models, and satellites. It will place a 200 pound payload in a 300 nautical mile (550 km) circular orbit, or will project a 50 pound vertical probe to 12,000 nautical miles (22,000 km). Thus, the Scout may be regarded as intermediate between the sounding rocket and the deep space probe, while at the same time being a useful satellite launching vehicle.

Using the vehicles described above the NASA is conducting a broad program of research on the earth's atmosphere and spatial environs. As rapidly as possible this research is being extended into the depths of space, to the moon, and the planets. It is planned to apply satellite techniques to the field of astronomy, so that observations of the stars and galaxies may be made free from the obscuring and distorting effects of the earth's atmosphere. The NASA space program also includes life sciences research, a particularly exciting aspect of which will be the search for extraterrestrial life.

The NASA program includes work on advanced technology. Examples are the development of advanced chemical-propulsion

systems, nuclear propulsion, electrial propulsion, nuclear and solar power supplies, and advanced guidance and control systems for space applications. There is also research on life support systems required for keeping man alive in space.

A very important facet of NASA's program is the application of space science and technology results to practical uses. At the present time, this includes research on the use of satellites for meteorological observations, for communications, and for geodetic measurements.

Finally, the NASA program includes manned exploration of space. In the course of time, it is expected that this program will include manned flight at the edge of the earth's atmosphere, manned orbital flight in the vicinity of the earth, and eventually flight to the moon and planets. At present, the initial steps toward such space exploration are being taken in Project Mercury. This project is directed toward the early achievement of orbital flight using techniques, equipment, and vehicles that are either already available, or available with a minimum of development. As must be the case in all manned flight projects, the engineering program for Project Mercury is directed toward the achievement of the utmost reliability before a man is to be committed to actual flight. Project Mercury by no means involves the ultimate in manned space flight; rather it is to be regarded as a first step toward later space explorations.

THE SPACE SCIENCE PROGRAM

The NASA program in space science has grown out of activities of the past 13 or 14 years, including the International Geophysical Year. It involves the use of sounding rockets, earth satellites, and space probes to investigate the earth, its atmosphere, its environment, and the objects and phenomena of outer space. The sounding rocket program continues at a pace comparable to that of the International Geophysical Year, and covers the broad area covered during the past dozen years in various programs of the Department of Defense. No attempt will be made here to review past firings in detail.

Satellites and space probes launched by the United States for space science investigations are listed in Table 2. Those launched after the first of October 1958, were under the auspices of the National Aeronautics and Space Administration. In them, the NASA has continued the work begun in the early Explorers and Vanguards. Extensive results from the early satellites and space probes have already been reported in the literature, and I am sure that these are well known to this audience. Exciting results continue to appear, particularly from the latest satellites and space probes. I shall attempt here to summarize, without detail, some of the latest results that have been reported.

Table 2

U.S. SATELLITES AND SPACE PROBES
FOR SPACE SCIENCE INVESTIGATIONS

October 1958 to April 1960

VEHICLE	LAUNCH DATE	EXPERIMENT
Earth Satellites:		
Explorer I	31 Jan 58	Cosmic Rays; Micrometeors.
Vanguard I	17 Mar 58	Test.
Explorer III	26 Mar 58	Cosmic Rays; Micrometeors.
Explorer IV	26 Jul 58	Radiation Belt.
Vanguard II	17 Feb 59	Cloud Cover.
Explorer VI	7 Aug 59	Radiation Belt and Cosmic Rays; Magnetic Field; Micrometeors; Very Low Frequency Radiowave Propagation; Single Line Television Scanner.
Vanguard III	18 Sep 59	Magnetic Field; Solar X-rays; Micrometeors.
Explorer VII	13 Oct 59	Solar Ultraviolet and X-ray Radiations; Cosmic Rays; Earth Radiation; Micrometeors.
Space Probes:		
Pioneer I	11 Oct 58	Radiation Belt; Magnetic Field; Micrometeors; Television Scanner.
Pioneer III	6 Dec 58	Radiation Belt.
Pioneer IV	3 Mar 59	Radiation Belt.
Pioneer V	11 Mar 60	Radiation Belt; Particles and Cosmic Rays in Space; Magnetic Fields; Micrometeors.

Vanguard III (1959 Eta)

The satellite Vanguard III was the last of the Vanguard International Geophysical Year satellites to be launched. Descriptive information about Vanguard III is contained in Table 3. The satellite itself is shown in Figure 4.

Although the lifetime in orbit of Vanguard III is estimated to lie between 30 and 40 years, the equipment was powered for only about 3 months of operation. After 86 days the satellite became silent. During the interval of operation, the proton precessional magnetometer provided a comprehensive survey of the earth's magnetic field throughout the range of altitudes and latitudes covered by the Vanguard orbit; namely, within the belt from 33.4° N latitude to 34.4° S latitude geographic, and from 510 to 3750 km. Dr. Heppner has provided the following summary of the magnetic field results to date from the Vanguard III data:

> "Although reduction of Vanguard III magnetic field data is only 50 percent complete, preliminary analyses have provided considerable information concerning the earth's main field. Over large regions of the Western Hemisphere, Australia, and South Africa it is now possible to state the absolute value of the total magnetic field intensity to a high accuracy. This information has been especially valuable in illustrating both the strong and weak points in existing descriptions of the magnetic field by spherical harmonic analyses.

Table 3

Vanguard III Earth Satellite

(1959 Eta)

Launch Date (Lifetime)	Dimensions	General Shape	Weight (pounds)	Initial Perigee (miles)	Initial Apogee (miles)	Initial Period (minutes)	Inclination (degrees)
18 Sep 59 (30 to 40 years)	20 inches diameter (51 cm)	Sphere with 26 inch tapered tube extension; plus empty third stage.	100 (45 kg)	319 (513km)	2329 (3748 km)	130	33.4

Experiments	Experimenters
Proton precessional magnetometer.	Goddard Space Flight Center (Heppner).
Solar X-rays.	Naval Research Laboratory (Friedman).
Micrometeor detectors.	Goddard Space Flight Center (LaGow).
Thermistors.	Goddard Space Flight Center (LaGow).

"In the most recent analysis, evidence was found that a magnetic field discontinuity exists at the lower edge of the inner radiation belt at magnetic latitudes greater than 25 degrees. Work is under way to make sure that this discontinuity is real and not the result of an unknown peculiarity in orbit computation. There is additional evidence for one or more discontinuities in lower latitude regions but it is felt that more data will have to be processed for confirmation.

"The study of measurements taken during magnetic storms shows that the field disturbance observed by the satellite is strongly dependent on the location of the satellite. At magnetic latitudes greater than 25 degrees the satellite disturbance is often considerably larger than that observed on the ground when the satellite is located near the lower edge of the inner radiation belt or in the 'radiation slot' that bounds the inner belt at its northern and southern limits. On the other hand, measurements taken within the inner belt at these latitudes appear to be relatively undisturbed during storms. This is illustrated in Figure 4.1. The numbers indicate the time sequence of the measurements during the storm. Measurements 7, 8, 9, and 12, which were not disturbed, were taken during the maximum of the main phase of this magnetic storm. Measurements 6, 10, and 11, also during the main phase maximum were disturbed with the same sign as the ground disturbance. Measurements 14, and 16 which occurred later in the storm were

strongly disturbed but with a sign opposite to that of the ground disturbance. (The two undisturbed points at low altitude over Woomera, Australia can be ignored here as they coincide with short periods when the ground disturbance was very small). In equatorial regions, where it is first essential that one remove electrojet influences, a clear picture of storm effects has not as yet been obtained. When this is accomplished a better understanding of the unexpected results at higher latitudes is expected."

Because the Vanguard III satellite spent so much of its time in the Van Allen Radiation Belt, the Naval Research Laboratory ionization chambers for observation of solar X-rays were saturated much of the time. Although this prevented investigation of the solar X-rays, nevertheless the chambers did provide a considerable amount of detail on the location of the lower edge of the Radiation Belt, which could be determined from the locations at which the counters either went from nonsaturated to saturated condition or vice versa.¶ The micrometeorite data was collected over a period of 78 days by counting the impact vibrations. About 3700 impacts were counted over this period, with the largest influx level occuring during the month of November. The estimated mass of the impacting particles was greater than 3.3×10^{-9}g. The density of this component of dust is computed to be 7×10^{-22}g. cm^{-3}, approximately the same as measured from Explorer I. The two pressure zones were not punctured, and no measurable amount of erosion was detected on the photodetector and the chromium strip experiments.

Explorer VII (1959 Iota I)

Explorer VII was launched by a Juno II rocket on October 13, 1959. This satellite was the last of the satellites planned as part of the International Geophysical Year program. It was the most complex and diversely instrumented of the satellites planned for IGY, and had come to be known colloquially as "the Heavy IGY" or "composite radiation" satellite. Descriptive information on Explorer VII is given in Table 4. A photograph of the Explorer VII satellite appears in Figure 5.

The following material from the experimenters on Explorer VII has been provided by the satellite project manager, H. LaGow:

"Telemetering signals have already been recorded for more than seven months from 1959 Iota. Many of the records have not yet been collected, processed, distributed and analyzed but many significant geophysical results have already been reported by the experimenters. The principal results reported to date, include:

(1) The State University of Iowa measurements of time and spatial variations in the outer radiation zone show interesting correlations with other geophysical observations. Figure 5.1 shows (a) a stable outer radiation zone on 27 November; (b) a very disturbed outer zone on 28 November during a severe magnetic storm; and (c) a narrow 3-second wide peak at 0336.30Z on 28 November over an observed auroral arc.

Table 4

Explorer VII Earth Satellite (1959 Iota I)

Launch Date (Lifetime)	Dimensions	General Shape	Weight (pounds)	Initial Perigee (miles)	Initial Apogee (miles)	Initial Period (minutes)	Inclination (degrees)
13 Oct 59 (20 to 30 years)	30 inches high (76 cm) 30 inches diameter (76 cm)	Toroid	91.5 (41.5kg)	345 (555 km)	678 (1091 km)	101.3	50.3

Experiments	Experimenters
Lyman-alpha and X-ray solar radiation detectors.	Naval Research Laboratory (Friedman).
Ionization chamber for heavy cosmic rays.	Martin Co. RIAS* (Groetziner and Schwed), Bartol Research Foundation (Pomerantz).
3 Micrometeor detectors.	Goddard Space Flight Center (LaGow).
2 Geiger-Mueller tubes.	State University of Iowa (Van Allen).
Earth radiation balance measurements.	University of Wisconsin (Suomi).

*Research Institute for Advanced Studies

(2) A drastic modification of the outer zone on 31 March to 10 April 1960, commencing with the great magnetic storm on 31 March. Intensity levels went from a nominal 200 counts/second down to less than 10 and up to over 10,000 counts/second on the State University of Iowa experiment. Pioneer V also detected an increased counting rate of soft radiation on 31 March at some 5×10^6 km from the earth.

(3) The Bartol-RIAS heavy primary cosmic ray experiment reveals that the integral flux varies approximately as the inverse first power of the magnetic rigidity and that during the 11 days immediately following launch, the flux of heavy primary cosmic rays remained constant within the statistical uncertainties of measurements over the entire range of rigidities covered.

(4) The Army Ballistic Missile Agency temperature measurements which show that temperatures have stayed within the design limits of 0-60°C during the first 185 days after launch. During this period the satellite has gone through two periods when the satellite was in sunlight 100 percent of its orbital period.

(5) The first micrometeorite penetration of a sensor in flight. A Goddard Space Flight Center cadmium sulphide detector was exposed to sunlight after the penetration of

its evaporated aluminum coating on a 1/4 mil thick Mylar film only 5 mm in diameter.

(6) The detection of large scale weather patterns by the University of Wisconsin radiation balance experiment. Figure 5.2 shows isolines of rate of heat loss from top of atmosphere as measured by 1959 Iota. The area shown is between Hawaii and the mainland of the United States at 10° N latitude. It is covered with cold air or high clouds."

Pioneer V (1960 Alpha)

The deep space probe Pioneer V was launched on 11 March 1960 at 8:00 a.m. EST. Descriptive information on Pioneer V is contained in Table 5. At first perihelion passage it is estimated that Pioneer V will be 46 million miles from the earth.

The Pioneer V space probe is equipped with a solar-cell nickel-cadmium battery power supply and a digitized telemetry system capable of indefinite operation. A 5-watt transmitter is carried in the payload for relaying the data and information from the satellite during the initial portion of the trajectory. With the 250 foot dish at Manchester, it is estimated that contact with the payload could be maintained until about 20 million miles (32 million km) from the earth; however it was planned to switch the transmission from 5-watts to 150-watts at an earlier time, and this has been done. With the 150 watt transmitter operating, it is estimated that the Manchester dish can maintain contact with the payload

Table 5

Pioneer V Deep Space Probe (1960 Alpha)

Launch Date (Lifetime)	Dimensions	General Shape	Weight (pounds)	Perihelion (million miles)	Aphelion (million miles)	Period (days)	Inclination To Ecliptic (degrees)
11 Mar 60 (in orbit about sun)	26 inch (66 cm) diameter	Spherical with extended solar cell paddles.	94.8 (43 kg)	74.9 (121 M. km)	92.3 (149 M. km)	312	3.35

Experiments	Experimenters
High energy radiation proportional counter.	University of Chicago (Simpson).
Ionization chamber, Geiger-Mueller tube.	University of Minnesota (Winckler).
Search coil magnetometer.	Space Technology Laboratories (Sonett and co-workers).
Micrometeor counter.	Air Force Cambridge Research Center (Cohen) and NASA (Dubin).

to distances in excess of 50 million miles (80 million km), perhaps to as much as 90 million miles (145 million km) from the earth. The operation of the Pioneer V payload is commanded on and off by signals from ground stations in Hawaii and in Manchester, England. For the 5-watt transmitter, the duty cycle of the operation is somewhere between 8 and 9 percent of the total time. As of the end of April 1960, more than a hundred hours of telemetering operation had been recorded. By that date, the probe was approaching the 7 million mile (11 million km) mark from the earth.

Many exciting results have been obtained by Pioneer V. They extend observations made from earth satellites in previous Pioneers. Many of the observations correlate with observations made at the earth's surface; some of the results from Pioneer V are related to results obtained in Explorer VII which is still functioning. The following information on Pioneer V results has been provided by the experimenters and the NASA project manager, John Lindsay.

The first two weeks following the launching of Pioneer V were relatively free of solar activity. At the end of March, however, from March 27 to April 6, 1960 there was a period of high solar activity. During this time, the space probe was in the vicinity of 5 million kilometers from the earth and approximately in the plane of the ecliptic. On March 31, at 0800 universal time, there began a severe magnetic storm on

the earth, which was accompanied by major earth current disturbances, a complete blackout of the North Atlantic communications channel, and auroral displays. Simultaneously a large Forbush decrease occurred in the galactic cosmic radiation. From measurements made in Pioneer V, J. A. Simpson and his co-workers report the following results:

(1) At the time of the March 31, 1960 Forbush decrease in the vicinity of the earth, a similar decrease occurred at Pioneer V. The decrease at 5 million kilometers from the earth was at least as great as that at the earth. Hence, existing theories for this phenomenon requiring the presence of the earth and its magnetic field are proved to be invalid.

(2) On April 1, 1960, not only protons but electrons and/or gamma rays from the sun were observed. At the same time, Leinbach reported polar cap absorption of radio noise. The time relations between these two observations were such as to indicate that the solar flare particles producing the ionization in the polar atmosphere over a period of many hours were not stored in the geomagnetic field nor at the sun.

(3) Simpson and co-workers also report evidence for the solar production of energetic electrons by processes other than solar flares. Bremstrahlung was measured in Pioneer V for many days of the period over which data are presently available.

Winckler and co-workers report the following results from the integrating ionization chamber and geiger counter in the space probe. During the interval of high solar activity, in at least five cases flares produced a response of the Pioneer instruments within a few hours. These responses can be identified as low energy solar cosmic rays of the type observed previously on many occasions and reported in the literature. The largest cosmic ray bursts occurred on April 1 accompanying a class 3^* flare beginning at 0830 universal time, and on April 5 associated with a major radio disturbance. The cosmic ray bursts have the following properties:

(1) The sizes range from just detectable above galactic cosmic ray background to particle fluxes ten times galactic background.

(2) The observed ion/count ratio is consistent with a differential energy spectrum of the form $E = CE^{-4}$, with a lower spectrum limit of about 40 mev.

(3) The decrease of the particles in space seems definitely more rapid than that associated with simple diffusion.

(4) Balloon observations at Minneapolis on April 1, 1960, during the large flare, showed the presence of solar protons of energy up to 400 mev. The flux and spectrum were consistent with the Pioneer V results.

(5) Three of the cosmic ray events observed at Pioneer V produced polar blackouts as reported by Leinbach at College, Alaska.

(6) Two of the cosmic ray events were also detected by counters on Explorer VII, and the particle fluxes are in good agreement with those obtained from Pioneer V.

Comparing Pioneer V observations with results from Explorer VII, and also from Explorer VI, Winckler reports that the electron flux observed in Pioneer V at great distance from the earth is only 10^{-4} that observed in the outer radiation belt at its maximum build-up following the initial depletion occurring at the time of the magnetic storm. The conclusion is that the great increase in the 50 kev electrons observed by Van Allen and co-workers in the outer zone on April 2 to 7 was not due to direct solar injection. Hence, there must be some local acceleration of a portion of a solar plasma cloud spectrum associated with the observed magnetic storm and Forbush event. It is this local acceleration of a portion of the plasma in the magnetic field of the earth that builds up the outer radiation zone.

A search coil magnetometer was carried aboard Pioneer V. C. P. Sonett and co-workers of the Space Technology Laboratories report the following results. The sensitivity of the search soil appears to be a few tenths of a gamma. The undisturbed magnetic field in space is about 2.5 gamma, but at the onset

of solar activity values as high as 40 gamma have been measured. From about 10 to 15 earth's radii, there exists an intense zone of magnetic field disturbance, appearing as waves in highly ionized distant regions from the earth. These observations confirm similar results obtained in Pioneer I. They indicate a collapse of the geomagnetic field at distances greater than 13 earth radii from the earth. The shapes and magnitudes of magnetic field fluctuations in space at a great distance from the earth are quite similar to the magnetic field variations observed at the surface of the earth during magnetic storms. The data from Explorer VI and Pioneer V indicate the existence of a ring current about the earth whose cross section is centered at an altitude of 10 earth's radii from the earth, and covers a region in space extending from approximately 7 to 13 earth's radii. Sonett and co-workers estimate the total current flowing inside this region of space to be about 5 million amperes. It is surmised that the ring current most probably consists of low energy particles, and for this reason has gone unobserved in the high energy detectors customarily used to investigate radiation belt particles.

Dubin reports that count data are being obtained from the micrometeor counter. Peculiarities of these data, however, indicate that the equipment may be malfunctioning. It is, therefore, not clear at the present time whether useful data will be obtained from this experiment.

Future Plans

NASA plans for continuation of the space science program, as recently presented to Congress, are reflected in Table 6. These plans reflect the present intentions of NASA. They are, of course, subject to change and modification as the program unfolds. It is intended at the appropriate time to announce the frequencies which will be radiated from the satellites, so that experimenters around the world may prepare observing equipment for using these frequencies for the study of the ionosphere and earth's upper atmosphere. It is also intended, where it can usefully be done, to make available to observers around the world the telemetering codes for various satellites, so that the scientists who wish to do so may participate in the collection of telemetered data and in the analysis thereof. It is clearly not possible or useful to do this for all satellites and space probes, but in those cases in which other observers around the world can usefully participate, every effort will be made to make the codes available. This will be done through the U.S. National Academy of Sciences, who will in turn make them available to the Committee on Space Research of the International Council of Scientific Unions.

Table 6

NASA SPACE SCIENCE EXPERIMENTS
PLANNED AS OF 1 APRIL 1960

Mission	Number	Experiments
Sounding Rockets	100/yr	Atmosphere; Ionosphere; Energetic Particles; Magnetic Field; Astronomy; Special.
Earth Satellites	4 or 5/yr	Ionospheric Properties; Gamma and Cosmic Rays; Ionospheric Beacon; Solar Spectroscopy; Atmospheric Structure; Geodesy; Ionospheric Topside Sounder; Radiation Belt; International; Polar Radiation; Polar Atmospheric Structure; Polar Ionospheric; Polar Geophysics; Sun-Earth Relations; Geophysics; Astronomical Observatory.
Space Probes	Sev/yr	Two Ionospheric Structure; Nuclear Emulsions; Outer Atmosphere Winds; Interplanetary Plasma; Magnetic Field; Energetic Particles; Magnetic Fields in Space; Interplanetary Environment; Technological Development; Lunar Surface Properties.

SATELLITE APPLICATIONS

As stated earlier, the NASA is actively exploring the possible applications of space research results and space technology to practical uses. Foreseeable applications of space techniques are to be found in the use of satellites for weather observation, for radio communication, for geodesy, and for navigation. TIROS I, launched this spring, was part of the meteorological program.

Before proceeding to describe the TIROS satellite, it should be emphasized that this is in no way to be regarded as an operational system. At this stage, the TIROS satellite is part of a research program, designed to explore what sort of data can be acquired by means of satellite techniques, and what use can be made of those data. An extremely important part of this research effort is to determine what can be learned from the cloud cover pictures obtained from TIROS, and where possible to relate photographic observations to measurements of the heat balance obtained by the Explorer VII scientific satellite, and other observations made with sounding rockets and balloons. Only after the proper groundwork has been laid by such research activities, can one proceed to the designing and development of a truly operational meteorological satellite system.

TIROS I (1960 Beta)

The TIROS I weather satellite was launched into orbit on April 1, 1960. Descriptive information concerning TIROS is contained in Table 7. A photograph of TIROS I is shown in Figure 7.

Table 7

TIROS I Earth Satellite (1960 Beta)

Launch Date (Lifetime)	Dimensions	General Shape	Weight (pounds)	Initial Perigee (miles)	Initial Apogee (miles)	Initial Period (minutes)	Inclination (degrees)
1 Apr 60 (20 to 30 years)	42 inches (107 cm) diameter 19 inches (48 cm) high	Cylinder	270 (122.5 kg)	429 (690 km)	466 (750 km)	99	48.3

Experiment	Experimenter
Cloud Cover Television.	Radio Corporation of America

The full significance to weather research, and ultimately to the development of practical weather observing systems, must await the study and analysis of the pictures obtained by the satellite borne television cameras. In the meantime, the pictures obtained speak graphically for themselves. Several such pictures are shown in Figures 8 thru 10.

INTERNATIONAL COOPERATION

By its very nature, science is universal, international. The history of science is a continuing record of international cooperation on a voluntary basis. The ideas and insights that have advanced science to its present day status have not been, nor are they now, the prerogative of any single country. Advancing ideas have come from every quarter of the globe.

Recognizing the great importance of widespread cooperation in the conduct of space science, the National Aeronautics and Space Administration intends to participate extensively in international programs of space research. In fact the National Space Act calls for "cooperation by the United States with other nations and groups of nations in work done pursuant to this Act, and in the peaceful application of the results thereof . . .". During the first year and a half of its existence NASA has taken many steps in the development of an international cooperation in space activities.

In order to provide for aggressive support of international objectives within NASA in response to the Congressional mandate, the Administrator established the Office of International Programs. It is the function of this office to generate, to encourage, to coordinate, and to provide necessary supporting services for NASA's cooperative activity. The following statement, made recently by the Director of the Office of International Programs will highlight the principles that NASA is following in this area:

> "We feel that programs of international cooperation should be substantive in character, contributing toward the technical and scientific objectives of space research. This suggests that the programs themselves should grow out of, or be capable of integration with, NASA's own operating and research programs. But we do not wish to suggest to other nations' scientists what projects or programs they should adopt, or indeed, that they should enter into space research at all. If cooperation is desired, however, we are eager to discuss the possibilities. In such cases, we believe that consideration should be given to specific, limited projects, for it is too early in this new science to chart broad general programs. The essential criterion should be that the projects have scientific or technical validity. We would hope that proposals would represent experiments or other projects which we ourselves would wish to carry out if they were not to be done jointly.

"Generally speaking we cannot at this time consider programs which would involve an exchange of funds. Rather, each nation should be able to support its own contribution. However, it is not necessary that contributions be of equal scope and magnitude. Beyond these particular points, it goes without saying that the free exchange of information, and especially the results of our experiments should be made available to the scientists of all nations. To this end we support the activity in the United Nations regarding the peaceful uses of outer space. Similarly we are, through our National Academy of Sciences, giving full support to the International Committee on Space Research (COSPAR), one of the permanent offshoots of the International Committee for IGY (CSAGI)."

At the present time, NASA's international cooperative program involves many different types of activities. These include cooperation in the tracking and telemetry of satellites and space probes, including Project Mercury, and cooperation in planning for, preparing for, and carrying out scientific experiments in the atmosphere and outer space. The pattern of these various cooperations varies from country to country. NASA has been holding discussions with representatives of many countries, exploring the best way to develop a cooperative program in each individual case. In the case of space research, only a few programs have become active as of

the present time. On the other hand, out of the considerable amount of discussion that is underway, it is hoped active co-operative programs will arise.

Within a very few months of its establishment, NASA was engaged in preliminary technical discussions with representatives of the Canadian Defense Research Board on a proposed joint project to sound the ionosphere from above. The Canadians will also provide the antenna and satellite shell required. Meanwhile, NASA will develop a fixed frequency sounder. Both are scheduled for launching attempts by the United States. Tracking installations will be modified to acquire data from both, and a coordinated ground-based net will simultaneously probe the ionosphere from below. The British have expressed interest in this phase of the project; thus, a multilateral experiment is already in preparation and will be conducted sometime in 1961.

In March 1959, NASA authorized the National Academy of Sciences' delegate to COSPAR to offer, on behalf of the United States, to launch individual experiments or complete satellite payloads prepared by scientists of other nations. Because the closest possible collaboration is desirable in such efforts, it was stated that the experimenters were welcome to work together with American teams in the development of their projects.

In July, the United Kingdom sent a team to the U.S. under Prof. H.W.S. Massey to discuss a United Kingdom proposal within the framework of NASA's offer to COSPAR. It was tentatively agreed

that British scientists, over a two to four year period, would instrument perhaps three satellites for launching, probably by means of NASA's Scout vehicle. Each nation assumes responsibility for its own contribution. Specific proposals for four experiments to be flown in the first joint satellite were agreed upon in January of 1960. They will involve studies of solar radiation, electron density and temperature, and cosmic radiation. These will permit unique correlations of the on-board experiments themselves as well as between these and ground-based or air-space experiments. An exchange of notes at the government level will formalize this arrangement. The proposed experiments were communicated to COSPAR in January and have been endorsed by that Committee.

The two cooperative programs described serve to illustrate what can develop in this important and exciting area. The final arrangements may or may not be consummated by formal governmental agreements. Certainly if the expenses involved are considerable, as they may well be in the space research business, then governmental agreements are required. On the other hand, if the cooperative effort under discussion is of a limited nature, it may well be appropriate to make arrangements and carry out the program jointly between NASA and an appropriate agency within the cooperating country. In either case, NASA feels that the actual cooperative agreement should be preceded by informal technical discussions between the working levels in the countries involved, in order that specific cooperative projects may be clearly defined. It is

NASA's hope that cooperation in space research may indeed be truly worldwide.

The possibilities of cooperation with the USSR have been explored as opportunity presented. Discussion of preliminary nature was conducted in mid-November with the Chairman of the Soviet Commission for Interplanetary Travel, Professor Sedov, and another member of the Commission, Academician Blagonravov. This discussion took place during a visit of a USSR delegation to the American Rocket Society meeting in Washington. Soviet scientists expressed willingness to consider some form of cooperation in space activity, but stated their belief that such cooperation would have to proceed "step by step". The only step which they were at that time willing to discuss was the space conference under United Nations' auspices, which had been proposed by their representative in the United Nations. More recently, the NASA Administrator, Dr. T. Keith Glennan, in an address before the Institute of World Affairs in Pasadena, California, on December 7, 1959, offered the services of tracking stations to the Soviet Union, when, and if, it should conduct a man in space program.

Acknowledgements

I am grateful to the experimenters on Vanguard III and Explorer VII satellites, and the Pioneer V probe for providing information on their results; also to a number of my colleagues at NASA for helpful discussions and assistance, particularly John Lindsay, Herman LaGow, James Heppner, Maurice Dubin, Maurice Tepper, and Leonard Jaffe.

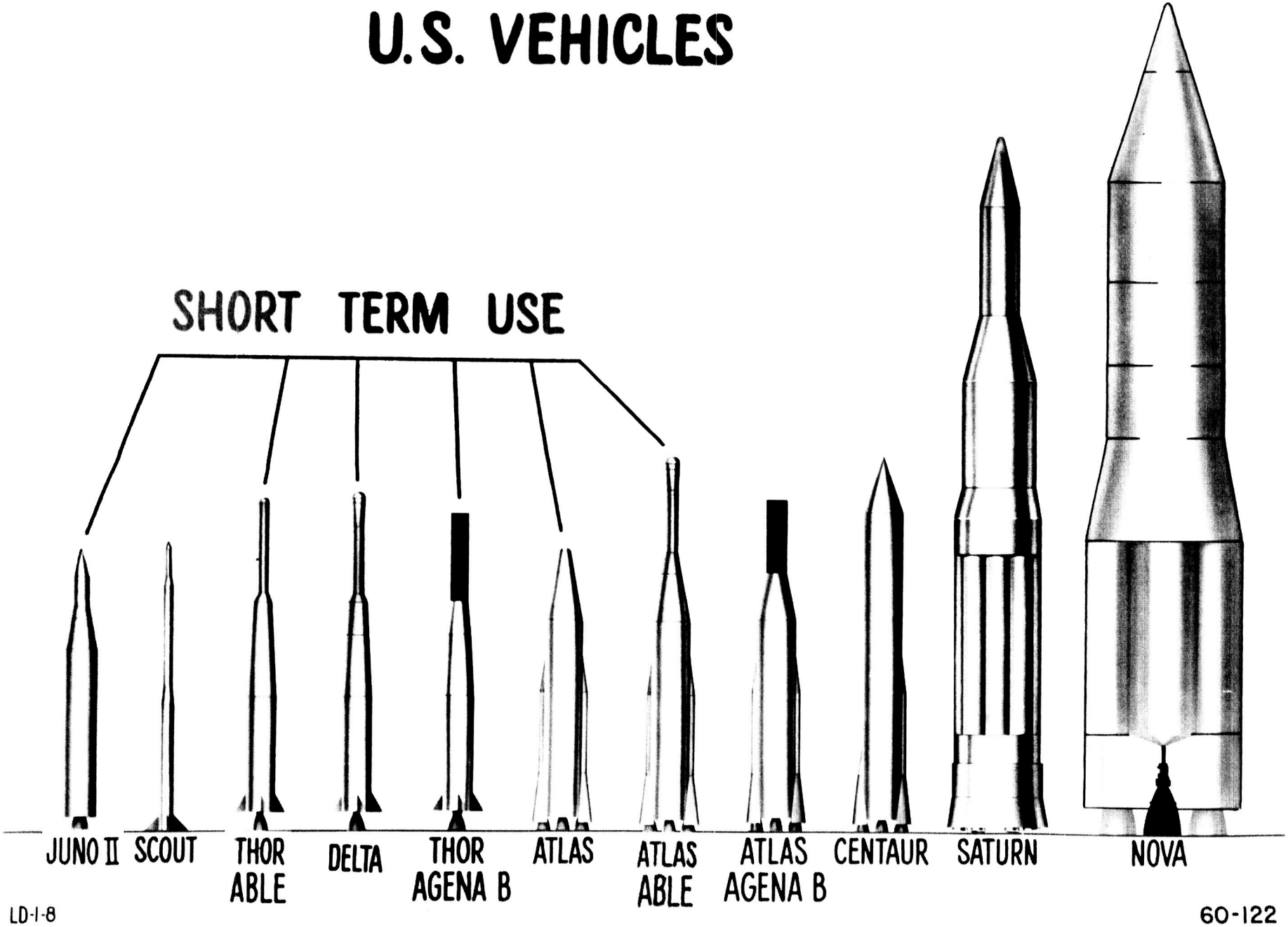

Fig. 1 U.S. Satellite and Space Probe Vehicles. These vehicles form the basis for the planned NASA space program.

ANTICIPATED GROWTH OF NASA SPACECRAFT SIZE

(IN TERMS OF THE WEIGHT OF A NEAR EARTH SATELLITE)

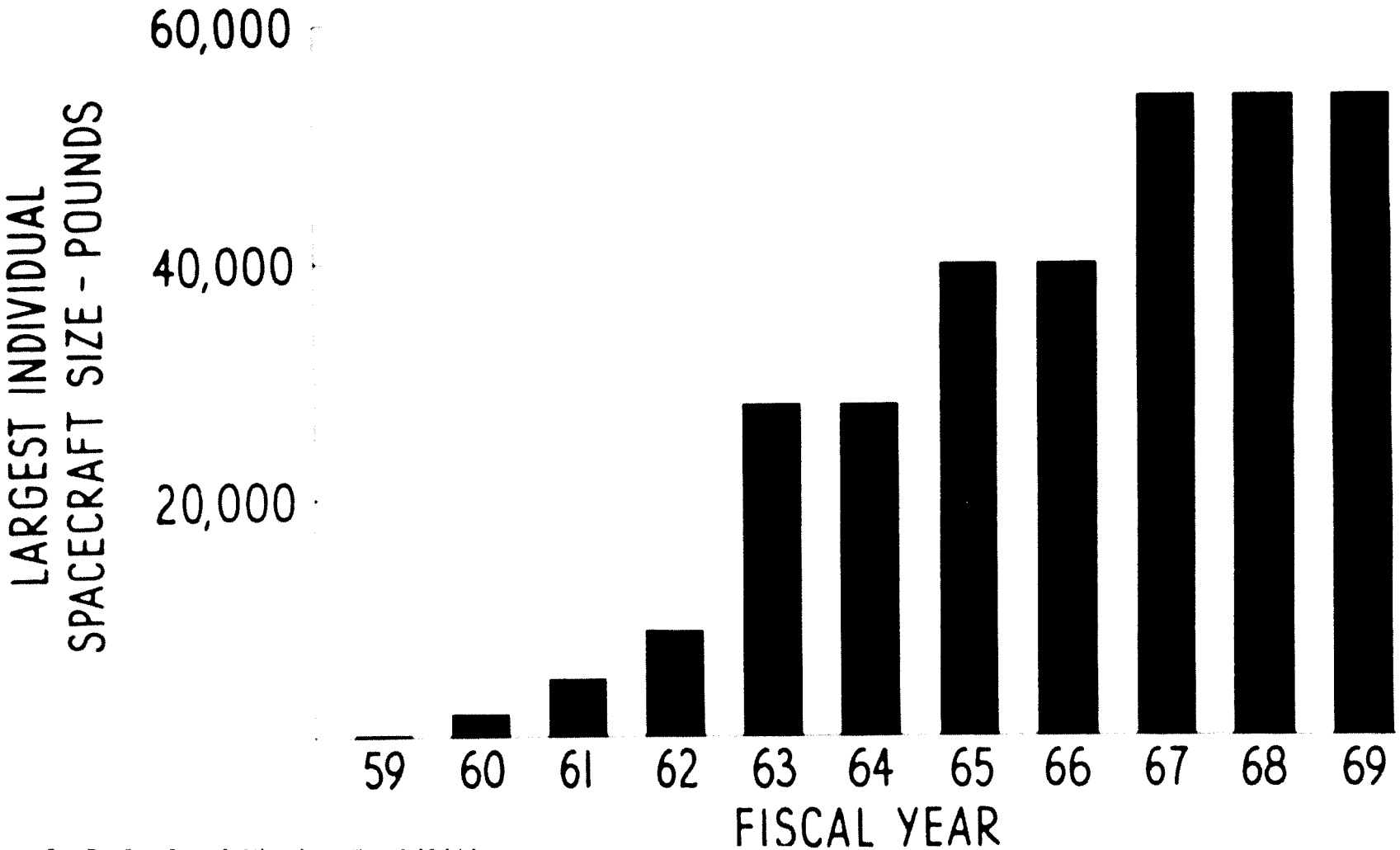

Fig. 2 Payload and Mission Capabilities.
As a result of the launching vehicle development work, the payload and mission capabilities of the National Aeronautics and Space Administration is expected to increase during the next decade as shown.

SCOUT

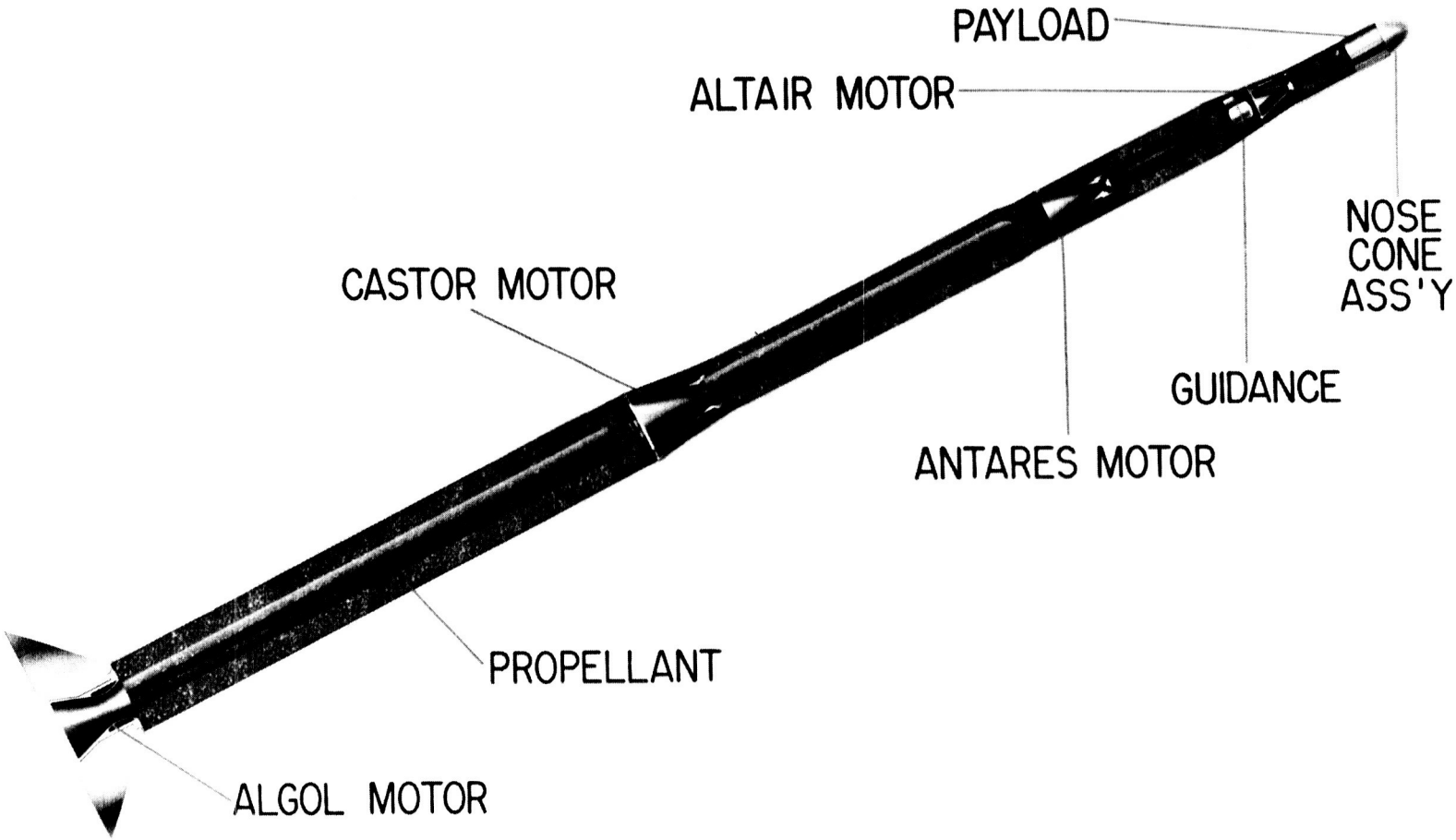

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Fig. 3 The Scout Launching Rocket.
The Scout is intended to be an inexpensive multipurpose launching vehicle.

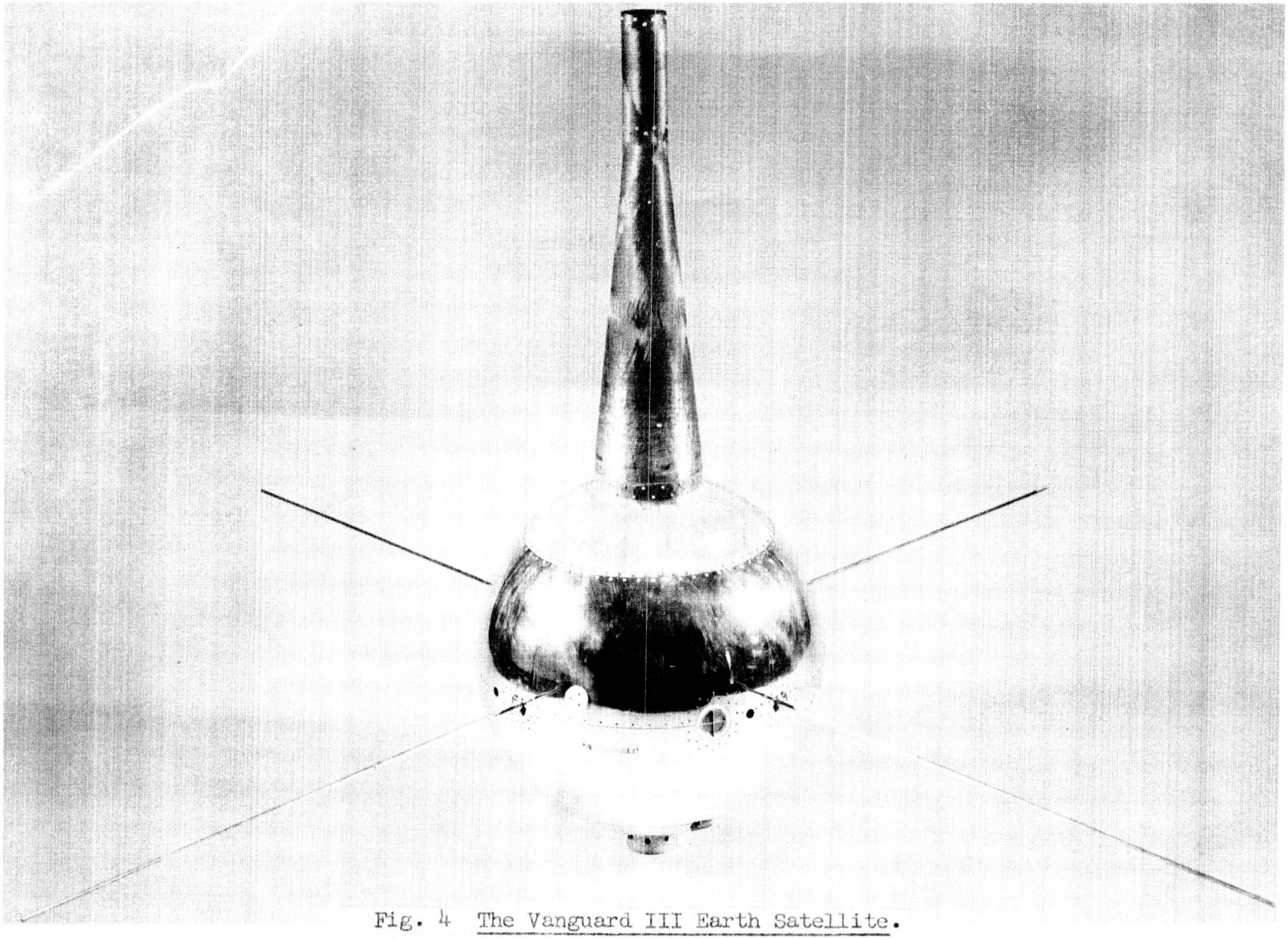


Fig. 4 The Vanguard III Earth Satellite.

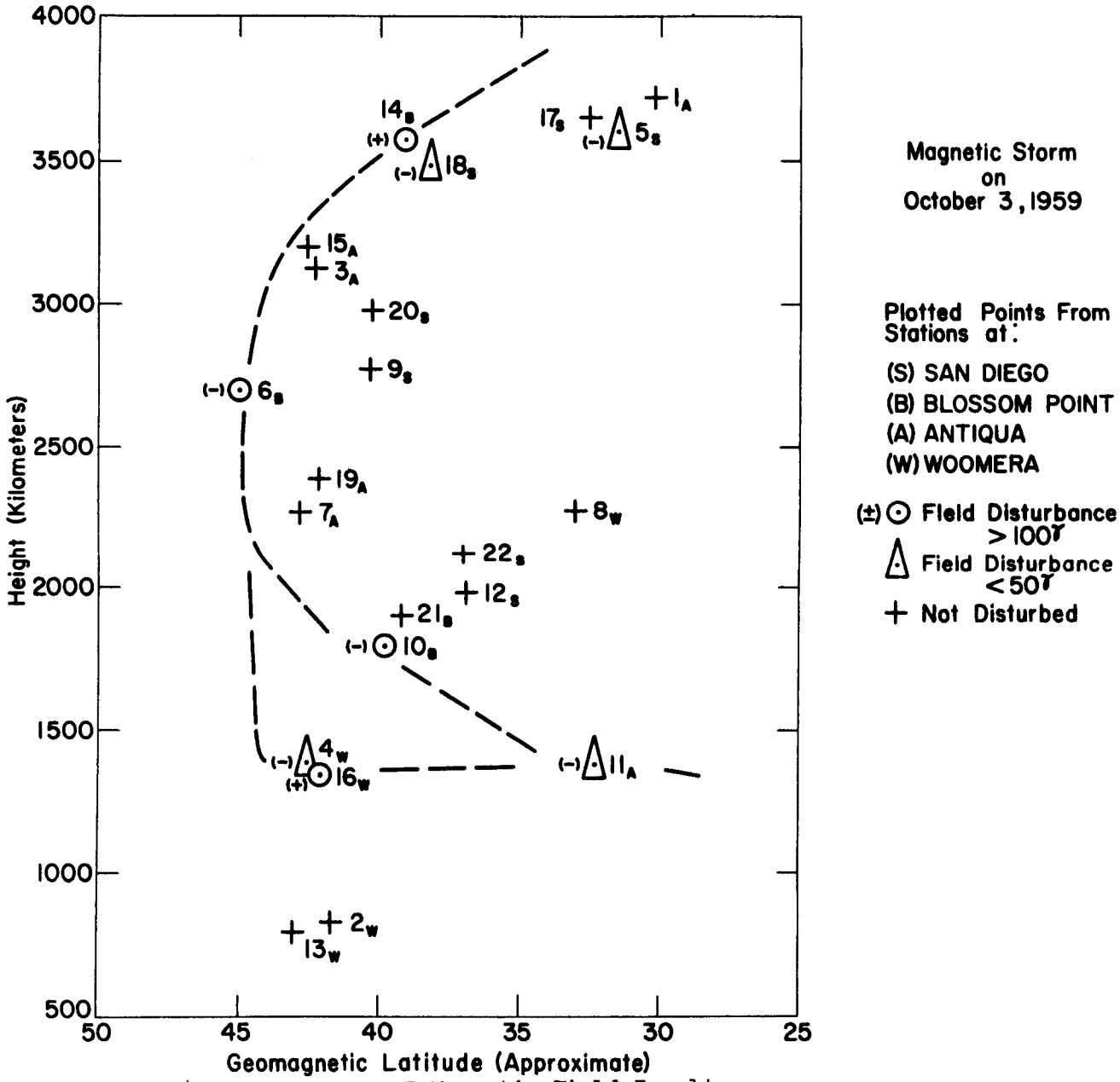


Fig. 4.1 Vangaurd III Magnetic Field Results.

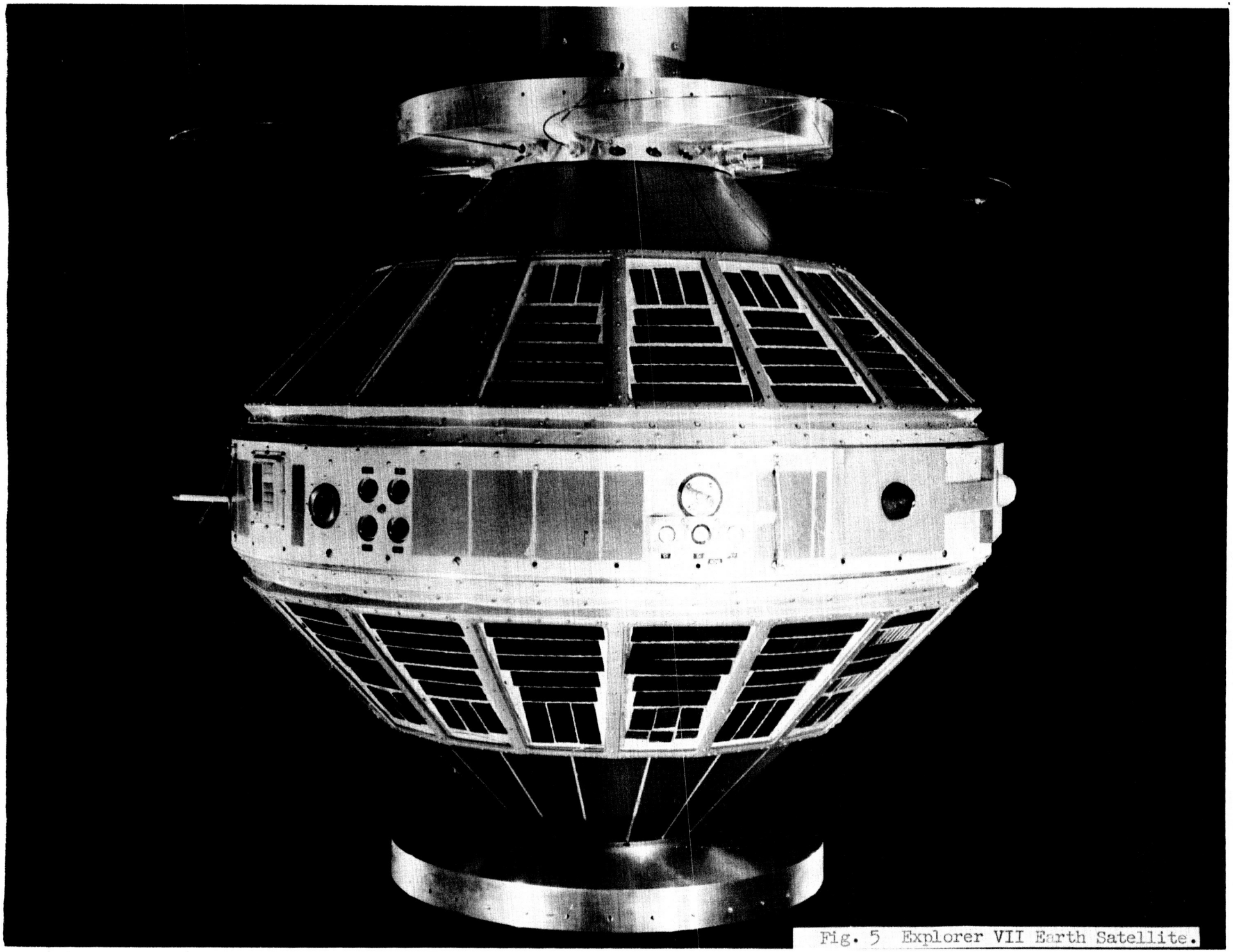


Fig. 5 Explorer VII Earth Satellite.

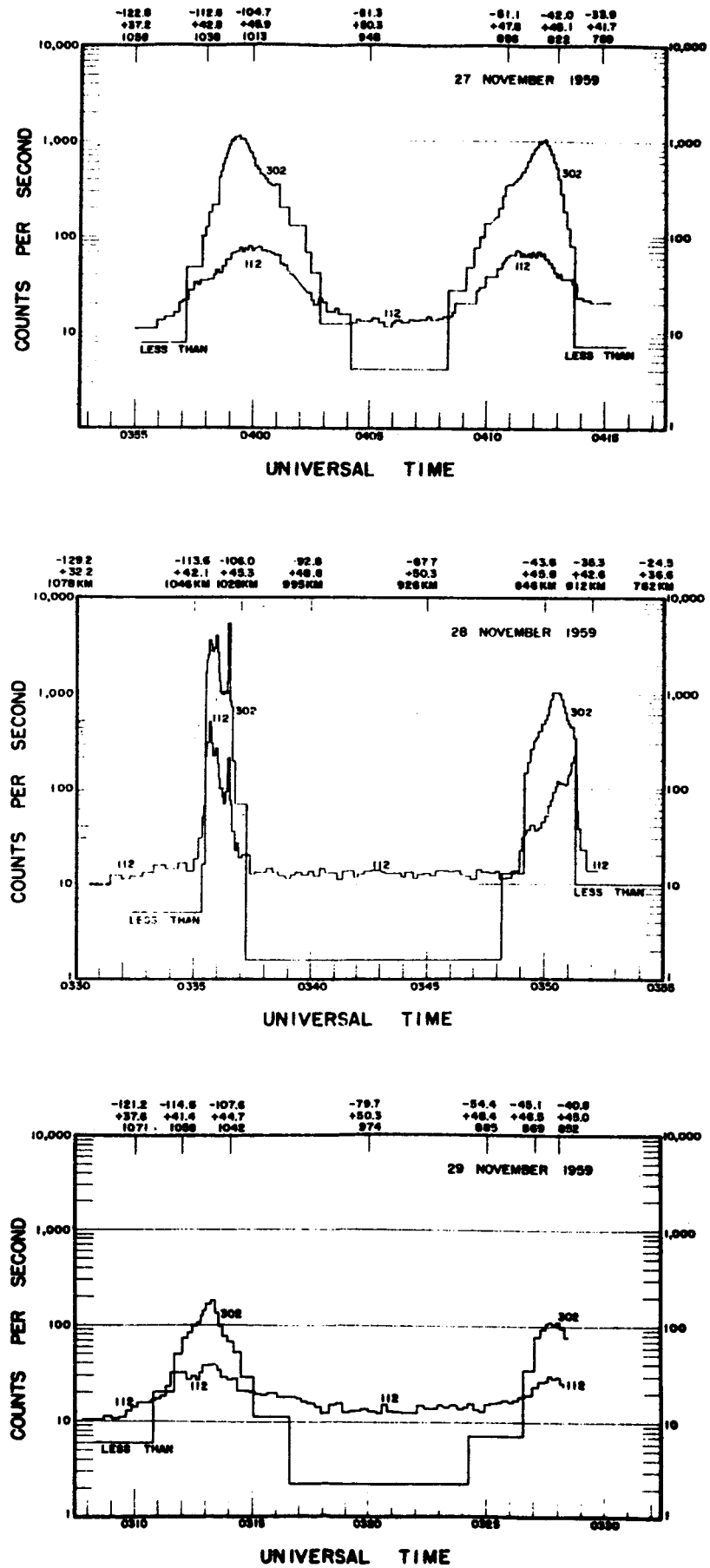


Fig. 5.1 Radiation Belt Observations from Explorer VII (1959 Iota I)

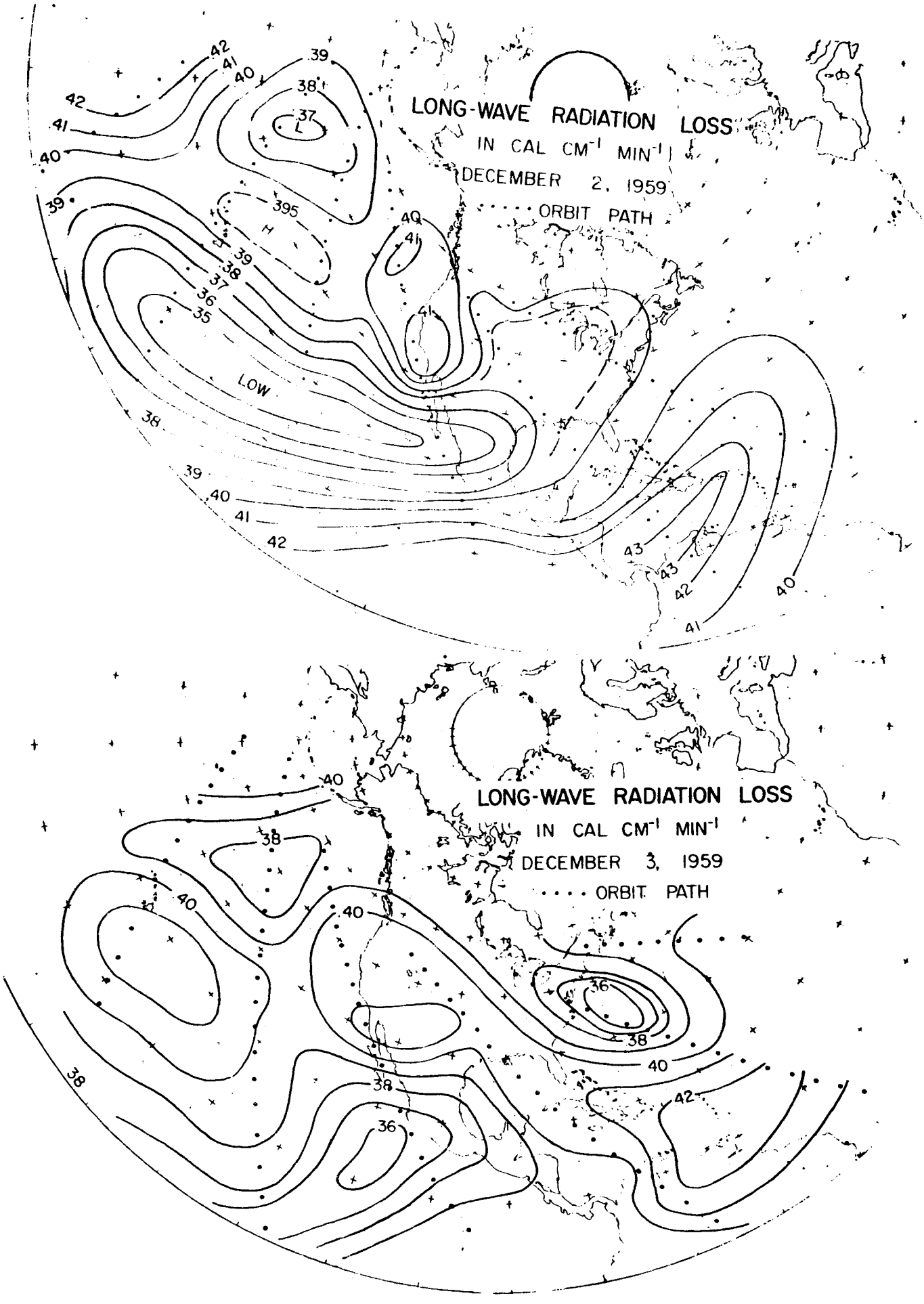


Figure 5.2 Atmospheric Radiation Balance Results from Explorer VII.

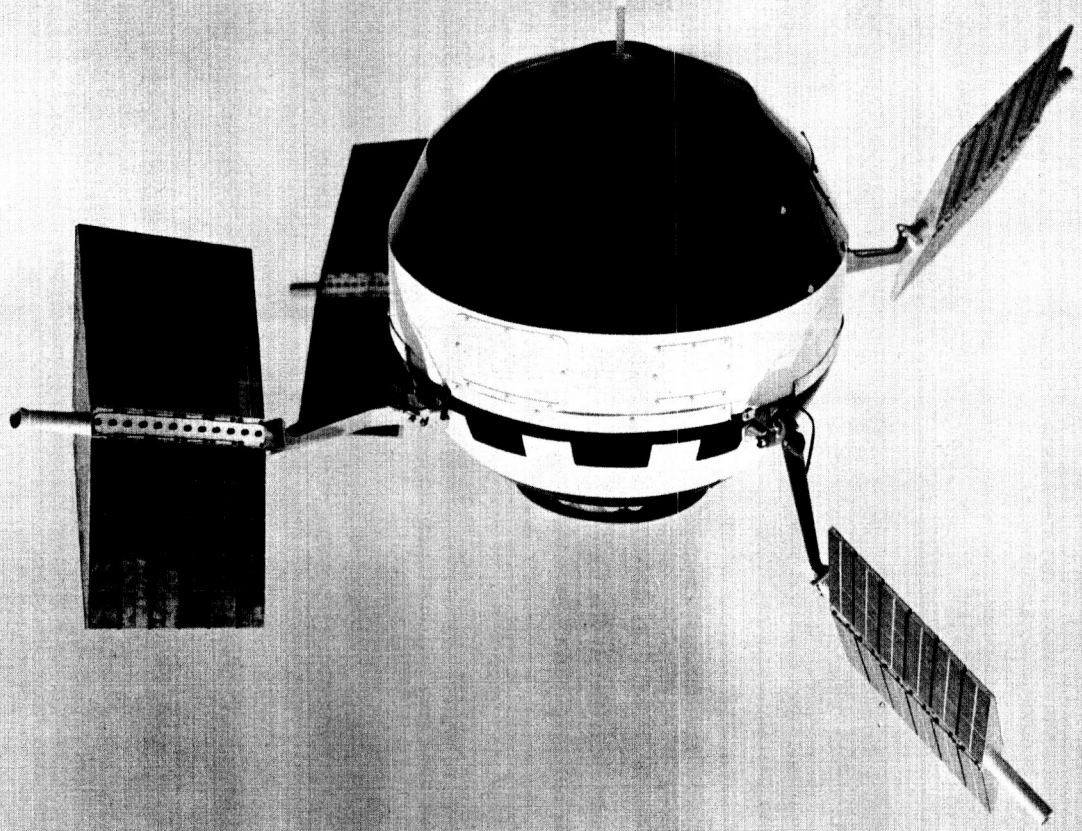


Fig. 6 The Pioneer V Deep Space Probe.

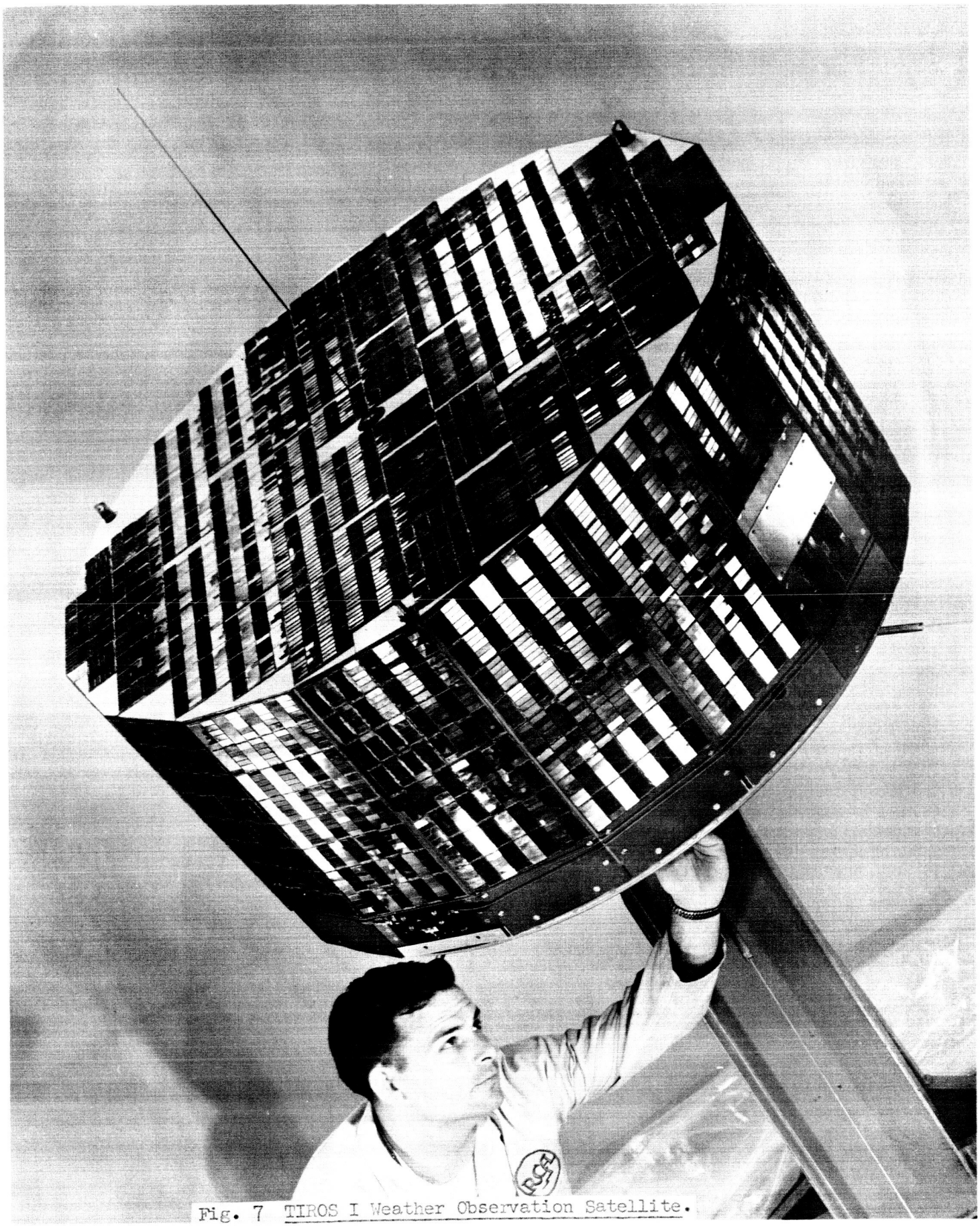
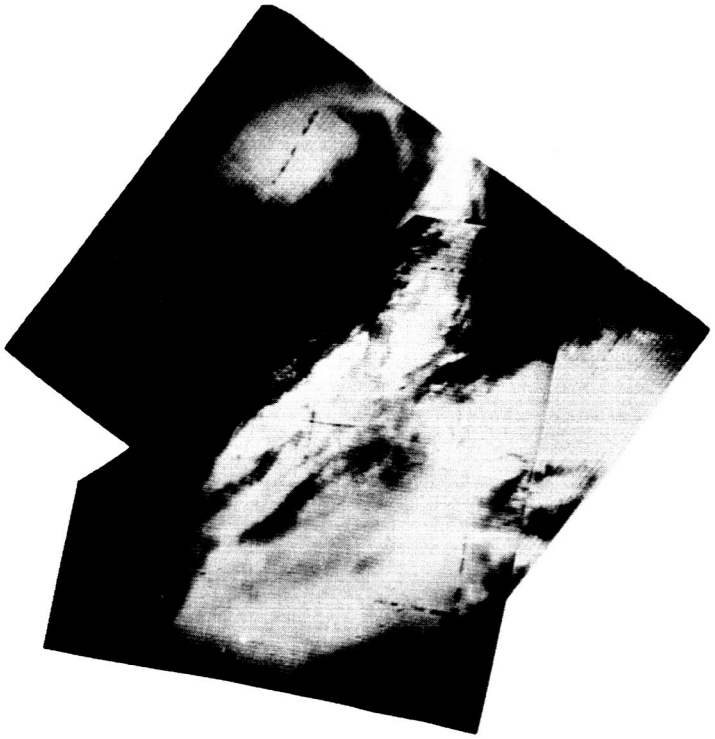


Fig. 7 TIROS I Weather Observation Satellite.



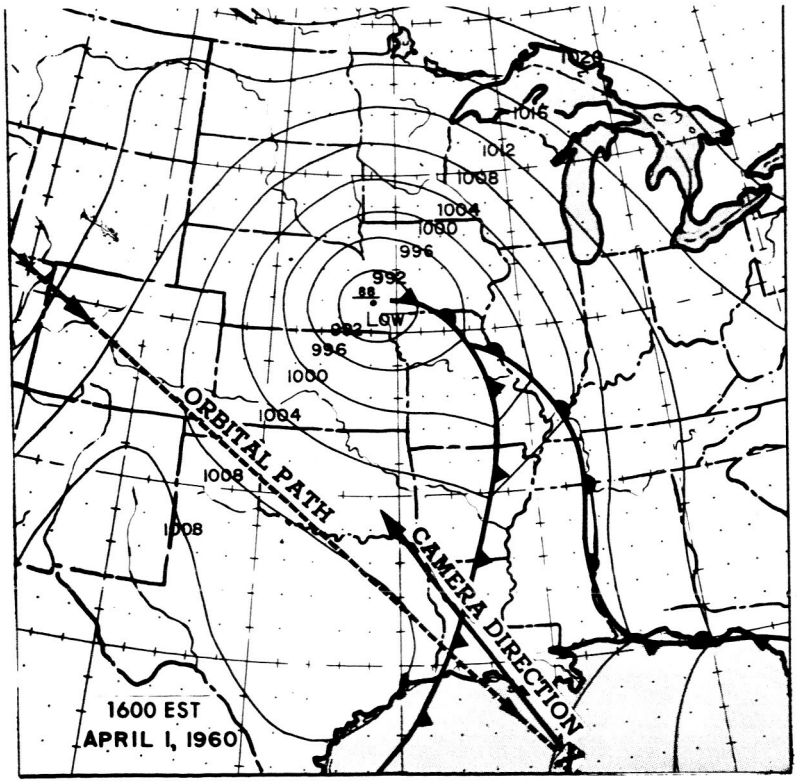


Fig. 8 Weather Picture Taken by the TIROS Satellite.

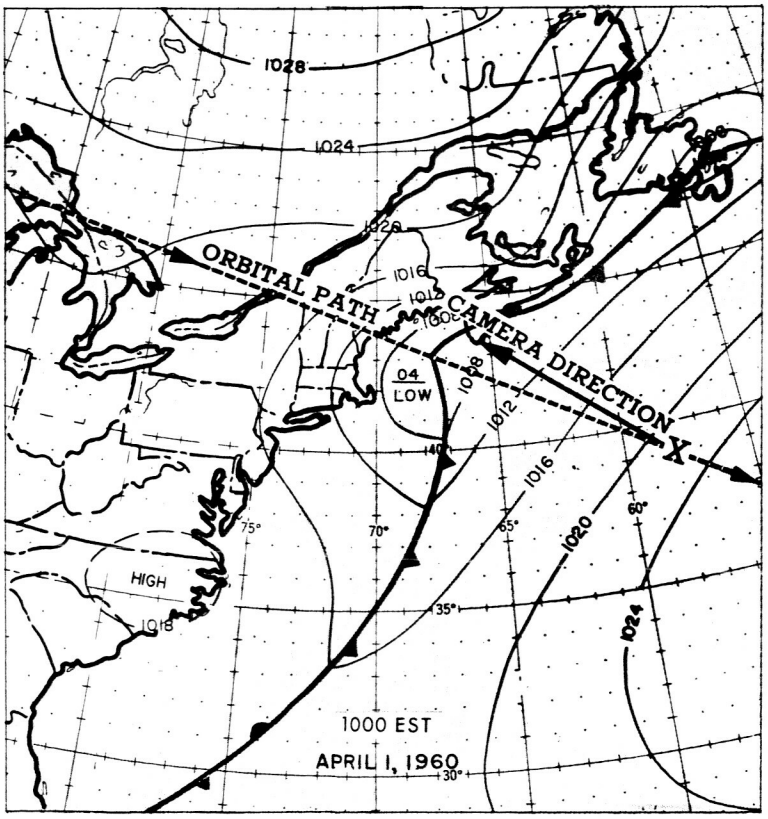


Fig. 9 Weather Picture Taken by the TIROS Satellite.

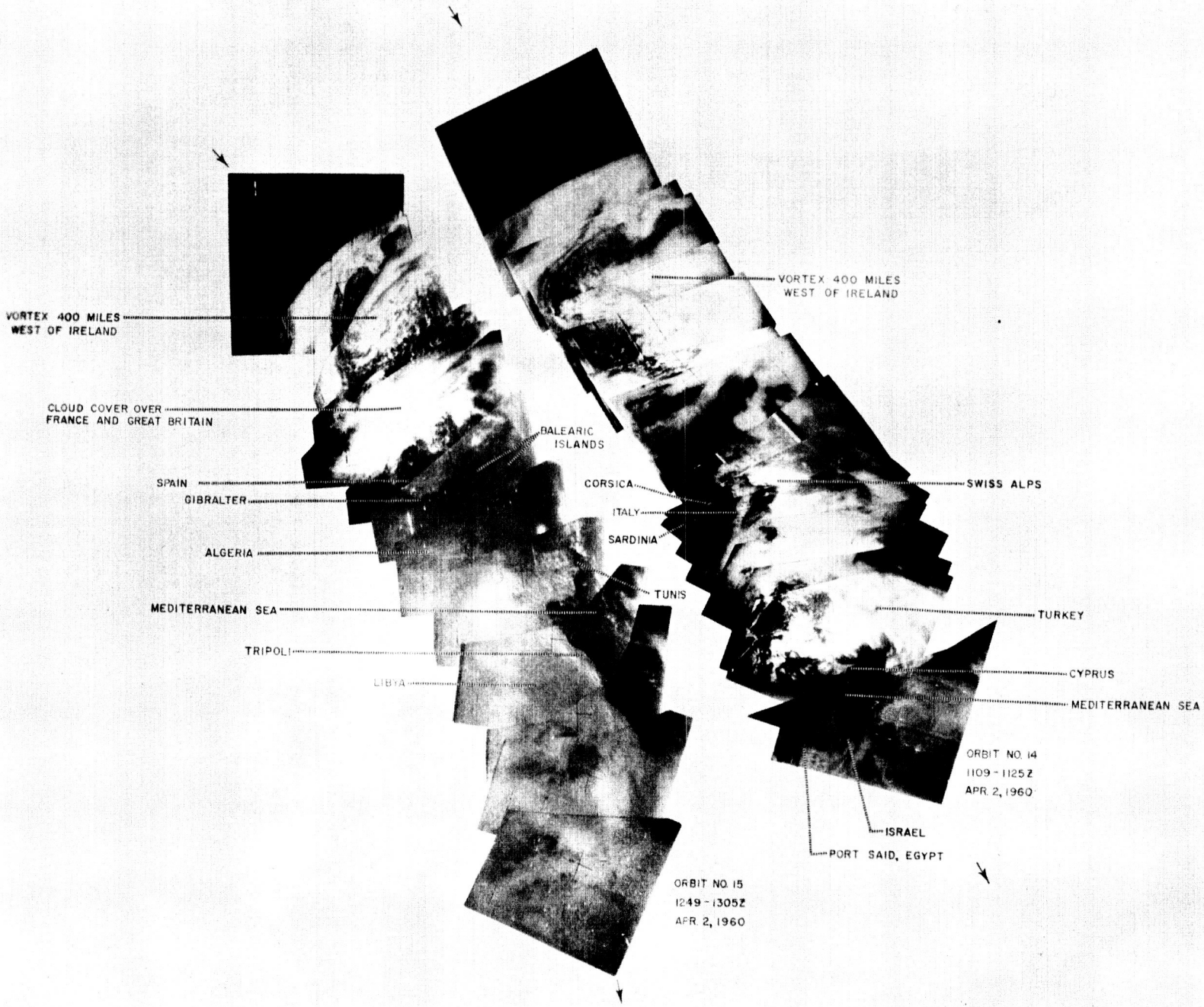


Fig. 10 Weather Picture Taken by the TIROS Satellite.