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Army Participation in the National Satellite and Space Program.

By

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Army Ballistic Missile Agency

9 June 1959

Semi-Annual ARS Meeting

When the American Rocket Society met for the celebration of its 25th anniversary in 1955, the exploration of space by rocket-powered vehicles was little more than the dream and the prophecy of a few. Then came the fateful 4th of October 1957 with the first launching of an artificial earth satellite. Almost within hours, it became strikingly evident that the step into space means far more than a scientific dream; it is a national challenge, and it affects the prestige, and even the security, of any great nation that desires to retain its place among the other nations.

The evolution of space activities in our country which followed the Sputnik launching is probably without a similar precedent in history.

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Two great national space agencies have been created since. Each of the three services promotes vigorous space programs, the Department of Defense takes a very active part, and the National Science Foundation establishes and supports space projects. No less than 51 satellites and space probes, to be launched before the end of 1961, were announced recently by the National Aeronautics and Space Administration. Powerful three and four stage carrier vehicles, based on Atlas and Titan, are in the making. Two projects were initiated last year which will provide boosters of one and one half million pounds, and a clustered booster of 6 million pounds may power manned lunar exploration vehicles within less than ten years.

What is the role of the United States Army in this impressive array of national space activities? Let us first look back to the early beginnings. Shortly after the war, a number of captured V-2 missiles were shipped to White Sands and launched by a little Army group. This project, under the command and the personal care of General Toftoy, served a dual purpose: it gave the troops an opportunity to acquire some familiarity with guided missiles, and it provided a marvelous tool to the scientists who wished to do research work in the highest layers of the earth's atmosphere. Even though they were a modest beginning, the White Sands launchings sparked off a scientific program of the first order. The High Altitude Research Panel has flourished ever since; it experienced a high boom during the IGY, and it continues to reap a rich harvest from the scientific satellite and space probe projects which are now under the sponsorship of NASA. Most of those who contribute now to the exploration of the great radiation belts, to the analysis of solar

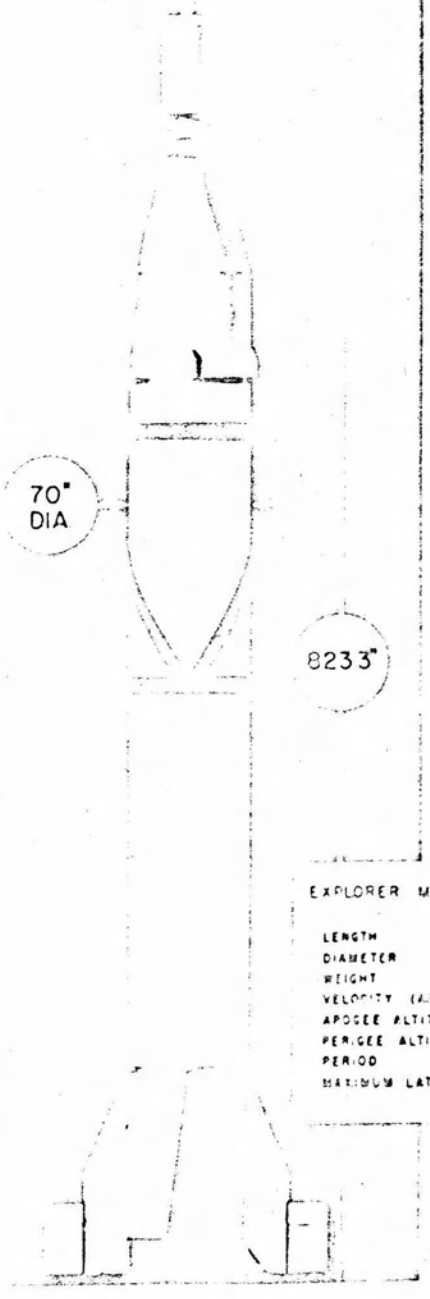
radiation, to meteorite detection, to the measurement of atmospheric density, magnetic fields, ion currents, wave propagation, and cosmic particles, are old veterans from the sky-storming days in White Sands back in 1946 and 1947. A two-stage combination of a V-2 and a Wac Corporal reached a record altitude of 250 miles in 1949. Many of the data on the upper atmosphere, and also many of the measuring and telemetering techniques which are in use today, are a direct outgrowth of the V-2 project in White Sands.

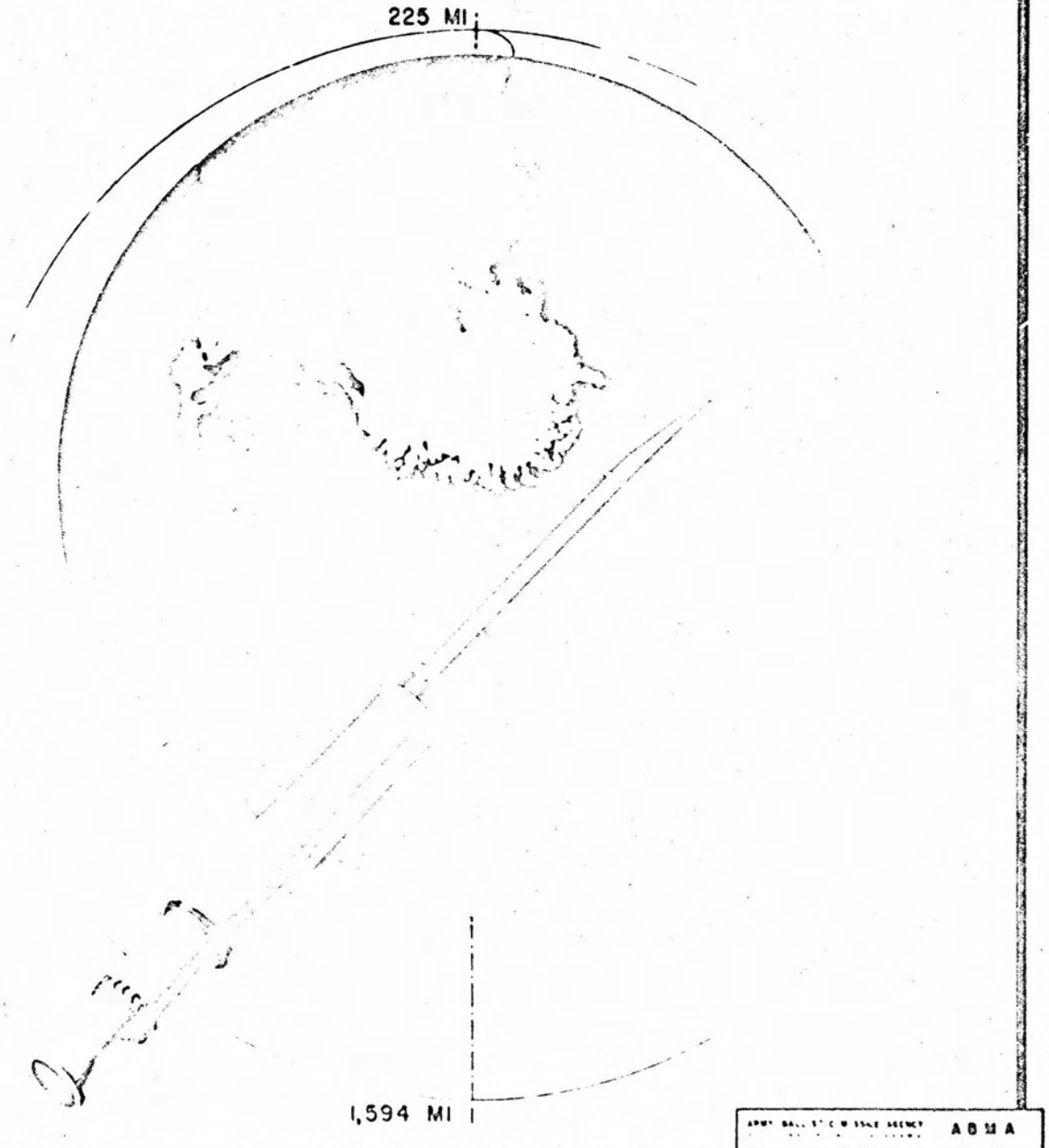
In 1950, while the Korean War was raging, the Army was assigned the development of a 200 mile ballistic missile, the Redstone. Design, development, and pilot production was done at the Redstone Arsenal in Huntsville. The Redstone would not be termed a very modern missile today because it had to be designed for one of the early versions of an atomic warhead which weighed as much as 6400 lbs; however, it has acquired by now a very impressive record of reliability and accuracy. In 1954, the Huntsville team, together with members of the Naval Office of Research, presented a proposal to launch a small satellite with a Redstone missile combined with 3 upper stages of solid Loki rockets. Later on, when the Navy withdrew its support from the project, the Army teamed up with the Jet Propulsion Laboratory. The Loki rockets were replaced by scaled-down Sergeants, and the launching of a satellite late in 1956 appeared feasible. In the meantime, the Naval Research Laboratory had prepared another satellite proposal, which was subsequently accepted as "Project Vanguard" by a national satellite committee. Around that time, the Army was directed to work out plans for a 1500 mile Intermediate Range Ballistic Missile, which later became known as

Jupiter. One of the most significant differences between 200 mile and 1500 mile missiles is the high heat influx into the nose cone of the IRBM during re-entry. Since there was no possibility to study the behavior of re-entering IRBM nose cones by simulation on the ground, the Army team, which in the meantime had developed into the Army Ballistic Missile Agency under the command of Major General Medaris, decided to use the components which had been prepared for a satellite vehicle for re-entry tests of IRBM nose cones of reduced scale. The first flight of a three-stage ballistic missile, consisting of a Redstone and 2 live upper stages, took place in September 1956; it covered 3000 miles. The first successful recovery test, which proved at the same time the soundness of the fiberglass ablation nose cone design of the Army Ballistic Missile Agency, was also flown with a Redstone and two upper solid propellant stages. Most gratifyingly to the Army-JPL team, this nose cone was exhibited by President Eisenhower in a nationwide announcement from his office on 7 November 1957.

A few days after the second Sputnik had been put in orbit, the Army Ballistic Missile Agency wad directed to launch an instrumented satellite as soon as possible. The earlier work on a satellite project, and particularly the re-entry tests with multistage vehicles, proved extremely valuable as a basis for this new crash program. Again, the Army joined with JPL. Dr. Van Allen from the State University of Iowa provided the cosmic ray instrumentation, the Naval Research Laboratory and JPL supplied transmitters for tracking and telemetry, and on 31 January 1958, Explorer I began its long journey around the earth. A second successful satellite followed in March, and a third one, Explorer IV, in July.

JUPITER-C (EXPLORER I)



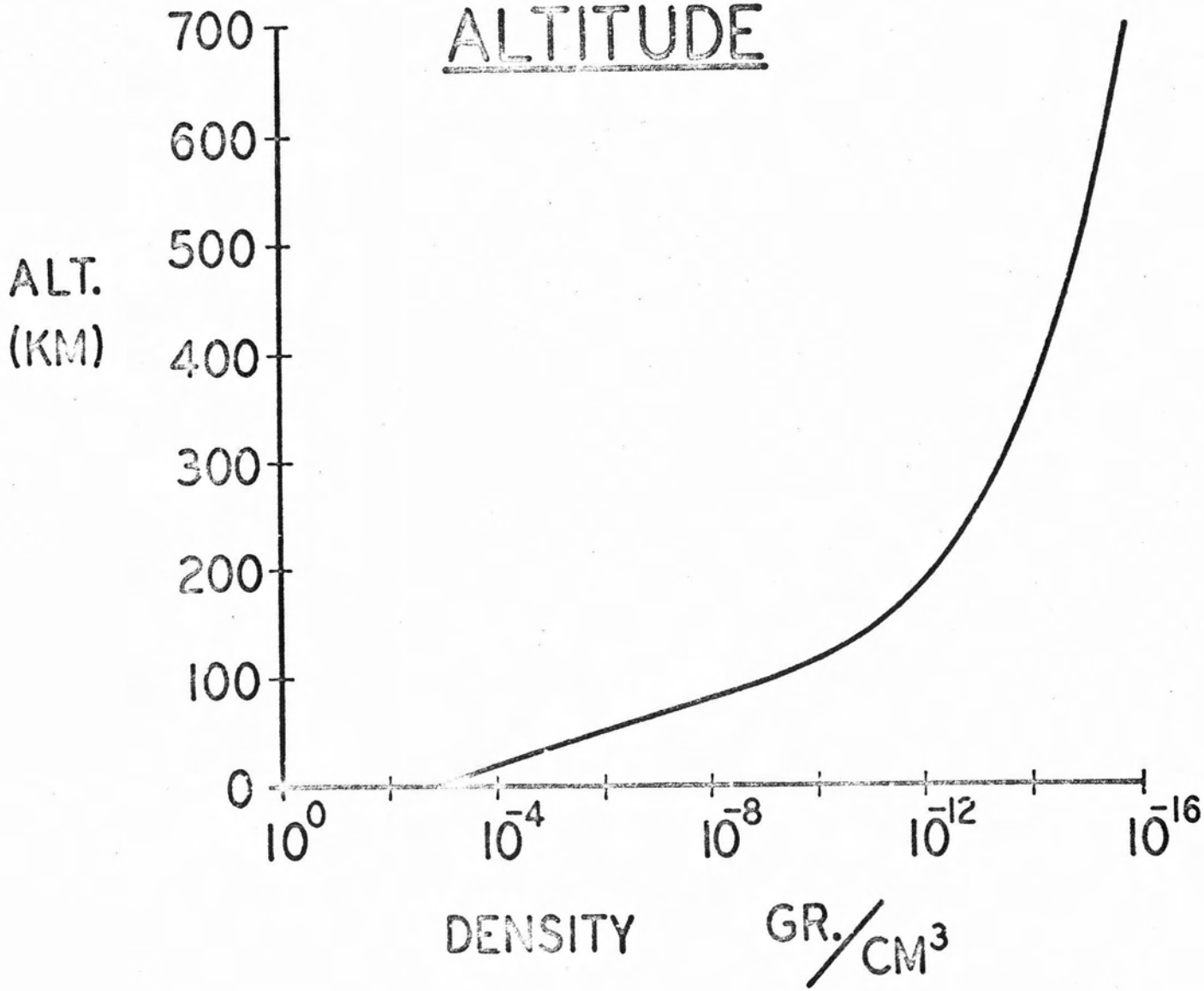


EXPLORER MAIN CHARACTERISTICS

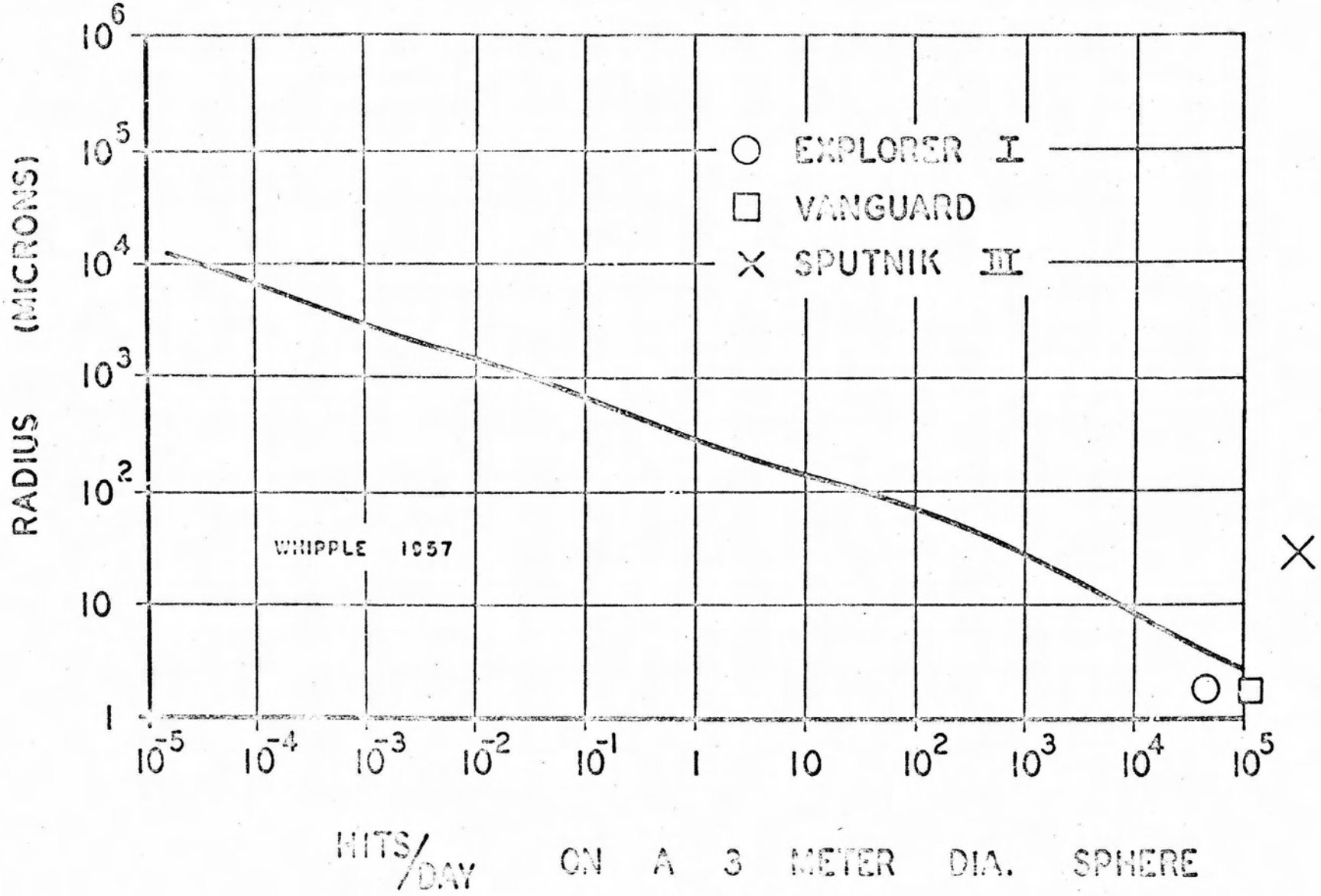
LENGTH	80"
DIAMETER	8"
WEIGHT	30.8 LB
VELOCITY (APPROX)	18,000 MPH
APOGEE ALTITUDE	1,594 MI
PERIGEE ALTITUDE	225 MI
PERIOD	114.78 MIN
MAXIMUM LATITUDE	33.3 DEG

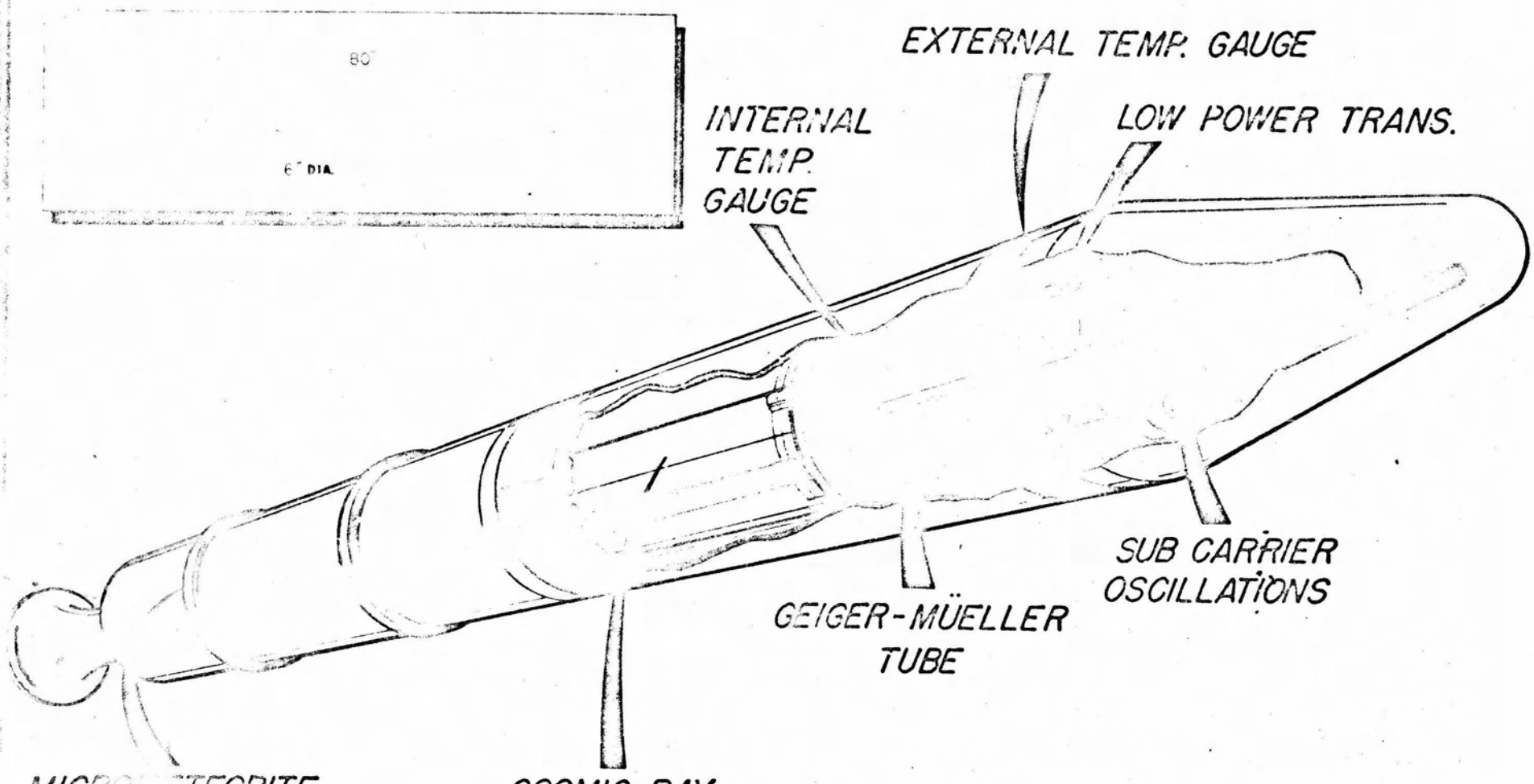
ABMA

ATMOSPHERE DENSITY VS. ALTITUDE



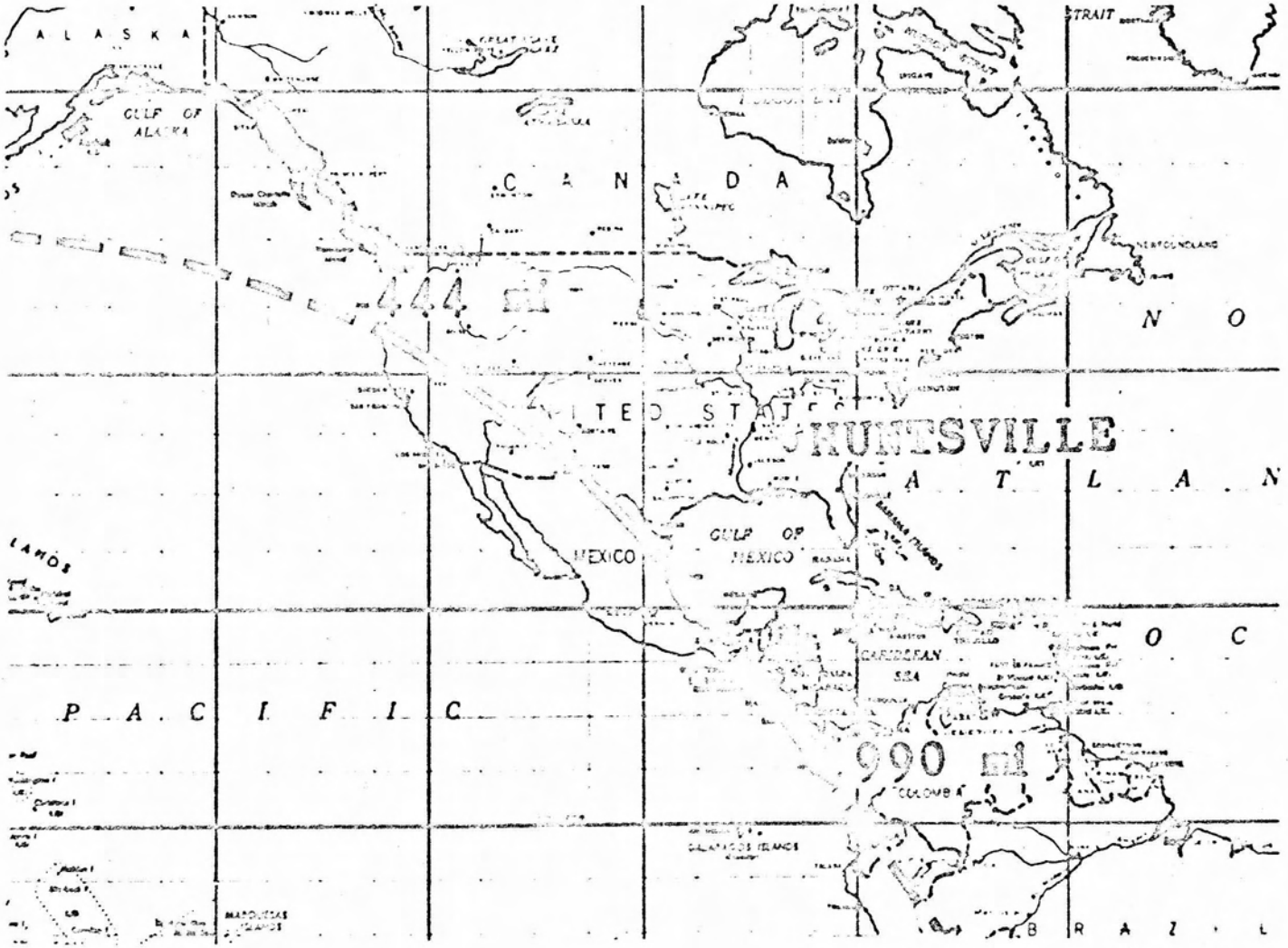
METEORIC PARTICLES IN THE EARTH'S VICINITY





EXPLORER III

EXPLORER IV



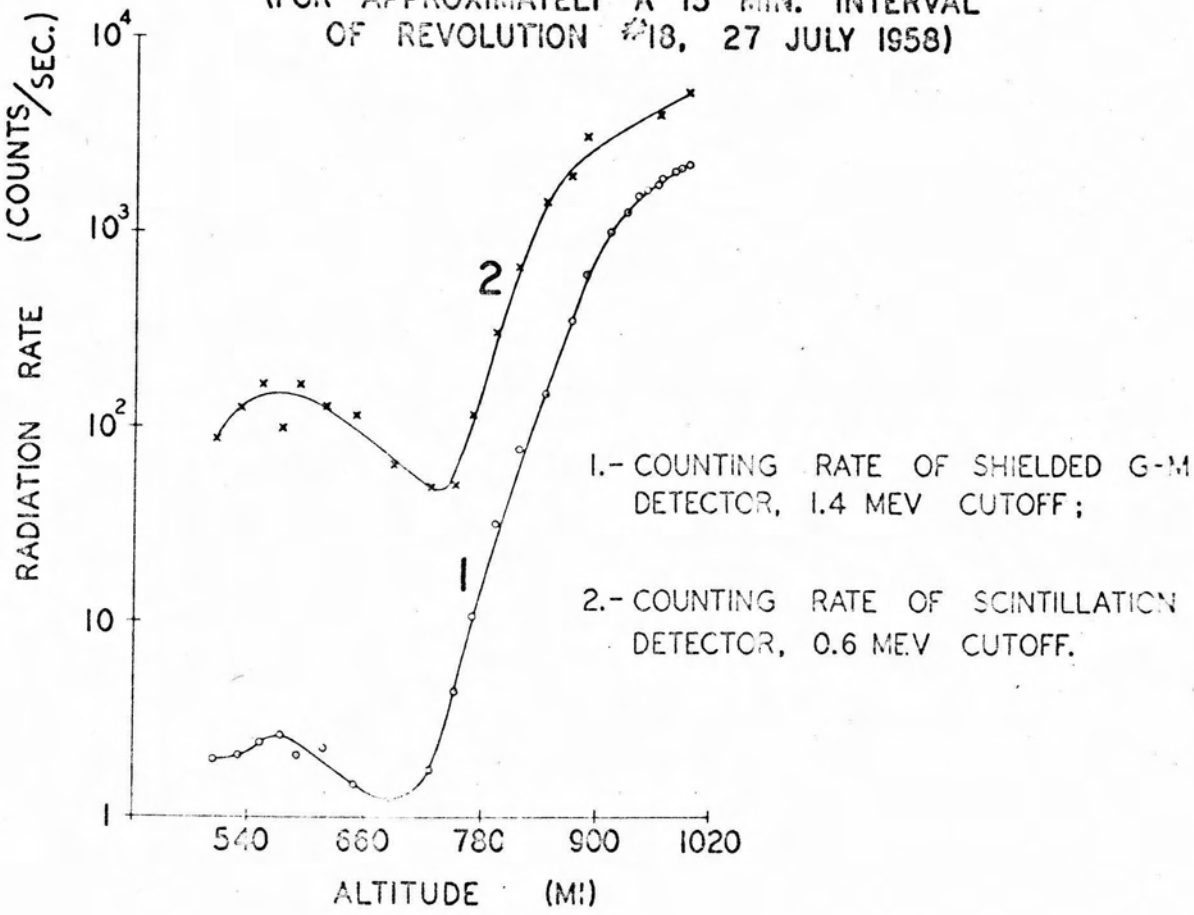
Portion of Revolution #18, received by tracking station at Redstone Arsenal, 27 July 1958 - 2030 to 2045 EDT.

The discovery of the Great Radiation Belts by the Explorers has been described so often that it is common knowledge by now. It may well prove to be the finest and most surprising discovery of the IGY. While the radiation counters of Explorer IV were operating, a series of three high-altitude atomic explosions were set off in the South Atlantic. This project, later publicly known as "Project Argus", was undertaken to study the long-time radiation effects of atomic bombs which explode at high altitudes. It was expected that electrons, both from the initial blast and from radioactive decay of the fission fragments, would be trapped by the magnetic field of the earth, and would oscillate between the magnetic poles along the field lines on cork screw trajectories for days and even months. The theory had been worked out by Christofilos and Panovsky, and the measurements, providing data on the density of the artificial electron cloud, its growth in thickness, its spreading around the earth, and its lifetime, confirmed in essence the theory. Even though many of the details of a possible artificial radiation belt are still not known, the Argus experiment proved very helpful for the prediction of electron densities that can be created artifically at high altitudes, and of their possible effects on radio and radar communication on earth. A continuation of the Argus experiment is presently planned as part of the Willow Project. The Army Ballistic Missile Agency will probably participate in Willow with a number of vertical missile launchings which carry atomic devices, and with instrumented satellites measuring the radiation effects of the explosions.

In December last year, the Army-JPL-Van Allen team made its first attempt at the Moon, with a Juno II vehicle, consisting of a Jupiter as

RADIATION COUNTING RATES VS. ALTITUDES OF EXPLORER IV

(FOR APPROXIMATELY A 15 MIN. INTERVAL OF REVOLUTION #18, 27 JULY 1958)



1.- COUNTING RATE OF SHIELDED G-M DETECTOR, 1.4 MEV CUTOFF;

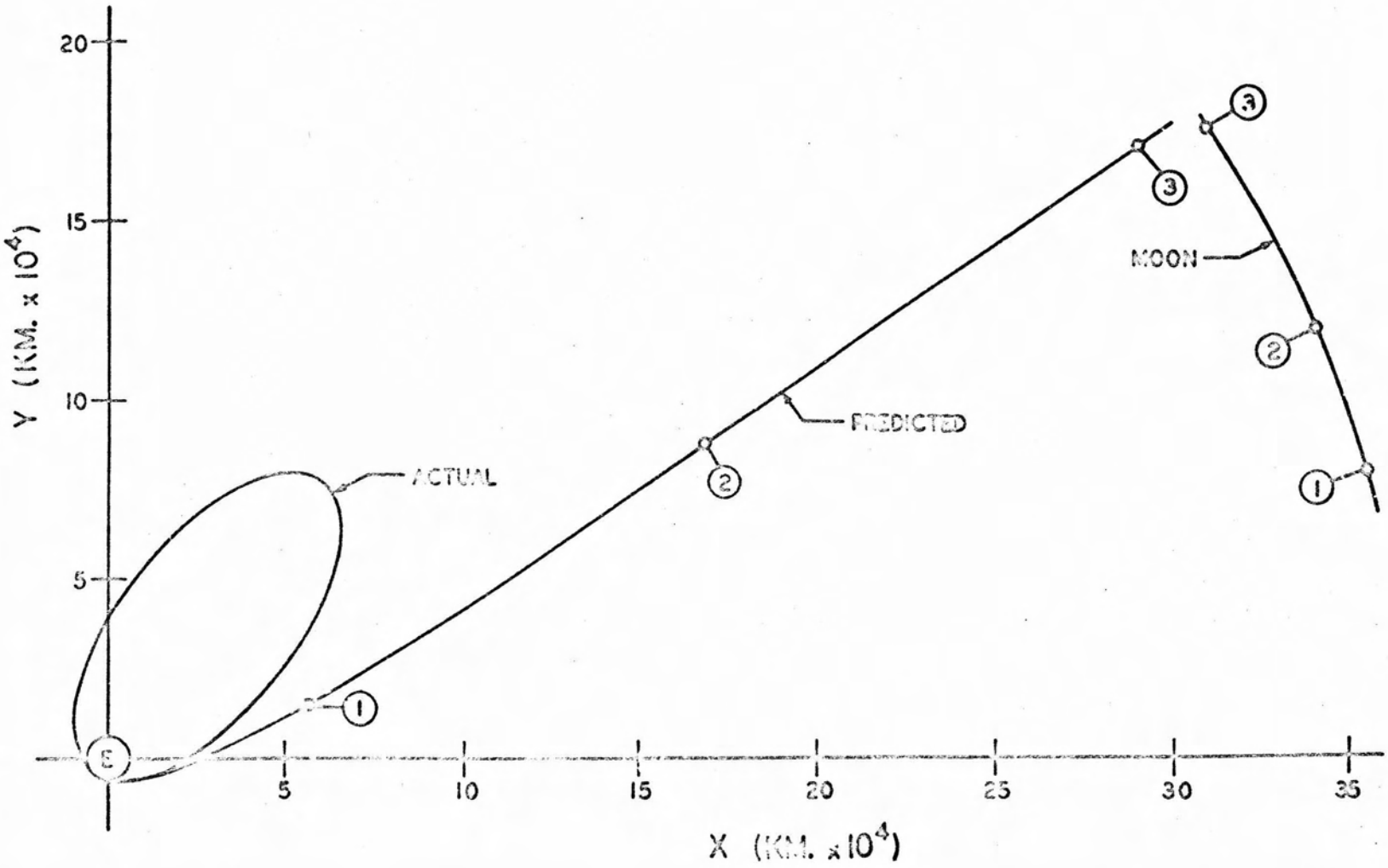
2.- COUNTING RATE OF SCINTILLATION DETECTOR, 0.6 MEV CUTOFF.

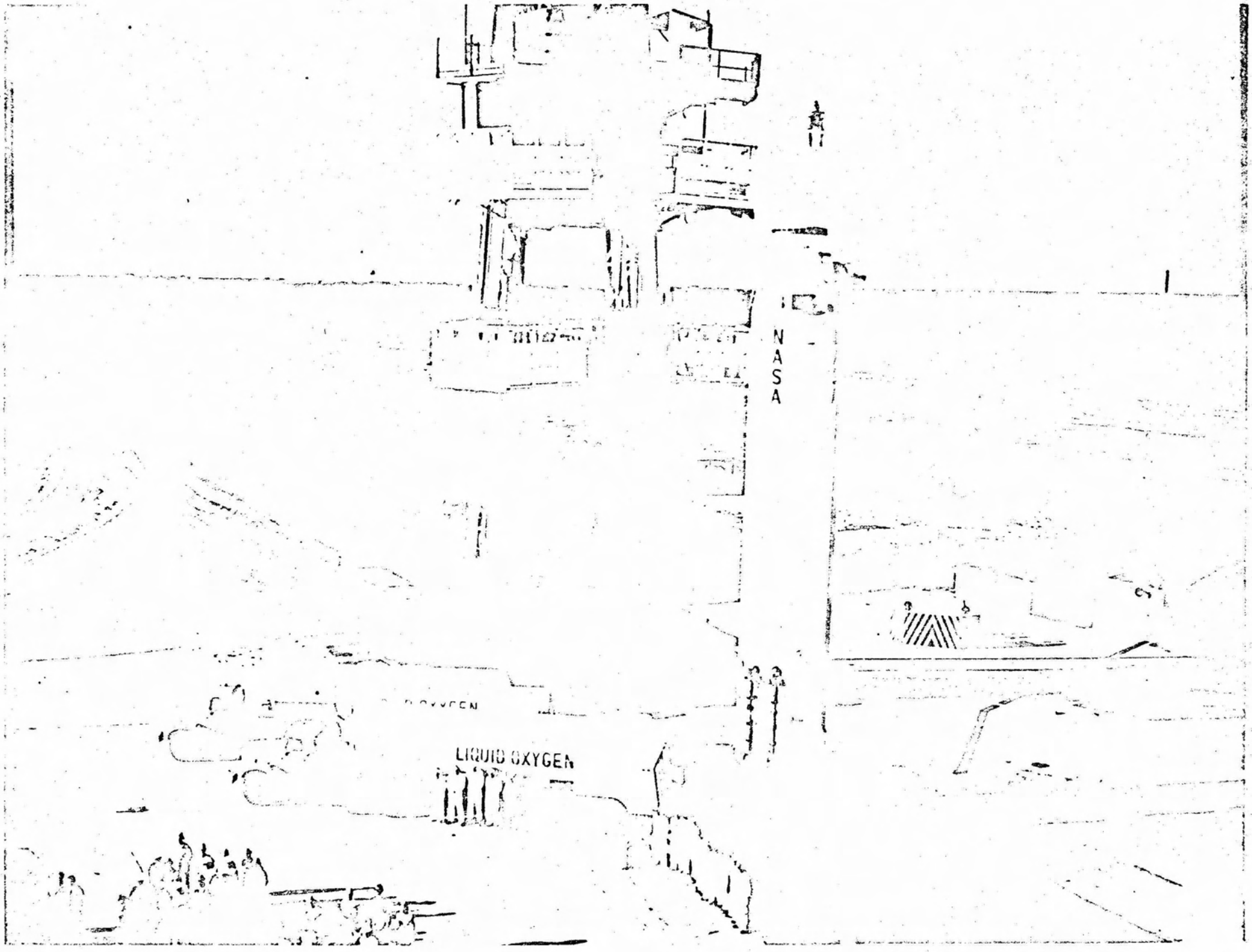
booster and the same upper stages which had been successfully used on the Redstone for the re-entry tests and the Explorers. The flight failed as a lunar probe, but it provided excellent data on radiation intensities as far out as 65000 miles, and it proved that there are two distinct belts of very intense radiation. The second attempt in March of this year was a success. The 15 lbs package, again providing excellent radiation data, passed the Moon at a distance of about 40000 miles and entered into a planetary orbit around the sun. Even though our thinking today is fairly well adapted to large figures and new concepts, it is still a strange and almost eerie thought that this little gilded cone, which bears the fingerprints of many of us - and even of some who are here today in this audience - will continue its lonely journey around the sun for millions and millions of years, probably as long as the solar system stays together.

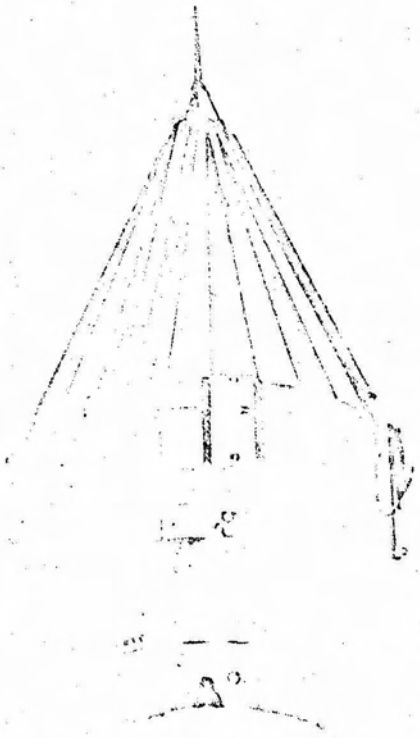
About 5 days before the launching of Pioneer IV, a large flare erupted on the sun. This is probably the reason why the intensity of the second radiation belt was found so much greater by Pioneer IV than by Pioneer III. The many additional peaks in the intensity curve at greater distances are very likely also a result of increased solar activity.

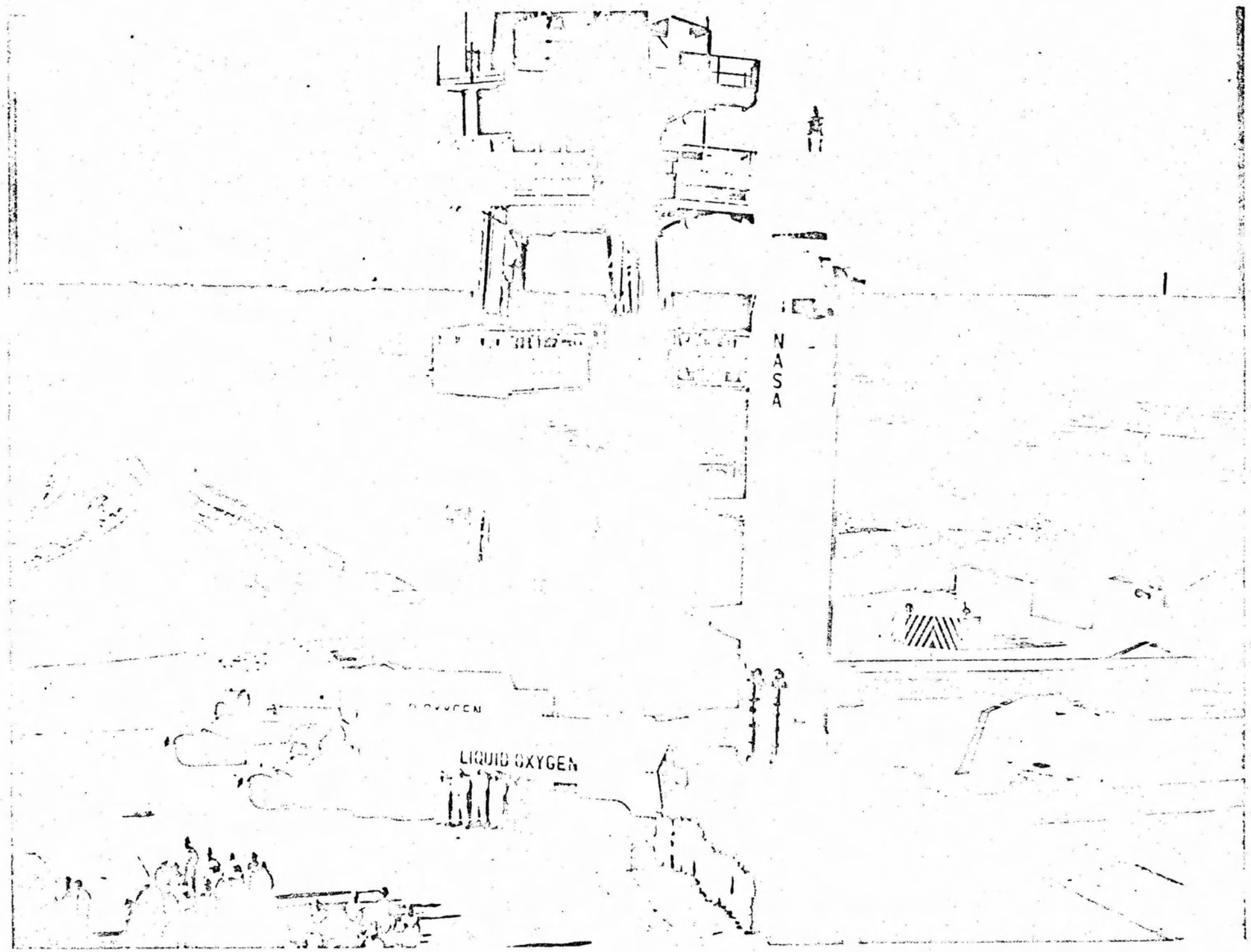
Towards the end of last year, one of the Jupiters which were prepared for nose cone recovery carried, in a special capsule, a live squirrel monkey provided by the Naval School of Aviation Medicine. All the body functions like breathing rate, heart beat, cardiogram, and temperatures, which were telemetered back to the ground, indicated that the animal was in good shape during the flight until the end when trouble

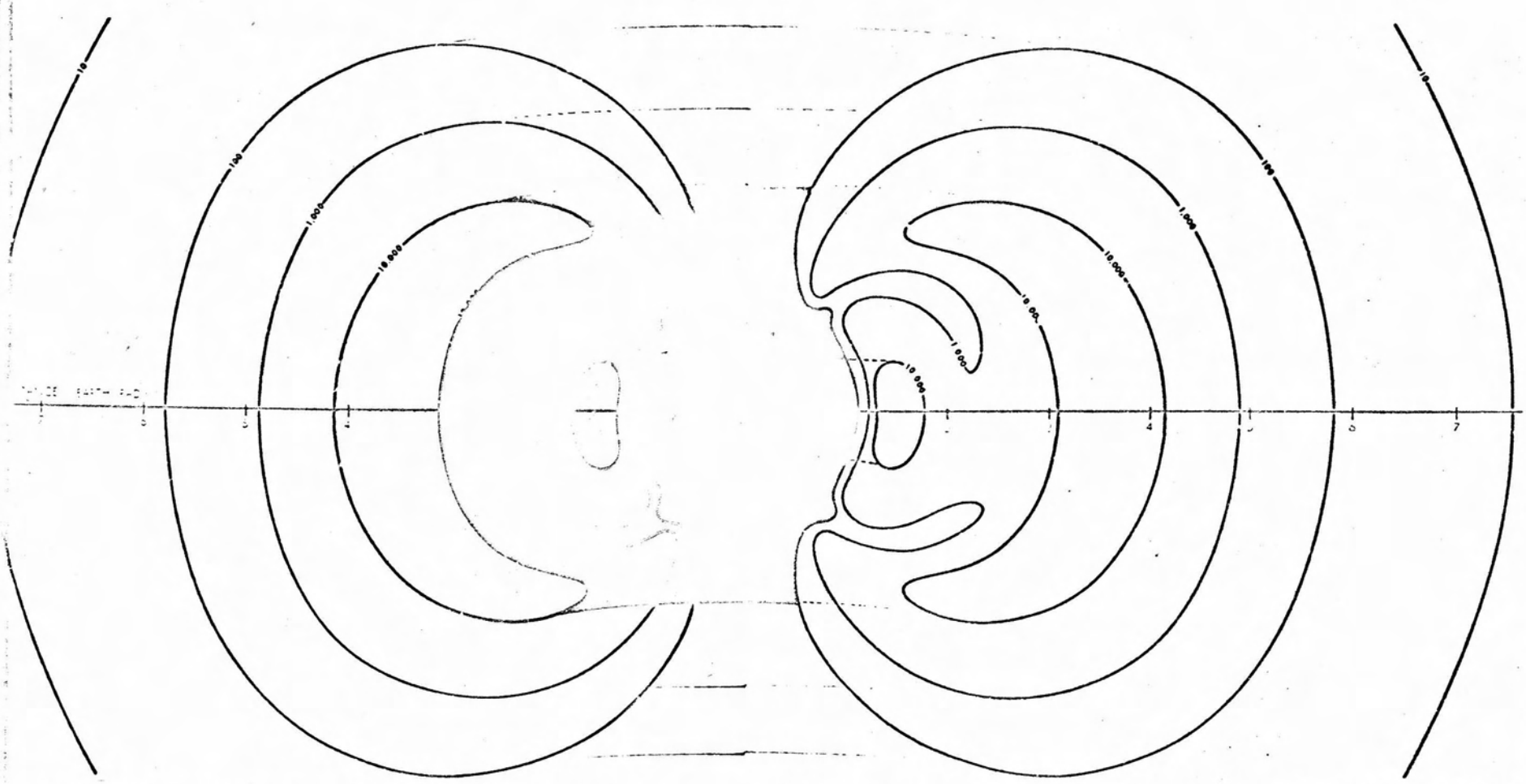
PIONEER III


20
15
10
5
Y (KM. x 10⁴)
ACTUAL
PREDICTED
MOON
E
1
2
3
3
2
1
5
10
15
20
25
30
35
X (KM. x10⁴)


NASA
LIQUID OXYGEN

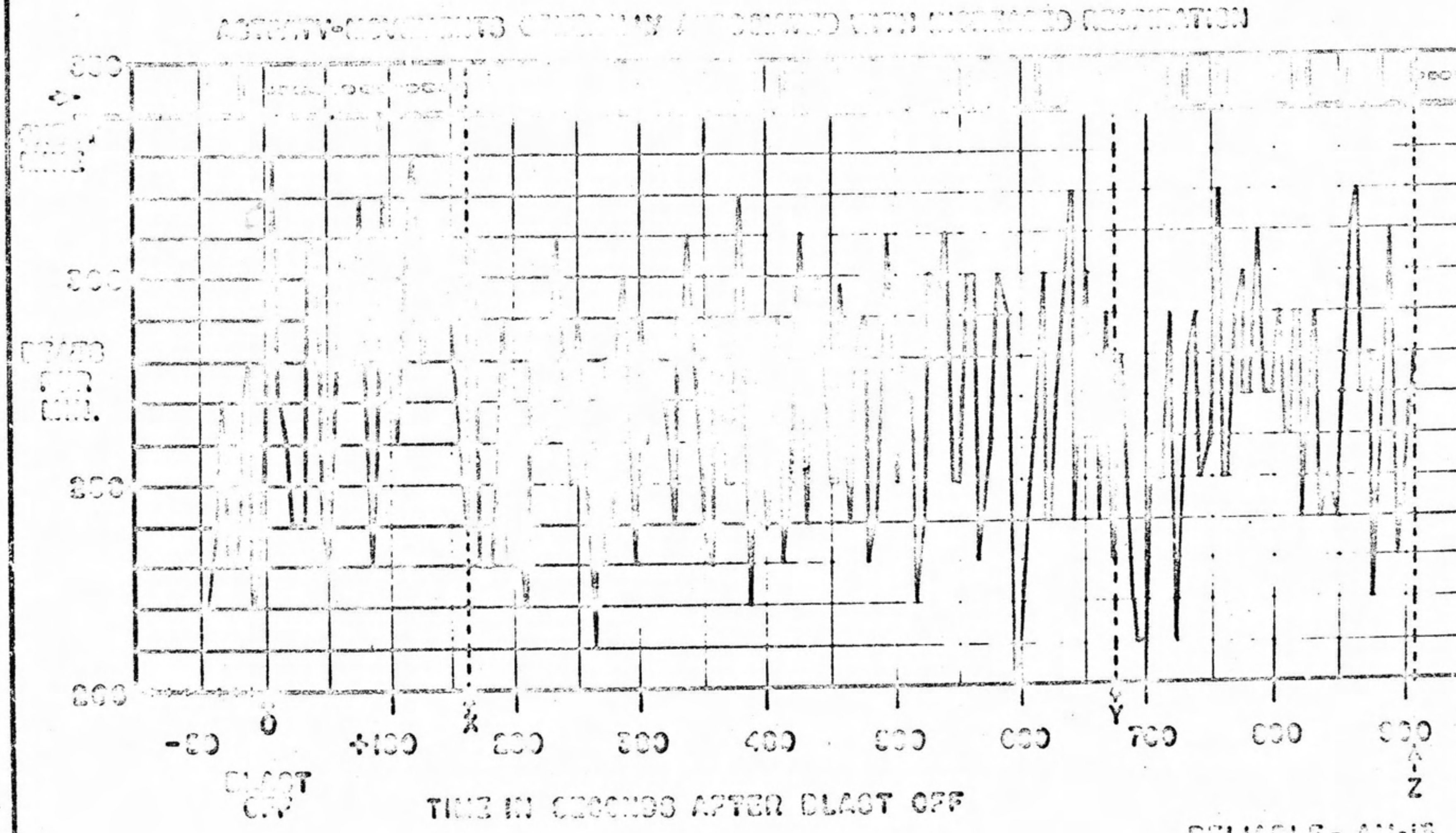



NASA
LIQUID OXYGEN



TURE OF RADIATION BELTS revealed by contours of
n intensity (*black lines*) is shown schematically by shading
(*dots*). dots (*right*) suggest distribution of particles in the two
belts. Contour numbers give counts per second; horizontal scale
shows distance in earth radii (about 4000 miles) from the center
of the earth. Particles in the inner belt may originate with the
radioactive decay of neutrons liberated in the upper atmosphere by
cosmic rays; those in the outer belt probably originate in the sun

HEART RATE -
AVERAGED OVER 5 SECOND INTERVALS

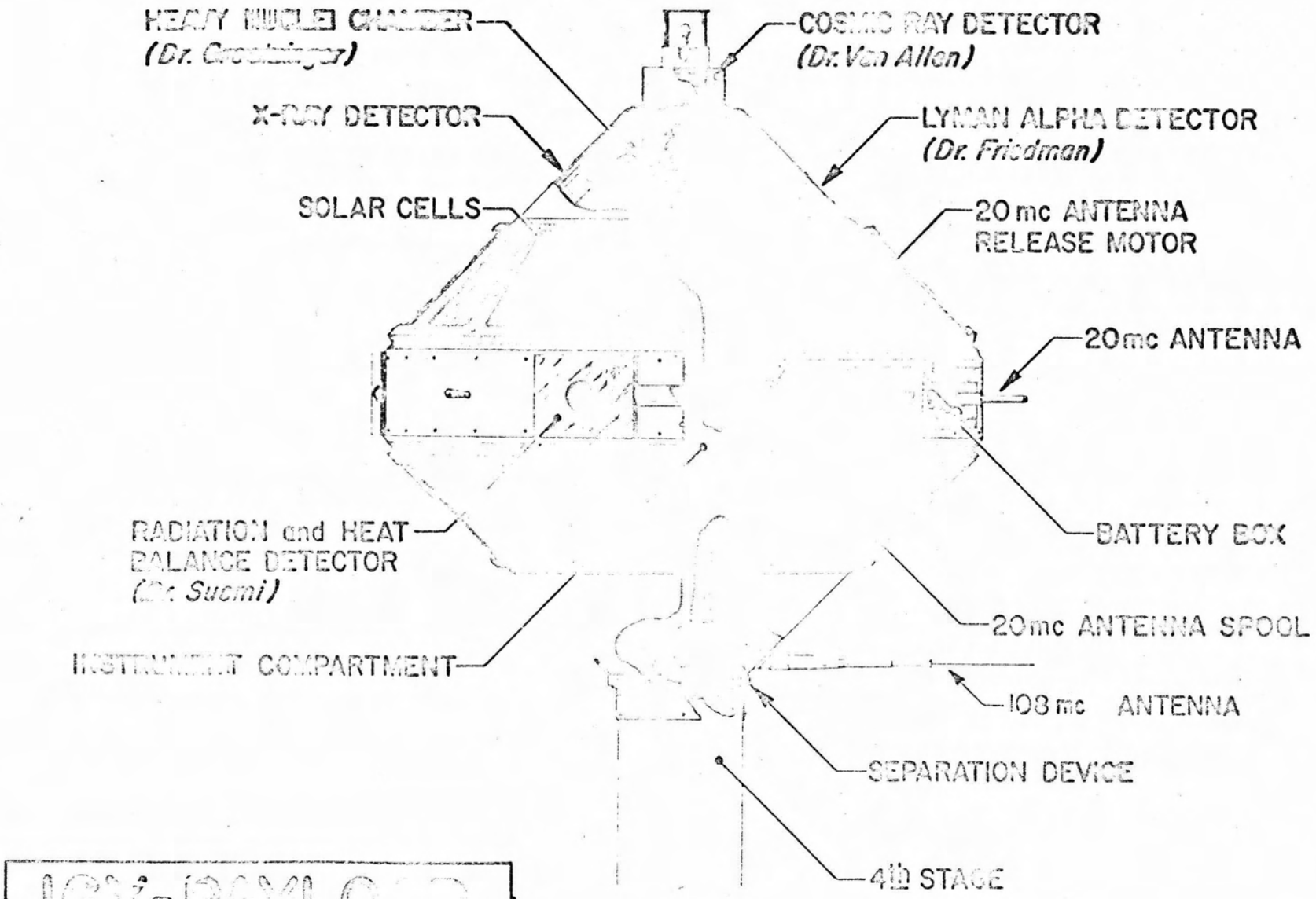


in the re-e try gear developed. This particular nose cone could not be recovered, and the little monkey found an early grave in the Atlantic.

A second monkey-carrying Jupiter took off a few days ago. An American born Rhesus monkey had been provided by the Army Surgeon General, a South American Squirrel monkey by the Naval School of Aviation Medicine in Pensacola. This time, recovery was a full success, not only for the bio-medical project planners, but particularly for the two brave space travelling monkeys. Their fame sped quickly around the globe, and they were readily promoted to the most enviable status of Army and Navy VIP's. The same Jupiter nose carried a selection of bio-medical and bio-physical specimen such as yeast, sea urchin eggs, corn seeds, and human blood. They had been prepared by members of the Army Medical Research Laboratory at Ft. Knox, Kentucky, of the Army Ballistic Missile Agency, and of the Florida State University at Tallahassee. Even though these experiments may not have as much public appeal as the monkeys, they will prove very valuable for our understanding of life functions in outer space.

You may have realized so far that the Army, in addition to its development of tactical Redstones, Jupiters, and Pershings, pursued a very lively program of space exploration during the past years. What are the plans for the future? Right at this moment, the next satellite-launching Jupiter, sponsored by NASA, is being checked out in Patrick for a take-off later this month. Again, the solid propellant upper stages were provided by JPL. The vehicle will carry an 80 lb satellite, equipped with solar batteries, and filled with more scientific instrumentation than any other U. S. satellite carried so far. Geiger counters and scintillation detectors, prepared by Van Allen, will record the

intensity, the energy, and the nature of the corpuscular radiation found at 300 to 400 miles altitude. An ionization chamber will detect and analyze heavy nuclei in the cosmic radiation. It was designed by Dr. Groetzinger from the Martin Company, but he will not be able to see the success of his work: Dr. Groetzinger died a few weeks ago; his experiment will be conducted by his friends, Dr. Pomerantz and Dr. Schwed. The resonance emission of solar hydrogen, commonly known as Lyman - α radiation in the deep ultra-violet, will be measured by an ionization chamber of high selectivity developed and built by Dr. Friedman from the Naval Research Laboratory. A similar chamber, designed to respond to much shorter wave lengths, will detect solar X-rays. Both detectors will hopefully record radiations through periods of increased solar flare activity. A fourth experiment, designed by Dr. Suemi from the University of Wisconsin, will measure the various amounts of heat radiation which are emitted by the sun and by the earth, reflected by the earth, and backscattered by the atmosphere. Knowledge of these different amounts of heat will greatly help us to understand the energy balance of the earth's atmosphere. Another experiment will record the impacts of meteorites. Prepared by Dr. LaGow from NASA, it consists of a photo cell, covered by a thin foil of metal. When a meteorite pierces the foil, sunlight will fall upon the cell, whose output current is then proportional to the size of the meteor. In spite of its simplicity, this instrument represents an almost ideal integrator for meteor impacts with continuous transmission of the instantaneous readout. Satellite temperatures will be recorded from various places near the skin and within the instrument package. The satellite will transmit three



IGY-PAYLOAD
·ABMA·

SCALE: 0 1 2 3 4 5 6 INCHES

FILE NO. 902-1
23 JUNE 1958

frequencies: 20, 40, and 108 mcy; aside from their use for tracking and telemetry, these radio signals will be analyzed with regard to the ionospheric structure between satellite and ground.

It is hoped that the solar batteries will keep the satellite in operation for a number of months, possibly a year. The excellent success of the solar battery on Vanguard I encourages us to foster this hope.

Another satellite to be launched with a Jupiter booster in August will carry a thin-walled mylar sphere of twelve foot diameter. The sphere, covered with aluminum and inflated in orbit, should be easily visible to the unaided eye during dawn and dusk. Its main purpose will be to support the study of radio and radar reflection effects. Besides, the very high drag-to-weight ratio will make this sphere a sensitive tool to measure atmospheric densities at high altitudes. The sphere has been developed by O'Sullivan from NASA.

Late this year, a small satellite will be launched into an elliptical orbit which reaches out to about 60000 Km. Equipped with Geiger counters by the Van Allen group and with solar cells for long-time operation, this satellite will record variations in the intensities and the magnitudes of the radiation belts.

Three more satellites, boosted by Jupiter missiles, are scheduled for 1960. The first, to be equipped by the Army Ballistic Missile Agency, will transmit six different, but phase-related frequencies for ionospheric studies. The second, instrumented by NASA, will measure ion densities and electric fields surrounding the satellite; the third, with instruments developed by MIT, will detect γ- radiation from the sun, and from other

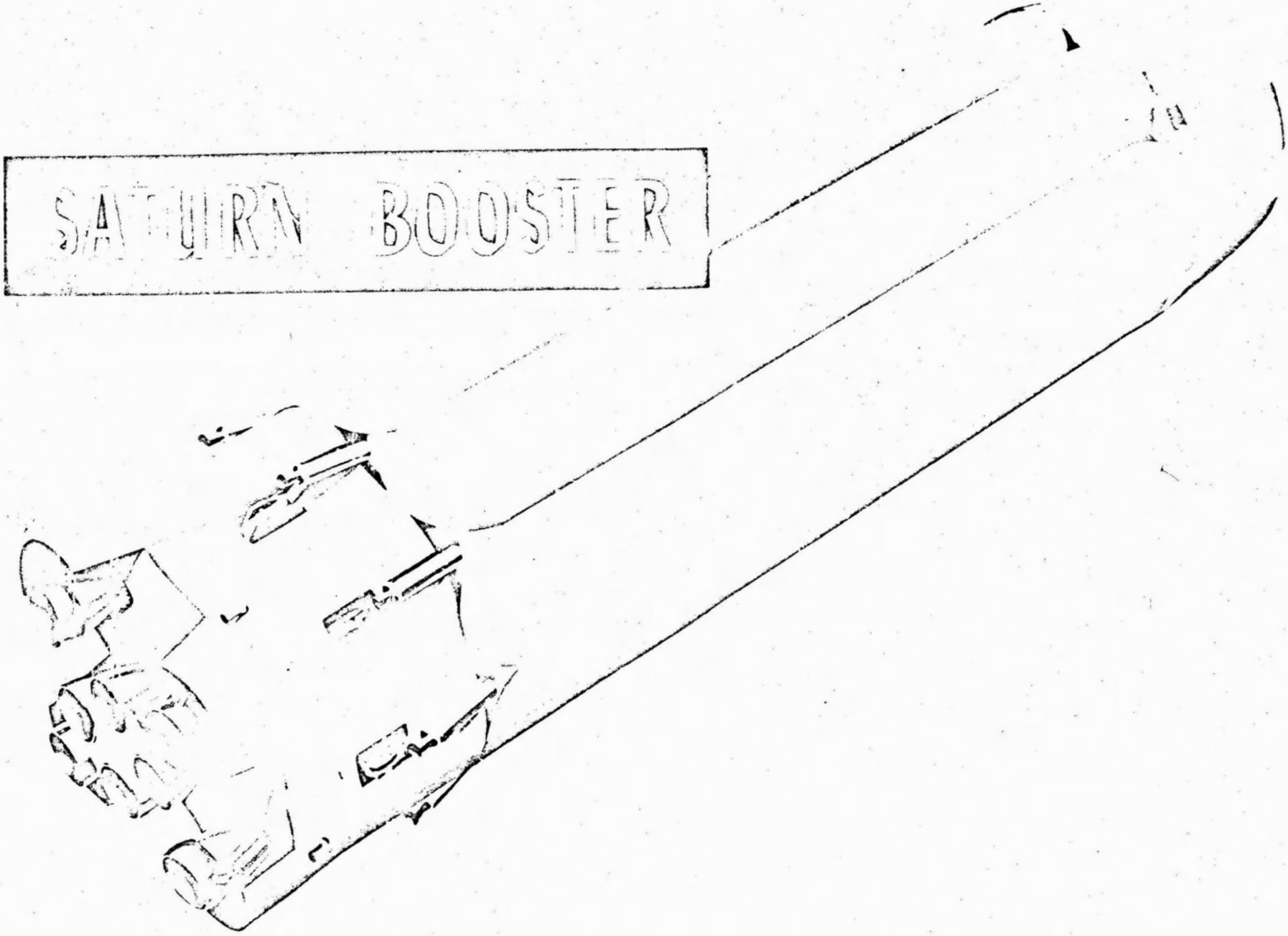
sources in the sky.

Under the auspices of the Advanced Research Projects Agency, the Army Ballistic Missile Agency is presently making studies for a large satellite to be boosted into a 22,000 mile high, 24 hour orbit by the new one and one half million pound Saturn vehicle. With a Titan as a second, and the hydrogen-oxygen Centaur as the third stage, a total weight of 6000 lbs can be put into a 24 hour orbit from an equatorial launching site. This satellite is scheduled to carry communication equipment developed and built by the Signal Corps.

The same combination of a Saturn with a Titan and a Centaur will be capable of carrying 14000 lbs to escape. If designed for a lunar landing with approach guidance system and retro rockets to brake the fall towards the Moon, this vehicle can still land about 1200 lbs of scientific instruments softly on the Moon for lunar exploration. The study for a project of this kind was recently assigned to AEMA by the National Aeronautics and Space Administration. It appears that a first lunar landing could be achieved with this project around 1963 or 1964.

Once the three stage Saturn-boosted vehicle is developed, there will be many other applications for it besides the 24 hour satellite and the soft lunar landing. It can put up to 35000 lbs into low orbits, which makes it very attractive for manned return operations and also for freight transportation into orbit. It can be used for the supply and maintenance of a lunar station or for the operation of a large telescope in an orbit; it can place a satellite of a few thousand pounds around Mars or Venus, and it even can land an instrumented package on one of the planets. It may well be that the Saturn develops into a workhorse

SATURN BOOSTER



GE 8-59
2 JULY59

SATURN VEHICLE
STANDARD FIRST GENERATION

CONFIGURATION "A" & "B"

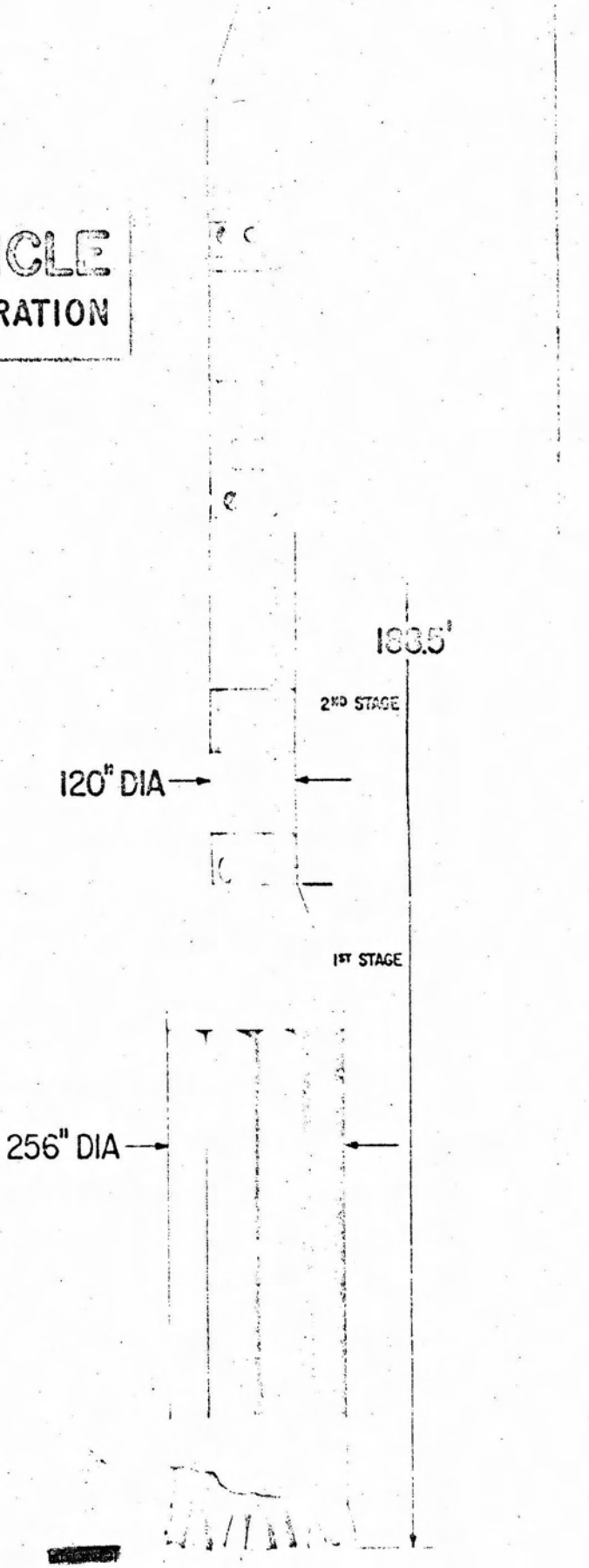


FIG. II

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13 NOV '58

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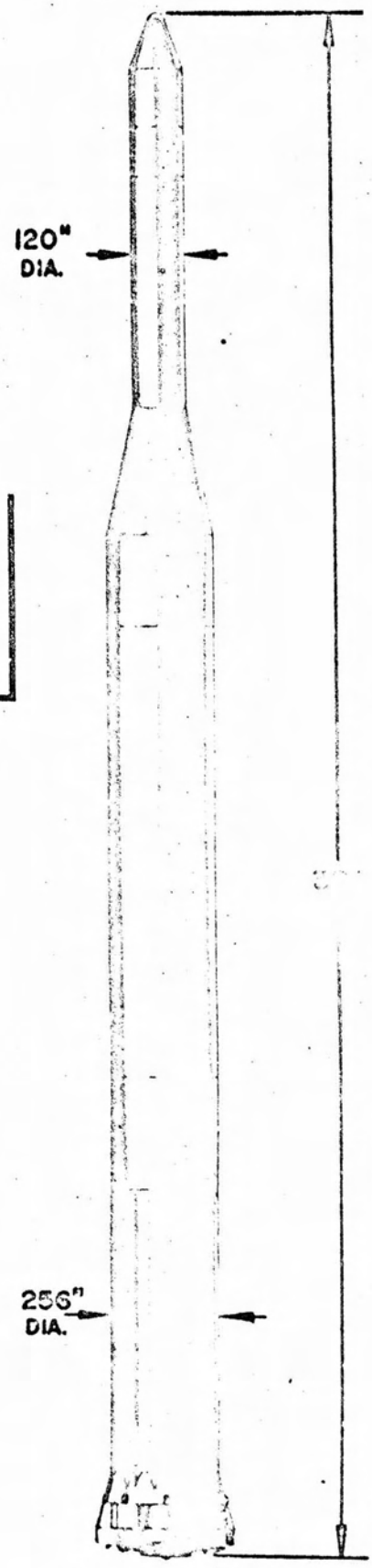
SATURN

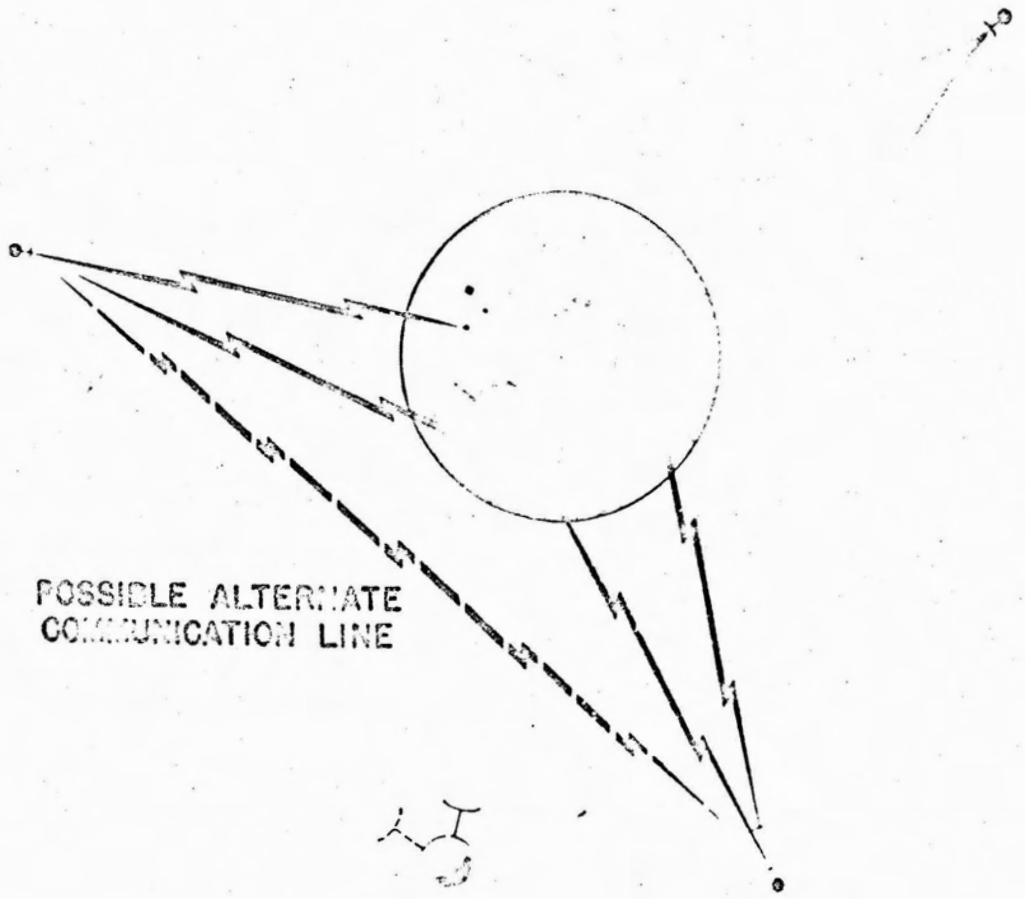


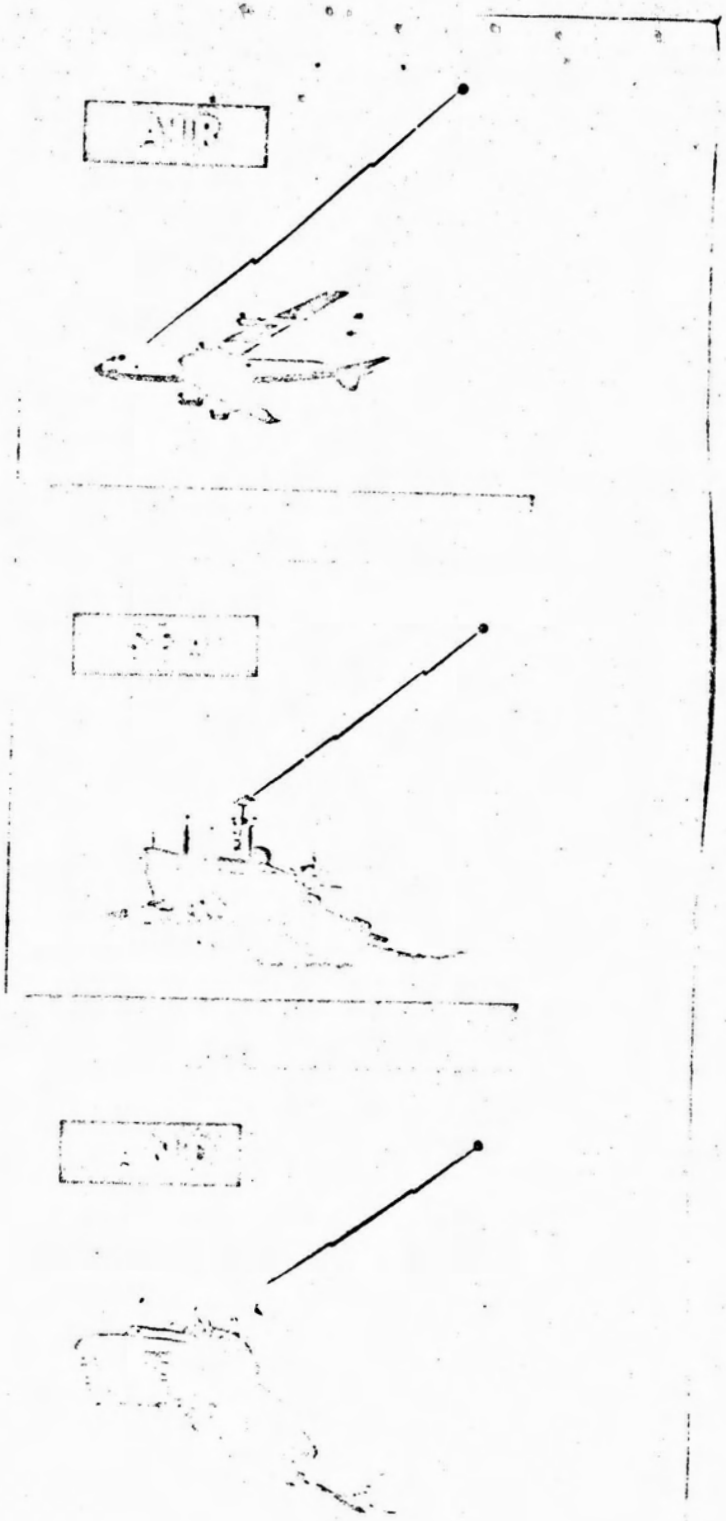
CE 62-2-59
9 MAY 1962

SECRET

LARGE AREA COVERAGE

WORLD WIDE 24 HOUR SATELLITE COMMUNICATION SYSTEM





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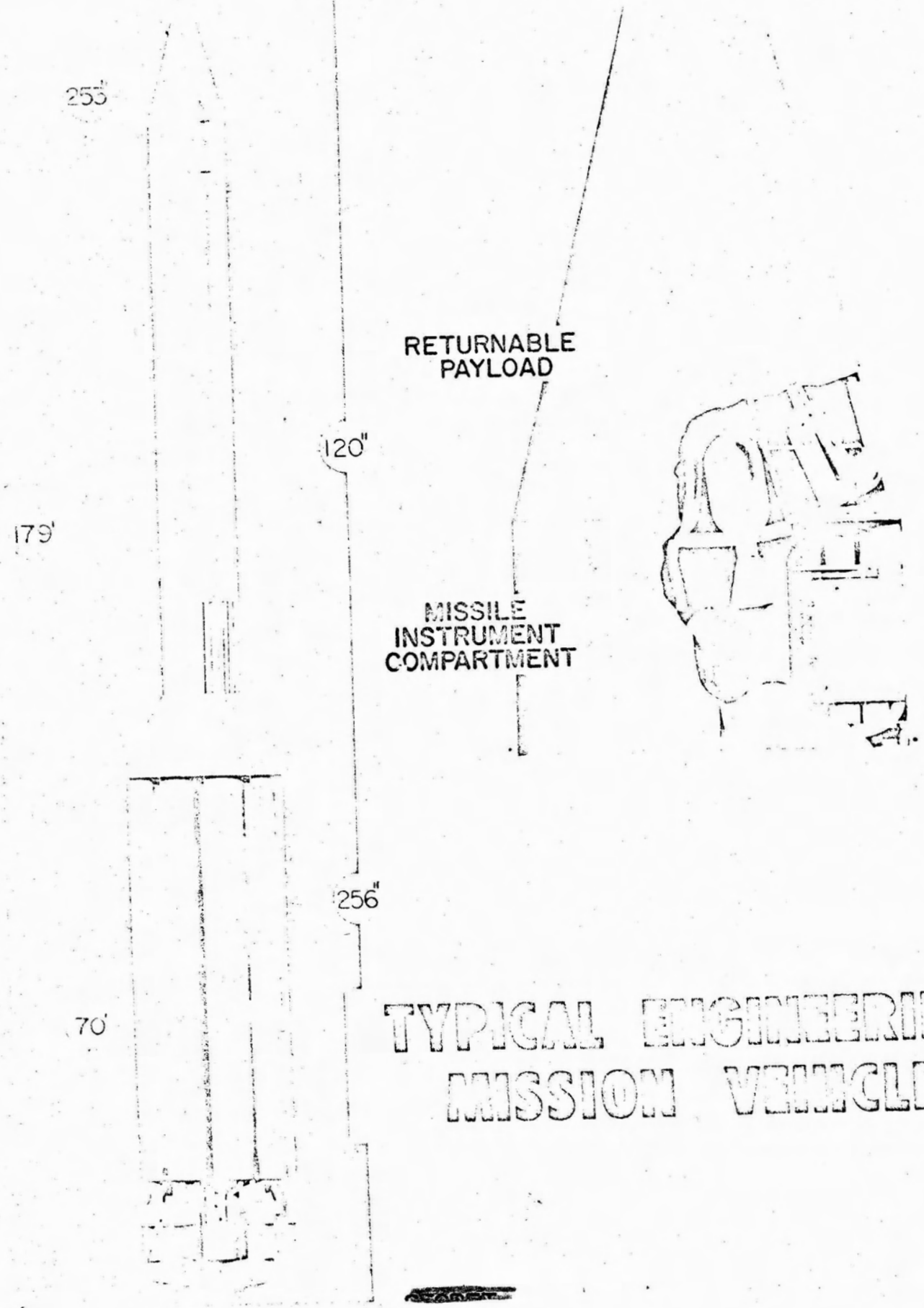
12 MAY 59



TYPICAL ENGINEERING MISSION VEHICLE

GE 54-8-59
8 JUNE 1959

LUNAR SOFT LANDING VEHICLE

GE 47-59 28APR59

EXPERIMENTS FOR ENGINEERING SATELLITE

MATERIAL EXPERIMENTS

- MATERIALS FOR SOLAR MIRRORS
- SOLAR RADIATION EFFECTS ON MATERIALS

MECHANICAL EXPERIMENTS

- H_2O_2 STORAGE EXPERIMENT
- BEARING PERFORMANCE

TEMPERATURE CONTROL EXPERIMENTS

- ACTIVE TEMPERATURE CONTROL DEVICES

MICROMETEORITE EXPERIMENTS

- MICROMETEORITE FLUX DENSITY TEST

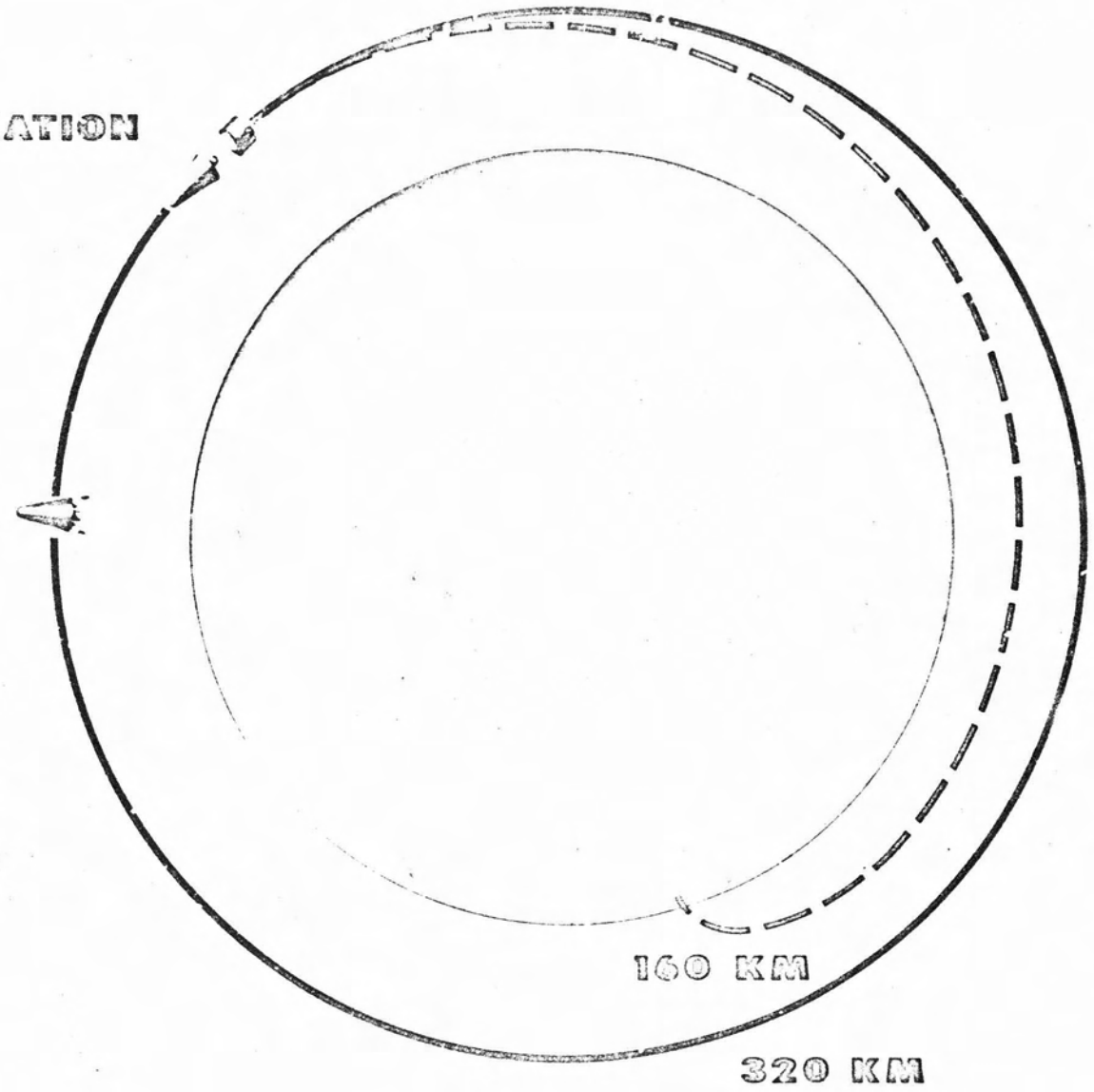
SCANNING (TELEVISION SYSTEMS)

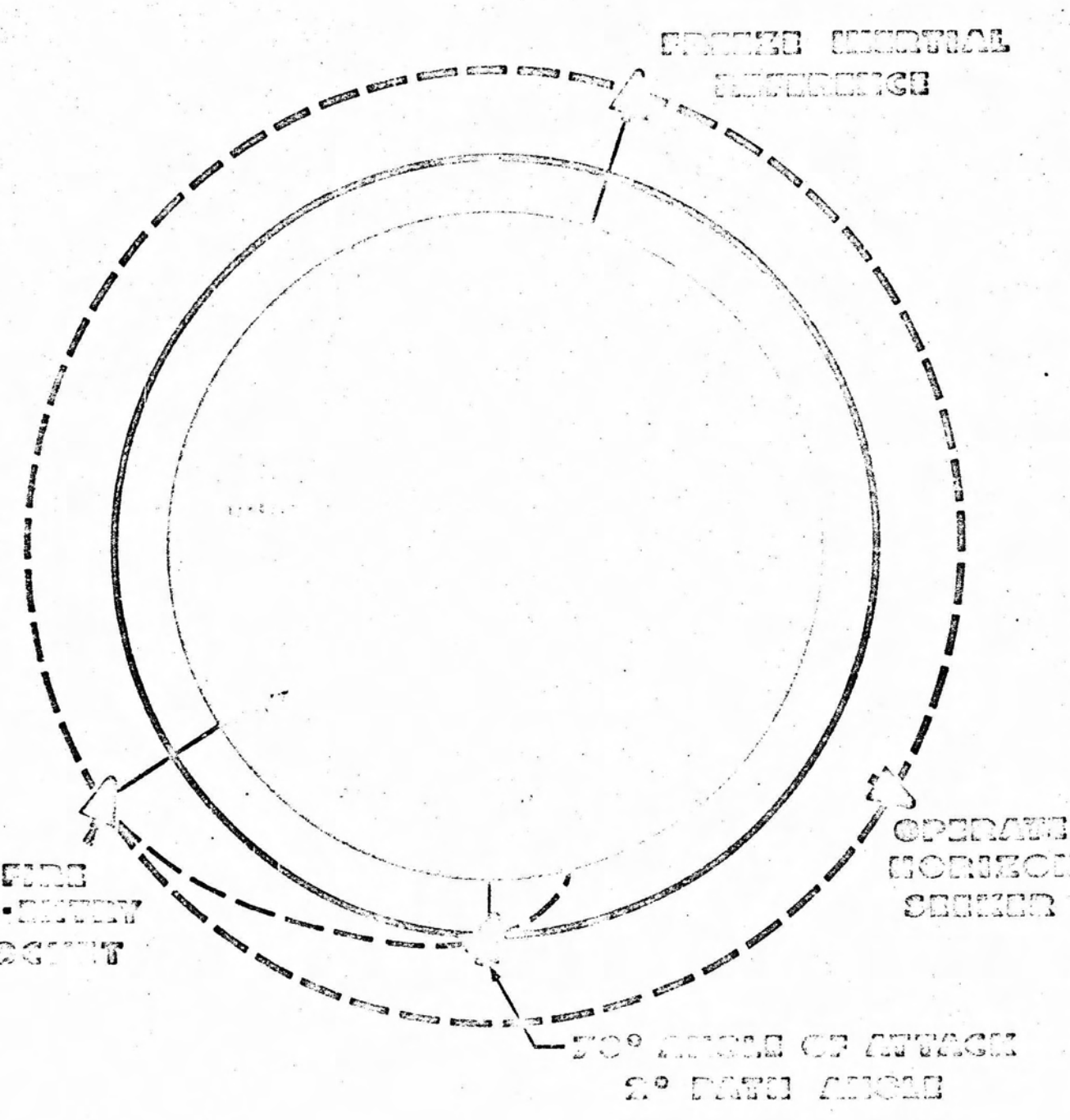
- EXTERNAL SCANNING VISUAL SPECTRUM

GUIDANCE & CONTROL EXPERIMENTS

- FLYWHEEL ATTITUDE CONTROL SYSTEM

OPERATIONAL SCHEME





CZ 83-3-ED. REV. A
15 MAY 83

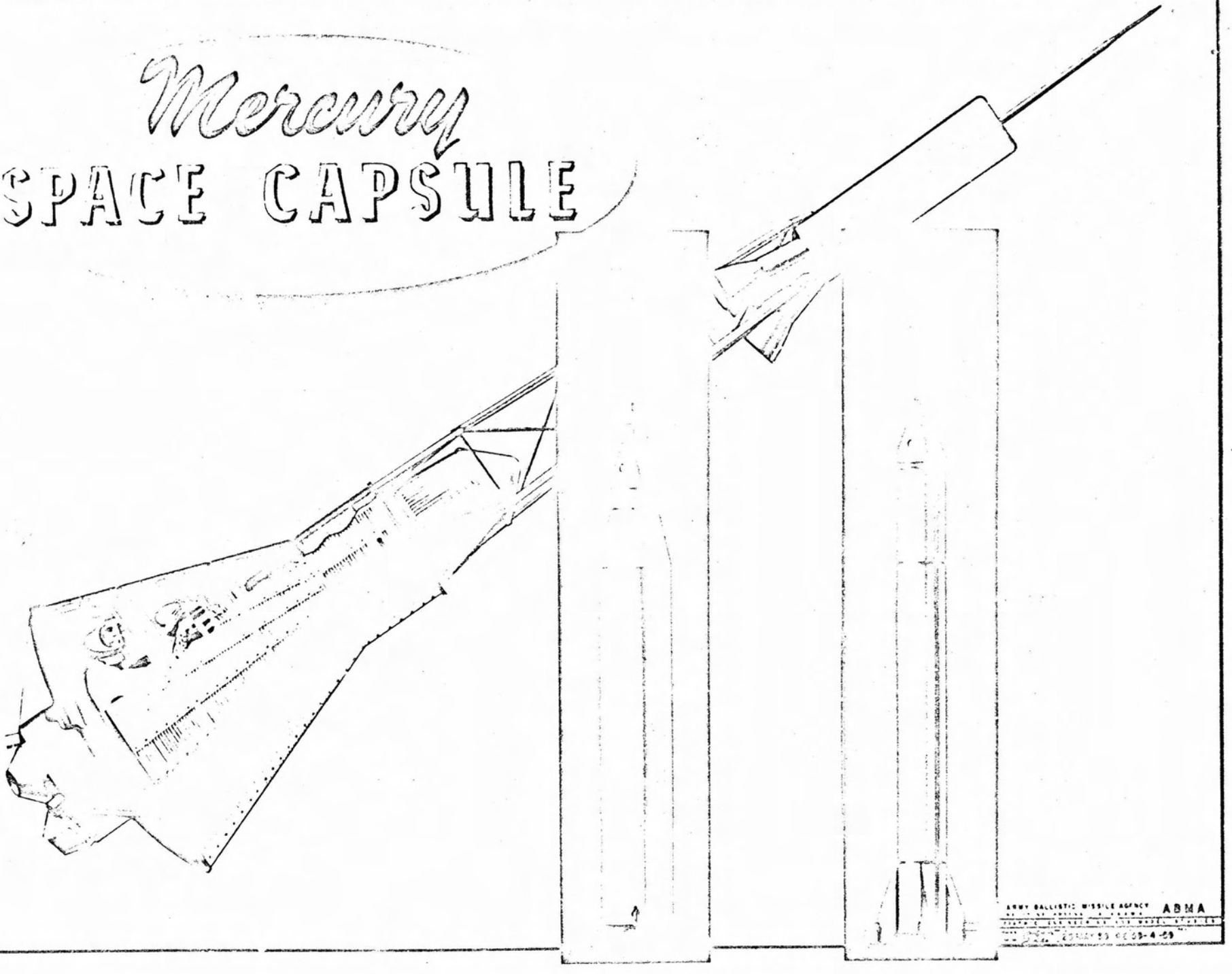
that plays the same role for astronautics that the DC3 played for aeronautics; by the time it is superceded by more modern designs, it has become so reliable and useful that one just cannot afford to get rid of it.

Several months ago, the ABMA was directed by NASA to contribute to Project Mercury. This project will climax in manned satellite operation with, of course, return of the pilot. A number of short ballistic flights are planned prior to orbital flight of the capsule with the man. Eight of the short-distance flights will be made by Redstones, and two by Jupiters. The Redstone missile was selected because of its outstanding record of reliability, and because it is aerodynamically stable. Even if the engine should fail during ascent, separation of the capsule with subsequent recovery could be achieved without difficulty. If the engine of an unstable missile fails, immidiate tumbling is unavoidable, which normally renders safe separation of the forward section impossible.

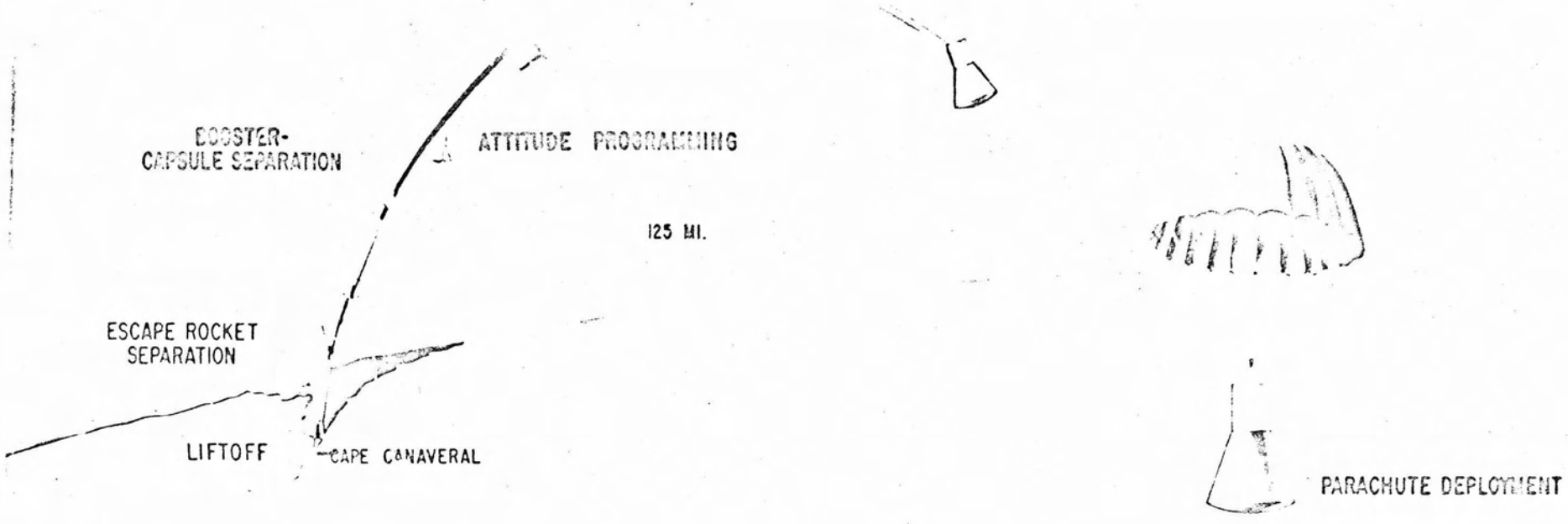
The first two capsules to be flown on Redstones will not contain live passengers; the next two will carry large primates, and probably four will give future human satellite pilots a first impression and feeling of capsule flight under weightlessness. The pilots will have a limited capability of influencing the automatic control by which the capsule is kept in the desired attitude and trajectory. Redstone flights will provide about two minutes of weightlessness, Jupiter flights about 20 minutes; accelerations and decelerations during ascent will go up to eight g's.

The wisdom of exposing a pilot to a short ballistic flight before he boards a satellite has been questioned. However, we feel that the

Mercury
SPACE CAPSULE



ARMY BALLISTIC MISSILE AGENCY ABMA



MERCURY PROJECT

ABMA

ABMA Studies Contributing To The National Space Program

National Integrated Missile & Space Vehicle Development Program

National Space Defense System

Manned Ballistic Transportation Systems

National Deep Space Research Program

Lunar Transportation Systems

Satellite Recovery Systems

Booster Recovery Systems

Equatorial Launching Facility

Nuclear Rocket Propulsion System

Advanced Propulsion Systems for Space Vehicles

Mid-course Navigation for Manned Interplanetary Space Flight

Payload Utilization for Orbital and Space Vehicles

Mission Requirements for U.S. Space Program

Materials Research for Space Application

Supporting Research for a National Space Program

Physics of the Atmosphere and Ionosphere

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chances for a full success of the first manned satellite flight will be much better if it is preceded by a few manned ballistic flights over shorter distances. The functioning of capsule equipment, the efficient handling of manual controls, the use of instruments for observations, the operation of the recovery system, are functions which will certainly undergo countless improvements after each single flight. The need for many of those improvements will show even during short ballistic flights. Why then should not a number of such short flights, which are much safer for the pilot and much less costly than satellite flights, precede orbital launchings?

Before I end this presentation on Army contributions to the National space and satellite program, I would like to say that in none of these projects the Army was alone. In each of them, we enjoyed the help and brilliant cooperation of other services. When we fired the first American V-2's back in 1946, the Navy prepared and operated the telemeter. The Explorer satellites were tracked by the Navy Minitrack Systems. Explorer IV carried instrumentation from the Navy and from the Air Force. Our nose cone recovery operations are joint ventures with the Air Force, the Navy, and the Marine Corps. All of our Florida launchings are accomplished under the splendid hospitality, and with the most efficient support, of the Patrick Air Force Base under Major General Yates. There is not one member in our Army team who would not have a whole handful of very close and sincere friends in the Air Force and in the Navy, friends of whom we are very proud, and without whom we could not have achieved our past successes, nor will we be able, I believe, to accomplish the projects which are ahead of us. For this most powerful and efficient friendship we are very grateful.