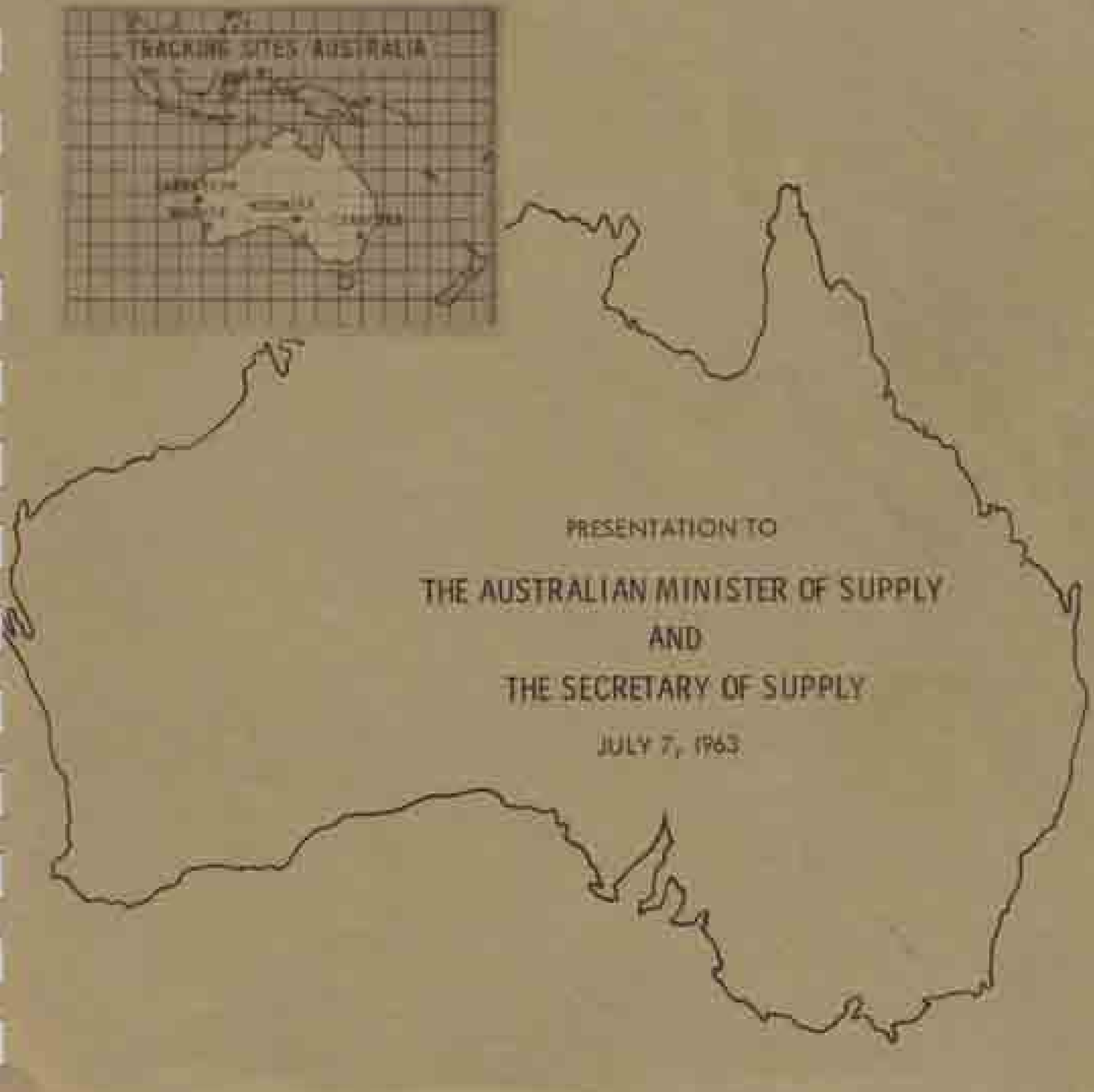
OFFICE OF TRACKING AND DATA ACQUISITION



PRESENTATION TO

THE AUSTRALIAN MINISTER OF SUPPLY
AND
THE SECRETARY OF SUPPLY

JULY 7, 1963

OFFICE OF TRACKING AND DATA ACQUISITION

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PUBLISHED BY:

The Office of Tracking &
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NASA Headquarters
Washington 25, D. C.

Forward

The following material was developed by the Office of Tracking and Data Acquisition for presentation to the Australian Minister of Supply on July 7, 1963.

Contents

TRACKING AND DATA ACQUISITION
REVIEW

Office of Tracking and
Data Acquisition
July 7, 1963

INTRODUCTION

Mr. Buckley

Minister Fairhall, Secretary Knott, Gentlemen:

It is with real pleasure that I welcome our distinguished visitors from Australia, the people who have been intimately involved in our efforts to provide appropriate tracking and data acquisition support in Australia for the NASA space program. Last year we became aware, because of our expanding program in Australia, that there should be discussions between our two agencies with regularity. There have been many visits to Australia by NASA personnel in connection with these new stations; however, we thought it would be most beneficial if those in Australia in charge of the program had an opportunity to become better acquainted with NASA's program, its organization, its Field Centers, and the people who run its day-to-day business.

With this objective in mind, we have prepared a briefing which is intended to provide a description of the NASA program as it relates to the tracking and data acquisition support, with special emphasis upon the role of Australia.

This briefing, incidentally, will be about an hour and 15 minutes, broken into three parts: the first will cover the Scientific and Applications Satellites; the second, the unmanned lunar and planetary aspects; and finally, the manned flight program. Although the talks will emphasize the ground support systems associated with each of these areas, of which the facilities in Australia are a part, we will precede each of the talks with some description of the projects and the spacecrafts which provide the requirements that result in the ground network.

We will begin with the Scientific and Applications Satellites. This will be given by Mr. Brockett. As Minister Fairhall and Secretary Knott know, Mr. Brockett has spent considerable time recently in Australia.

SCIENTIFIC & APPLICATIONS SATELLITES

BROCKETT: Thank you Mr. Buckley. I would like to briefly describe that part of the Space Exploration Program using unmanned earth satellites and the ground support that they require. These include the smaller satellites of the Explorer class, many of which are in orbit today, and which have provided the bulk of scientific measurements in space to date. They also include the Meteorological Satellites such as TIROS and NIMBUS that provide TV cloud coverage photographs and infrared measurements which aid in understanding and forecasting the weather. Also included are the Communication Satellites such as Relay and Syncom, and the planned Observatory Satellites. In terms of ground support required, we have divided these satellites into three groups.

There are, first, the small satellites launched primarily by Scouts and Thor-Deltas. They are tracked by the Minitrack stations such as the one in Woomera. They transmit relatively small amounts of data in contrast to the observatories that will be discussed later. The relatively modest telemetry facilities at the Minitrack station are used to acquire scientific information from them.

The second group are the Meteorological and Communication Satellites. They are also tracked by the Minitrack stations, but to obtain the experimental data from them, we must use special ground stations not part of the Minitrack. For example, for Relay, the television experiments that were carried on between here and Europe used the U.S. AT&T facility at Andover, Maine, and cooperative stations including those in England and France. For TIROS, in order to obtain the cloud cover pictures obtained, special ground stations are required. There are two of them, one of which is located at Wallops Island, Virginia, and the other at Point Mugu, California, at the Pacific Missile Range.

The third group of satellites is the planned Observatory Satellites. These are the second generation scientific satellites and much larger than the present Explorer class. Tracking will still be basically provided by the Minitrack stations but the large volumes of data that will be transmitted from them require high gain, large antenna facilities. I'll describe these satellites in more detail later, but first I will briefly cover the Minitrack stations.

Shown in Fig. 1 are the 13 stations of the Minitrack network. Basically we have a north-south fence from North America to South America. This gives us primary coverage for lower inclination orbits. The stations at Woomera and South Africa provide additional coverage needed for vital information for southern hemisphere measurements. Stations in England, Canada, and Alaska provide coverage for higher inclination orbits and polar orbits. This network is the backbone of the Satellite Network.

Fig. 2 shows a list of the satellites that are being supported by the Satellite Network at this time. There are 20 of them. You will notice that they are not all NASA satellites; included are the cooperative programs with Canada and the United Kingdom, plus the Scientific Satellites launched by the Department of Defense.

Turning now to the Observatory Satellites, there are two main points as indicated in Fig. 3 that we had to consider in determining the facilities that were required for support. The first is the large amount of data that we are required to record from them. As I said before, this means that we need high gain antenna facilities and more

PRESENT MINITRACK STATIONS

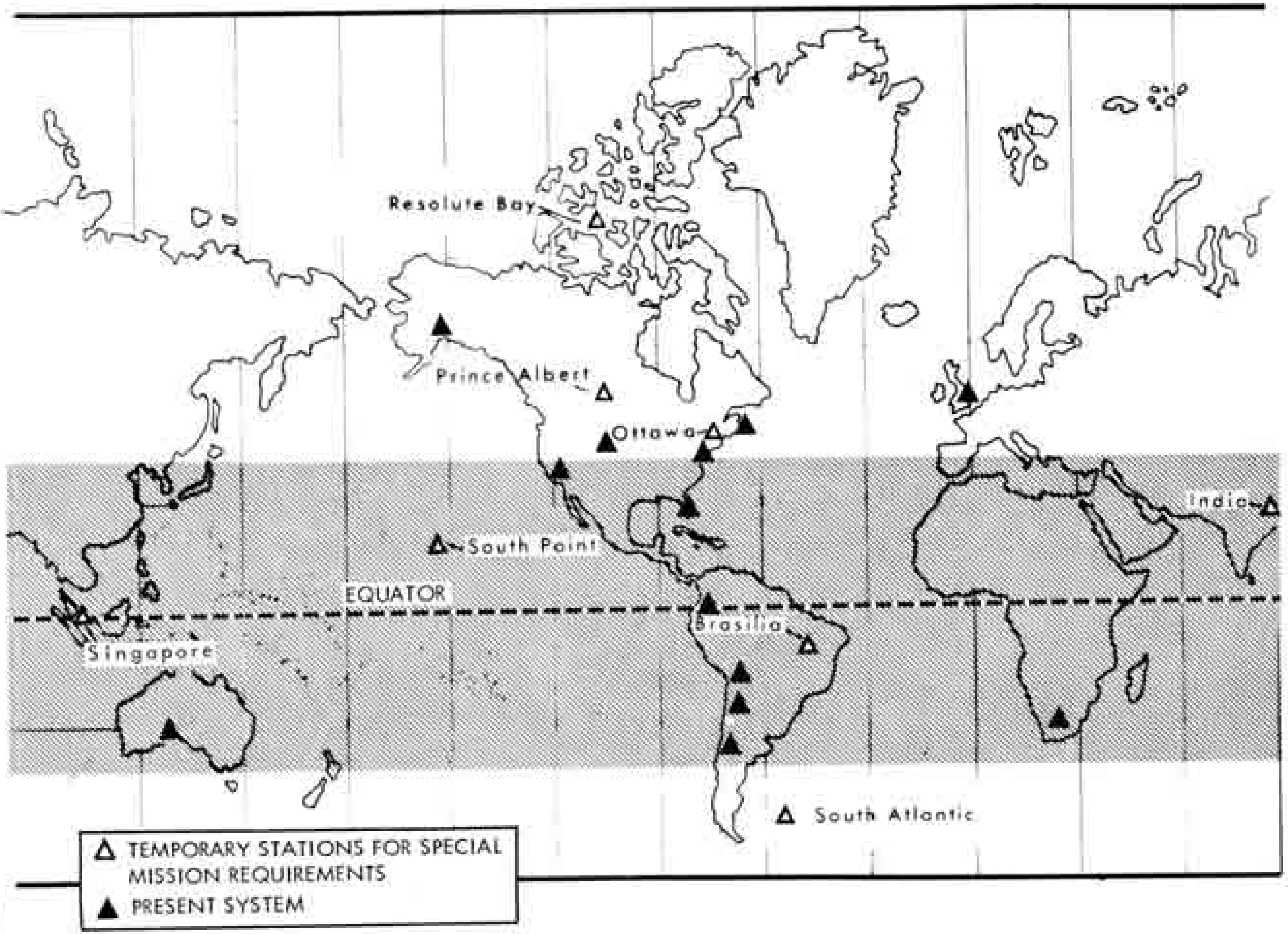


FIG. 1

FIG. 2

SATELLITE NETWORK STATION PARTICIPATION

JULY 10, 1963

VANGUARD I	1958 BETA	NASA
A-11 ECHO I	1960 IOTA	NASA
S-16 OSO I	1962 ZETA	NASA
S-51 ARIEL'	1962 OMICRON	UK/US
A-50 TIROS V	1962 A- ALPHA	NASA
A-51 TIROS VI	1962 A-PSI	NASA
S-27 ALOUETTE	1962 B-ALPHA	CANADA/NASA
S-3A EXPLORER XIV	1962 B-GAMMA	NASA
INJUN 3	1962 B-TAU	DOD
A-15 RELAY	1962 B-UPSILON	NASA
S-55B EXPLORER XVI	1962 B-CHI	NASA
S-6 EXPLORER XVII	1963 9A	NASA
TELSTAR 2	1963 13A	AT & T
TETRAHEDRAL	1963 14 B	DOD
TETRAHEDRAL	1963 14 C	DOD
LOFTI	1963 21 B	DOD
SOLAR RADIATION	1963 21 C	DOD
(NO NAME)	1963 21 D	DOD
TIROS VII	1963 24 A	NASA
GEOPHYSICS SATELLITE	1963 26 A	DOD

OBSERVATORY SATELLITE CHARACTERISTICS

- LARGE AMOUNTS OF DATA RECORDED
  - EXPLORERS - 50 TO 150 DATA POINTS/SECOND
  - OBSERVATORIES - 700 TO 1200 DATA POINTS/SECOND
- DATA STORED FOR READOUT WHEN IN SIGHT OF GROUND STATION.

FIG. 3

complex electronic readout and recording equipment. The other is the fact that the Observatory Satellites are large enough that we have included a significant amount of storage capacity on board. This means that the satellites can collect data while in orbit and then, when it comes in sight of a station, the satellite can be commanded and the data transmitted to the station. This allows a certain amount of flexibility in the location of stations. We don't have to have a station located under the satellite when it is making its measurements but rather can wait till a more convenient time (within reason). By studying the requirements for the various satellites, we can combine coverage to some extent and as a result minimize the number of stations required.

Shown in Fig. 4 are the three major orbiting observatories. We have tried to depict the various orbits with respect to the earth. Fig. 5 is an illustration of the Orbiting Astronomical Observatory, or OAO. The OAO is a precisely stabilized satellite designed to accommodate various types of astronomical equipment. It is to perform astronomical studies in those regions of the spectrum that cannot be seen from the earth because of the atmospheric absorption. The first three Observatories are all concerned with stellar astronomy and the ultra-violet region. The first Observatory will map the sky in three ultra-violet regions and will record the brightness of approximately 20,000 stars. The second one will contain a 36" cassegrain telescope in conjunction with a spectro-photometer to obtain spectro-photometric data on selected stars, nebulae, and galaxies. The third will contain equipment for quantitative observations of the absorption spectrum of the interstellar gas. Fig. 6 is intended to indicate the orbital paths of the OAO.

ORBITING OBSERVATORIES

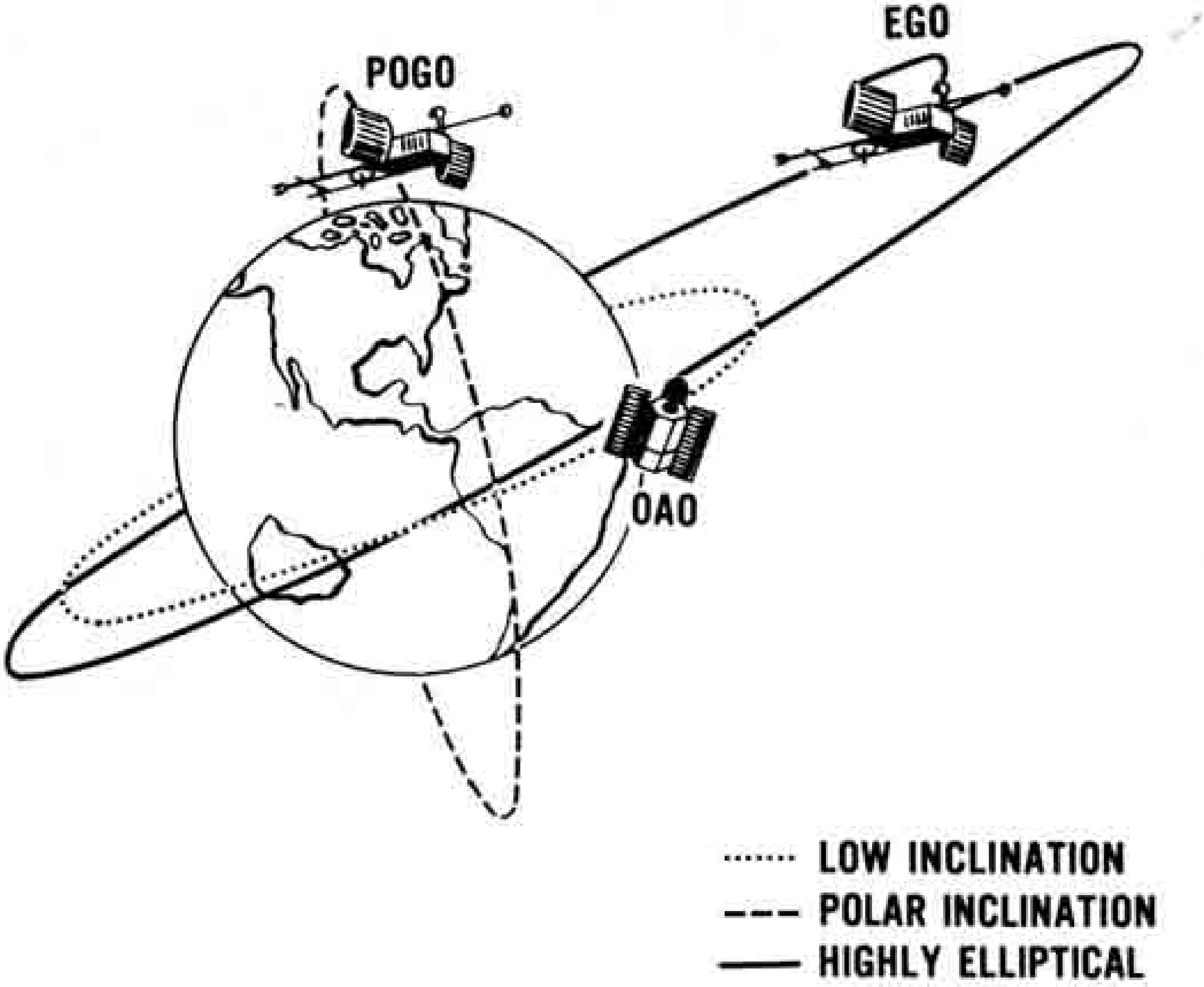
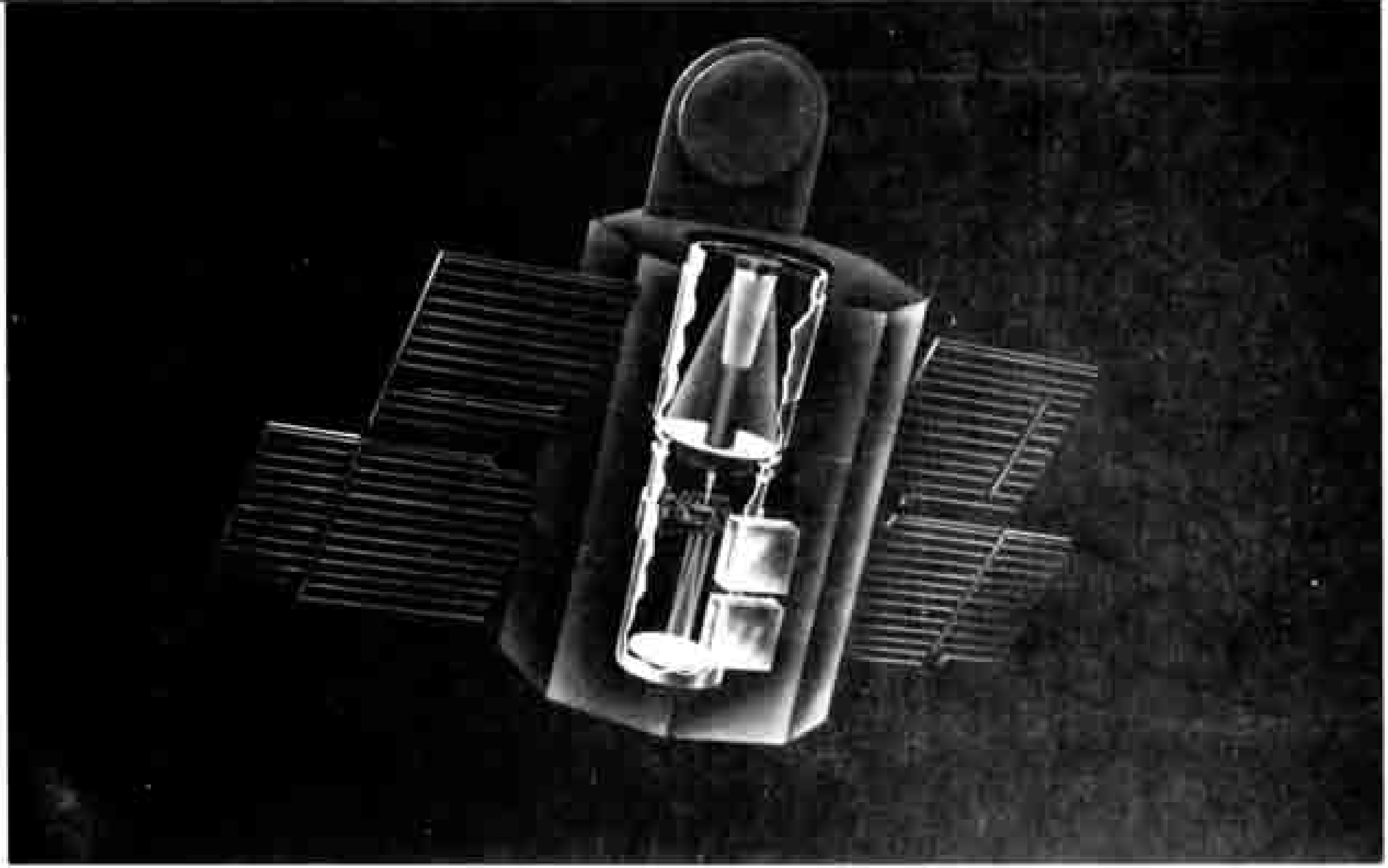


FIG. 4

ORBITING ASTRONOMICAL OBSERVATORY

FIG. 5



NASA SD61-1295

LOW INCLINATION

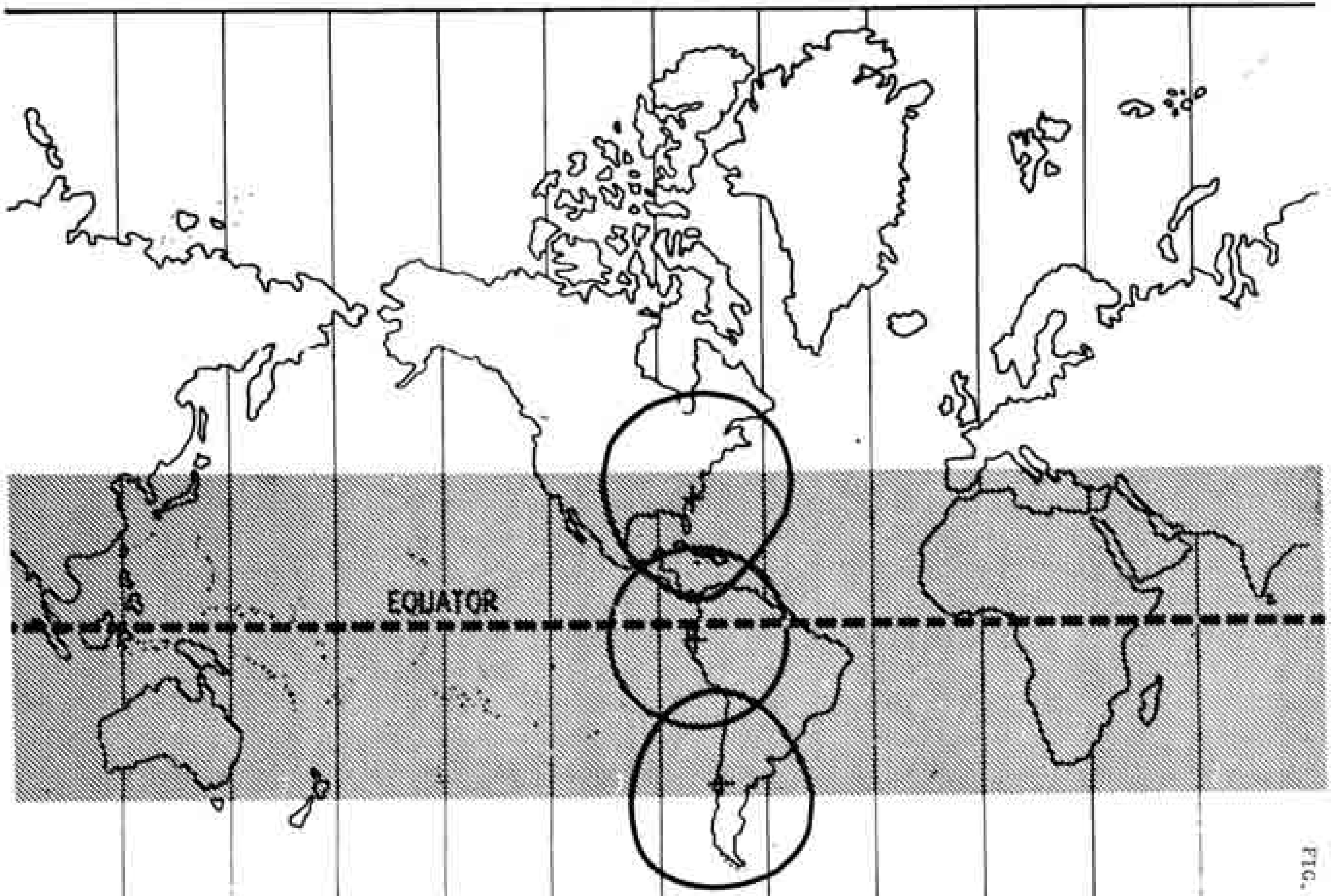


FIG. 6

The dark band indicates the northern most and southern most excursion of the satellite around the equator. One of the ground support requirements is to have one contact per orbit for the satellite. By locating stations in the U.S.; Quito, Ecuador; and Santiago, Chile (the circles indicate the coverage that can be provided); you can see that we can get one contact per orbit. So what we have is a north-south fence that the satellites must pass through once each orbit.

The other class of Orbiting Observatories is the Orbiting Geophysical Observatory, or OGO. These observatories are capable of accommodating 30 or more experiments for conducting scientific studies in various orbits from near-earth to lunar space. Two types are planned, as shown in Fig. 7. The EGO or the Eccentric Geophysical Observatory will be launched from AMR using an Atlas-Agena; the perigee will be approximately 170 miles, the apogee about 70,000 miles. The purpose is to investigate primary cosmic radiation in the outer Van Allen radiation belts, the earth's magnetic field, and the transistion regions to the interplanetary field in plasma.

The other type of Observatory is the Polar Orbiting Geophysical Observatory, or POGO. It will be launched from PMR using a Thor-Agena in a fairly low Polar Orbit of 160 perigee, 570 miles apogee. It will emphasize the investigation of the phenomena of the Polar regions including the Arora activities, low energy cosmic rays, the earth's magnetic field, and the ionosphere. For the EGO type satellite, which has an apogee of 70,000 miles, on the ground it appears much like a deep space probe rather than a satellite. It spends much of its time above synchronous altitude and the earth just turns underneath

ORBITING GEOPHYSICAL OBSERVATORY

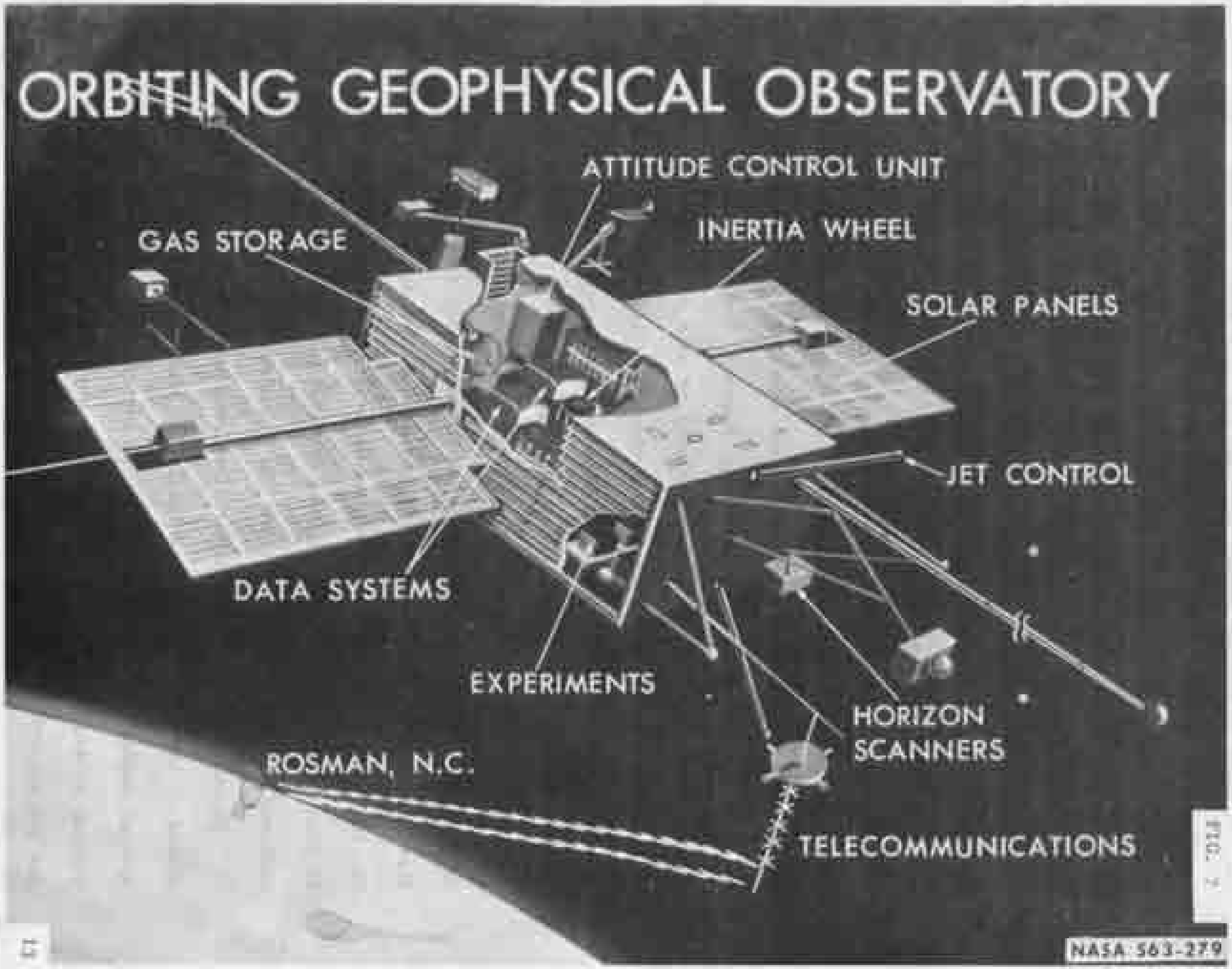


FIG. 2

it. In order to provide apogee coverage for this then, you need longitudinal coverage. We plan to use the station in the United States and the proposed Data Acquisition facilities in Canberra as shown in Fig. 8. These are the two stations and they will both be 85' facilities.

Now for the POGO, the Polar Orbiting Satellite, coverage is shown in Fig. 9. You are looking down at the North Pole. Shown are a typical set of orbits covering one day.

Now the darker circles show the coverage of the Alaskan station plus the station in the United States. The faint arcs indicates those passes that are actually contacted by the stations. The two darker arcs are the ones that cannot be seen. However, the satellite will have storage capability aboard and we will be able to acquire a great majority of the data not picked up on those particular orbits. There also may be one of the other facilities described earlier that might be able to pick up at least one of the passes.

Fig. 10 is a summary of the facilities for the Observatory Satellites. You notice the one in the United States is supporting all three classes. I didn't mention it before but we also have requirements for the coverage of EGO perigee which occurs in the Southern hemisphere. We plan to use the proposed Canberra DAF station, the two South American stations and the 40' antenna shown for Johannesburg.

In conclusion, I would like to indicate the present and future status of the Satellite Network facilities that we see today with special emphasis as far as Australia is concerned. For the Minitrack station at Woomera it appears to us that we will have continuing need for the support of the station indefinitely. We don't plan any

HIGHLY ELLIPTICAL

FIG. 8

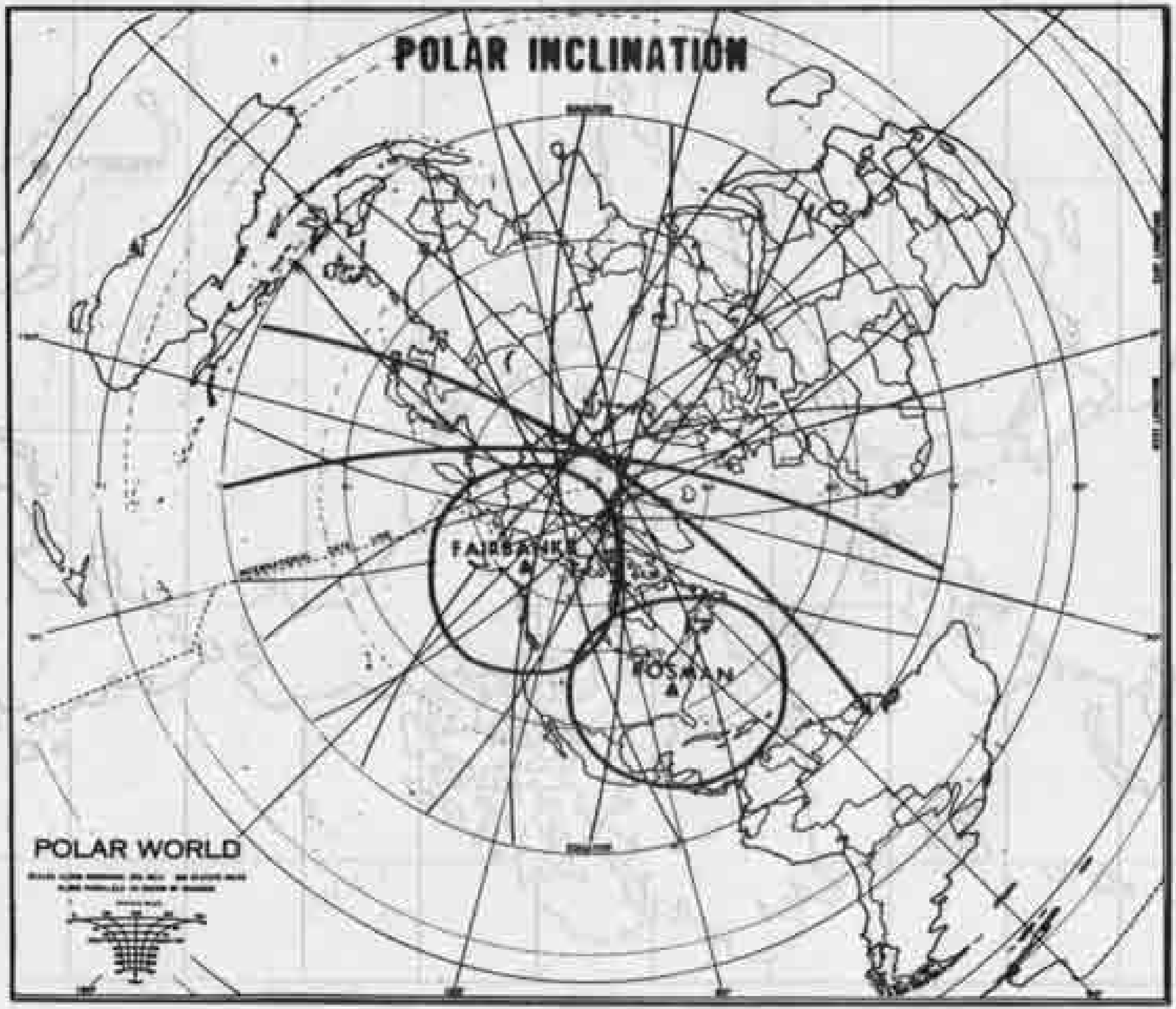


FIG. 9

PRIMARY FACILITIES FOR OBSERVATORY SATELLITES

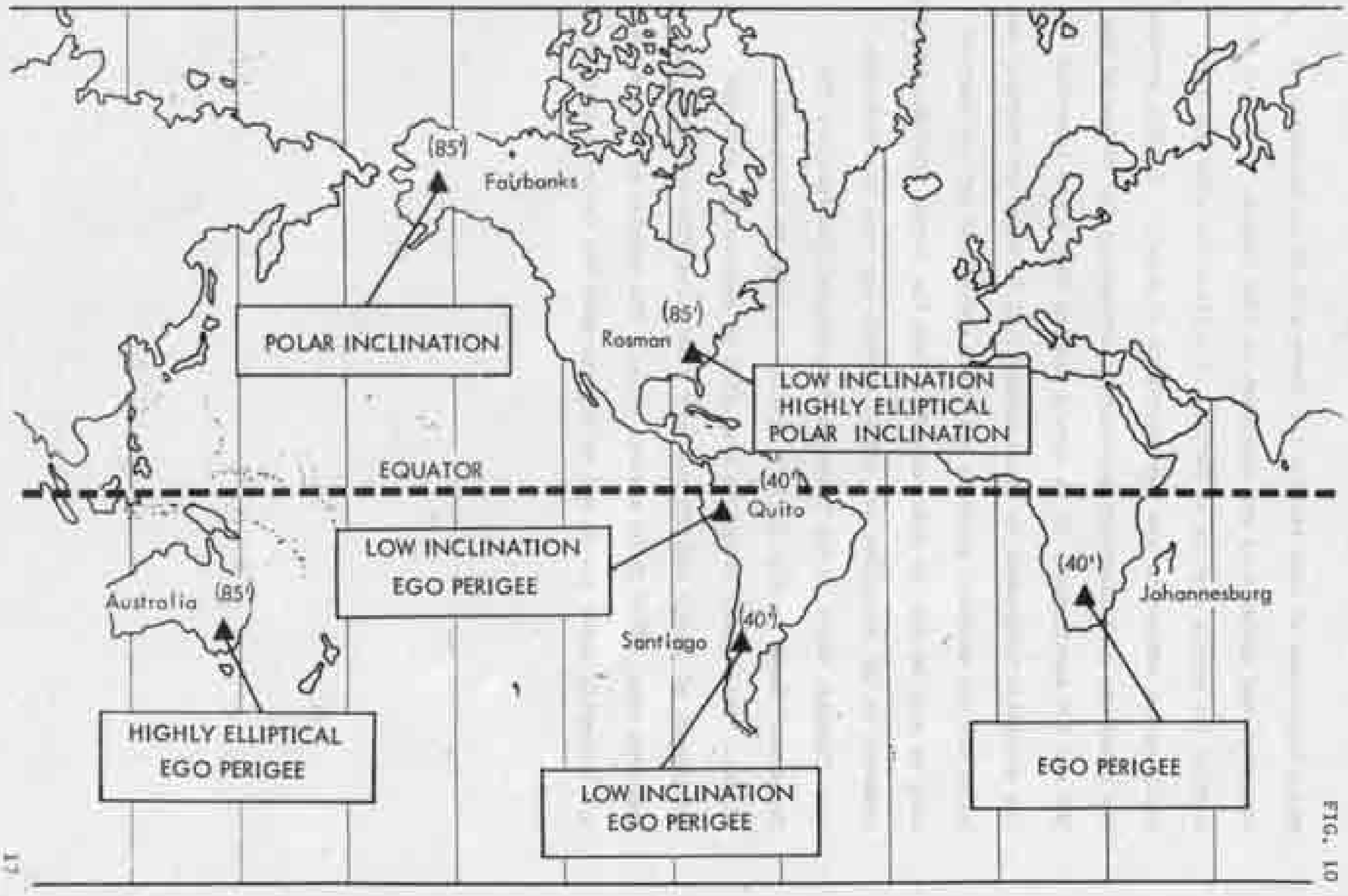


FIG. 10

major expansions of this station but there will be an up-dating of equipment and undoubtedly new equipment as time passes. I failed to mention the mobile station at Darwin. I believe the site has been fully agreed between us and the Department of Supply. It will provide the immediate post insertion information concerning the status of the OAO and EGO satellites. If it should develop that after insertion the automatic programmer on board should fail to function properly and booms are not extended properly and other operations are not carried out, we will be able to determine this from the Darwin station, and send commands to the satellite and try to correct any such malfunctions.

Finally, there is the proposed Data Acquisition Facility for Canberra. Shown in Fig. 11 is a similar facility at Fairbanks, Alaska. The present status is that GSFC in cooperation with the Department of Supply and WRE has made a detailed site survey in the Canberra area. They found several sites. The results of this survey are presently under review and we hope to make the decision very shortly.

FIG. 11

UNMANNED LUNAR AND PLANETARY SPACECRAFT

BUCKLEY: The next area we would like to talk to you about is the unmanned lunar and planetary spacecraft. Mr. Gerald Truszynski, Deputy Director of the Office of Tracking and Data Acquisition will describe that part.

TRUSZYNSKI: Thank you Mr. Buckley. One of the NASA's major efforts is in the area of lunar and planetary exploration. I would like to describe briefly these programs and the facilities required to collect data from missions of this type.

As far as the lunar program is concerned, there are three major projects for lunar exploration with unmanned spacecraft. All of these have three major objectives: (1) To survey likely landing areas for the manned landings to be accomplished later, (2) To obtain data on the lunar environment also in direct support of the manned landing, and (3) To obtain scientific data about the moon and its origin.

The first slide (Figure 1) illustrates the Ranger Spacecraft. I am sure you are familiar with the type of mission we have planned to date with this type of vehicle. This, you may recall, was initially the project for rough-landing a capsule on the Moon to obtain seismic data. The project has been reoriented, (Figure 2) and its primary objective now is to obtain high-resolution T.V. pictures of the Moon's surface as the spacecraft approaches, prior to crashing. No landing capsule is planned during this part of the project. However, the capsule may be incorporated into later flights with seismic devices, penetrometers, or a scanning T. V. camera all being considered as possible passengers in the capsule.

RANGER

FIG. 1

MISSION: LUNAR IMPACT
WEIGHT: 750 POUNDS
LAUNCH VEHICLE: ATLAS/AGENA
STATUS: OPERATIONAL

NASA 563-690

RANGER CAPABILITIES

HI RESOLUTION TV PACKAGE

PHOTOFACSIMILE CAPSULE

- 3,250 PICTURES OF SURFACE WITH A FINAL RESOLUTION APPROACHING ONE FOOT
  - AREA TOPOGRAPHY
  - SURFACE TEXTURE
  - EXPLORATORY LANDING AREA RECONNAISSANCE
- 360° PANORAMIC PICTURE OF SURFACE WITH A RESOLUTION OF 0.1 INCH.
  - FINE DETAIL OF SMALL AREA
  - SURFACE MATERIALS
  - SURFACE HARDNESS

NASA S63-242

Ranger is launched on an Atlas-Agena vehicle and the next flight is currently planned for later this year.

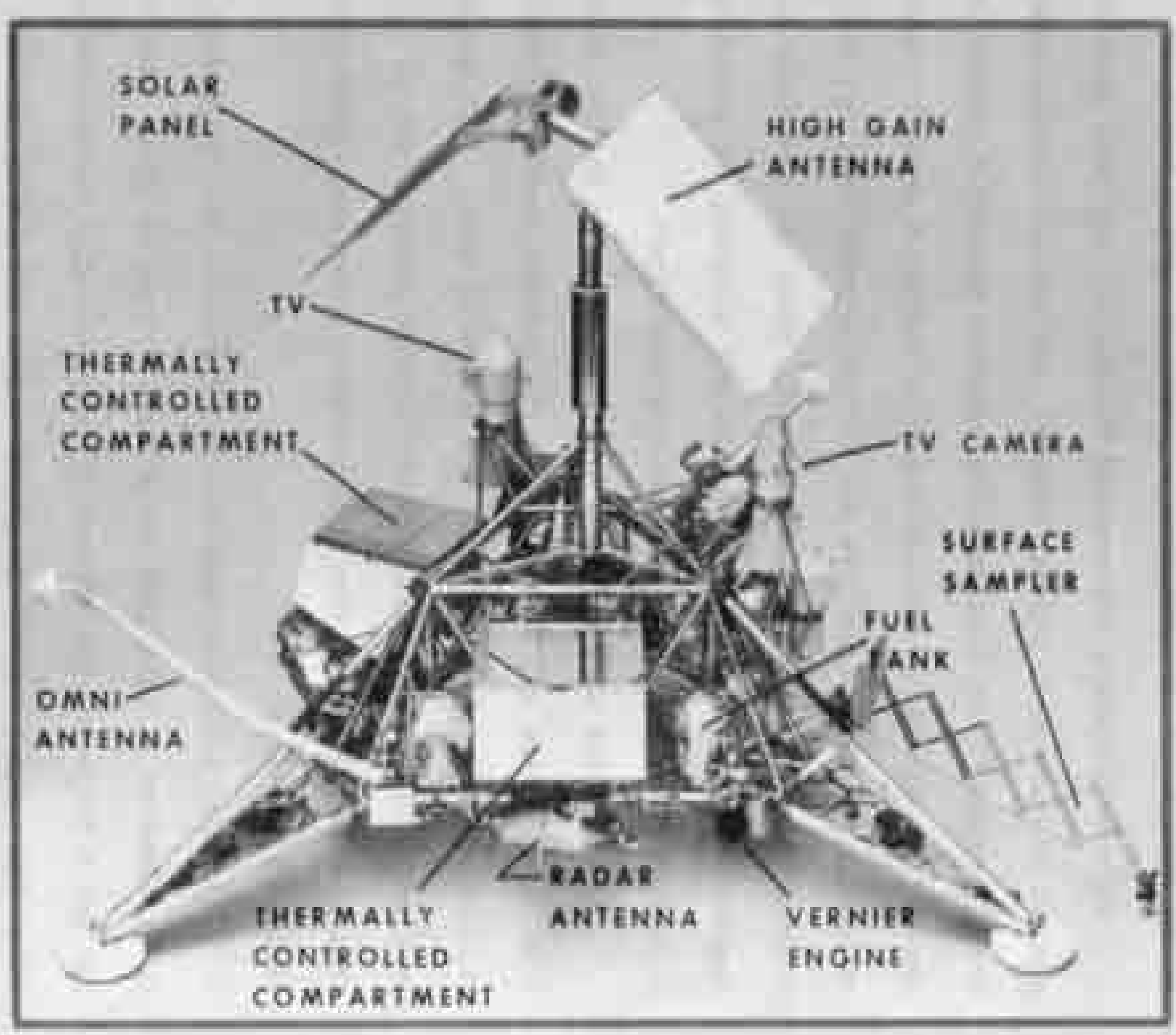
The next slide (Figure 3) illustrates the Surveyor Spacecraft. This is our project for a lunar soft landing to be launched on an Atlas-Centaur vehicle beginning in the 1964-1965 period. Centaur is a new liquid-hydrogen/liquid-oxygen space vehicle now under development.

The Surveyor Spacecraft will carry various scientific payloads, principal among these being two scanning Television Cameras for broad coverage of the lunar landscape. Other instruments will perform experiments in soil mechanics and soil analysis such as hardness, composition, temperature, and radioactivity, etc.

After landing, Surveyor will go through various mechanized operations - for example, the arm and scoop that you see off to the side there, will extend to pick up a sample of the Moon's soil which is then fed by a transport belt past various analytical instruments, the resulting data being telemetered back to Earth. These operations are pre-programmed, but are also monitored and controlled from a control center, this being the Space Flight Operations Facility at our Jet Propulsion Laboratory. Thus, a continuing two-way communications link with the spacecraft will be needed for more or less the full life of the mission -- which is expected to be about 30 days on the Moon.

A lunar orbiter project is also under consideration. The objective here is to make a photo reconnaissance of the entire Moon's surface, to aid in selection of landing sites for up-coming Apollo. The spacecraft will be launched by an Atlas-Agena vehicle. As it reaches the proper distance from the Moon, retro-rockets will be fired to place it in a somewhat elliptical orbit about the Moon with a perigee of 50 to 100

SURVEYOR SPACECRAFT



- **DEMONSTRATE**
  - SOFT LANDING TECHNOLOGY
- **SURVEY**
  - VARIOUS LANDING AREAS
- **MEASURE**
  - PHYSICAL & CHEMICAL PROPERTIES

NASA S63-261

FIG. 1

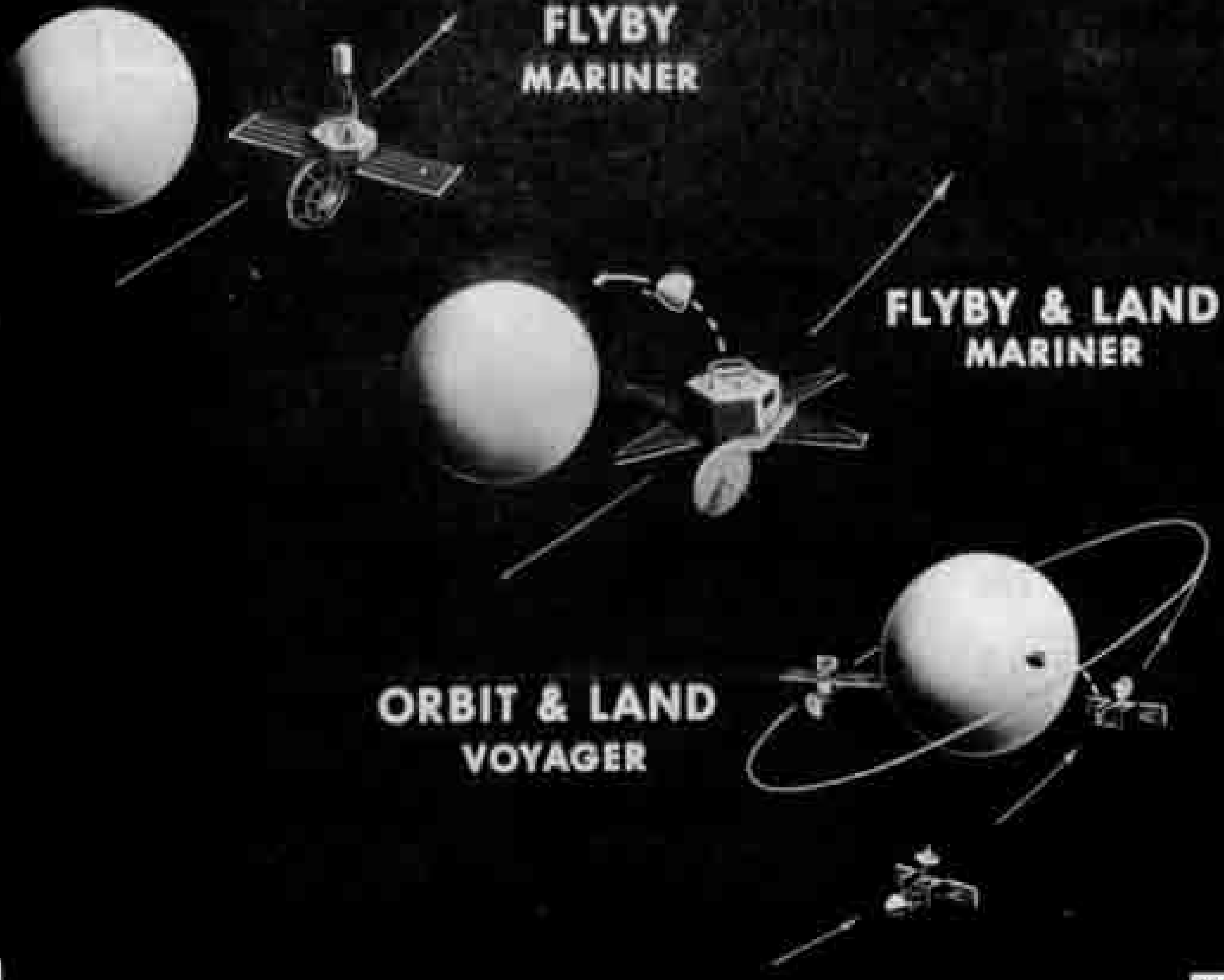
miles and an apogee of several hundred miles. The spacecraft will probably use an actual photographic system, with on-board film processing and facsimile scanner and transmitter, as opposed to a normal television system. In order to keep transmitter power requirements low and at the same time to give good photographic detail, the readout rate will be rather slow, and it may take on the order of a month or so to scan and transmit the pictures resulting from only a few minutes of normal photography. This project thus represents potentially a very heavy workload on the ground data facilities.

For the planetary exploration (Figure 4), our NASA programs are planned in successive phases, namely: the present Mariner series, which are planetary fly-by missions; the proposed Mariner B program which will use the Centaur launch vehicle and will include a capsule lander to enter the planet's atmosphere and survive a rough landing; the Voyager program which is at present in the study phase and envisions a large spacecraft to be launched on a Saturn and to orbit the planet and eject a landing spacecraft from the orbiting spacecraft.

Now the next slide (Figure 5) illustrates the Mariner II vehicle. I am sure you are all familiar with the accomplishemnts of the Venus Mission of last fall, so I will not review it here. This mission was very successful in terms of scientific data obtained and it is likely that the next Venus mission will probably incorporate provisions for a planetary lander.

The next NASA Planetary Mission (Figure 6) will be a Mars Fly-By, to be launched in late 1964 for a Mars arrival in 1965. This is the Mariner C project. The Mariner C spacecraft will be launched on an Atlas-Agena vehicle. The principal spacecraft instrumentation will be a slow-scan TV camera and transmission system and an ultraviolet photo-

STEPS IN PLANETARY EXPLORATION



FLYBY
MARINER

FLYBY & LAND
MARINER

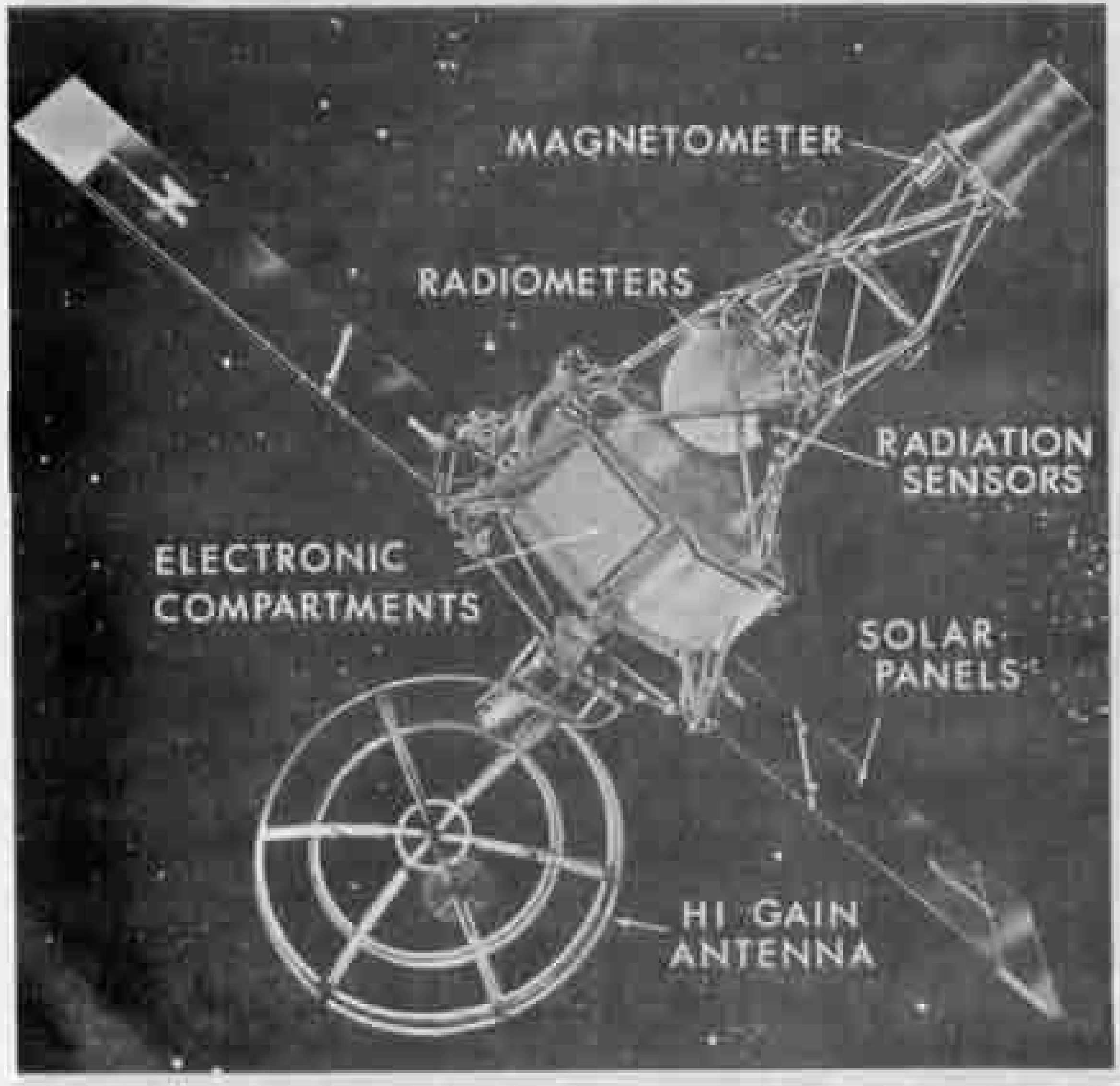
ORBIT & LAND
VOYAGER

NASA S63-282

FIG. 4

FIG. 3

MARINER II



LAUNCHED:
AUGUST 27, 1962

FLEW BY VENUS:
DECEMBER 14, 1962

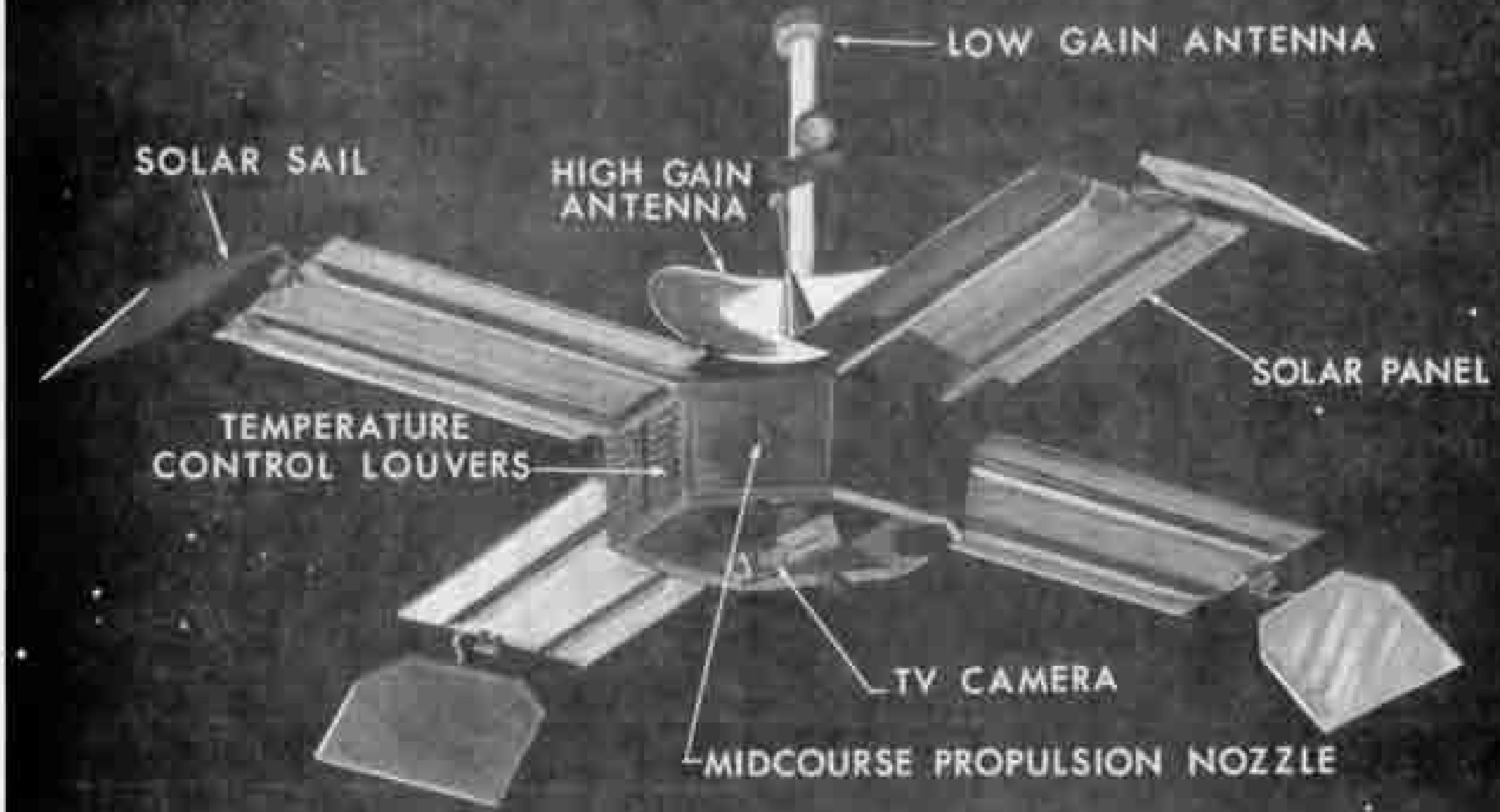
WEIGHT: 447 LBS

41 LBS INSTRUMENTS

- MICROWAVE RADIOMETER
- INFRARED RADIOMETER
- MAGNETOMETER
- PARTICLE RADIATION
- SOLAR PLASMA
- COSMIC DUST

NASA S63-233

MARINER TO MARS — 1964



- MISSION – MARS FLYBY
- WEIGHT – ABOUT 500 LBS
- LAUNCH VEHICLE – ATLAS AGENA

FIG. 6

NASA S63-296

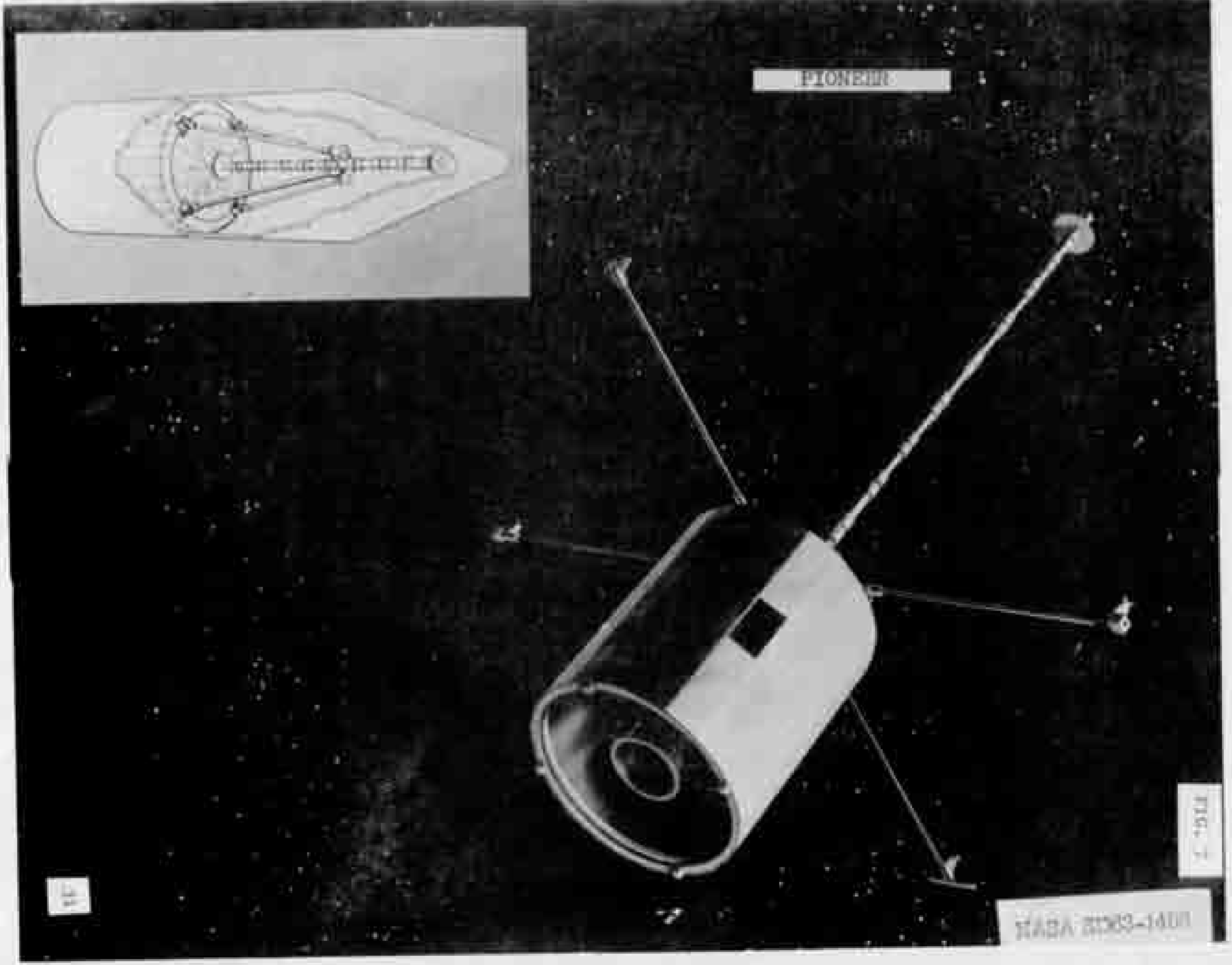
meter. Magnetometers and radiation counters will also be included.

Finally, a very necessary part of the total area of lunar and planetary research is the investigation of the space medium through the use of interplanetary probes. This will be done with our Pioneer series of spacecraft. The next slide (Figure 7) illustrates one of these proposed spacecraft.

This particular spacecraft has the objective of obtaining scientific data on the environment in the general region of the Earth's orbit. The spacecraft will be launched on a trajectory (Figure 8) to carry it either ahead of or behind the Earth in its orbit, to estimated distances of more than 50 million miles during which communications must be maintained. The project is being undertaken as a part of the international quiet solar year program.

Now the next slide (Figure 9) illustrates a composite schedule of all lunar and planetary missions with an indication of the length of time after launch wherein tracking and data acquisition support from the ground facilities is required. As you can see, this represents a rather healthy workload for some years to come.

I would now like to review the ground network which NASA has developed to support these types of lunar and planetary missions. As you know, the Deep Space Network presently consists of three stations distributed geographically as shown on this next slide (Figure 10). Stations are located at Johannesburg, South Africa; Goldstone, California; and Woomera, Australia. These sites are approximately 120° apart in longitude. The inner circle represents the area of coverage for vehicles which are 8,000 miles in altitude with the outer circle

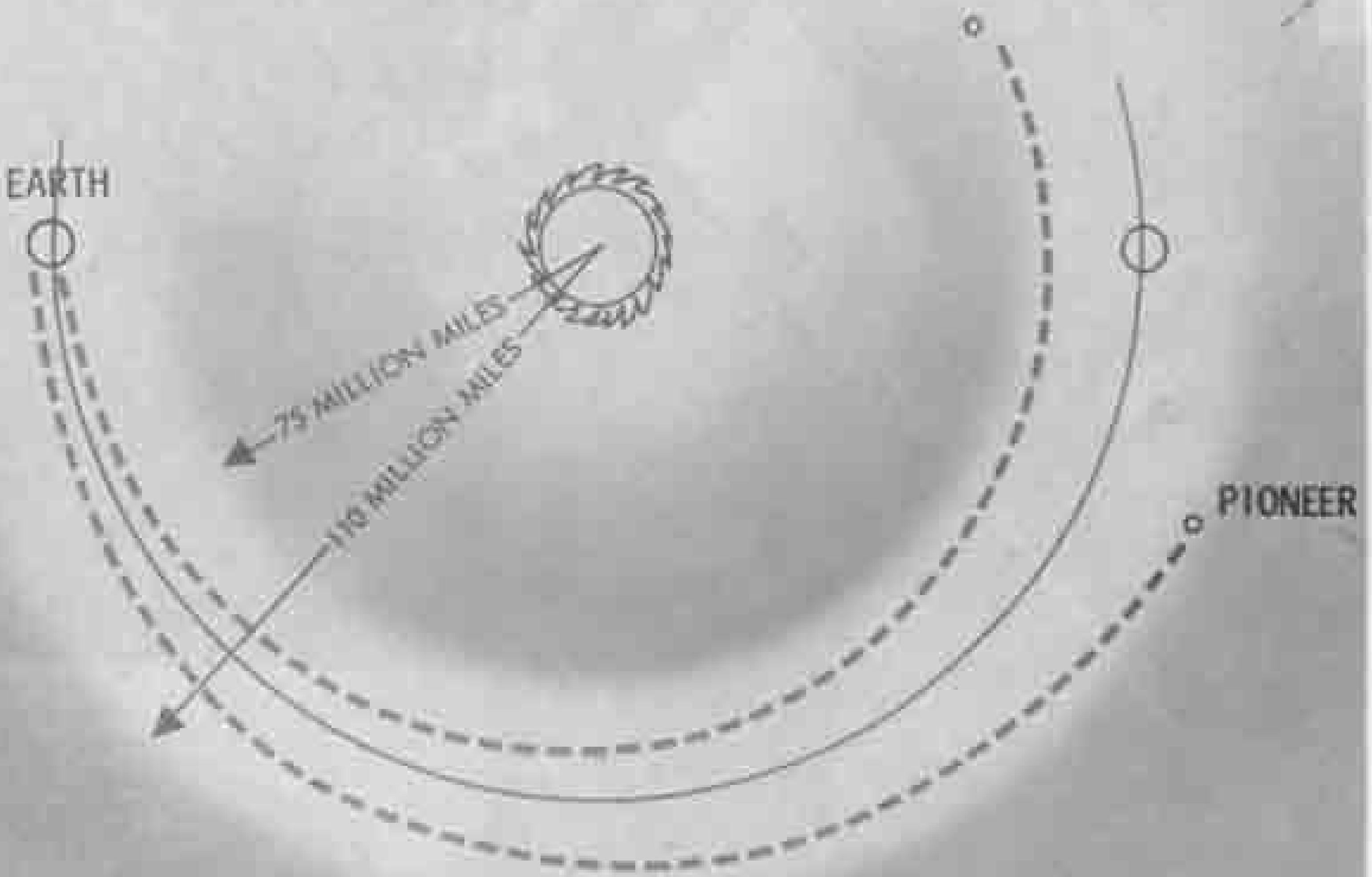


PIONEER

FIG. 7

NASA SC63-1400

PIONEER ORBITS



EARTH-PROBE DISTANCE AT 6 MOS-50 MILLION MILES

DSIF WORKLOAD FORECAST

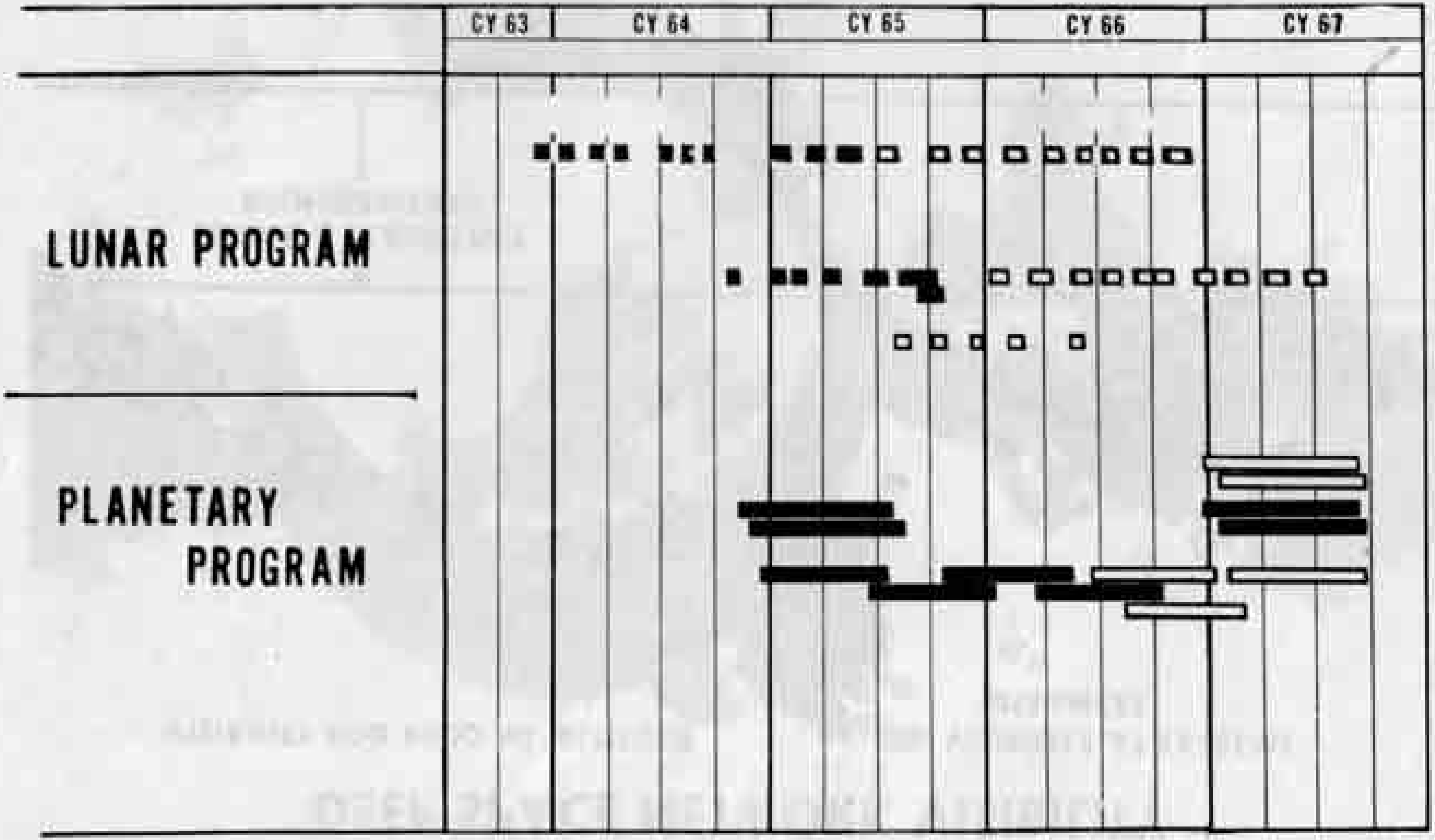
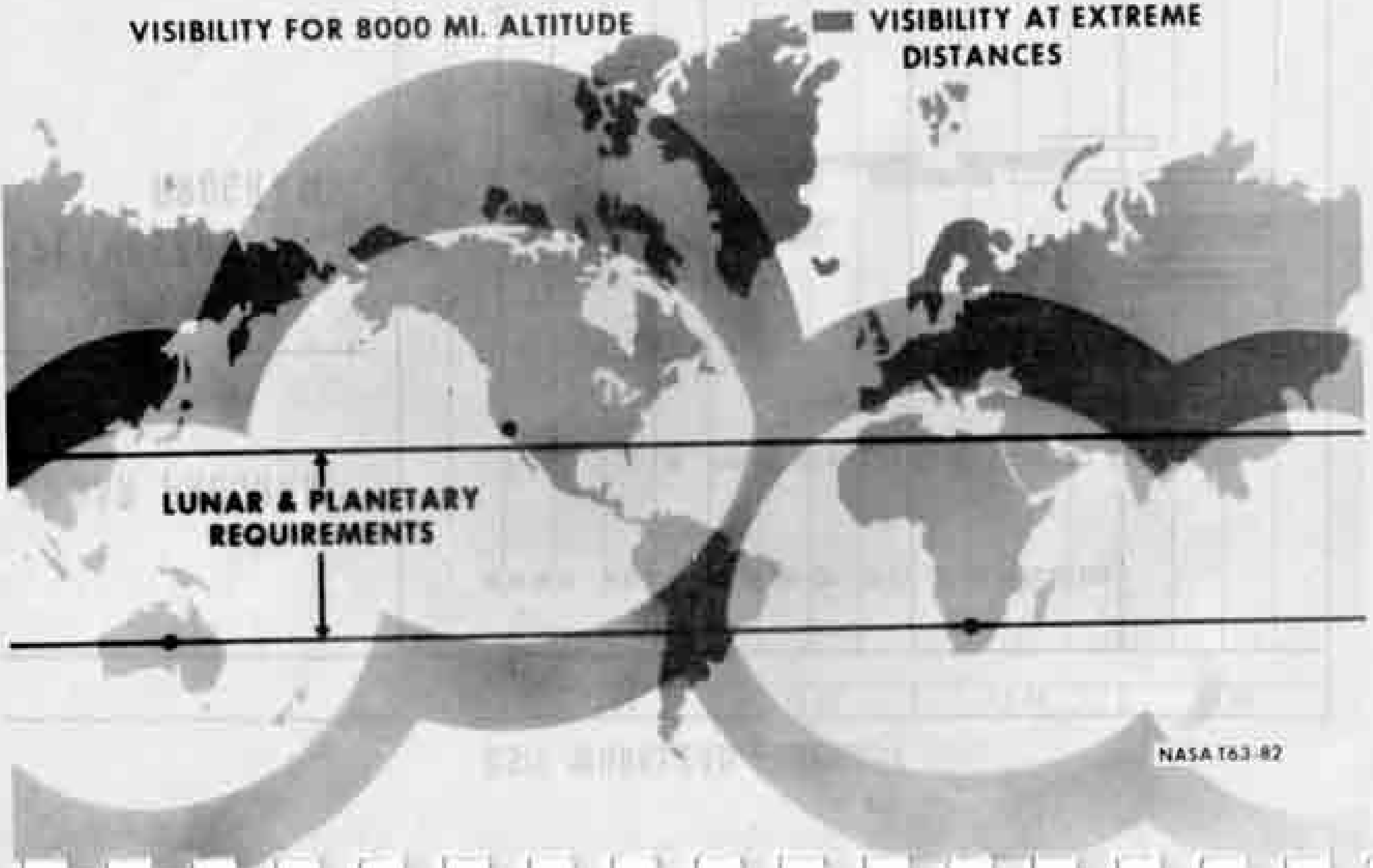


FIG. 9

DEEP SPACE NETWORK VISIBILITY



NASA T63-82

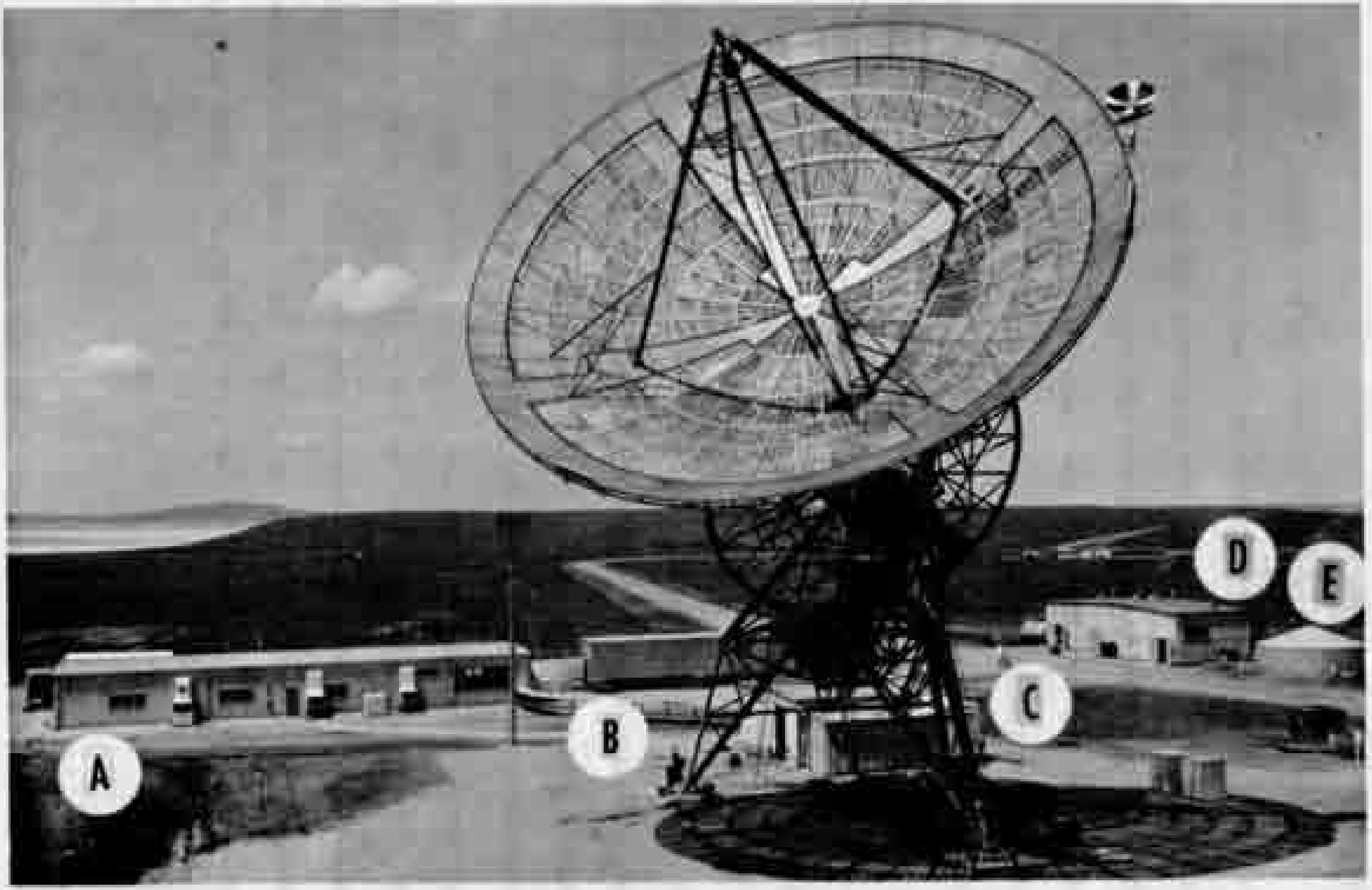
representing the coverage of this network for vehicles at extreme distances. The paths of the Moon and planets all lie within these parallel lines indicated.

The next slide (Figure 11) illustrates the station at Woomera with which I am sure you are familiar. Each of the stations is similarly equipped with an 85-foot parabolic antenna particularly suited to the tracking of lunar and planetary type trajectories. The stations are utilized to track the spacecraft for the purpose of precisely determining its trajectory; to receive the telemetered scientific data from the spacecraft during its ascent and after landing on the Moon or planet, and very importantly, for the transmission of commands to the spacecraft where certain control functions must be performed.

The next slide (Figure 12) illustrates a typical Earth trace of a lunar mission; this particular trajectory is that of the last Ranger flight, namely Ranger V. While the launch azimuth varies with the time of launch and the phase of the Moon, the trajectory shown here is representative. The important thing to note here is that the launch range tracks the vehicle to the end of second burn at which time Ranger is injected into its final lunar trajectory. At this point in space, acquisition by the station at Johannesburg is marginal since the altitude of the spacecraft is still quite low. This means that the Deep Space Net station at Woomera is the first station following injection

DEEP SPACE STATION
WOOMERA, AUSTRALIA

FIG. 11



A. CONTROL BLDG.
B. TRAILER SHED
C. HYDRO-MECHANICAL BLDG.
D. GENERATOR BLDG.
E. WATER TANK

EARTH TRACK OF RANGER V

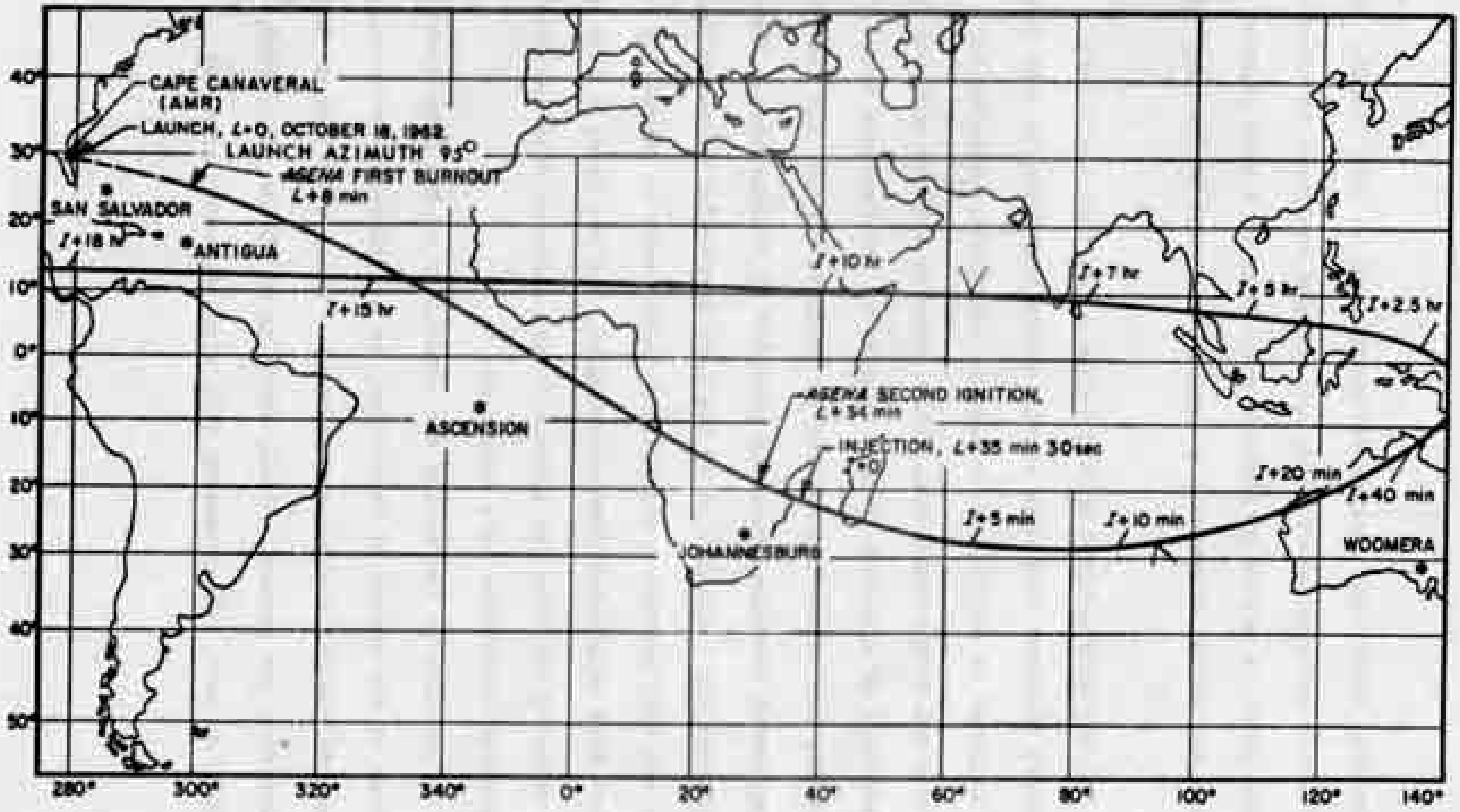


FIG. 12

to acquire, track, and receive telemetry data on this flight. Initial acquisition occurred about here, and Woomera continued to track around to this point, a period of eight hours. This is a good example of why the Australian station is a very critical one in the Deep Space Net.

You may have noticed on a previous slide that the Lunar/Planetary workload increases significantly beginning in late 1964. This increase is sufficient to require additional capacity for tracking and data acquisition. This capacity will be acquired by the addition of a second 85-foot antenna in the Canberra area of Australia, and an 85-foot antenna in Southern Europe, the latter to supplement coverage presently provided by Johannesburg. These are planned for installation by the last quarter of Calendar Year 1964, and will provide a significant improvement in capability to support this particular research program. As you know, a site has been selected for this new antenna in the Canberra area and site preparation activities have commenced.

In addition to increasing the capability of the Deep Space Net in terms of the number of facilities, we are planning technical improvements for all the present stations. These will include conversion from the present L-band, which is at 960 Mc, to S-band, in the 2200 Mc band. Improvements will also be accomplished by installation of low noise maser amplifiers and the installation of cassegrain feeds. In addition, the transmitter output of Woomera is being increased to 10 Kw which will give a full command capability to this station. The total data rate capability from these improvements will be about 30 times the present L-band capability and the entire conversion is scheduled for completion in late 1964. As part of a general increase in capability to handle future planetary programs, particularly with high data rates, an advanced antenna system is being developed. The first prototype is presently under construction and will be installed at Goldstone. The next slide (Figure 13) illustrates a model of this antenna and indicates its size. The system is designed to achieve a tenfold increase in the amount of data obtained at S-band with the present network converted to it.

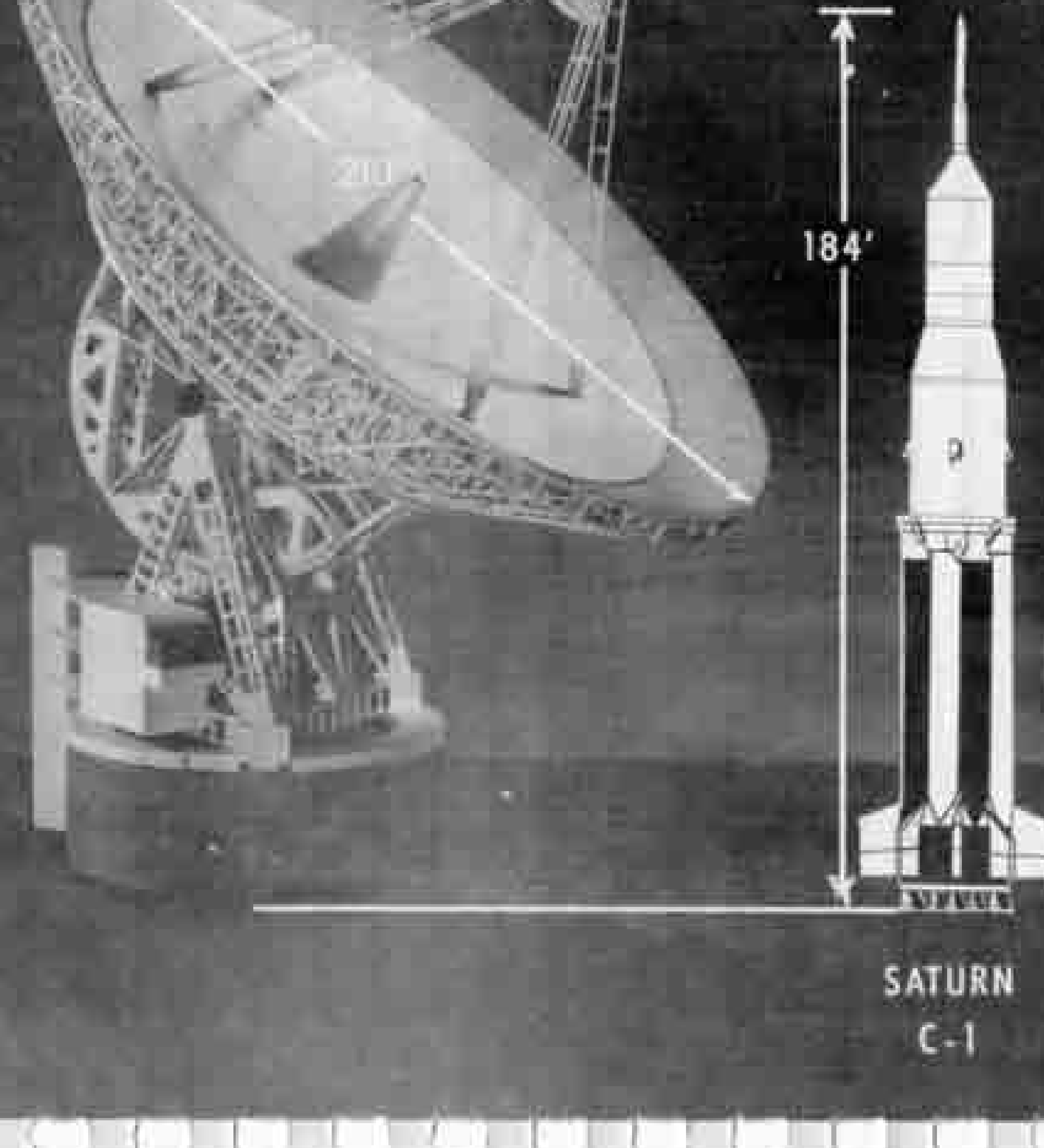
As a matter of interest, our office has a grant with your Dr. Bowen, of CSIRO, who is assisting this development not only in obtaining experimental data on large antennas but also in the design of this particular antenna illustrated here.

The system will utilize a 210-foot diameter antenna on an AZ-EL Mount. It will meet performance requirements as indicated on this next slide (Figure 14).

It must be capable of multi-frequency operation capability; we expect a minimum gain of 59 db at S-band; must be capable of operating at 45 mph winds with angular coverage ± 300° azimuth, 4° -91° elevation;

FIG. 13

210' ADVANCED ANTENNA SYSTEM



MAJOR PERFORMANCE REQUIREMENTS
210 FT. ANTENNA

- MULTI FREQUENCY OPERATING CAPABILITY
- MINIMUM GAIN OF 59 DB AT 2.3 KMC
- CAPABLE OF OPERATING AT 45 MPH WINDS
- ANGULAR COVERAGE: ± 300 AZIMUTH, 4°-91° ELEVATION
- TRACKING RATES: 0.5°/SEC
- TRACKING ACCURACY: ± 0.01°
- RELIABLE LONG TIME OPERATION

FIG. 14

tracking rates: 0.5°/sec; tracking accuracy: ± 0.01°; reliable long time operation, a necessary criteria for the operation of an antenna this size.

The operational target date for the prototype antenna is the first half of Calendar Year 1966. It is planned that successful completion and evaluation of this prototype will be followed by installation in Australia, and one near the zero degree meridian to complete a three station network. This advance antenna network is planned for completion in 1968 in time to support the advanced planetary missions of the Voyager type.

This completes my short review of the NASA Lunar and Planetary programs.

MANNED SPACE FLIGHT PROGRAM

BUCKLEY: The final area is that of Manned Space Flight and Mr. Briskman of our office will discuss that. Incidentally, Mr. Briskman worked over in Australia as a member of the site selection team for the Canberra and Carnarvon sites.

BRISKMAN: Thank you Mr. Buckley. Good afternoon gentlemen. It is nice to see you again.

I will be discussing the Manned Space Flight Network that supports our Manned Space Flight program. The program that you see outlined in Figure 1 consists of the Mercury project, which has been completed, and I might add - quite successfully, the Gemini project and the Apollo project. The Gemini project has two phases. The first phase consists of Earth orbital missions and the second is the rendezvous missions. Following Gemini is the Apollo project which consists of three phases. The first two phases of Apollo involve Earth orbital missions, and the final phase of the Apollo project is the manned lunar landing mission. I will describe these in detail later.

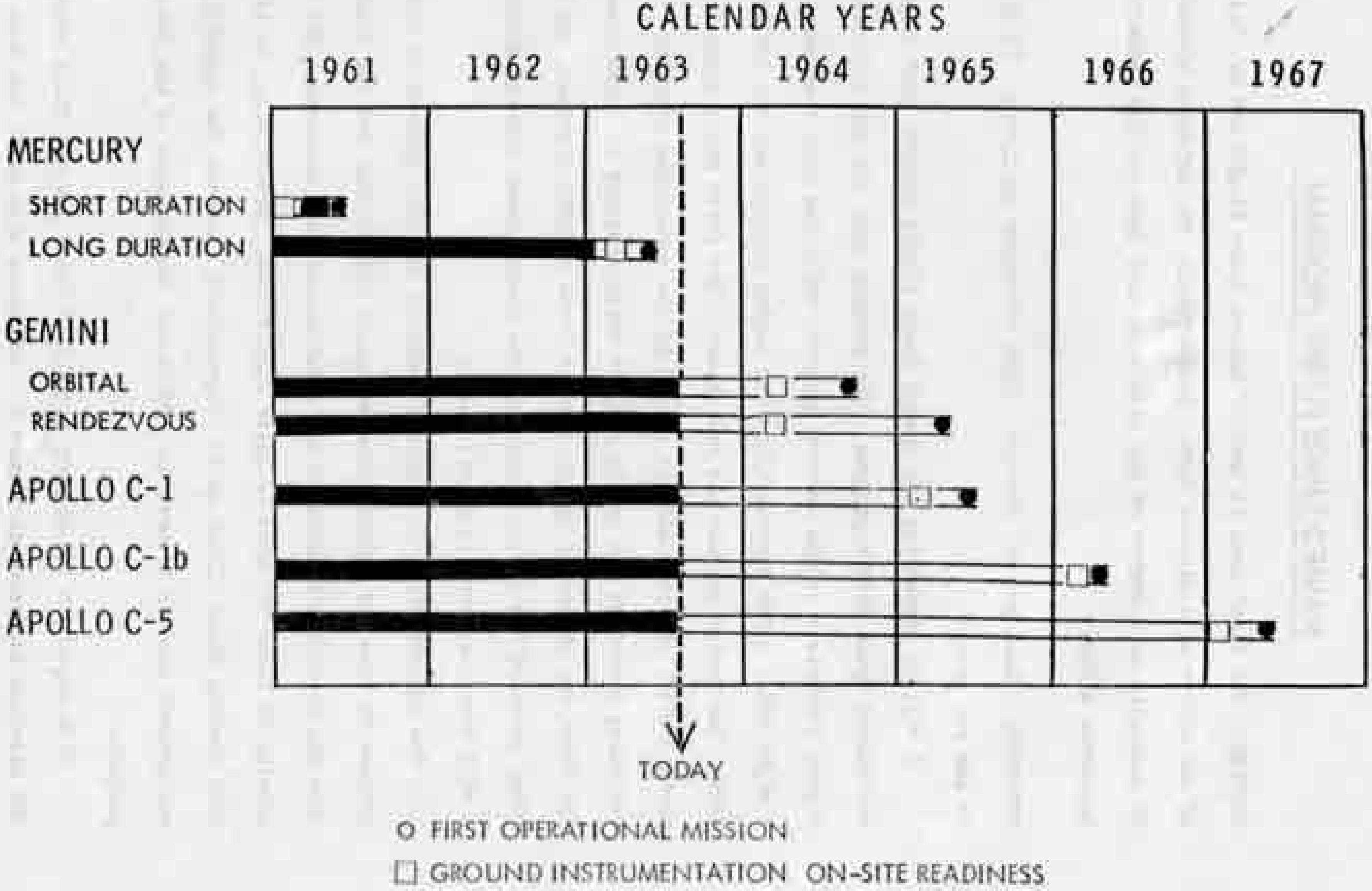
The squares shown in Figure 1 indicate the time periods in which we propose to have our ground instrumentation operational and the black dots show the approximate dates of the first operational missions. The time phasing of these projects is quite significant. Essentially, it is this time phasing which allows us to progressively increase the capability of our present network to meet the additional requirements of the future projects.

With regard to the Mercury project, I think you are fully aware of the missions indicated in Figure 2. Beginning with MA-4, the data from

FIG. 1

MANNED SPACEFLIGHT NETWORK

PROGRAM SUPPORT SCHEDULE



MANNED SPACEFLIGHT NETWORK

MISSIONS SUPPORTED

MR-3	MAY 5, 1961	BALLISTIC
MR-4	JULY 21, 1961	BALLISTIC
MA-4	SEPTEMBER 13, 1961	1 ORBIT
MA-5	NOVEMBER 29, 1961	2 ORBIT
MA-6	FEBRUARY 20, 1962	3 ORBIT
MA-7	MAY 24, 1962	3 ORBIT
MA-8	OCTOBER 3, 1962	6 ORBIT
MA - 9	MAY 15, 16, 1963	22 ORBIT

FIG. 2

the two stations in Australia, Woomera and Muchea, was very significant in the success of the Mercury missions. Figure 3 shows a brief summary of some of the more interesting performance achieved by the Manned Space Flight Network. The performance shown in this particular figure was derived from MA-6 and MA-7 data. The performance of the Network on MA-8 and MA-9 was equally fine, if not better, in all instances. Especially note the very high accuracy of the orbital elements and the landing point prediction. To achieve performance like this, it is necessary that the individual ground instrumentation stations function as an integral part of the overall Network. Figure 4 shows some of the cooperating foreign organizations which participated in the Mercury program. Actually, it was the tremendous cooperative effort between all of the participating foreign organizations, the Department of Defense, and the NASA which made the Mercury project a success.

I will leave Mercury now and go on to the Gemini project. Since you are probably not very familiar with Gemini, I will start with a short discussion of the Gemini spacecraft. Figure 5 is an artist's cut-away drawing of the Gemini spacecraft and shows a comparison between the Gemini and Mercury spacecraft. The Gemini spacecraft is a more spacious vehicle and Figure 6 shows some of the features of the Gemini spacecraft which were not available on the Mercury spacecraft. The adapter equipment section affords space for mission oriented equipment and special experiments. It provides the spacecraft with the capability to do a variety of different experiments during its mission in space and gives the spacecraft inherent mission flexibility. The spacecraft includes ejection seats which give the astronauts the option of either landing with the

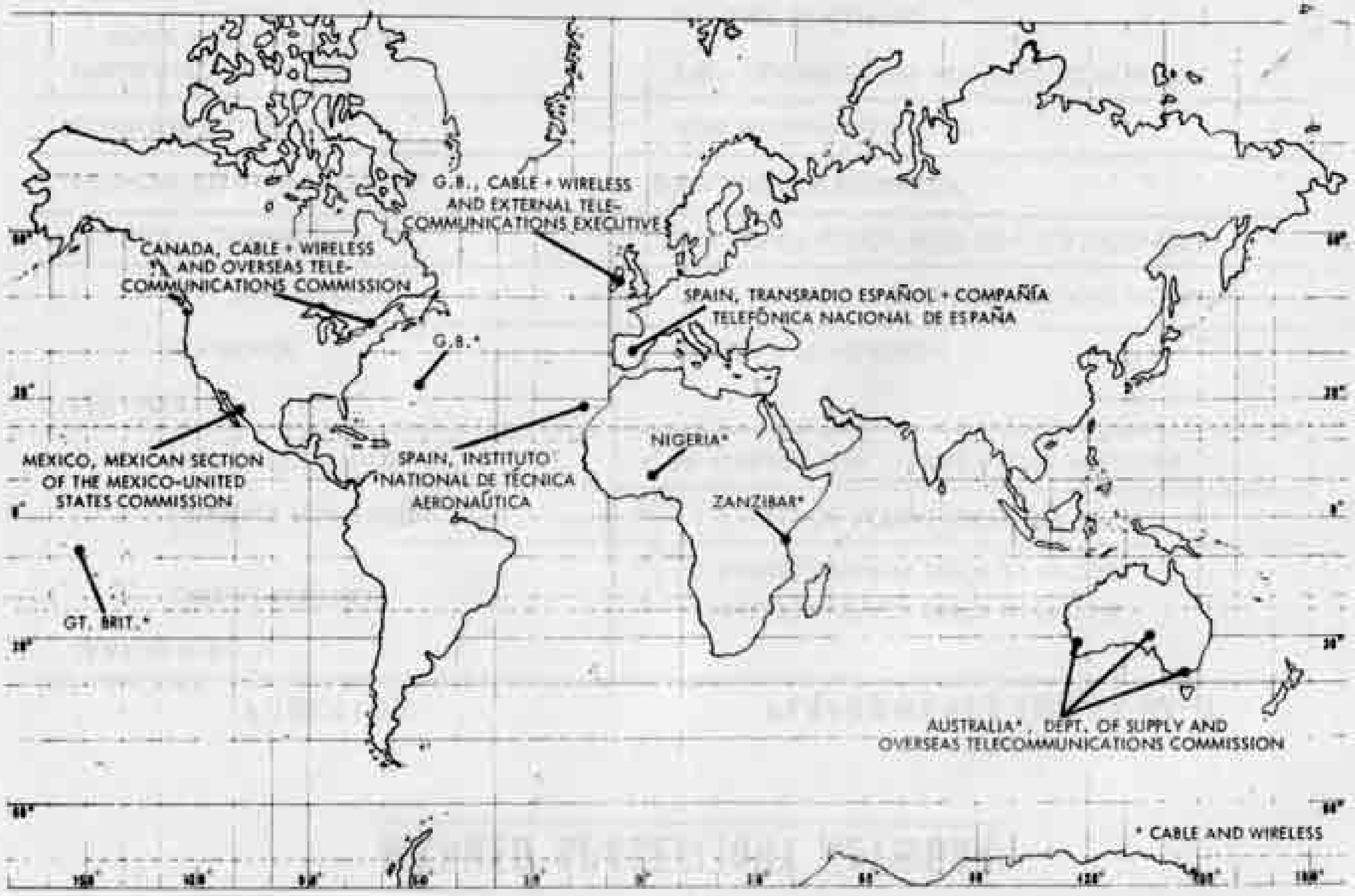
MANNED SPACEFLIGHT NETWORK

FUNCTION	PERFORMANCE (MA-6 & MA-7)
TRACKING	
ORBITAL ACURACY	< ± 0.4 MILES AVERAGE ERROR IN PERIGEE < ± 0.9 MILES AVERAGE ERROR IN APOGEE
LANDING POINT PREDICTION	< ± 1.9 MILES OF ACTUAL RECOVERY
RADAR ACQUISITION	< 2° AVERAGE ELEV. ANGLE ABOVE HORIZON
TELEMETRY	
COVERAGE	HORIZON TO HORIZON
REAL TIME READOUT	CONTINUOUS S/C ENGINEERING AND BIO DATA
UP-DATA (COMMAND)	SPACECRAFT CLOCK RESET TO ± 0.5 SECONDS
NETWORK COMMUNICATIONS	> 98% MISSION RELIABILITY
COMPUTER RELIABILITY	100% MISSION RELIABILITY
SPACECRAFT - NETWORK VOICE COMMUNICATION	VHF - READABLE 90% HORIZON TO HORIZON HF - NOT EVALUATED

FIG. 3

FIG. 4

PARTICIPATING FOREIGN ORGANIZATIONS



COMPARISON OF MANNED SPACECRAFT

PROJECT GEMINI

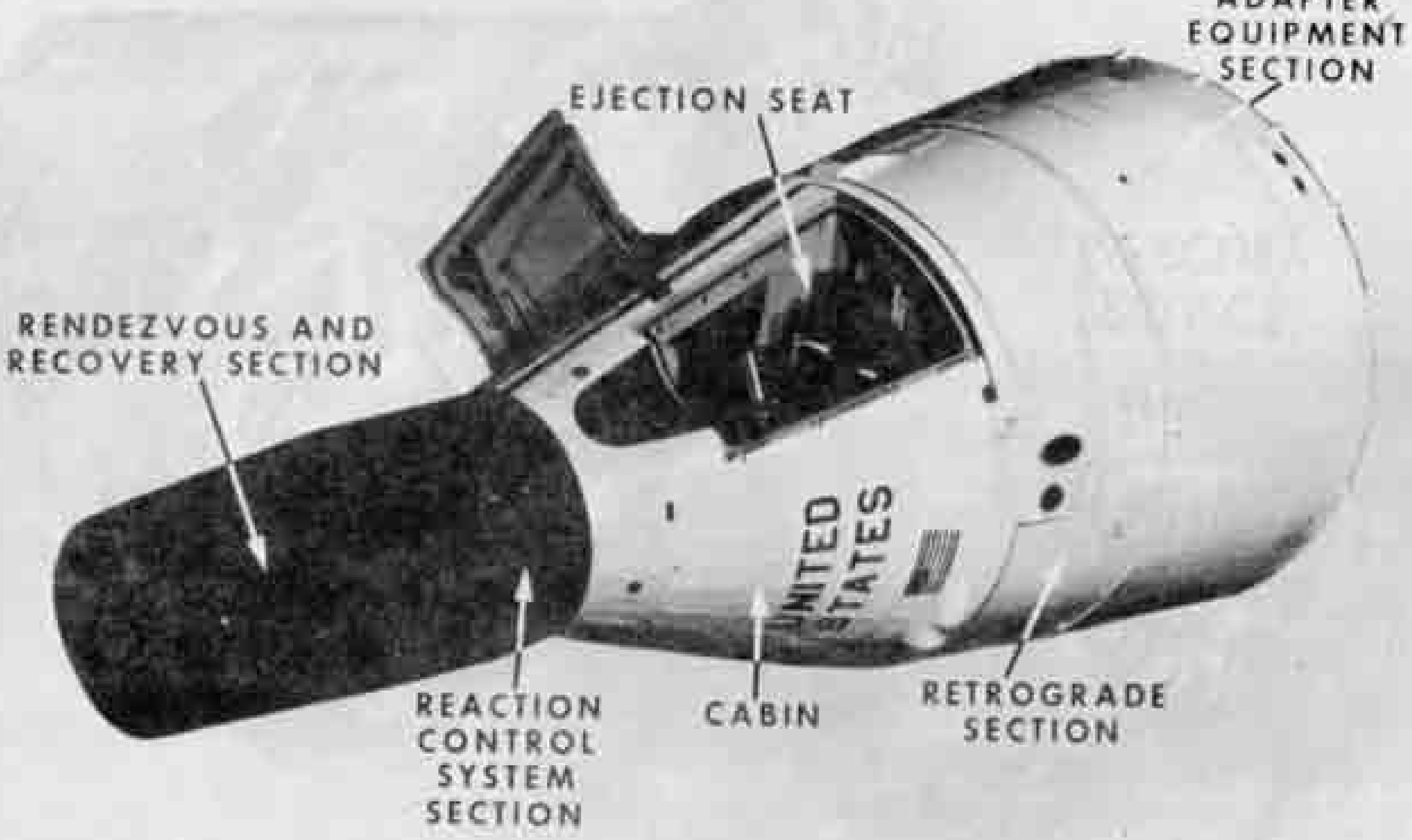
PROJECT MERCURY

FIG. 5

M 62-149

GEMINI CAPSULE

FIG. 6



NASA MA2 142

spacecraft itself, or ejecting free of the spacecraft and landing separately with a parachute. The rendezvous section is used in the later Gemini missions for actual rendezvous with an Agena spacecraft.

Figure 7 is a picture of a full scale model of the Gemini spacecraft which was built by the contractor, McDonnell Aircraft Company, St. Louis, Missouri. An actual Mercury capsule is also shown in this figure for comparison of size. The forward rendezvous section is visible and the white section in the lower left of the picture is the aft end of the Agena spacecraft which mates with the rendezvous section of the Gemini spacecraft. Figure 8 is an artist's conception of the rendezvous operation. The manned Gemini spacecraft is launched by the Titan II booster, which is more powerful than the Atlas booster that was used to launch the Mercury spacecraft. The Gemini spacecraft makes a rendezvous with an Agena target spacecraft. The Agena is the second stage of a launch vehicle called the Atlas-Agena.

There are several modes of rendezvous. The mode which I will describe at this time is the one in which the Agena is launched first and the Gemini spacecraft afterwards. In this mode, the Agena separates from the Atlas and inserts itself into orbit through the use of its propulsion capability. The Titan II and the manned Gemini spacecraft combination is launched later and, after separation from the Titan II, the Gemini spacecraft performs the rendezvous as indicated in Figure 8. Another feature of the Gemini project that I haven't mentioned is that in the later flights a paraglider will be used during the landing operation. The paraglider is shown in Figure 9. This technique will give the astronauts the ability to maneuver the spacecraft in the atmosphere after reentry and to land it at a preselected site.

FIG. 7


GEMINI RENDEZVOUS MISSION
PERIGEE
100 MILES
RENDEZVOUS
AT APOGEE
185 MILES

FIG. 8

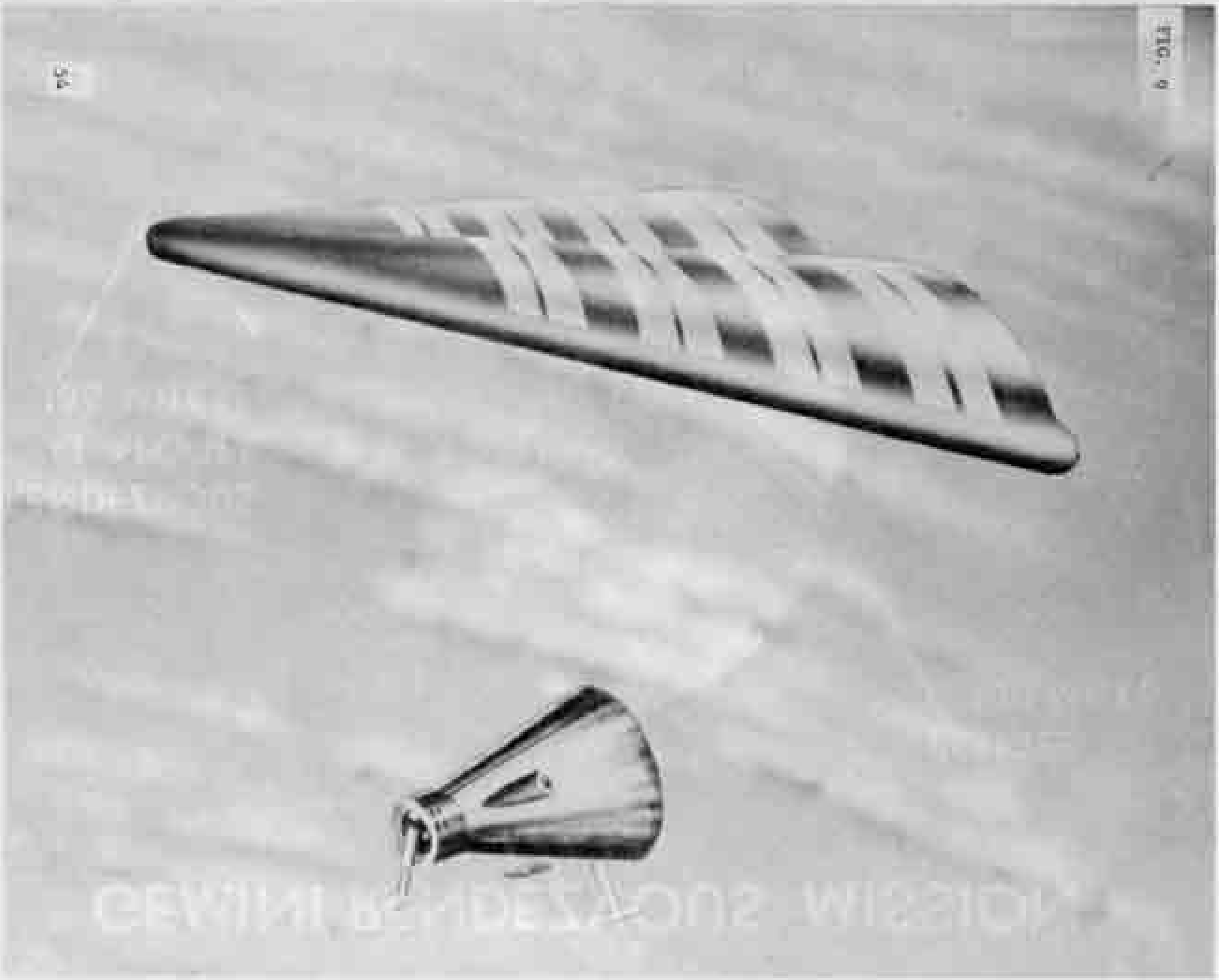


FIG. 6

The Gemini project presents many new requirements to the Manned Space Flight Network. A summary of the major requirements is shown in Figure 10. One of the more important items is the required coverage of variable azimuth launches which will be used in the rendezvous missions. Within the limits of launch azimuths between 73° and 106°, a spacecraft can be launched from Cape Canaveral into orbits with inclinations ranging from 28° to 32.5°. In the Gemini rendezvous mission, two spacecraft are simultaneously in orbit. We must track and receive telemetry from both vehicles. This will require augmentation of certain ground station equipments. We are changing from the analog type of telemetry, the PAM/FM/FM telemetry which was used in Mercury, to a digital telemetry system which I will be referring to as Pulse Code Modulation (PCM) telemetry. To effect rendezvous, we must be able to send commands from the ground which change the orbits of the spacecraft. Consequently, we must have "in-orbit" control and command of the spacecraft from the Earth.

I will describe the variable launch azimuth problem because I think it will be particularly interesting to you. Essentially, the problem is to determine the orbit of the spacecraft quickly and accurately in order to initiate immediate orbital maneuvers which may be needed to effect rendezvous or possibly to establish the necessary action to bring the astronaut down at the end of the first orbit in case of emergency. To determine a good orbit quickly, we must obtain accurate tracking near the point of insertion and also accurate tracking at a point approximately half way around the first orbit. In Mercury, as you know, this was accomplished by obtaining tracking data from Bermuda and from Muchea and Woomera. The variable launch azimuth range indicated in Figure 11 for

FIG. 10

MANNED SPACEFLIGHT NETWORK

NEW REQUIREMENTS FOR GEMINI

- TRAJECTORY CHANGES — { VARIABLE LAUNCH AZIMUTH / ORBITAL INCLINATIONS 28° - 33°
- TWO SPACECRAFT
- DIGITAL TELEMETRY
- SPACECRAFT IN-ORBIT CONTROL AND COMMAND FROM EARTH

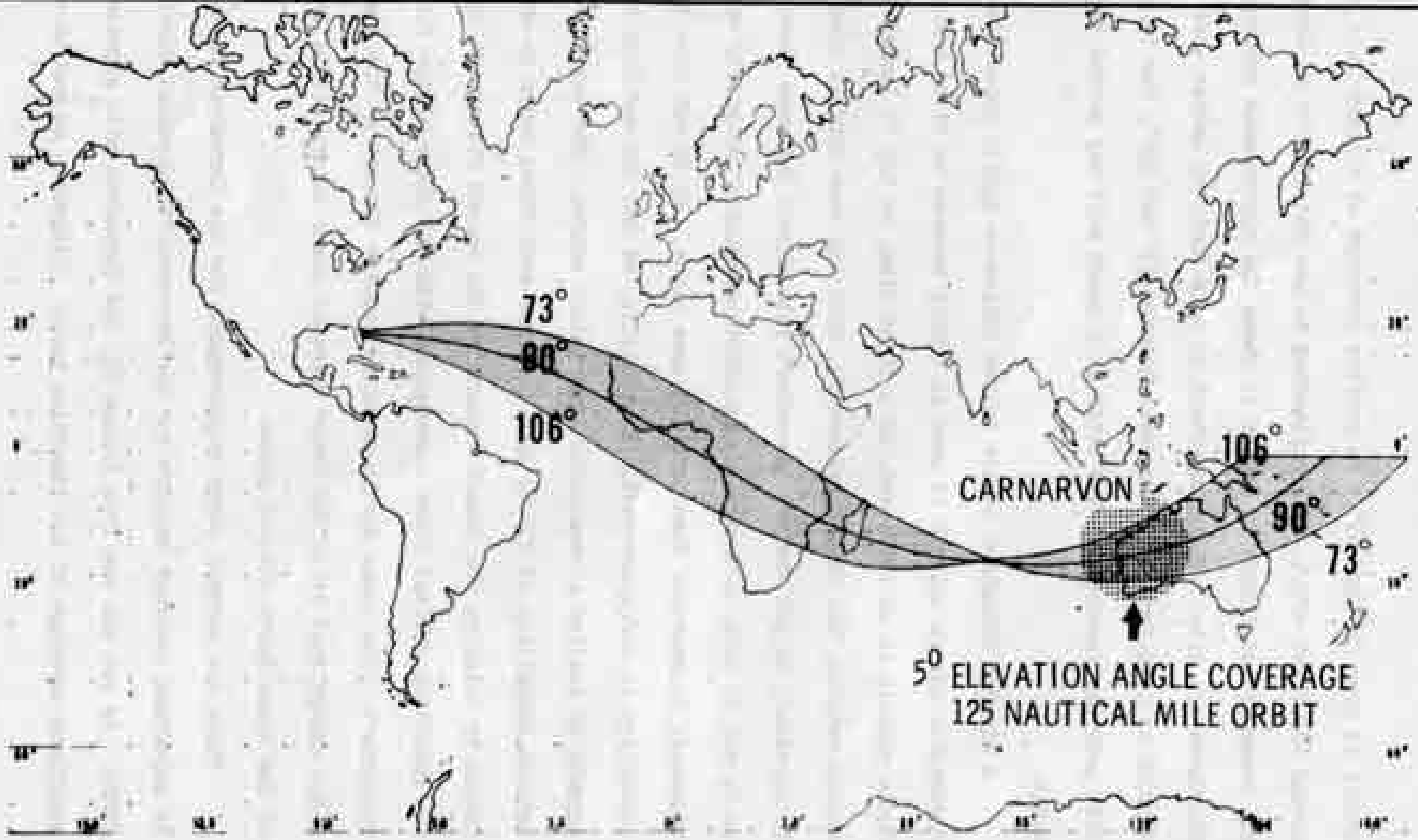
Gemini is from 73° to 106°. To provide coverage at a point half way around the first orbit, we are planning to use the station at Carnarvon. The crosshatched circle in Figure 11 shows the approximate coverage from the Carnarvon site. It is important to note that, no matter what launch azimuth is used from Cape Canaveral between 73° and 106°, the Carnarvon site provides coverage of the orbit at a point half way around the first orbit.

A similar situation occurs in the follow-on Apollo lunar missions. A variable launch azimuth is used in Gemini because we first have the Agena vehicle in an orbit and, at a later time, we try to launch the second vehicle, the Gemini spacecraft, into the same orbital plane. It is necessary to get the two spacecraft into almost the same plane. If we do not do this, a tremendous in-orbit propulsion capability would be necessary to maneuver them into the same plane. We do not have this capability in the spacecraft. Essentially, we use the variable launch azimuth to realize a reasonably long launch window. The variable launch azimuth capability of 73° to 106° provides over three hours in which to launch by changing the launch azimuth of the second spacecraft so that its resulting orbital plane corresponds with the plane of the first spacecraft. The lunar Apollo missions require the use of the same technique except that it is the lunar transfer plane we are aiming for instead of the Agena Earth orbital plane.

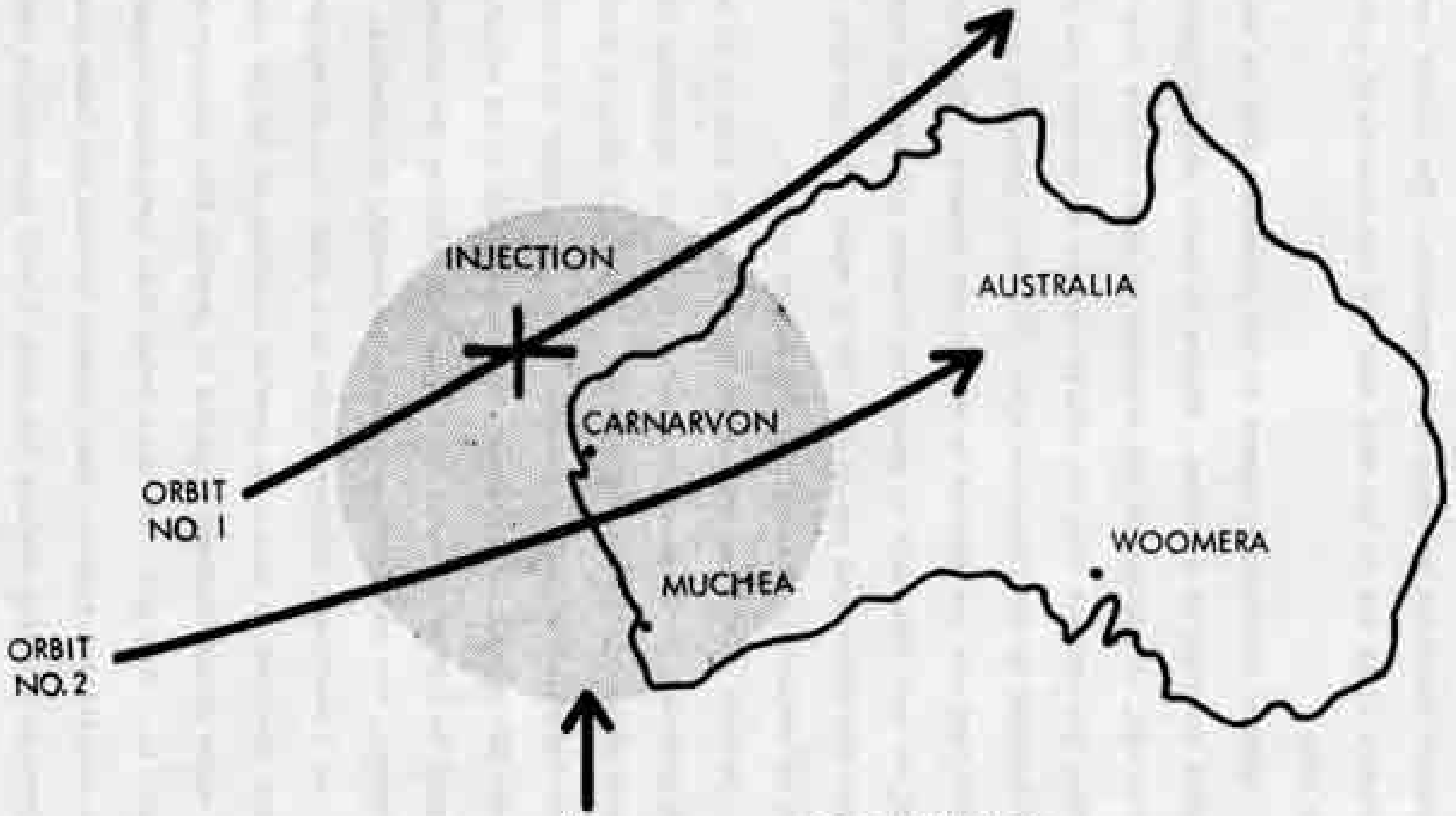
There are several other requirements for the Carnarvon site. One is injection coverage support for the Eccentric Geophysical Observatory (EGO). As you can see from Figure 12, the Carnarvon site provides excellent coverage of the insertion point. Likewise, as can be seen in

FIG. 11

VARIABLE LAUNCH AZIMUTH SUPPORT GEMINI AND APOLLO LUNAR MISSIONS



EGO INJECTION SUPPORT



5° ELEVATION ANGLE COVERAGE
100 NAUTICAL MILE ORBIT

FIG. 12

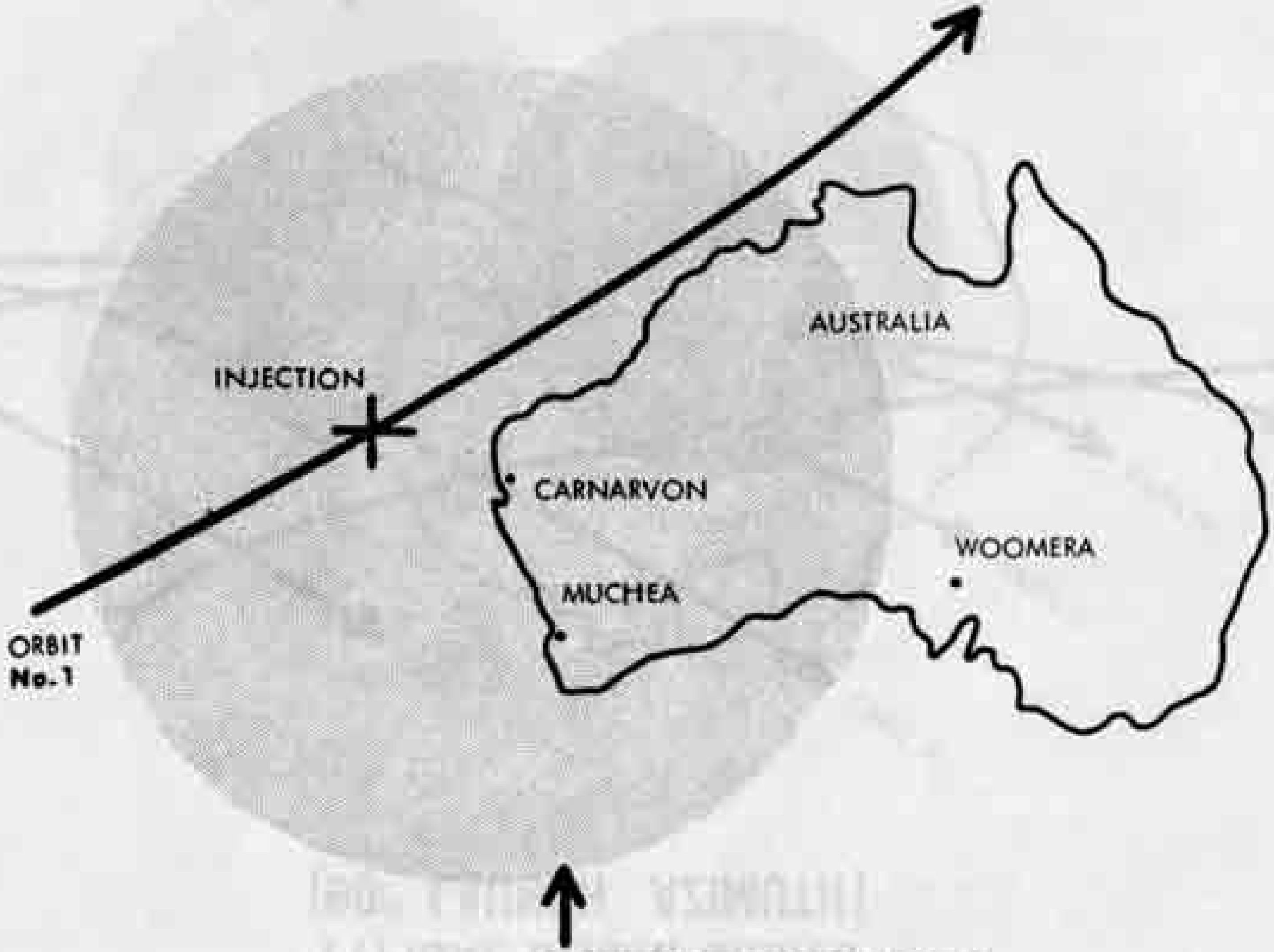
Figure 13, the Orbiting Astronomical Observatory (OAO) will also obtain excellent insertion coverage from Carnarvon. The larger coverage circle in Figure 13 is due to the fact that the OAO inserts at a higher altitude than EGO.

Another interesting aspect of the Carnarvon site is the general orbital coverage it provides. Figure 14 shows several typical Gemini orbits and, if you notice the coverage of these orbits from Woomera and Muchea, you can see that all orbits covered by Woomera and Muchea are also covered by the Carnarvon site. In fact, Carnarvon also covers some orbits that are not covered by Muchea and Woomera. Therefore, as you know, we have been able to phase the Woomera site out of the Network except for occasional use of the FPS-16 radar. We are also in the process of completely phasing out the Muchea station.

Because of the importance of the Carnarvon site to so many of the NASA programs, both manned and unmanned, we are equipping it with the latest state-of-the-art FPQ-6 radar. Figure 15 shows a similar FPQ-6 radar installed at Cape Canaveral. The FPQ-6 radar is being fabricated in the RCA plant in Moorestown, New Jersey, and it is expected to be shipped to Carnarvon early this fall. Concerning the present status at Carnarvon, the construction work is proceeding on schedule.

As I mentioned earlier, there is a great deal of equipment augmentation involved in Gemini to provide coverage of the two spacecraft. The major ground systems required to provide this coverage are noted in Figure 16. They are: the dual Pulse Code Modulation telemetry system, dual acquisition systems, dual command systems and radar pulse coders. To provide a better feeling for this, I will show you in terms of equipment racks what this implementation actually means. I will use a

OAO INJECTION SUPPORT

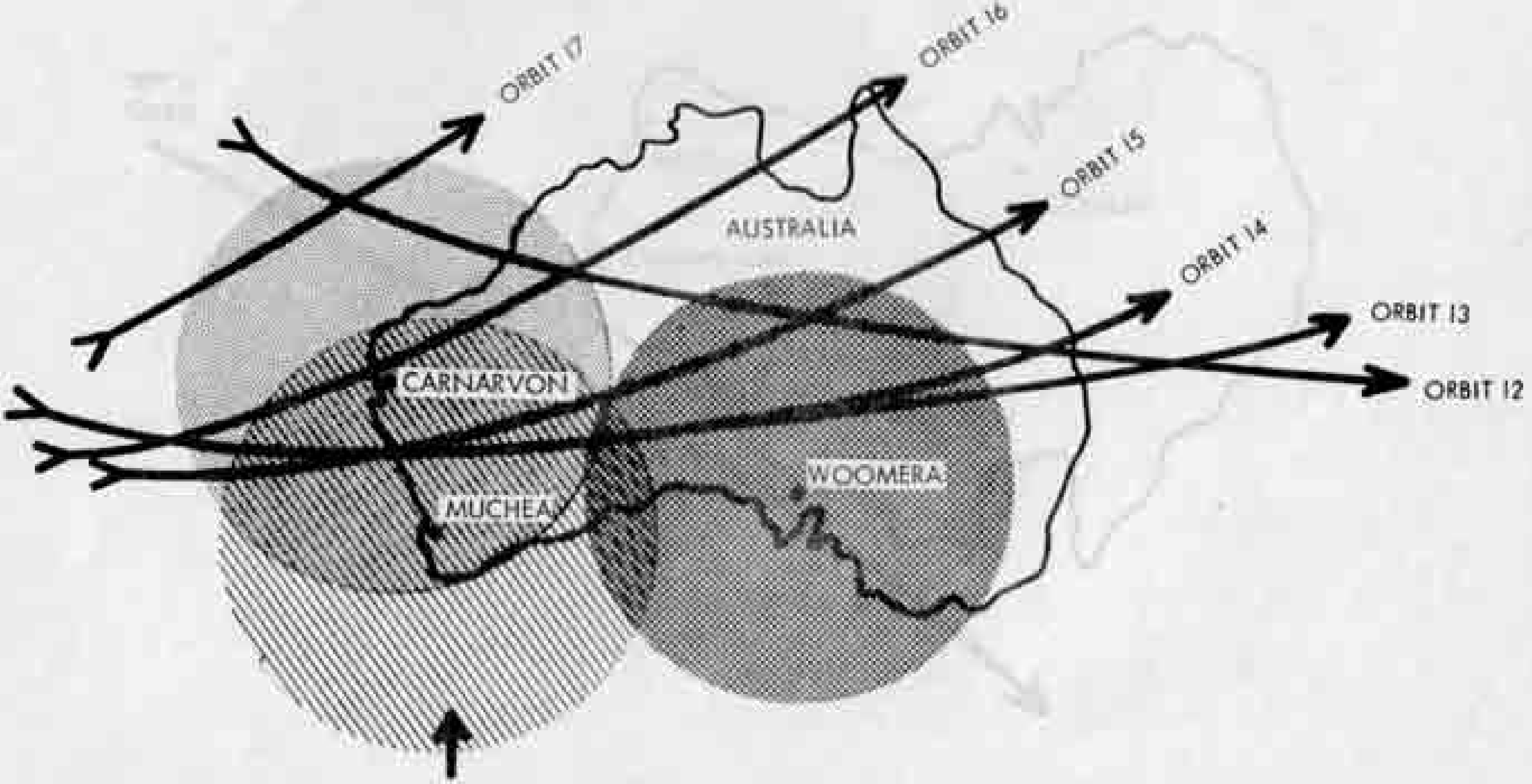


5° ELEVATION ANGLE COVERAGE
450 NAUTICAL MILE ORBIT

FIG. 13

FIG. 14

TYPICAL GEMINI ORBITS
(90° LAUNCH AZIMUTH)



CIRCLES SHOW 5° ELEVATION ANGLE COVERAGE
FOR 100 NAUTICAL MILE ORBIT

FPQ-6 RADAR

FIG. 13

FIG. 16

GEMINI SUPPORT

TWO SPACECRAFT REQUIREMENT

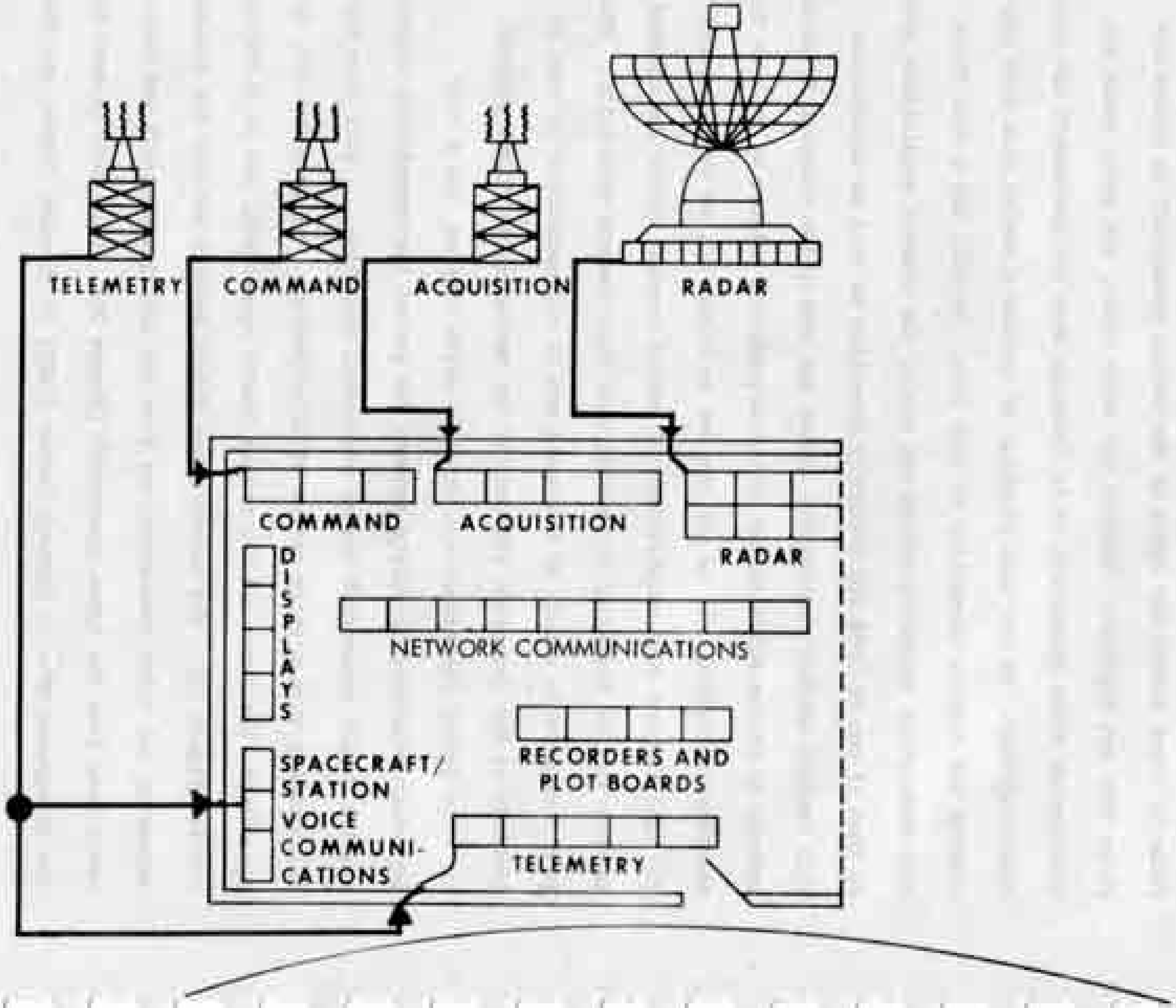
- DUAL PCM TELEMETRY SYSTEMS
- DUAL ACQUISITION SYSTEMS
- DUAL COMMAND SYSTEMS
- RADAR CODER

"typical" Mercury building diagram with the existing racks of equipment in place as shown in Figure 17. To this we will add a small building addition as shown in Figure 18 and a radar coder which will allow a single radar to track either the Agena or the Gemini spacecraft no matter how close they get together. Without the radar coder, the radar could not distinguish which spacecraft it is tracking when the spacecraft are very close together. We are also planning to include a medium size data processing and display capability at each site. We will add a dual Pulse Code Modulation telemetry system and modify the present acquisition antenna so that it can be used for telemetry reception as well as acquisition. We will install another acquisition system and modify the existing telemetry antenna so it can serve as the second acquisition antenna as well as for telemetry reception. So as you can see by Figure 18, we have provided for dual PCM and dual acquisition. A second command system and command antenna will be installed so we will have dual command capability. This is a considerable amount of equipment and is representative of what is involved at the Carnarvon station for the manned space flight program.

The Gemini rendezvous operation is quite complex, and a very important relationship exists between the ground instrumentation network and the Gemini spacecraft during rendezvous operation. I will show this relationship with a short series of illustrations. As we start off, both spacecraft, the Agena and the manned Gemini spacecraft, are in different orbits (Figure 19). The Manned Space Flight Network obtains the necessary telemetry and voice communications from the Gemini spacecraft and telemetry data from the Agena spacecraft (Figure 20). This data is sent to the Integrated Mission Control Center (IMCC) in Houston, Texas, via the

FIG. 17

TYPICAL EQUIPMENT CONFIGURATION- MERCURY STATION



TYPICAL EQUIPMENT CONFIGURATION- GEMINI PRIMARY STATION

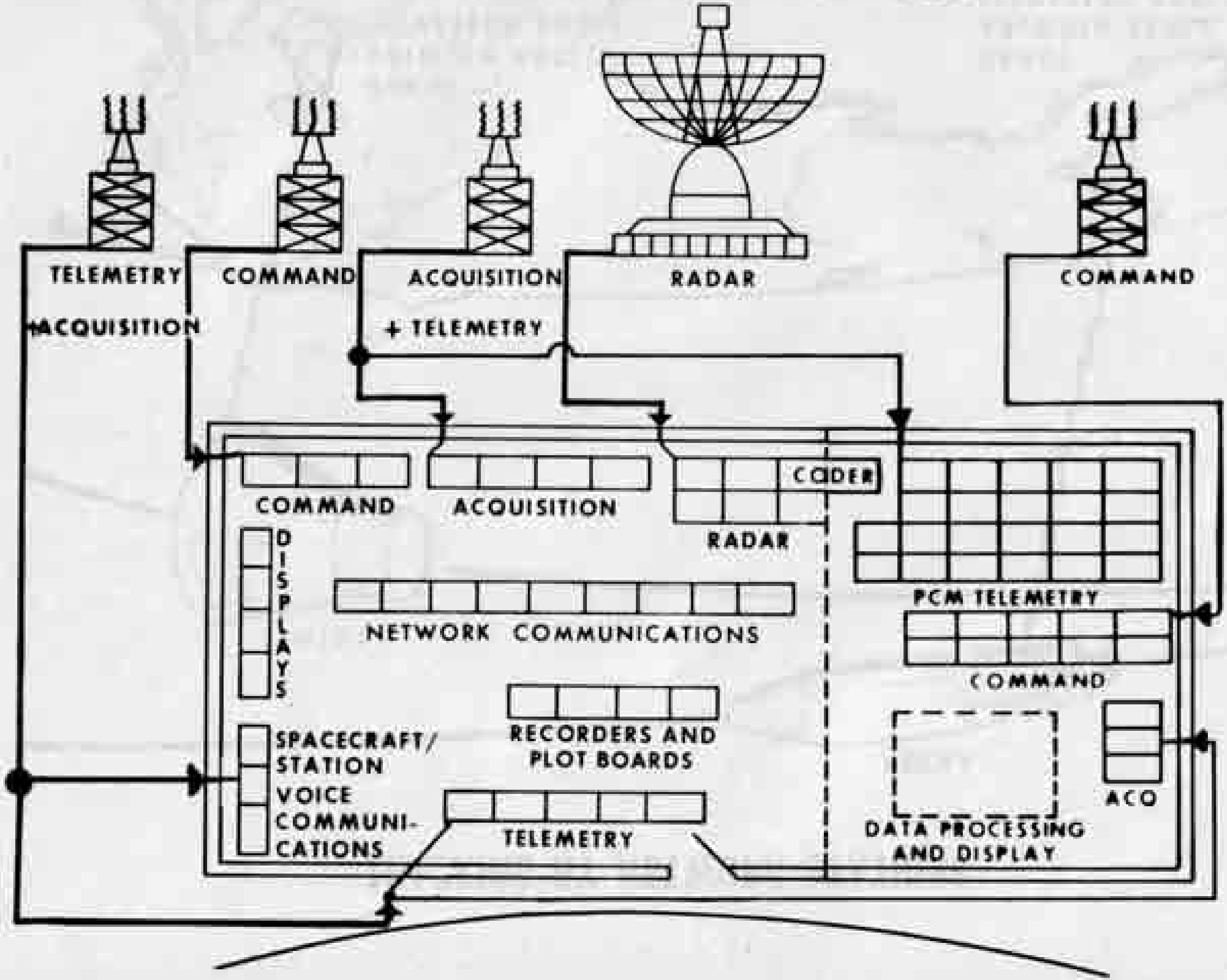
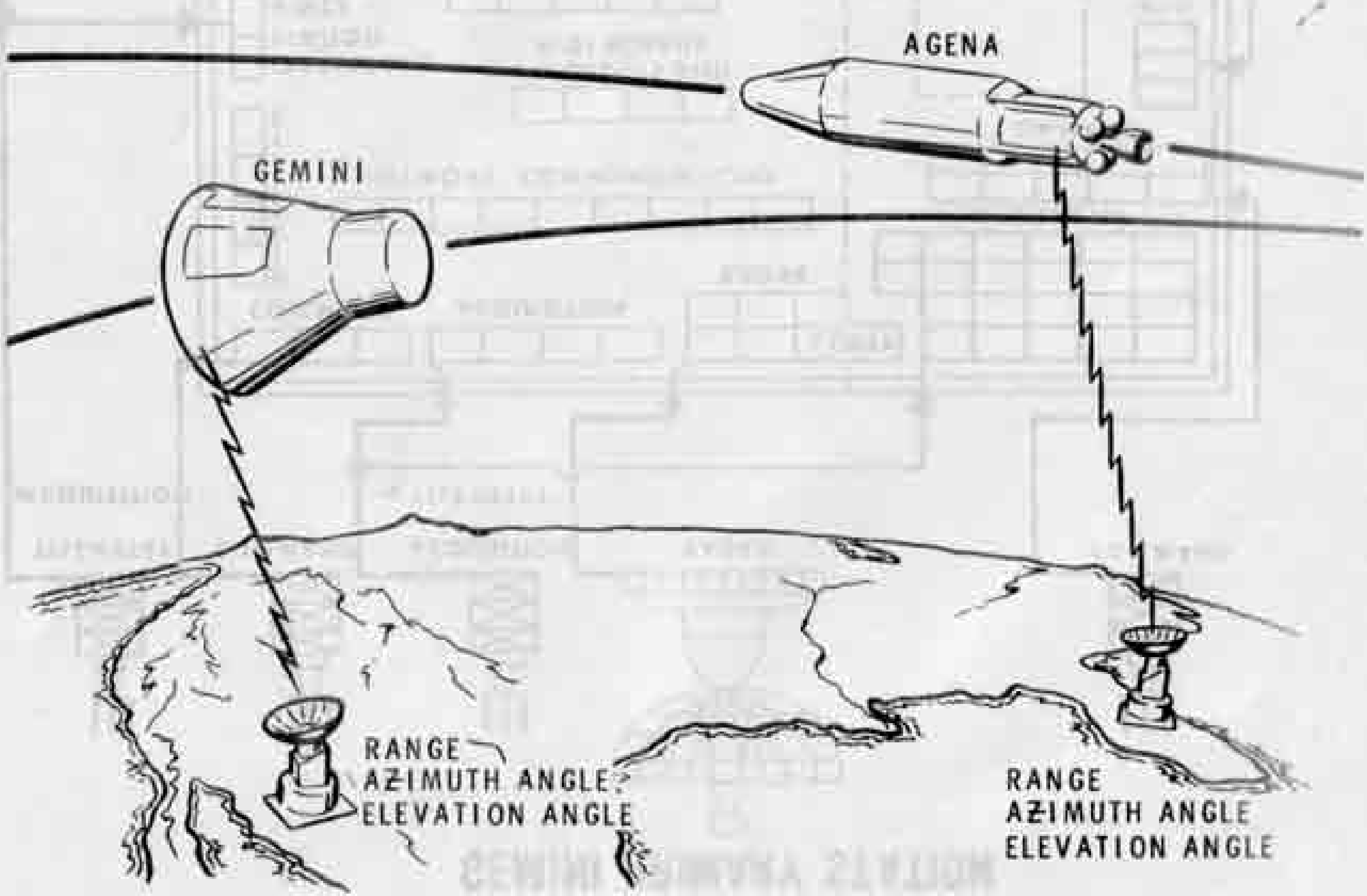


FIG. 18

FIG. 19

TRACKING BY NETWORK STATIONS



DATA ACQUISITION AND VOICE FROM SPACECRAFT TO NETWORK STATIONS FOR SPACECRAFT CONDITION AND SITUATION

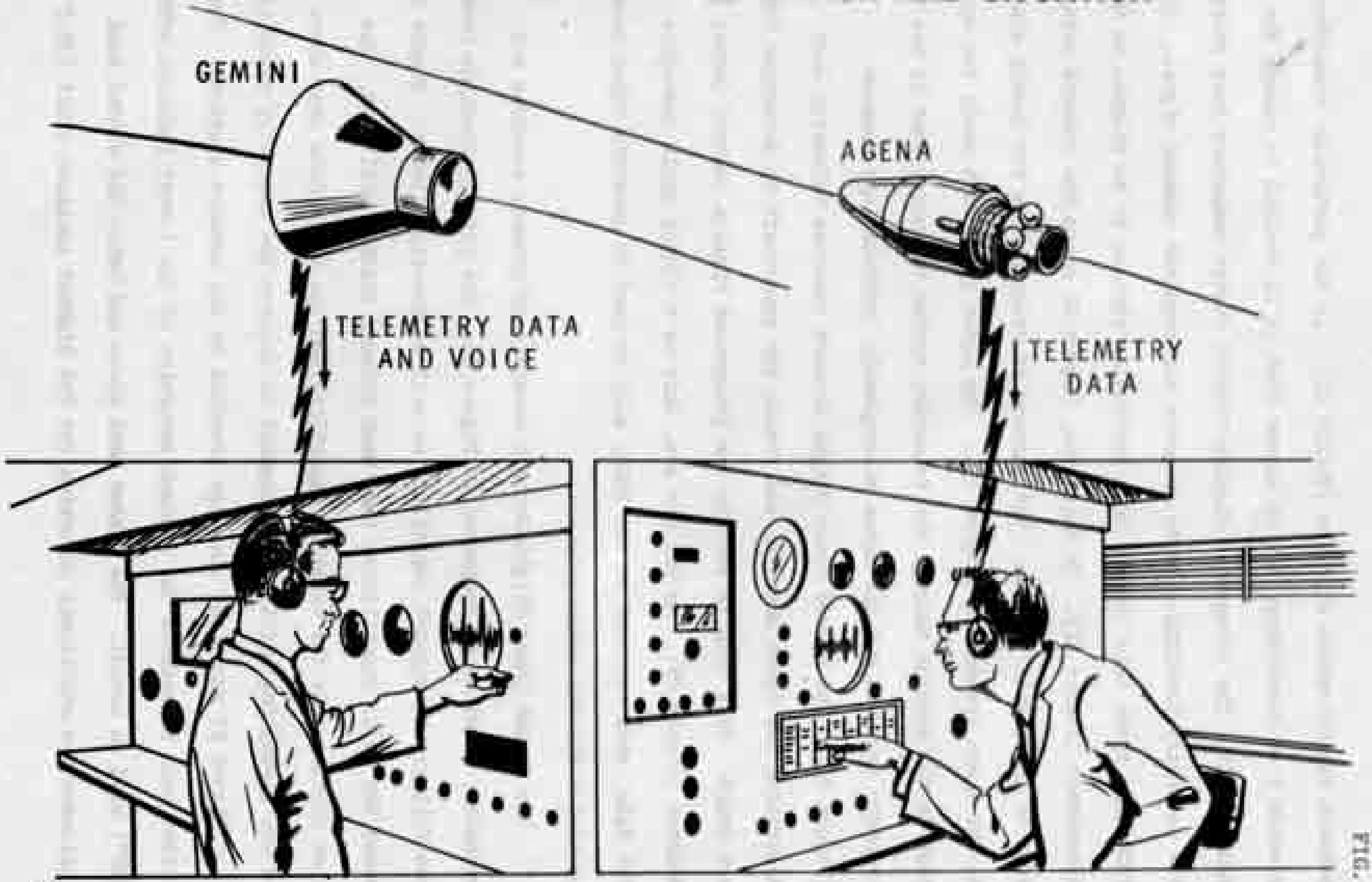


FIG. 20

network communication circuits (Figure 21). In the particular conceptual mission I am describing, let us assume that it is desired to change the Agena orbit. The Integrated Mission Control Center computers have received the necessary tracking data to generate the required command signal. The IMCC then sends this command to a particular station to be relayed to the spacecraft (Figure 22). In this case, Figure 22 shows the command being sent to the Hawaii station. The command is relayed from the Hawaii station to the Agena spacecraft (Figure 23). The Agena spacecraft sends the command back to the station through the telemetry system to verify that it has been properly received and the Agena subsequently initiates the command (Figure 24). The Manned Space Flight Network receives telemetry data describing the Agena maneuver and tracks the spacecraft to determine the new orbit. This data is sent to the Integrated Mission Control Center in Houston (Figure 25). As you can see, this is a closed cycle operation. The data, when received in the IMCC, will be used to generate other commands or advice for the astronauts.

The Manned Space Flight Network consists of primary stations and secondary stations as indicated in Figure 26. The primary stations have the full ground support capability as will be described later. Figure 26 shows the major capabilities that each primary station will have. The open circles show the existing capability and the black dots show where we are installing additional equipment to achieve the necessary capability.

Figure 27 shows the coverage provided by the network stations. The dotted band represents the maximum excursion of the lowest inclined orbit (28°) used on Gemini. The shaded band above and below the dotted band indicates the additional excursion for the highest inclined orbit (32.5°)

TRANSMISSION OF TRACKING, VOICE AND TELEMETRY DATA FROM NETWORK STATIONS TO IMCC

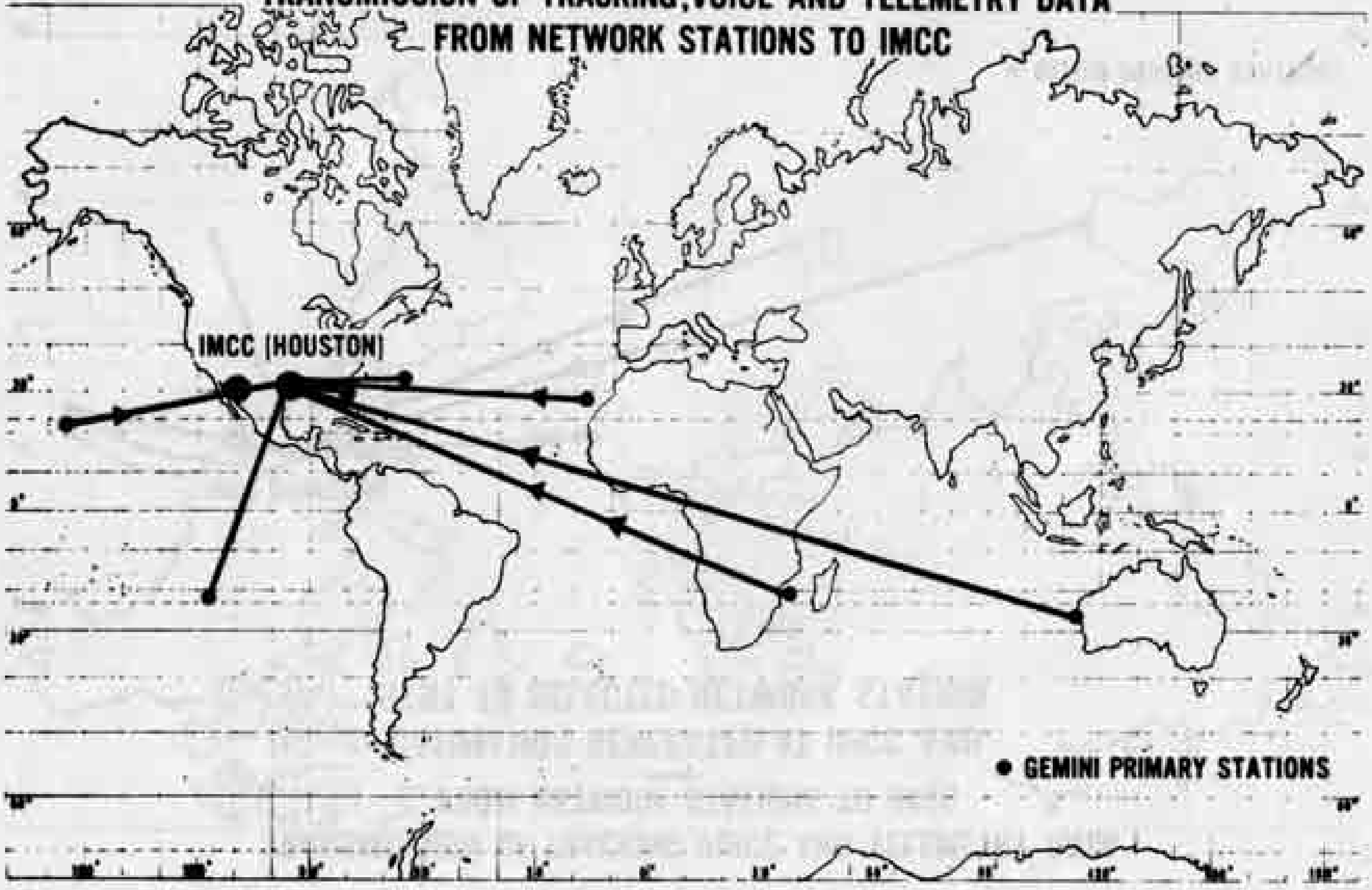
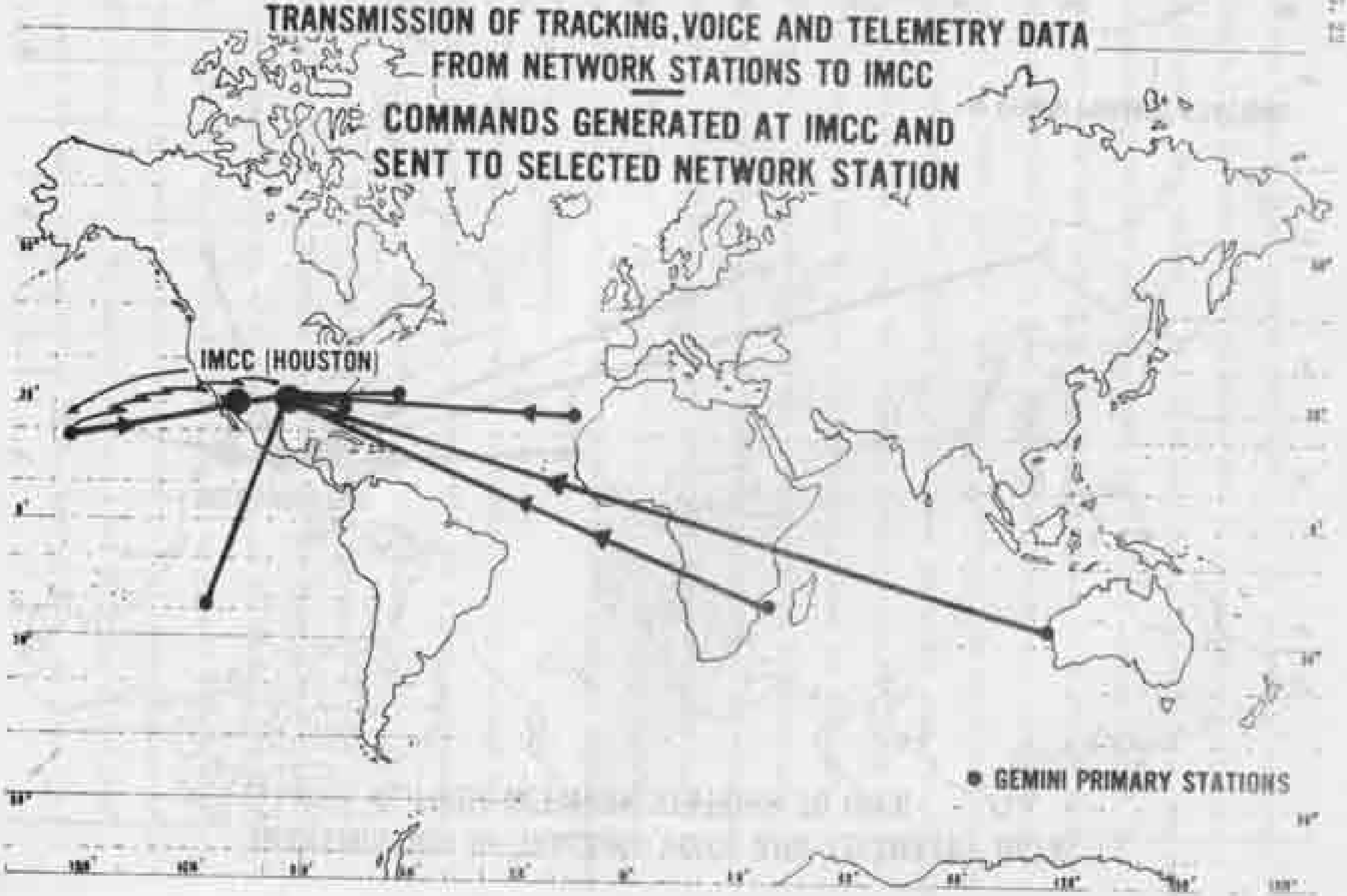


FIG. 21

FIG. 23



TRANSMISSION OF TRACKING, VOICE AND TELEMETRY DATA FROM NETWORK STATIONS TO IMCC

COMMANDS GENERATED AT IMCC AND SENT TO SELECTED NETWORK STATION

COMMANDS SENT FROM NETWORK STATION TO SPACECRAFT

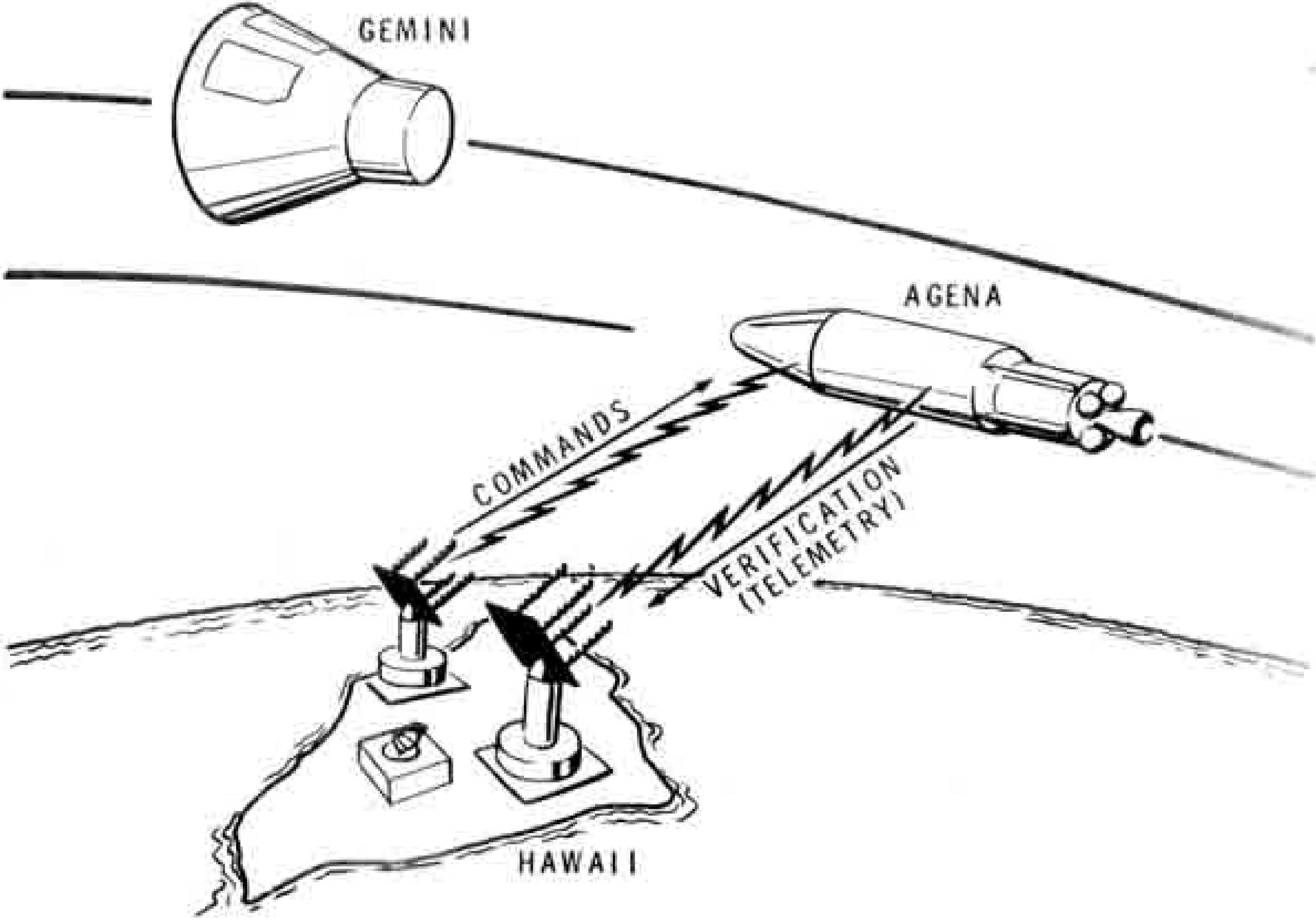
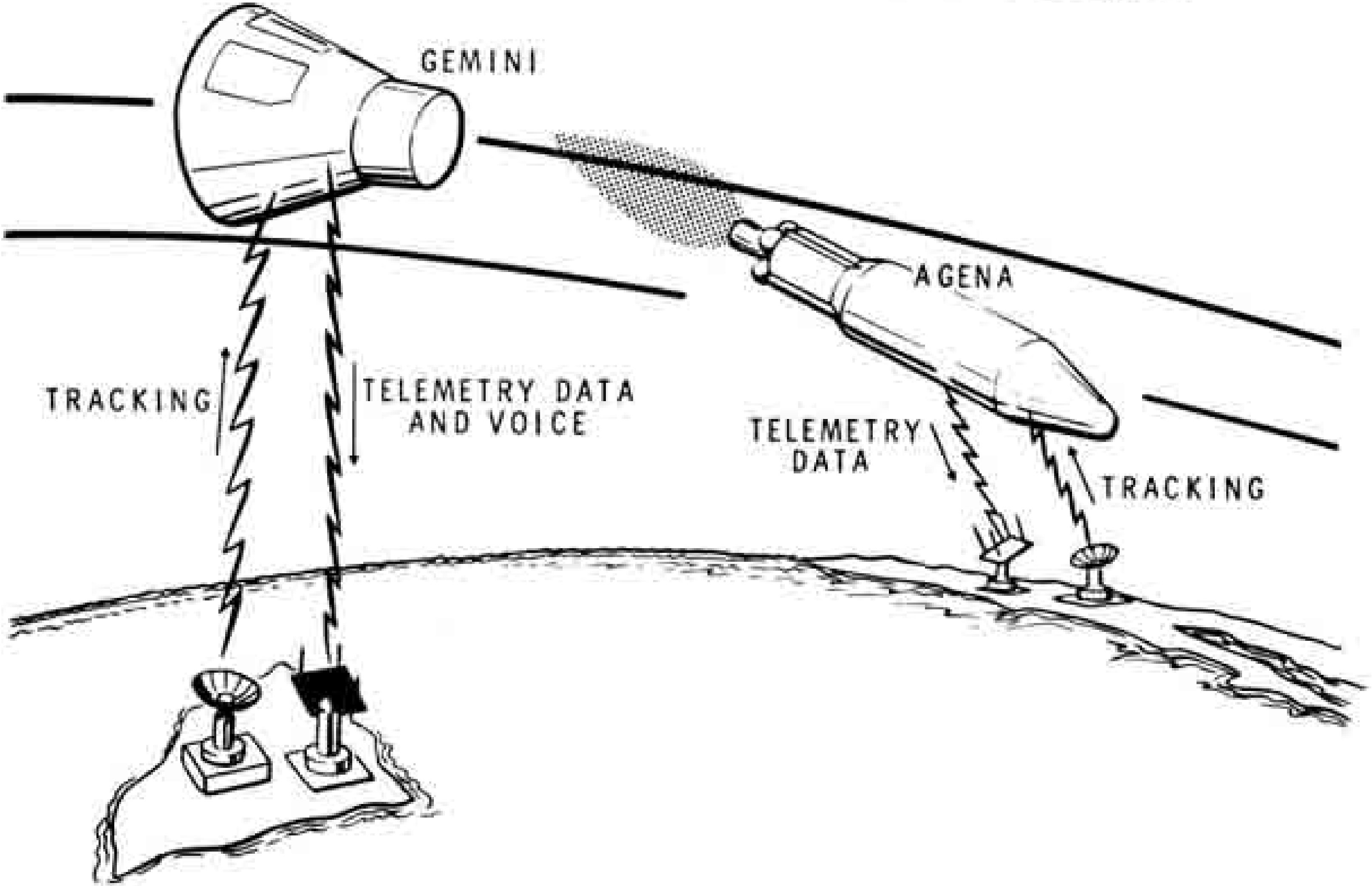
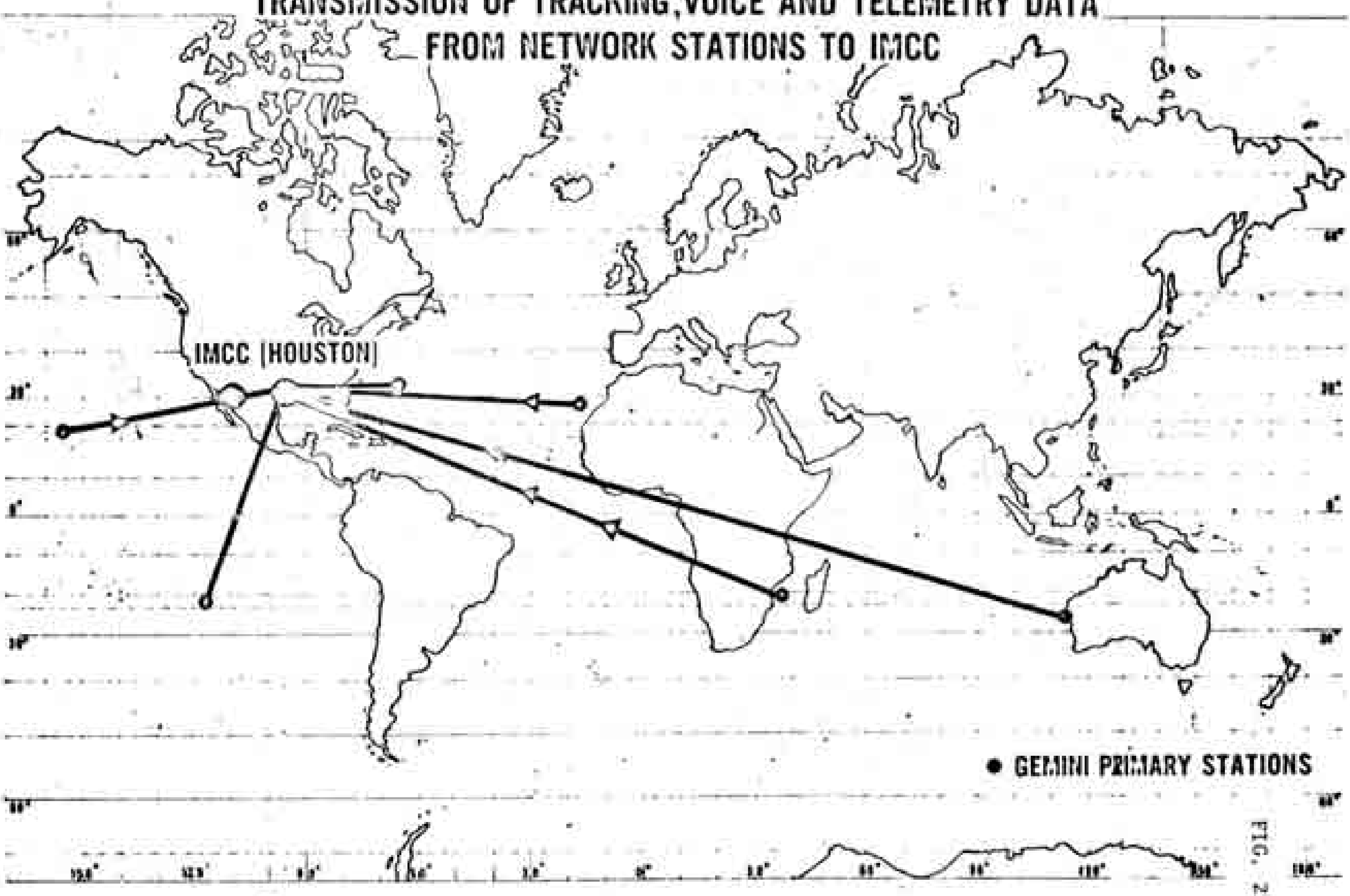


FIG. 23

FIG. 24

TRACKING AND DATA ACQUISITION BY NETWORK STATIONS TO DETERMINE NEW ORBIT AND SPACECRAFT STATUS





TRANSMISSION OF TRACKING, VOICE AND TELEMETRY DATA FROM NETWORK STATIONS TO IMCC

FIG. 25

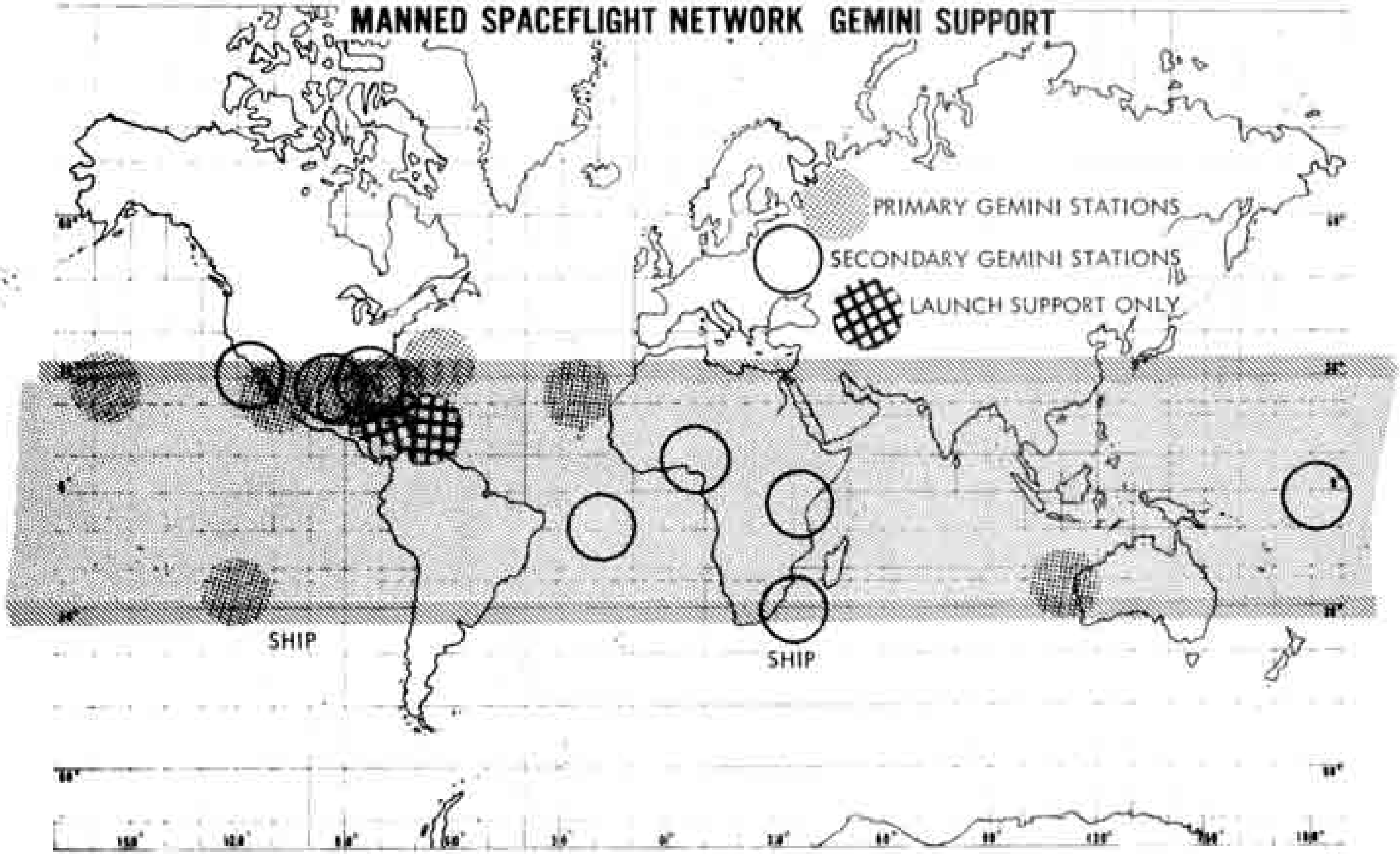
FIG. 26

MANNED SPACEFLIGHT NETWORK

GEMINI SUPPORT

	GEMINI & AGENA TRACKING	GEMINI & AGENA TELEMETRY	GEMINI & AGENA COMMAND	GEMINI VOICE
PRIMARY GEMINI STATIONS				
CAPE CANAVERAL	○	●	●	○
BERMUDA	○	●	●	○
CANARY ISLAND	○	●	●	○
CARNARVON	●	●	●	○
HAWAII	○	●	●	○
TEXAS	○	●	●	○
GUAYMAS	○	●		○
SHIP (SE PACIFIC OCEAN)		●	●	○
SHIP (SOUTH OF JAPAN)		●	●	○
SECONDARY GEMINI STATIONS				
ANTIGUA (LAUNCH PHASE ONLY)	○		○	●
SAN SALVADOR (LAUNCH PHASE ONLY)	○		○	
CANTON				○
WHITE SANDS	○			
KANO				○
ZANZIBAR				○
ASCENSION	○			○
POINT ARGUELLO	○			○
EGLIN	○			

○ EXISTING EQUIPMENT ● ADDITIONAL EQUIPMENT



CIRCLES SHOW 5° ELEVATION COVERAGE FOR 100 NAUTICAL MILE ORBIT

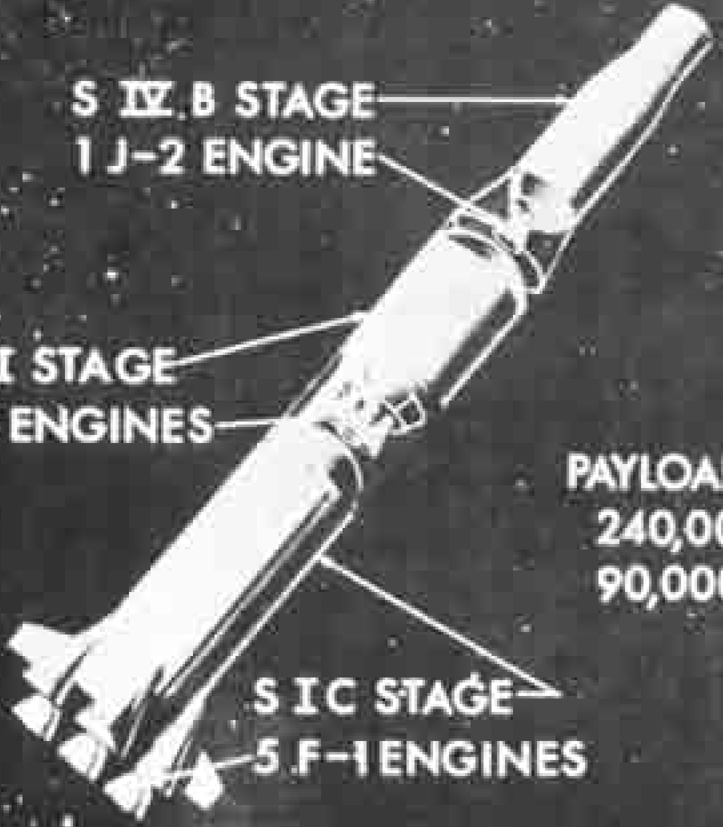
FIG. 27

used on Gemini. The variation is due to the use of the variable launch azimuth. It can be noted from Figure 27 that the variable launch azimuth does not cause any major increase in the required orbital coverage. The dotted circles show the coverage of the primary stations. A requirement also exists to obtain additional voice contact with the spacecraft and additional tracking on certain orbits. This is provided by the secondary stations which are shown by the open circles. The two stations indicated by the crosshatched circles are used during the launch and insertion phases only.

I will now discuss the Apollo program very briefly. Figure 28 shows the launch booster which will be used on the Apollo lunar mission. This is the largest one that we currently are planning. It is a three stage vehicle. The top stage, which is very important to our discussion, is the S-IVB stage and, in the lunar missions, it is fired twice. The first time it fires, it inserts the spacecraft into a parking orbit around the Earth and the second time it fires, it injects the spacecraft from the parking orbit into the transfer orbit toward the Moon.

The Apollo spacecraft is mounted at the top of the S-IVB stage as shown in Figure 29. It is composed of three major sections; The Command Module, the Service Module and the Lunar Excursion Module (LEM). The Command Module is shown in Figure 30. It has accommodations for three men and is the only section that acutally returns from the Moon to Earth and reenters. Figure 31 shows the Lunar Excursion Module which is used for the lunar landing operations, ascent from the lunar surface and lunar orbit rendezvous. Figure 29 shows the Lunar Excursion Module in its stored position during launch. The Service Module contains the basic propulsion and power supply for the mission and is not manned.

SATURN V



S IV B STAGE
1 J-2 ENGINE

S II STAGE
5 J-2 ENGINES

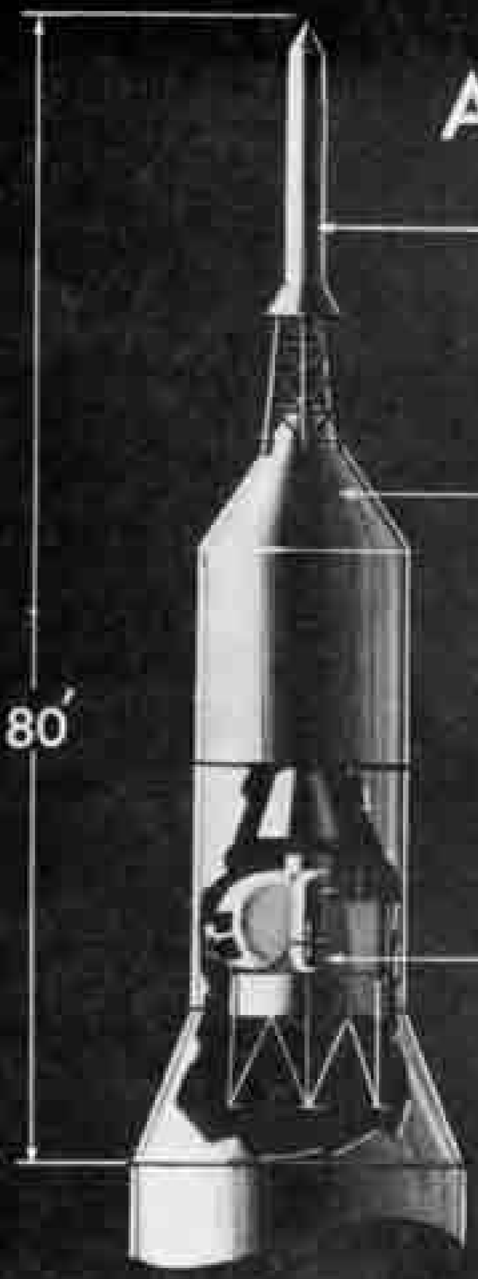
S I C STAGE
5 F-1 ENGINES

PAYLOAD-
240,000 LBS. IN 100 MILE ORBIT
90,000 LBS. ESCAPE VELOCITY

FIG. 28

FIG. 29

APOLLO SPACECRAFT



LAUNCH ESCAPE SYSTEM

COMMAND MODULE

SERVICE MODULE

LUNAR EXCURSION MODULE

TOTAL WEIGHT FUELED
ABOUT 90,000 LBS.

NASA M63-580

FIG. 30

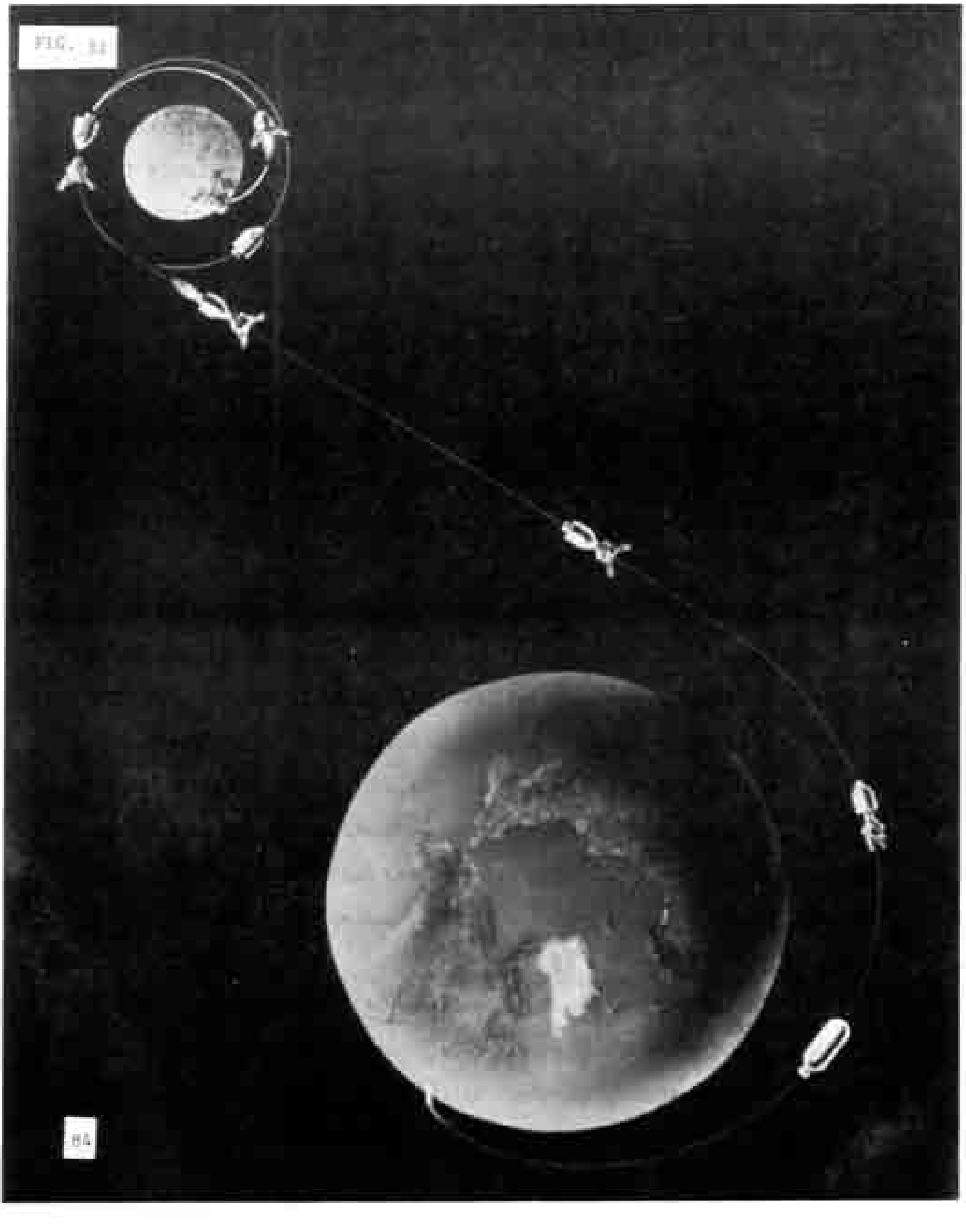
FIG. 31

Figure 32 depicts a typical lunar mission. The first phase is the outgoing one from the Earth. As I mentioned, a variable launch azimuth is used and injection into the lunar trajectory is made from a parking orbit. When the spacecraft approaches the Moon, the Service Module fires its propulsion system and places the spacecraft into an orbit around the Moon. At a determined point in this orbit, the Lunar Excursion Module is detached, fires its "descent motor" and lands. This maneuver is shown in Figure 33. The Command/Service Module combination that remains in lunar orbit is also shown. This combination continues around in lunar orbit after the LEM lands. In the landing sequence, the LEM propulsion is used to change from an elliptical orbit to a hover position and then makes a landing on the lunar surface. Figure 34 is an artist's conception of the lunar touchdown.

On the return trip, the Lunar Excursion Module takes off from the surface of the Moon and accomplishes a rendezvous with the Command/Service Module. After the rendezvous, the astronauts transfer back from the LEM to the Command Module, the LEM is left in lunar orbit and the Service Module fires, injecting the Command/Service Module from the lunar orbit into a trans-Earth trajectory. When the Command/Service Module gets near the Earth, the Service Module is detached and the Command Module proceeds on a ballistic reentry trajectory, finally landing by parachute as shown in Figure 36.

Now I will describe the characteristics of the early Earth orbital Apollo missions which are approaching us rather rapidly. The first are the Apollo C-I missions. The characteristics of these missions are shown in Figure 37. They are long duration orbital missions. The present

FIG. 33



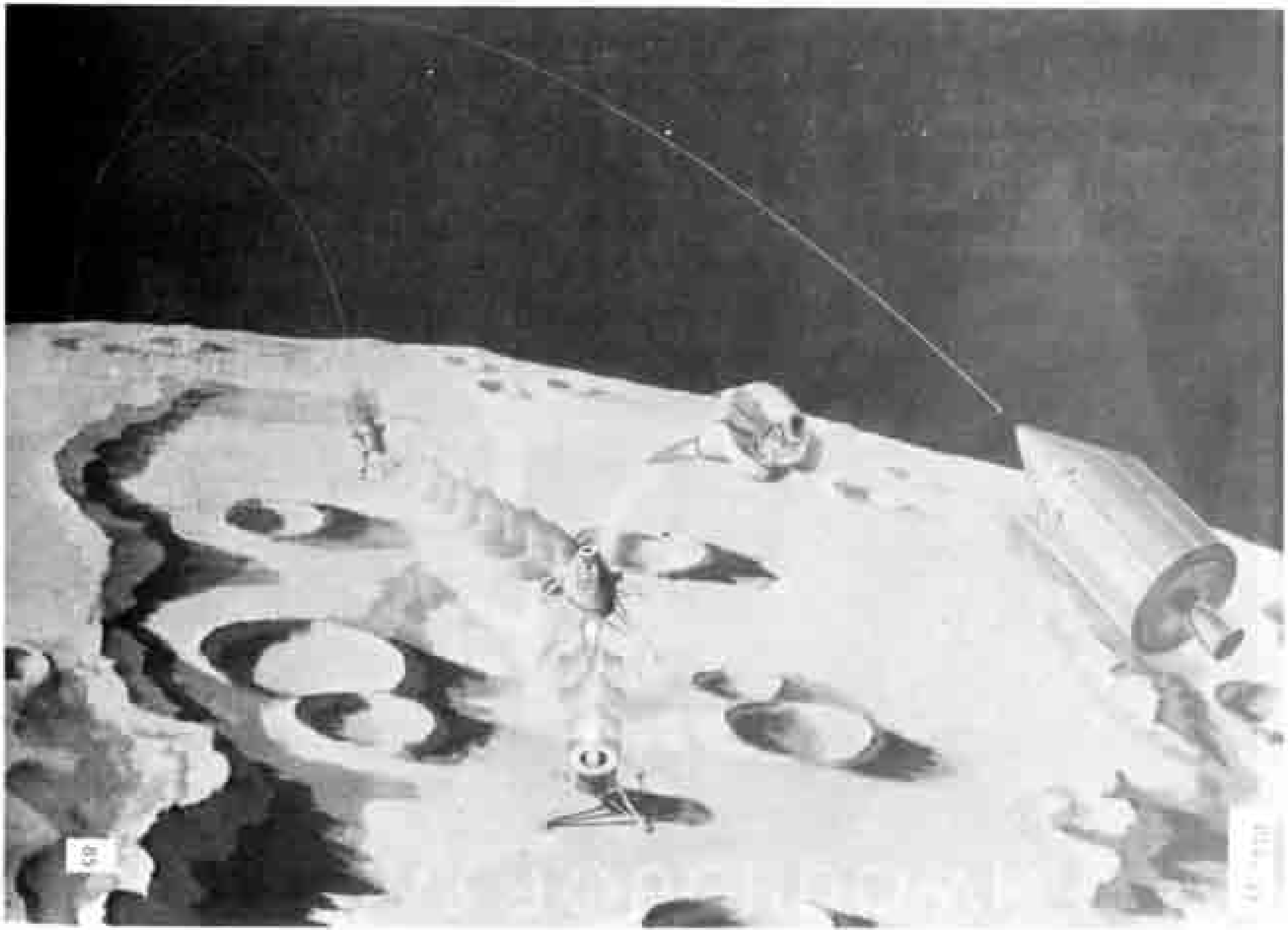
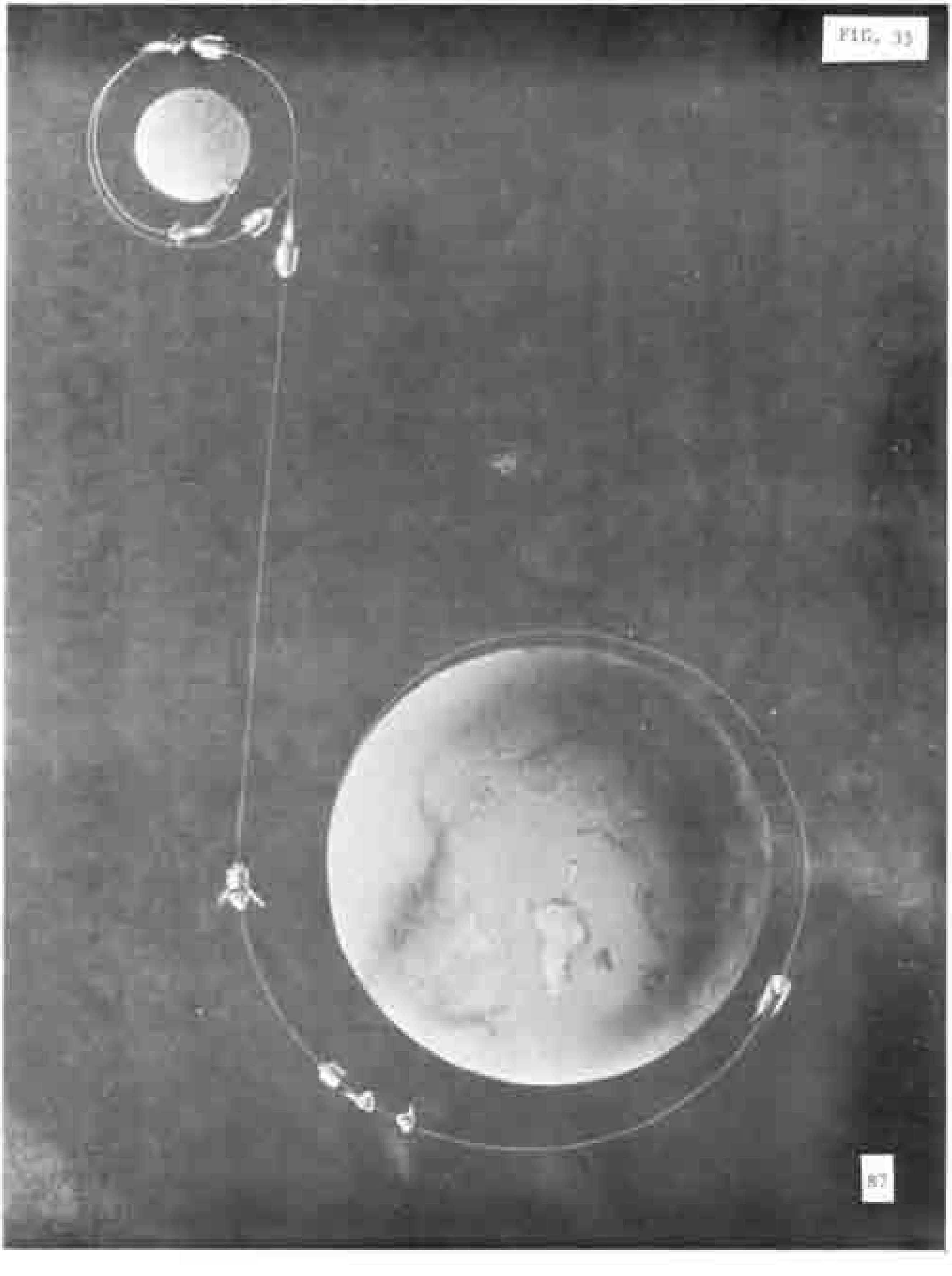


FIG. 34

LUNAR TOUCHDOWN

FIG. 33



TERMINAL DESCENT

FIG. 36

NASA M61-124

APOLLO C-1 MISSIONS

- LONG DURATION ORBITAL MISSIONS
- USE PRESENT MERCURY LAUNCH AZIMUTH (73°)
- QUALIFICATION OF PROTOTYPE SPACECRAFT SUBSYSTEMS

FIG. 37

Mercury 73° launch azimuth will be used. These missions will be used to qualify prototype spacecraft subsystems. The C-I missions will be followed closely in time by the C-IB missions outlined in Figure 38. The C-IB missions are also long duration Earth orbital missions and also use the 73° launch azimuth. The important difference in these missions is that the C-IB missions will be the first time that we will have both the S-IVB and the LEM, as well as the Command/Service Module, in orbit. From a ground instrumentation standpoint, this is the first time we will be able to exercise our ground instrumentation against the Apollo operational spacecraft configuration. Simulation of lunar rendezvous while in Earth orbit will also be accomplished during C-IB missions. After the preceding missions, we progress to the Apollo lunar missions which I have previously described.

The Apollo missions place several new requirements on the Manned Space Flight Network. A summary of the most critical and important new requirements are shown in Figure 39. First is the S-IVB/Apollo spacecraft insertion into the parking orbit and injection of the Apollo spacecraft into the lunar transfer orbit. Due to the variable launch azimuth and the changing position of the Moon, many of the places on the Earth over which these events occur are broad ocean areas and will require the use of shipborne instrumentation to provide the necessary coverage. We will also have a requirement for "in-orbit checkout and countdown" of the S-IVB and spacecraft while in Earth orbit. This means that while the spacecraft is in the parking orbit around the Earth, before it injects towards the Moon, we must operate the telemetry system to check it out thoroughly and make sure the spacecraft equipment is working properly. Another require-

APOLLO C-1B MISSIONS

- LONG DURATION ORBITAL MISSIONS
- USE PRESENT MERCURY LAUNCH AZIMUTH (73°)
- QUALIFICATION OF FLIGHT OPERATIONAL SYSTEMS
    - S-IVB
    - COMMAND/SERVICE MODULE
    - LEM
- ELLIPTICAL AND RENDEZVOUS (LEM-COMMAND MOD.) FLIGHTS

FIG. 38

FIG. 39

MANNED SPACEFLIGHT NETWORK

NEW REQUIREMENTS FOR APOLLO C-5 MISSION

- S-IVB INSERTION
- IN-ORBIT CHECKOUT & COUNTDOWN (S-IVB & SPACECRAFT)
- LUNAR DISTANCE COMMUNICATION & TRACKING
- UNIFIED S-BAND SYSTEM

ment is that we must have the capability in the Manned Space Flight Network of lunar distance communication and tracking. We also have a requirement to increase our overall ground to spacecraft communications capability due to the greater complexity of the spacecraft and missions. This capability increase will be provided through the use of the Unified S-band system.

For lunar distance communication and tracking, it is planned to use three new 85-foot antennas and three existing or programmed 85-foot antennas as backup. This is indicated in Figure 40. These antennas will be grouped, two each, at three locations to obtain, through redundancy, the required Apollo reliability. The capabilities that will be achieved at lunar distance are also shown in Figure 40 for the Unified S-band system.

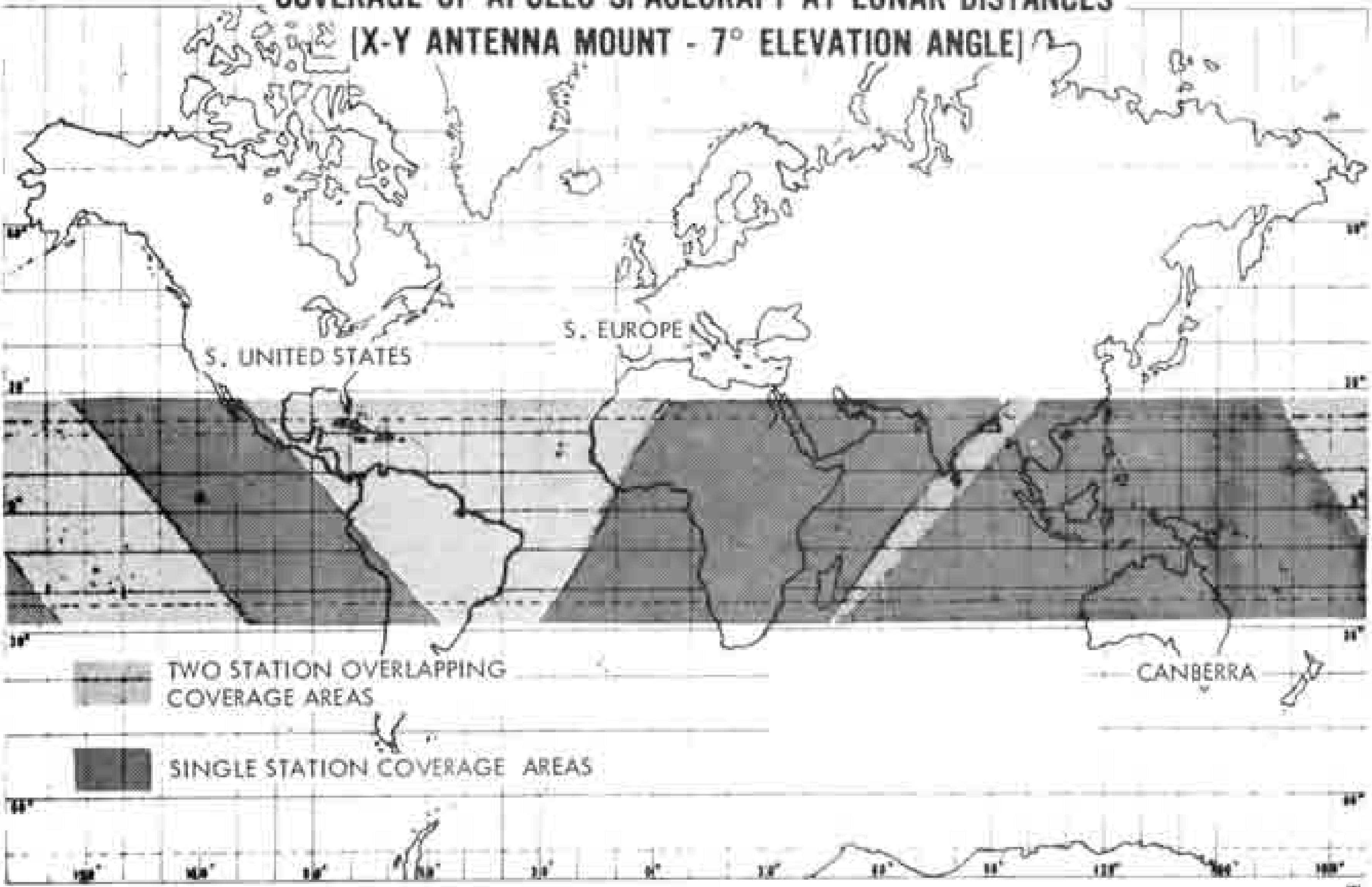
Figure 41 shows the coverage provided by the 85-foot antenna sites. The gray band is the locus of all possible lunar subsatellite points on the Earth. If this gray band is completely covered by the Network stations, the spacecraft is always in communication with the Earth at lunar distances. The three primary 85-foot antenna stations are planned to be located in South Europe, Canberra and Goldstone, California. The coverage from these locations is shown as the darker gray areas. The light gray areas show where two stations can simultaneously provide lunar distance coverage. The important point is that continuous coverage of the spacecraft at lunar distances is possible and, in fact, there are many instances where overlapping coverage is possible.

Figure 42 shows the Manned Space Flight Network for the Apollo project. The stations indicated in Figure 42 do not include any special

FIG. 60

LUNAR DISTANCE COMMUNICATION AND TRACKING

- ▶ AUGMENT PRESENT DEEP SPACE STATIONS
  - 3 NEW 85 FOOT ANTENNAS - APOLLO PRIME ASSIGNMENT
  - 3 EXISTING/PROGRAMMED 85 FOOT ANTENNAS - APOLLO BACKUP
- ▶ CAPABILITIES
  - TWO-WAY VOICE (4 Kcs)
  - PCM TELEMETRY (32,000 bits/sec)
  - RANGE (50 ft resolution) AND RANGE RATE (0.5 ft/sec resolution)
  - UP-DATA
  - TV (10 frames/sec)
  - TWO SPACECRAFT SIMULTANEOUS RECEPTION (LEM & CM)

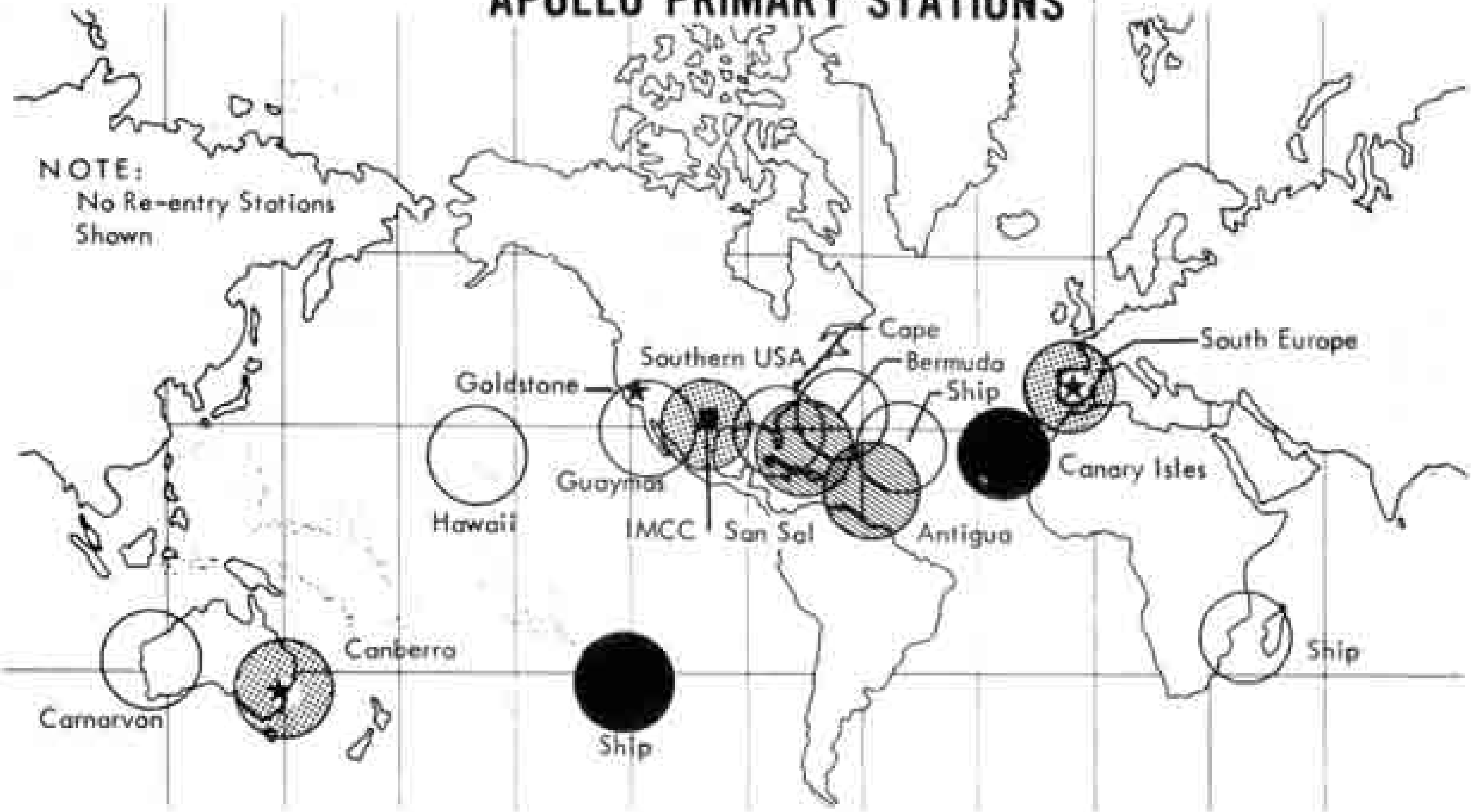


COVERAGE OF APOLLO SPACECRAFT AT LUNAR DISTANCES
(X-Y ANTENNA MOUNT - 7° ELEVATION ANGLE)

FIG. 41

FIG. 42

MANNED SPACEFLIGHT NETWORK APOLLO PRIMARY STATIONS



▨ LAUNCH PHASE ONLY

○ UNIFIED S BAND SYSTEMS 30 FOOT ANTENNAS

● LONG DURATION ORBITAL MISSIONS ONLY

░ UNIFIED S BAND SYSTEMS 85 FOOT ANTENNAS PRIME ASSIGNMENT

★ UNIFIED S BAND SYSTEMS 85 FT ANTENNAS BACKUP ASSIGNMENT sites for injection or reentry coverage. The dotted circles show the stations that will be used with the Unified S-band system and 30-foot antennas. These will provide coverage of the Earth orbital phases and the translunar phase of the Apollo missions. The black circles will be used primarily for coverage of the Apollo long duration Earth orbital missions. The two stations indicated by the crosshatched circles will be used for coverage of the launch phase only. The Integrated Mission Control Center, which will control the manned space flight operations, is shown at Houston, Texas. The 85-foot antennas are indicated by stars and circles at Canberra, South Europe and Goldstone, California.

I trust that in this brief presentation we were able to outline to your satisfaction the progressive development of the Manned Space Flight Network capability and to indicate the important contributions of the Australian stations, both past and planned, to this capability.

MR. BUCKLEY: That completes the presentation. We thought we would like to show you the planning leading to the complete network here. I know that at your end of the system it must sound as though these things pop up one after the other and you may see the relationship. Here we have tried to establish the relationship between them and to give you a feel of the involved planning and the long range planning that goes into this support system. Probably you also have an opinion, or you received an impression of the need for this support system, in order to make the decisions you have to make. And your question, Mr. Minister, about where the decisions were coming from, was answered, that in that case the man has the decision processed but we have an alternate on the ground in case something happens. In Mercury there were a tremendous number of redundant systems so if something happened, you had a pretty good chance of saving they mission one way or another. This is an indication that the ground system is necessary for the safety of the man or the success of the mission. Without a ground system you would be helpless. As a matter of fact, we couldn't exist in space at all without this ground system, of which you are a part. Bob Briskman mentioned the team concept and he mentioned that I feel pretty strongly about it--the job of running stations that are in Zanzibar, the Canary Islands, etc., and holding them under control so they perform when we want them to and we can perhaps help analyze any trouble they get into.

I strongly feel that the ability to do this depends on having these stations exactly alike. If these stations are exactly alike, then perhaps the peculiarity, that you get into in the radar, has been seen somewhere else, or a number of people on the network could help analyze it by knowing the symptoms. On the other hand, if this station, whether in the Canaries or in Zanzibar, were just a little bit different, then he would be entirely on his own to fix what happens. This was vividly demonstrated in, I guess, probably every one of our Mercury launchings. Let's say the one before the last in which we had some radar difficulty in the Canaries. It was very easy for us to appreciate the problems and difficulties they had in solving it. We could guess how long it would take to get a spare part, although it happened that with some checking on their part they discovered they had spare parts and they were back on the air very quickly - in something like 30 or 45 minutes. But we knew their problem. Although they were isolated, as they seem to be to us, geographically, we could visualize the whole system--exactly where it was and what they had to do to get it back on, etc. To insure that we achieve this success and reliability, it is necessary that the training of the people at the stations be exactly alike; that they, first of all, make the stations exactly alike, and the men do exactly the same job. And so the man in Zanzibar and the man in Muchea do exactly the same thing at the same time to calibrate the same way, etc., and we have been rather strict in holding this concept.

I'd like to express our appreciation, sir, for your wonderful cooperation and I think that you contributed in a major way to the success we have had. I want to close by saying that everybody who has come back from Australia sings the praises of your country most sincerely. They have made some real friends over there and they have liked all the people they have met.

MINISTER FAIRHALL: Mr. Buckley, I'd like to take this opportunity to thank you very much for quite a number of things. One is, of course, you are all very welcome there. Mr. Webb said something about how pleased he was to have us here and how good it was of us to spare the time to come. I'd like to say how good it was of you to spare the time you had this afternoon to take us through this program on the space program in order for us to understand the minor but nevertheless important part of their flying unit. It is quite true, of course, that the people of your organization are more than welcome in Australia and I'm glad to meet some of our friends this afternoon, especially Mr. Briskman and Mr. Covington who were with us. I did a little bit of flying with them on one occasion looking for the spot for the station because, being half a politician, I wanted to see it located in my own territory but this was not to be. I think what you have said about the kind of welcome and about the kind of people we have operating, comes very close to something put down by Mr. Covington when we talked about this in Australia. This describes the meeting of the minds; I think it is because they are people who are so keen to participate and do a good job on this and because we were getting along so very well with your people here, this is why we've been successful. We see no reason in the world why this success shouldn't go on, as we put in a few new stations and perhaps as new ones come along in time. For our part, we are grateful for the opportunity to talk to so many of you, to see this rundown, and for, certainly, tomorrow and later on, to see the facilities, the physical facilities, which lie beyond the NASA program.