SUMMARY RESULTS OF THE FIRST UNITED STATES MANNED ORBITAL SPACE FLIGHT

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You have been presented with booklets which go into considerable detail in describing the results of the First United States Manned Orbital Space Flight of February 20, 1962.

In the short time we have here today, it is my purpose to comment on highlights from that booklet and also provide some time for questions.

The test objectives for the MA-6 mission of Friendship 7, as quoted from the Mission Directive, were as follows:

(a) Evaluate the performance of a man-spacecraft system in a three-orbit mission.

(b) Evaluate the effects of space flight on the Astronaut.

(c) Obtain the Astronaut's opinions on the operational suitability of the spacecraft and supporting systems for manned space flight.

These goals were pursuant to the broad objective given to Project Mercury in 1958 to: "Determine man's capabilities in a space environment". Starting in September of 1959, a series of 19 launchings preceded the Friendship 7 flight, and involved Little Joe, Redstone and Atlas boosters. Two of the suborbital Redstone missions were manned.

Let us briefly examine some of the elements that go toward making an orbital space mission.

Network Stations. - In order to perform real-time analysis of both the powered phase and orbiting flight, a network of 16 stations located along the three-orbit ground track was constructed. The location of these

(Fig 1) sites is shown in Figure 1.

The sites were chosen for a great number of reasons but primarily to take advantage of the existing tracking and data-gathering facilities that were available at the start of the project. In addition, it was desirous to make available continuous real-time tracking during the launch and reentry phase, and to provide communications and telemetry data as often as possible throughout the flight. In addition, six of the sites at pertinent points along the ground track were provided with radio command capability in order to back up such functions as retrofire and clock changes. This network has proven to be an exceptionally good and capable tool in controlling orbiting vehicles and, in particular, manned spacecraft.

Recovery Forces. - One of the biggest considerations for Mercury operations planning was to provide for safe and quick recovery of the Astronaut. Plans were made to place teams in a large number of strategic locations to cover possible aborted flights during all phases of the mission.

(Fig 2) Figure 2 gives a general picture of the recovery operation. Plans were made for recovery in the launch area on the basis of any foreseeable catastrophe from an off-the-pad abort to aborts occurring at or shortly after lift-off. From this period to the point at which the spacecraft was inserted into orbit, a number of recovery areas were located across the entire Atlantic Ocean, based on the probabilities of aborted spacecraft malfunctions.

Other operational aspects included the training of personnel on the world-wide network, accurate weather information for the network as well as for launch conditions at Cape Canaveral, and the complex problem of deploying, supporting, and coordinating the activities of over 19,000 people directly involved in the manned orbital operation.

Spacecraft and Spacecraft Systems. - The Mercury spacecraft is designed to sustain a man in a space environment for a given period of time, to protect him from external heating and acceleration during exit and reentry, to provide him with means for controlling the attitude of the spacecraft, to permit him to perform observations, and a limited number of experiments in space, and to then bring him safely back to earth with sufficient location aids to permit rapid recovery by surface forces.

The spacecraft at the launch of MA-6 weighed 4,265 pounds. The weight at insertion into orbit was 2,987 pounds, and at retrograde, 2,970 pounds. The water-landing weight was 2,493 pounds, and the recovery weight was 2,422 pounds.

Heat Protection. - An artist's conception of the Mercury space-
(Fig 3) craft during the early stages of a normal reentry is shown in Figure 3, with shading indicating that the spacecraft is surrounded by a bright-orange envelope of heated air. The spacecraft has been designed to protect the interior from the effects of reentry aerodynamic heating. This heat protection consists of an ablation reentry heat shield for the forebody and an insulated double-wall structure for the afterbody.

Ablation Shield. - The ablation-shield material is a mixture of glass fibers and resin in the proper proportions such that the resin will boil off under applied heat with the glass fibers providing strength and shield integrity. During the high-heating period of reentry, the resin vaporizes and boils off at low temperatures into the hot boundary layer of air, thus cooling the boundary heat on the spacecraft.

In order to illustrate the effectiveness of the spacecraft heat protection, some significant temperatures are presented in Figure 4. From an overall standpoint, the most severe heating is encountered during reentry. During this time, the aircap surrounding the heat shield end of the spacecraft has a maximum temperature of about 9,500° F, which is nearly the same as the temperature of the surface of the sun. As a result, the surface of the heat shield reaches a maximum temperature of about 3,000° F and the spacecraft afterbody shingles attain maximum temperatures on the order of 1,000° F on the thin shingles and about 600° F on the thicker shingles.

(Fig 4)

During the exit flight, when the small end of the spacecraft points in the direction of flight, the afterbody shingles are also subjected to aerodynamic heating. They attain maximum temperatures as high as about 1,300° F, with the local temperatures dependent upon local flow conditions and the thermal mass of the spacecraft surface.

The temperature variation of the outer shingles around the Astronaut's pressure compartment is modest during the orbital phase of the mission, varying between 200° F and -50° F, depending upon the sun impingment. Of particular interest are the cabin-air and suit-air temperatures. These remain at acceptable levels during all phases of the mission, attesting to the effectiveness of the environmental control system and the insulation. On the outer conical surface and antenna section thin high-temperature alloy (René 41) shingles are used. On the outer cylindrical section thicker shingles of beryllium are used in a heat-sink arrangement. The shingles are blackened to aid the radiation of heat

(Fig 5)

away from the spacecraft, and they are attached to the basic structure in such a manner that they can expand and contract with temperature changes without transferring loads to the primary-load-carrying spacecraft structure.

Rocket Motor Systems. - The rocket motor assemblies used in the
(Fig 6) Mercury spacecraft are as shown in Figure 6, with their nominal per-
(Fig 7) formance characteristics shown in Figure 7. All of the rocket motors employ solid-propellant fuel.

In the MA-6 mission, all rocket motor systems appear to have operated properly. The escape tower was jettisoned as planned at the proper time. The firing of the posigrade rockets provided the expected velocity change, as did the retrorocket motors.

Control System. - The control system of the Mercury spacecraft provides the capability of attitude control throughout the orbital mission. One of its most important functions is in attaining a precise attitude for retrofire and holding the attitude closely during the stepped thrusting period of the retrorockets. Without such control, it is impossible to effectively fire the retrorockets. Because of this critical function, the Mercury control system has been designed to perform its function in event of multiple malfunctions.

Basically, there are two completely independent fuel supply, plumbing, and thruster systems. Each uses 90-percent hydrogen peroxide to provide selected impulse as desired. There are two means of controlling the outputs of each of these systems. On System A, the Astronaut has a choice of using either the automatic stabilization and control system (ASCS) or the fly-by-wire (FBW) system. The ASCS is automatic to the extent that it can provide the necessary attitude control throughout a complete mission without any action on the part of the Astronaut. This is the system that was used on the unmanned Mercury missions. The FBW system is manual control of the ASCS thrusters, operated by movement of the Astronaut's control stick to operate the solenoid control valves electrically.

On System B, the Astronaut has the choice of using either the manual proportional system (MP) or the rate stabilization control system (RSCS), both of which are operated through the Astronaut's control stick. In the MP system, linkages transmit the control stick movement to proportional control valves which regulate the flow of fuel to the thrusters. The RSCS uses a combination of stick positions and the computing components of the automatic system to provide rate control.

The mode of control can be selected by the Astronaut.

The thruster impulses are directed through 18 individual thruster units. Thrusts available vary from 1 to 24 pounds depending on the control mode selected.

For the MA-6 mission, the control system, with essential mode changes by the Astronaut, provided adequate control of spacecraft attitudes during all phases of the mission despite recurrences of small thruster malfunctions which disabled the minimum fuel consumption mode about the yaw axis early in the mission.

(Fig 8) Communications. - The spacecraft communications and instrumentation systems consisted of voice, radar, command, recovery and telemetry links. Each system had main and backup (or parallel) equipment for redundancy, with selection of the desired system generally at discretion of the Astronaut through switches mounted on the instrument panel.

The voice system, used for two-way voice conversation between the ground and spacecraft, was made up of high-frequency (HF) and ultra-high frequency (UHF) systems. From previous orbital experience and ground tests, it was known that the HF system had somewhat poorer voice fidelity but longer range than the UHF system. The UHF system, because of its slightly better voice quality was considered to be the primary system. From previous experience, it was known that the range of the UHF system was approximately equal to the line-of-sight range and was entirely adequate for a normal mission. The main voice traffic was, therefore, conducted on the UHF system, with a small amount on the HF to verify system operation.

Instrumentation. - Ninety commutator segments were available for data, plus seven continuous channels. The continuous channels were used mainly for aeromedical information and spacecraft control system performance data. Astronaut's EKG, respiration rate and depth, blood pressure, and body temperature were monitored in addition to many aspects of spacecraft system operation.

A 16mm camera photographed the Astronaut in color at 360 frames/min. or 5 frames/min., depending on the mission phase.

Electrical Power System. - Rechargeable silver-zinc batteries of both 3,000-watt hour and 1,500-watt hour ratings are arranged into three power sources to provide a total of 13,500 watt-hours.

A solid-state static inverter provides 115-volt, 400-cycle, single phase alternating current power.

(Fig 9) Sequential System. - Figure 9 shows the sequence of major events for the MA-6 mission. The only exception to the planned sequence occurred during event (9). As a result of being advised to retain the retropackage during reentry, I manually overrode the automatic sequencing.

Redundancy for the automatic initiation of spacecraft sequence events is furnished by the Astronaut's ability to initiate events manually by switches and controls and by ground-commanded initiation of certain events by means of a radio-command link. The Astronaut has control over all of the primary spacecraft automatic functions. The Astronaut also has indirect control over the important launch-vehicle functions, such as engine cutoff, through use of the spacecraft abort handle when necessary.

The performance of the spacecraft sequencing system was satisfactory during the MA-6 mission.

(Fig 10) <u>Landing System.</u> - The landing system consists of the drogue parachute, main and reserve parachutes, landing bag, and attendant functional systems. The landing system is armed when the escape tower is jettisoned during exit flight; however, it is not actuated until the spacecraft returns to the relatively dense parts of the earth's atmosphere.

The landing system is normally actuated at an altitude of about 21,000 feet by either one of two barostats which sense atmospheric pressure. At this time, the drogue parachute is deployed to decelerate, and stabilize the spacecraft. At approximately 10,000 feet, the antenna section and drogue parachute are jettisoned by the signals from another dual barostat. The main parachute is deployed in a reefed condition, opened to 12-percent of the maximum diameter for 4 seconds, to minimize the opening shock. The main parachute deploys fully after 4 seconds of reefing. A reserve parachute may be deployed by the Astronaut in the event the main parachute is unsatisfactory. After main parachute deployment, the landing bag is extended to provide attentuation of the 32 fps landing load. Immediately after landing, the main parachute is disconnected and the reserve parachute is ejected.

Life Support System. - The Mercury environmental control system provides a livable environment for the Astronaut in which total pressure, gaseous composition, and temperature are maintained, and a breathing oxygen supply is provided. To meet these requirements, a closed-type environment control system was developed.

The pressures in the cabin and pressure suit are maintained at 5.1 psi in normal flight with a 100-percent oxygen atmosphere.

Oxygen is supplied at an initial pressure of 7,500 psi from two spherical steel tanks.

The pressure suit functioned from its own control system and operated as a last-ditch pressure vessel if cabin pressure had been lost.

A survival kit was carried in case it was necessary to re-enter in an unprepared area.

Difficulties. - There were some systems difficulties experienced during the flight of Friendship 7:

(a) A limit switch malfunctioned and sent an erroneous telemetry signal that the ablation shield had released.

(b) Precession of the Automatic Stabilization and Control System when not in orbit attitude was altered somewhat more than anticipated.

(c) The one-pound yaw thruster chambers malfunctioned.

(d) Inverter cooling did not operate as planned.

The presence of an Astronaut onboard the spacecraft made these malfunctions of a minor nature. Corrections are being incorporated for each of these conditions.

Checkouts. - Detailed spacecraft systems checks were made many times prior to launch. Checkouts of other supporting elements were taking place simultaneously and included such complex systems as those on the launch pad, blockhouse, Atlas booster, Control Center, and the world-wide range.

Aeromedical checkout of the Astronaut was thorough and complete.

Aeromedical. - Comprehensive medical evaluations were performed prior to orbital space flight and as soon after this flight as recovery practices permitted. Primarily, these examinations were accomplished to determine the state of health and medical fitness for flight. In addition, such clinical evaluations serve as base-line medical data which may be correlated with inflight physiological information.

Detailed medical examinations were conducted prior to the canceled flight in January 1962, and before the flight in February. Aspects of the examination which were not time critical were completed several days before the launch and included the following: specialists' evaluations in neurology, ophthalmology, aviation medicine, psychiatry, radiology, a standard 12-lead electrocardiogram, an audiogram, an electroencephalogram, and biochemical studies of blood and urine. All of these evaluations showed normal results and revealed no change from the numerous preceding examinations.

Astronaut Preparation. - Astronaut training activities centered around such items as spacecraft systems discussions and operation, mission and system procedures and simulated emergencies, physical fitness (including five miles of running each day), and egress and recovery. Also of great value were the many hours spent participating directly in spacecraft preparation and checkout operations. In addition, much time was spent in the study of terrestial and extra-terrestial features in preparation for scientific and space-navigation observations in orbit. All of these training and study activities contributed greatly to readiness for the orbital mission.

Flight Plan. - A summary outline of the flight plan is given as follows:

The Astronaut was to evaluate the various modes of control available in the spacecraft and to report on the capabilities of these various systems. He was to determine his visual reference capabilities; that is, his ability to determine attitude by observing the horizon and/or the stars by using the window and periscope, and his ability to obtain this reference on both the light and dark sides of the earth. Certain specific maneuvers were set up to provide information on this capability. The effects of weightlessness for extended periods were to be determined by his ability to perform in this environment and, here again, specific tests were set up to aid in this determination. The Astronaut was to perform management of onboard systems such as cabin and suit cooling, use of A.C. and D.C. power. He was to report on the performance of all of the spacecraft systems and was to determine his ability to navigate by both earth and star reference. He was to perform visual observations of various astronomical and scientific interests. Finally, he was to report on any unusual phenomena within or outside of the spacecraft. Although the malfunction of some of the spacecraft systems may have altered the flight plan to some extent, it is felt that the flight test results achieved a (Fig 11) great majority of the objectives laid down and that the flight test was extremely successful.

Flight Observations. - I will not attempt to go through the flight in detail because most of you are probably already aware of most of the details from news accounts or from available technical sources.

There are a few items, however, of special note.

Some pictures were taken with a hand-held 35mm camera. Due to problems with the ASCS previously mentioned, picture-taking became of secondary importance. In spite of the haste with which they were made, some of the pictures show a few items of interest.

Color and Light.- As I looked back at the earth from space, colors and light intensities were much the same as I had observed when flying (Fig 12) at high altitude in airplanes.

Figure 12 is of the Atlas mountain area in North Africa. The colors observed when looking down at the ground appeared similar to those seen from 50,000 feet. When looking toward the horizon, however, the view is completely different, for then the blackness of space contrasts vividly with the brightness of the earth. The horizon itself is a brilliant, brilliant blue and white.

Throughout this flight, no trouble was encountered in seeing the horizon. During the day, the earth is bright and the background of space is dark. The horizon is vividly marked. At night, before the moon is up, the horizon can still be seen against the background of stars. After the moon rises (during this flight, the moon was full), the earth is well enough lighted so that the horizon can be clearly seen.

Only a few land areas were visible during the flight because of the cloud cover. Clouds covered much of the Atlantic, but this western (Sahara Desert) part of Africa was clear. In this desert region, I could plainly see dust storms and brush fires.

Western Australia was clear, but the eastern half was overcast. Most of the area across Mexico and nearly to New Orleans was covered with high cirrus clouds. Across the United States, I could see New Orleans, Charleston and Savannah very clearly. I could also see rivers and lakes. The best view of any land area during the flight was the clear desert region around El Paso on the second pass across the United States, where I could see the colors of the desert and the irrigated area north of El Paso. Off the east coast of the United States, I could see across Florida and
(Fig 13-14) far back along the Gulf Coast, as shown in Figures 13 and 14. Note clarity of Atlantic and Gulf Coasts. Together, the pictures cover an area from just above Canaveral to the Georgia border.

Over the Atlantic, I saw what I assume was the Gulf Stream. The different colors of the water were clearly visible.

I also observed what was probably the wake of a ship. Over the recovery area at the end of the second orbit, I looked down at the water and saw a little "V" and checked the map. I was over recovery area G at the time, so it was probably the wake from a recovery ship. When I looked again, the little "V" was under a cloud. The change in light reflections caused by the wakes of ships are sometimes visible for long distances from an airplane and will linger for miles. This type wake was probably what was visible.

Visibility of Clouds and Weather Bureau Experiments. - It was surprising how much of the earth's surface was covered by clouds. The clouds can be seen very clearly on the daylight side. The different types of clouds - vertical developments, stratus clouds, and cumulus clouds - are readily distinguished. There is little problem identifying them or in seeing the weather patterns. You can estimate the relative heights of the cloud layers from your knowledge of the types or from the shadows the high clouds cast on the clouds lower below. These observations are representative of information which the scientists of the U. S. Weather Bureau Meteorological Satellite Laboratory had asked Project Mercury to determine. They are interested in improving the optical equipment in their TIROS and NIMBUS weather satellites and would like to know if they could determine the altitude of cloud layers with better optical resolution. From this flight, I would say it is quite possible (Fig 14) to determine cloud heights from this orbital altitude.

(Fig 15) It is interesting to compare the photographs taken by the TIROS IV Satellite with the pictures which I took. Figure 15 shows a TIROS IV picture of the Florida peninsula taken approximately 3 hours before (Figure 14 repeated). This photo shows the clouds which covered the Cape earlier in the morning during the countdown and which have moved on south. The fringe of this same region is shown on the right side of my photograph. The two patches of clouds to the north are also clearly visible in the MA-6 photograph.

(Fig 16) Somewhat later, over the Atlantic, on my third orbit, I took other (Fig 17) pictures of the cloud formations. Figure 16 and 17 show a cloud picture and a TIROS IV photograph of approximately the same area 4 hours earlier. Both photographs show the overcast area to the north and west (upper part of the slide) and the broken clouds in the foreground.

(Fig 18) At dawn, over the Pacific on the first orbit, I caught the sunrise
(Fig 19) on the clouds. Note how the slanting rays of the sun help determine the cloud heights.

(Fig 20) Figure 20 was taken just before sunset over the Indian Ocean and shows solid cloud cover. Once again, shadows help define cloud heights.

Just off the east coast of Africa were two large storm areas. Weather Bureau scientists wondered whether lightning could be seen on the night side, and it certainly can. A large storm was visible just north of my track over the Indian Ocean and a smaller one to the south. Lightning could be seen flashing back and forth between the clouds but most prominent were lightning flashes within thunderheads illuminating them like light bulbs.

Obviously, on the night side of the earth, much less was visible. This may have been due not only to the reduced light, but also partly to the fact that I was never fully dark adapted. In the bright light of the full moon, the clouds are visible. I could see vertical development at night. Most of the cloudy areas, however, appeared to be stratoform.

Sunset and Orbital Twilight. - Some of the most spectacular sights during the flight were sunsets. The sunsets always occurred slightly to my left, and I turned the spacecraft to get a better view. The sunlight coming in the window was very brilliant, with an intense clear white light that reminded me of the arc lights while the spacecraft was on the launching pad.

As the sun moves toward the horizon, darkness moves across the earth until the whole surface, except for the bright band at the horizon,

(Fig 21) is dark.

The sun is perfectly round as it approaches the horizon. It retains most of its symmetry until just the last sliver is visible. The horizon on each side of the sun is extremely bright, and when the sun has gone down to the level of this bright band of the horizon, it seems to spread out to each side of the point where it is setting. With the

(Fig 22) camera, I caught the flattening of the sun just before it set. This is a phenomenon of some interest to the astronomers.

This band is extremely bright just as the sun sets, but as time passes, the bottom layer becomes a bright orange and fades into reds, then on into the darker colors, and finally, off into the blues and

(Fig 23) blacks, as you get farther toward space. One thing that surprised me was the distance the light extends on the horizon on each side of the point of the sunset; some 45 to 60 degrees on each side of orbital track.

(Fig 24, 25 & 26) Figures 24, 25 and 26 are views of this orbital twilight. I think that the eye can see more of the sunset color band than the camera captures. One point of interest was the length of time during which the orbital twilight persisted. Light was visible along the horizon for 4 to 5 minutes after the sunset, a long time when you consider that sunset occurred 18 times faster than normal.

Several other experiments were necessarily canceled due to the difficulty with the control system.

Luminous Particles. - The biggest surprise of the flight occurred at dawn. Coming out of the night on the first orbit, at the first glint of sunlight on the spacecraft, I was looking inside the spacecraft checking instruments for perhaps 15 to 20 seconds. When I glanced back through the window, my initial reaction was that the spacecraft had tumbled and that I could see nothing but stars through the window. I realized, however, that I was still in normal attitude. The spacecraft was surrounded by luminous particles.

These particles were a light yellowish green color. It was as if the spacecraft were moving through a field of fireflies. They were about the brightness of a first magnitude star and appeared to vary in size from a pinhead up to possibly 3/8 inch. They were about 8 to 10 feet apart and evenly distributed through the space around the spacecraft. Occasionally, one or two of them would move slowly up around the spacecraft and across the window, drifting very, very slowly, and would then gradually move off, back in the direction I was looking. I observed these luminous objects for approximately 4 minutes each time the sun came up.

During the third sunrise, I turned the spacecraft around and faced forward to see if I could determine where the particles were coming from. Facing forwards, I could see only about 10 percent as many particles as I had when my back was to the sun. Still, they seemed to be coming towards me from some distance so that they appeared not to be coming from the spacecraft. Just what these particles are is still subject to debate and awaits further clarification. Dr. John O'Keefe at the NASA Goddard Space Flight Center is making a study in an attempt to determine what these particles might be.

A more detailed description of the particles is given in the appendix to the booklet, with some of Dr. O'Keefe's conclusions. We are not at all convinced that we have the answer to what the particles are, and would invite comment or hypothesis from interested members of this group. I would be glad to discuss this further at the conclusion of the session, if anyone so desires.

The High Layer. - I had no trouble seeing the horizon on the nightside. Above the horizon, some 6 to 8 degrees, there was a layer that I would estimate to be 1½ to 2 degrees wide. I first noticed it as I was watching stars going down. I noticed that as they came down close to the horizon, they became relatively dim for a few seconds, then brightened up again and then went out of sight below the horizon. As I looked more carefully, I could see a band, parallel to the horizon, that was a different color than the clouds below. It was not the same white color as moonlight on clouds at night. It was a light tan color or buff white in comparison to the clouds, and not very bright. This band went clear across the horizon. I observed this layer on all three passes through the nightside. The intensity was reasonably constant through the night. It was more visible when the moon was up but during that short period when the moon was not up, I could still see this layer very dimly. I would not say for sure that you could actually observe the specific layer during that time, but you could see the dimming of the stars. When the moon was up, you very definitely could see the layer, though it did not have sharp edges. It looked like a dim hazy layer such as I have seen occasionally at lower altitudes, while flying. As stars would move into this layer, they would gradually dim and brighten as they came out of it. It was not a sharp discontinuity. Once again, I find my own opinions at variance with conclusions in the booklet which define this as probable window reflections. It, along with the luminous particles, are, in my mind, still open items for speculation.

<u>General Pilot Performance</u>. - The MA-6 flight showed that man can adapt to spacecraft activities in a space environment in much the same way he adapts to his first flight in a new airplane.

The value of static and dynamic simulators in providing accurate spacecraft systems and control familiarization was reaffirmed. Nearly all phases of the MA-6 flight had been simulated. Although I previously experienced zero-gravity flight for durations of only 1 minute in parabolic aircraft flight paths, the extension of weightlessness to $4\frac{1}{2}$ hours caused no concern and was, in fact, a pleasant contrast after spending several hours on my back at 1g.

Proposed concepts for manual control of advanced spacecraft and launch vehicles were given added impetus. By giving man a major role in systems operation, as in aircraft practice, the most rapid and efficient attainment of advanced missions will be possible. The possible malfunction of the MA-6 heat shield release mechanism required interruption of the automatic retropackage jettison sequence. The automatic control mode was similarly switched off when the small attitude control jets malfunctioned. The significance of these malfunctions and manual corrective measures can be extrapolated to the design and operational philosophy for highly-complex multi-stage missions of the future. It is clear that man must play an integral role.

Aeromedical Information. - To describe my post-flight condition briefly, the following is quoted from the Post-Flight Medical Report: Post-flight medical evaluation began when Astronaut Glenn emerged from the spacecraft onboard the Destroyer Noa, 39 minutes after landing. The pilot was described as appearing hot, sweating profusely, and somewhat tired.

He was lucid, although not talkative, and had no medical complaints other than being hot. There was no other subjective evidence of dehydration. After removal of the pressure suit and a shower, the pilot began with the shipboard medical debriefing.

A brief medical history of the space flight revealed that in spite of voluntary, rather violent head maneuvers by the pilot in flight, he specifically noted no gastrointestinal, vestibular, nor disorientation symptoms while weightless. Likewise, he experienced no adverse effects from isolation or confinement. Specifically, there was no sensory deprivation. His flight plan, in addition to the requirement to control the spacecraft on the fly-by-wire system, kept Astronaut Glenn very active and busy during the flight, and there was no so-called "breakoff" phenomenon. As evidenced by the numerous inflight reports, by task performance, and by the onboard film, the pilot's mental and psychomotor responses were consistently appropriate. Psychiatrically, both before, during and after the flight, he exhibited entirely normal behavior.

Physiological Responses. - The MA-6 mission provided a period of extended weightlessness during which the Astronaut's physiological responses apparently stabilized. The values attained were within ranges compatible with normal functions. No subjective abnormalities were reported by the pilot.

(Fig 27) Figure 27 illustrates the inflight physiological data and includes values from the Mercury-Atlas three-orbit centrifuge simulation for comparison. Minute pulse rates were determined by counting every

30 seconds during MA-6 launch and reentry and for 30 seconds at 3-minute intervals throughout the remainder of the flight. Because of the variation in the quality of the respiratory recording, rates were counted for 30 seconds whenever possible and varied from 8 to 19 breaths/minute throughout flight.

The pulse rate from lift-off to spacecraft separation reached a maximum of 114 beats/minute. The pulse rate varied from 88 to 114 beats/minute in the first 10 minutes of weightlessness. It then remained relatively stable with a mean rate of 86 beats/min. during the next 3 hours and 45 minutes of flight. At the time of retrorocket firing, the rate was 96 beats/minute. During reentry acceleration and parachute descent, the mean pulse rate was 109 beats/min., and the highest rate was 134 beats/min. just prior to drogue parachute deployment at a time of maximum spacecraft oscillation. This rate was the highest noted during the mission. These rates indicate that acceleration, weightlessness, and return to gravity were easily tolerated within acceptable physiological limits.

(Fig 28) Figure 28 shows a comparison of inflight physiologic data; during the three orbit centrifuge simulation, and the mean physiologic data of six Astronaut centrifuge simulations. As you can see, variations do not appear significant.

(Fig 29) Figure 29 is a sample respiration and EKG traces as received at Bermuda at T+4 minutes, during powered flight, and illustrate the quality of telemetered information.

General. - Many things have been learned from the flight of Friendship 7. In spacecraft systems alone, we verified some previous design concepts or have shown weak spots that need remedial action.

Now, what can be said of man in the system?

In general terms, man adds greatly to the mission in reliability and adaptability.

Reliability. - Of major significance is the probability that much more dependence can be placed on the man as a reliability operating portion of the man-spacecraft combination. In many areas his safe return can be made dependent on his own intelligent actions. Although this was a design philosophy that could not be followed up to this time, Project Mercury never considered the Astronaut as merely a passive passenger.

These areas must be assessed carefully, for man is not infallible, as we are all acutely aware.

Many things would be done differently if this flight could be flown over again, but we learn from our mistakes. I never flew a test flight on an airplane that I didn't return wishing I had done some things differently.

Even when automatic systems are still necessary, mission reliability is tremendously increased by having the man as a backup. The flight of Friendship 7 is a good example. This mission would almost certainly not have completed its three orbits, and might not have come back at all, if a man had not been aboard.

Adaptability. - The flight of the Friendship 7 Mercury spacecraft has proved that man can adapt very rapidly to this new environment. His senses and capabilities are little changed in space. At least for the 4.5 hour duration of this mission, weightlessness was no problem.

Man's adaptability is most evident in his powers of observation. He can accomplish many more and varied experiments per mission that can be obtained from an unmanned vehicle. When the unexpected arises, as happened with the luminous particles and layer observations on this flight, he can make observations that will permit more rapid evaluation of these phenomena on future flights. Indeed, on an unmanned flight, there likely would have been no such observations.

Future. - Most important, however, the future will not always find man's space vehicles as power limited as they are now. We will progress to the point where missions will not be totally preplanned. There will be choices of action in space, and man's intelligence and decision-making capability will be mandatory.

Our recent space efforts can be likened to the first flights at Kitty Hawk. They were first unmanned but were followed by manned flights, completely preplanned and of a few seconds duration. Their experiments were, again, power limited, but they soon progressed beyond that point.

Space exploration is now at the same stage of development.

I am sure you will agree with me that some big steps have been taken toward accomplishing the mission objectives expressed at the beginning of this paper.

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NETWORK STATION DISTRIBUTION

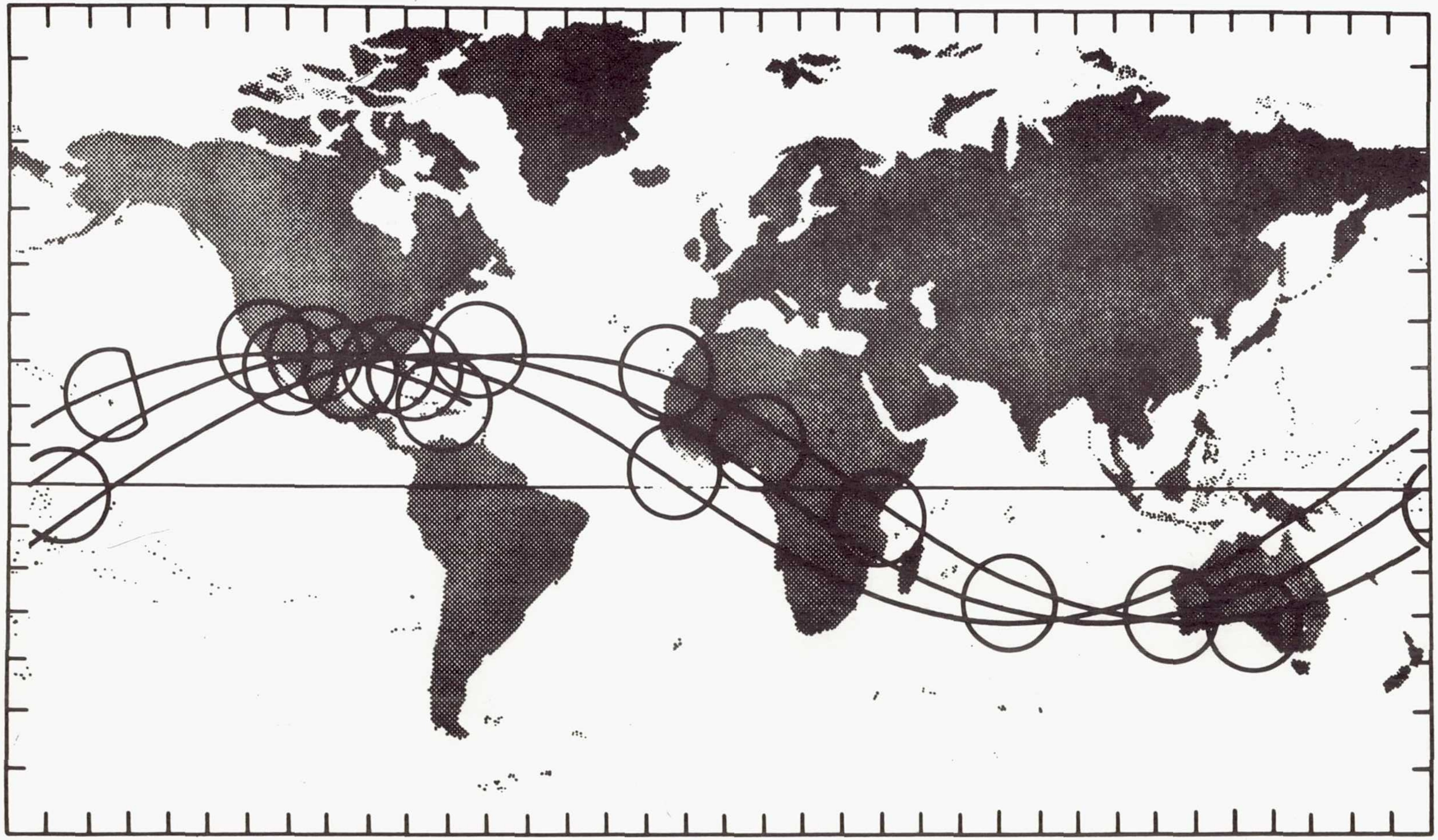

Figure 1

PROJECT MERCURY RECOVERY AREAS

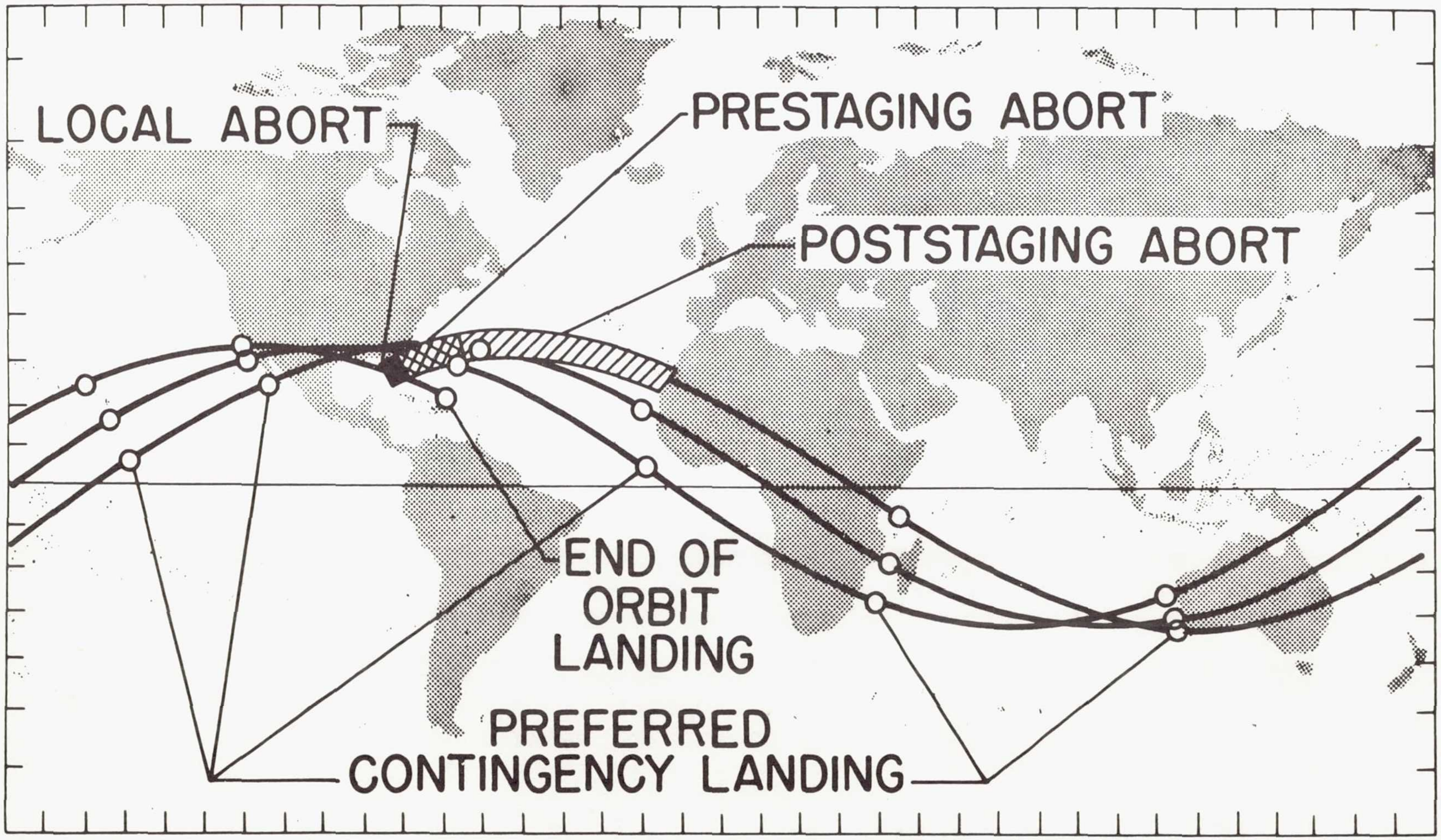

Figure 2

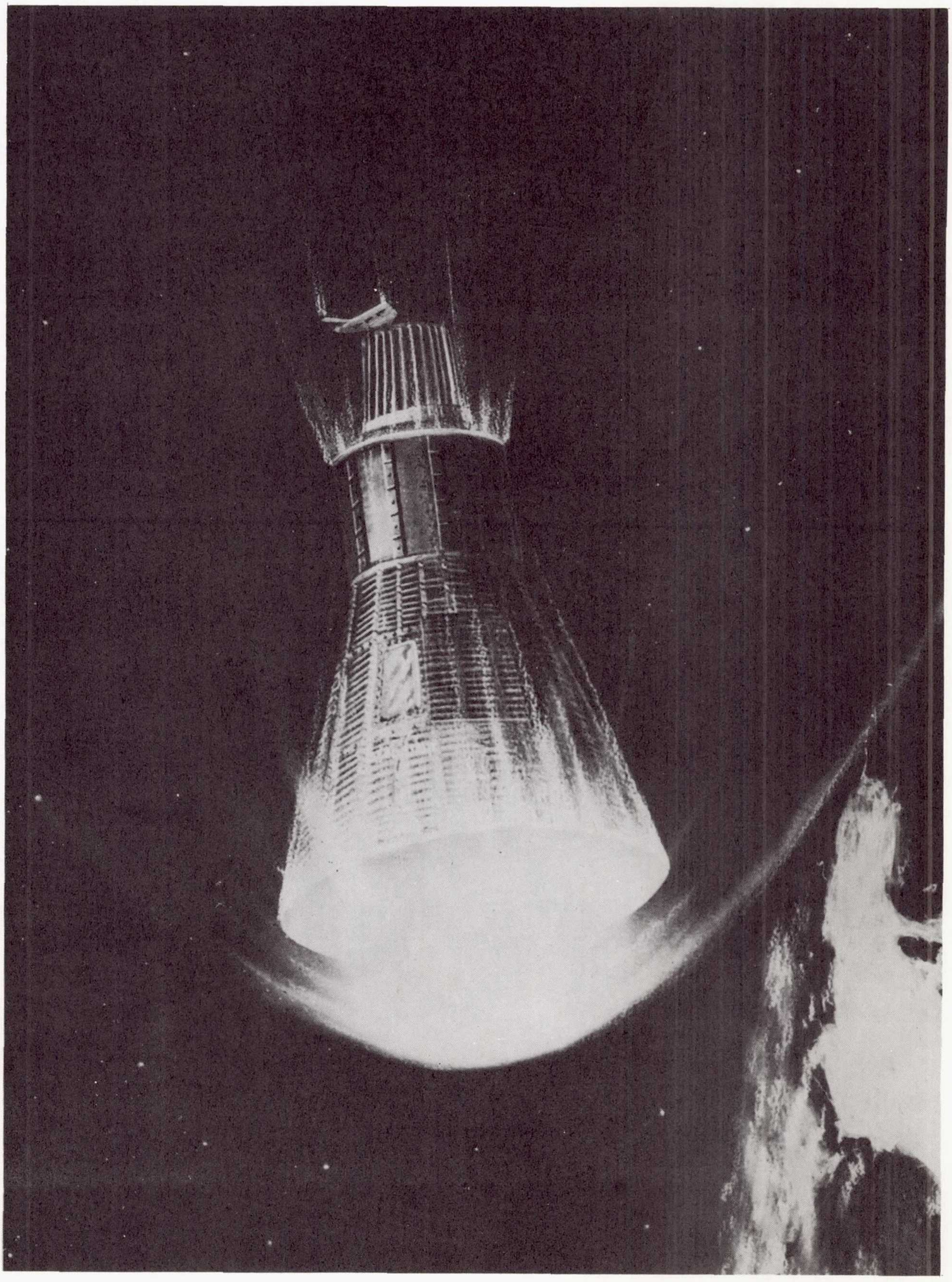

Figure 3

SPACECRAFT TEMPERATURES
DEGREES FAHRENHEIT

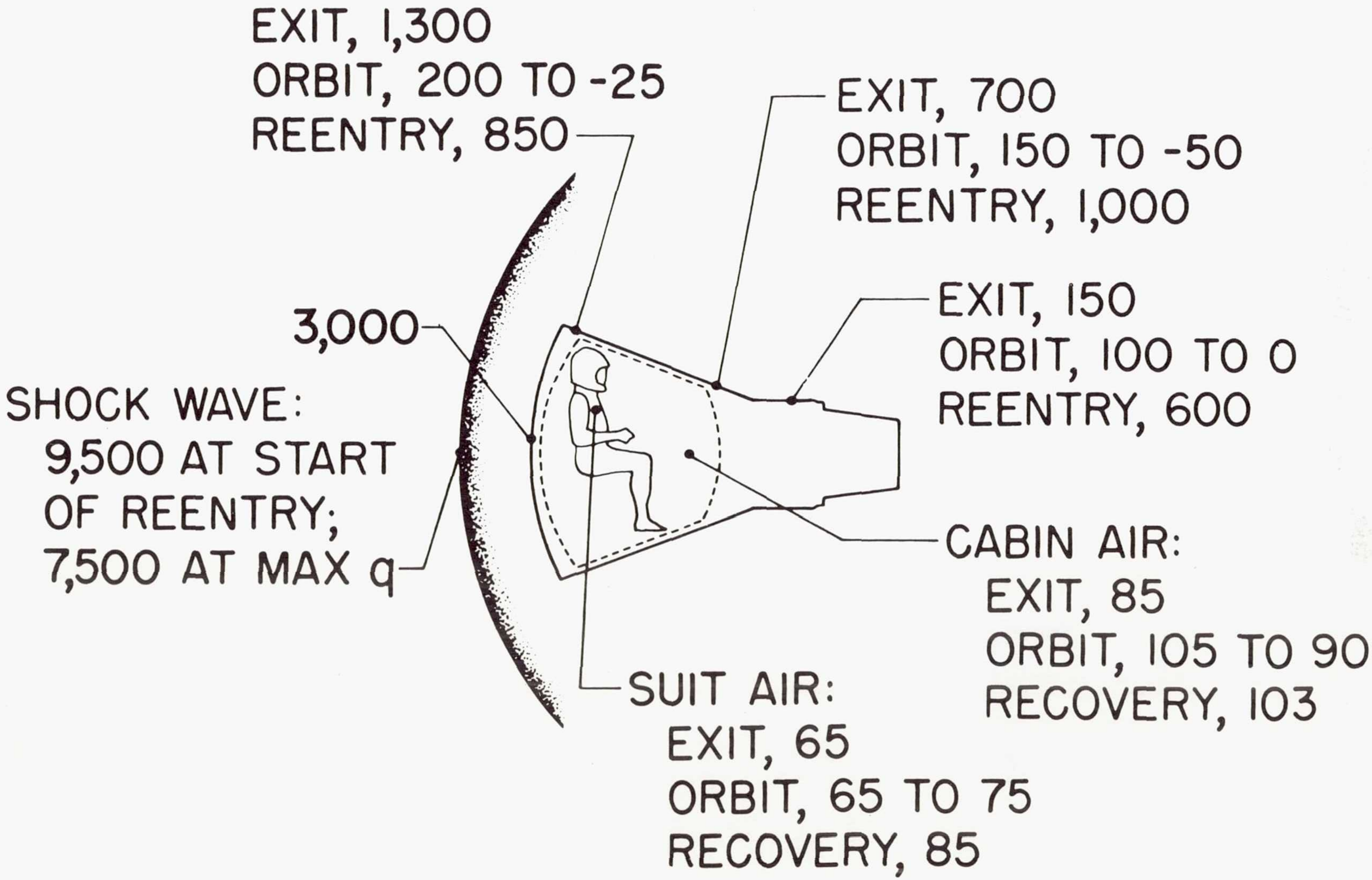

Figure 4

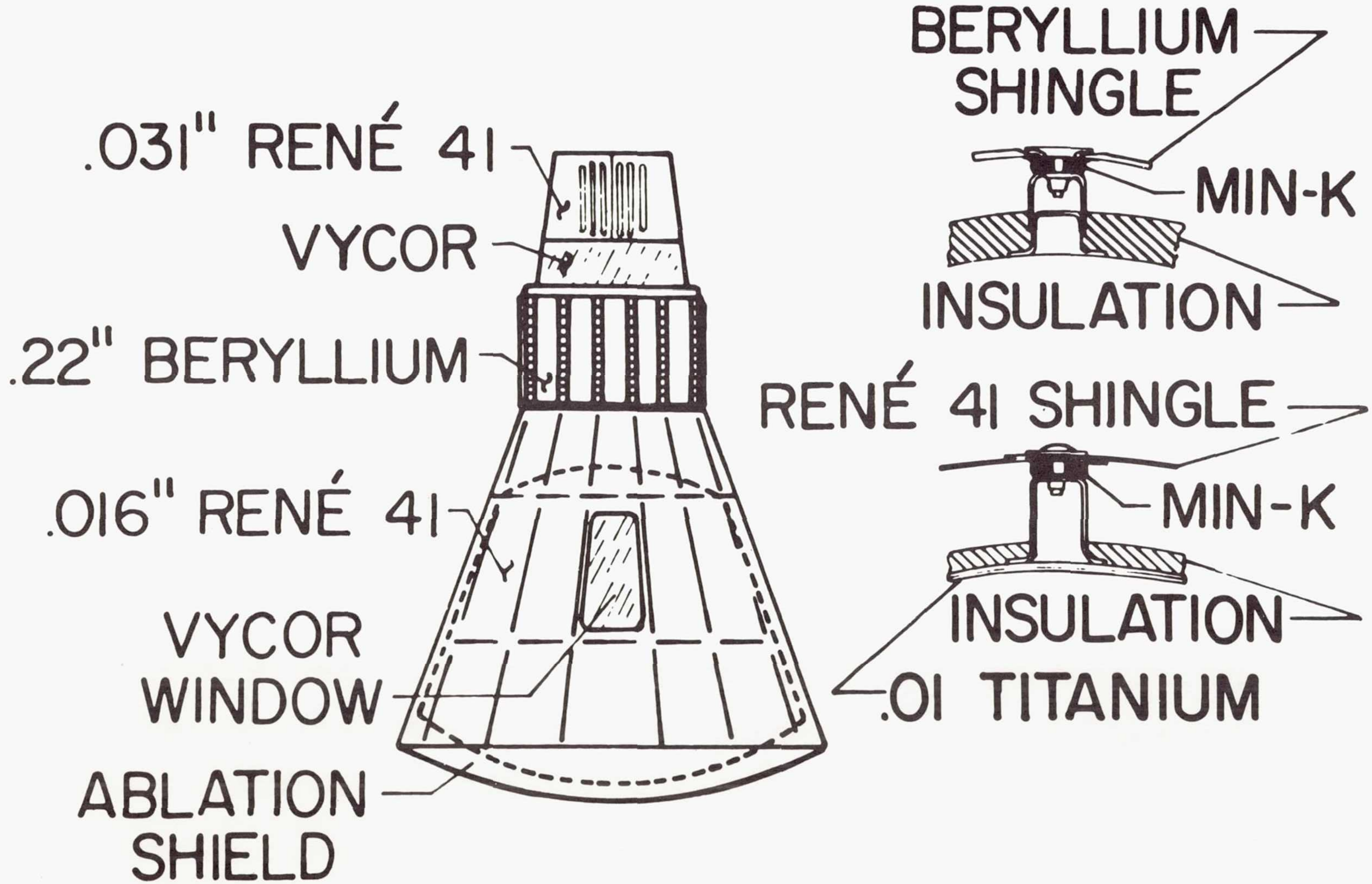
.031" RENÉ 41
VYCOR
.22" BERYLLIUM
.016" RENÉ 41
VYCOR WINDOW
ABLATION SHIELD
BERYLLIUM SHINGLE
MIN-K
INSULATION
RENÉ 41 SHINGLE
MIN-K
INSULATION
.01 TITANIUM

Figure 5

SPACECRAFT ROCKET MOTORS

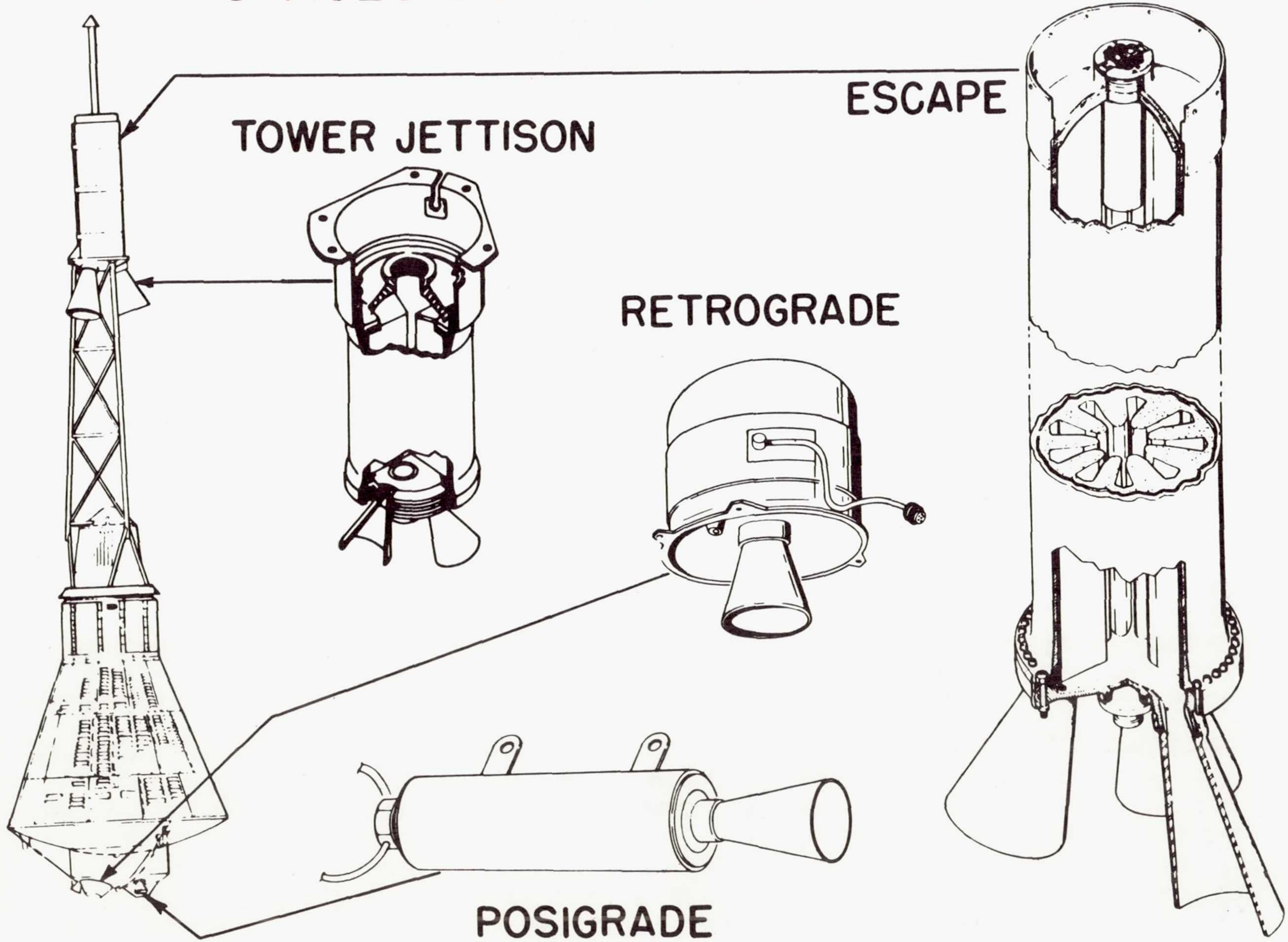

Figure 6

ROCKET MOTOR SYSTEMS

ROCKET MOTOR	NUMBER OF MOTORS	NOMINAL THRUST EACH, LB	APPROX-IMATE BURNING TIME EACH, SEC
ESCAPE	1	52,000	1
TOWER JETTISON	1	800	1.5
POSIGRADE	3	400	1
RETROGRADE	3	1,000	10

Figure 7

SPACECRAFT COMMUNICATIONS AND INSTRUMENTATION SYSTEMS

VOICE COMMUNICATION	
UHF TRANSCEIVER	2 WATTS
UHF TRANSCEIVER	0.5 WATT
HF TRANSCEIVER	5 WATTS
RADAR	
C-BAND BEACON	400-WATT TRANSPONDER
S-BAND BEACON	1,000-WATT TRANSPONDER
COMMANDS	
2 COMMAND RECEIVERS	10 CHANNELS EACH
TELEMETRY	
2 FM TRANSMITTERS	2 WATTS EACH
RECOVERY	
HF D/F BEACON SEASAVE	1 WATT
UHF D/F BEACON SARAH	7.5 WATTS
UHF D/F BEACON SUPERSARAH	91 WATTS
HF TRANSCEIVER	1 WATT

Figure 8

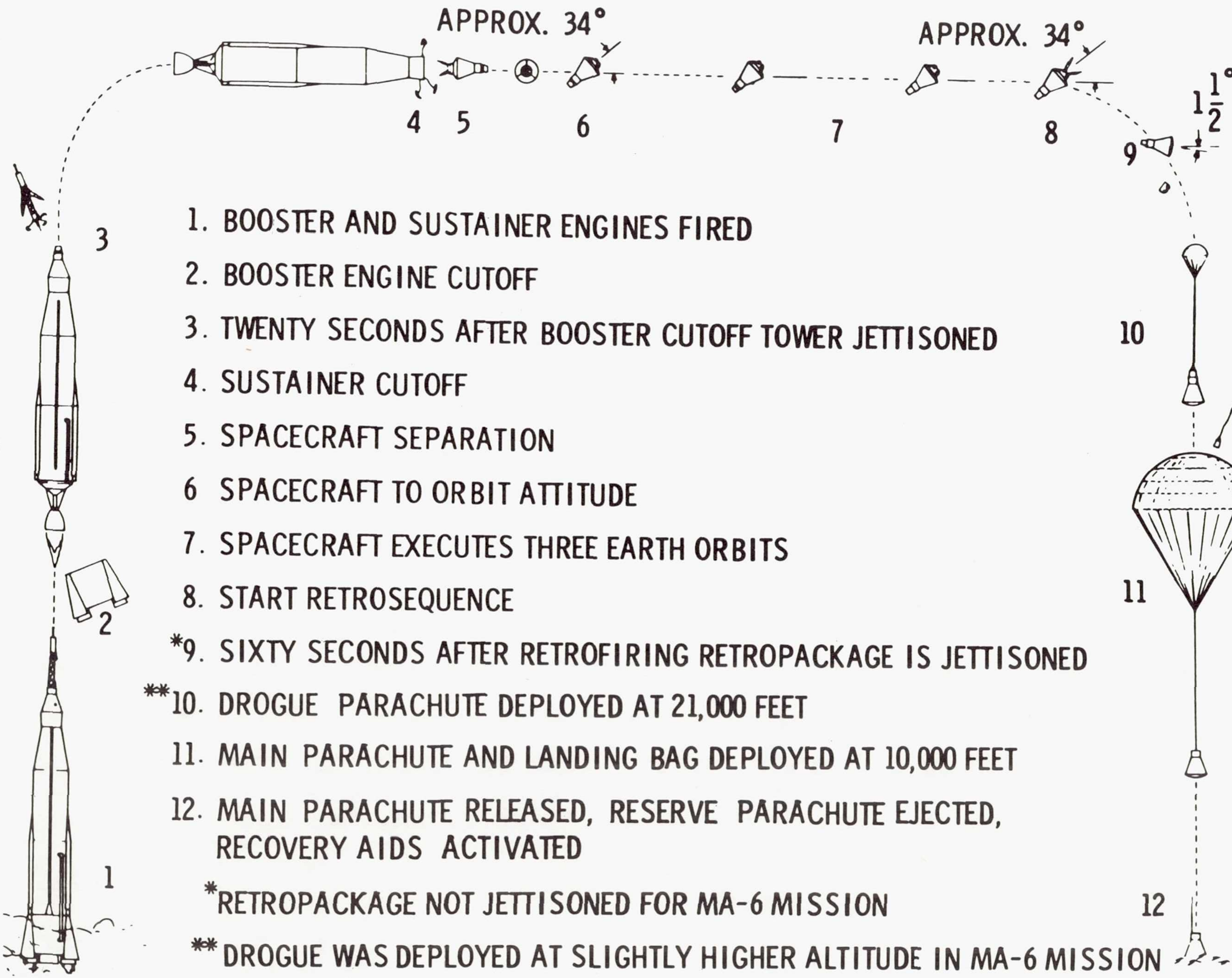
APPROX. 34°
APPROX. 34°
$1\frac{1}{2}°$
1
2
3
4
5
6
7
8
9
10
11
12
1. BOOSTER AND SUSTAINER ENGINES FIRED
2. BOOSTER ENGINE CUTOFF
3. TWENTY SECONDS AFTER BOOSTER CUTOFF TOWER JETTISONED
4. SUSTAINER CUTOFF
5. SPACECRAFT SEPARATION
6 SPACECRAFT TO ORBIT ATTITUDE
7. SPACECRAFT EXECUTES THREE EARTH ORBITS
8. START RETROSEQUENCE
*9. SIXTY SECONDS AFTER RETROFIRING RETROPACKAGE IS JETTISONED
**10. DROGUE PARACHUTE DEPLOYED AT 21,000 FEET
11. MAIN PARACHUTE AND LANDING BAG DEPLOYED AT 10,000 FEET
12. MAIN PARACHUTE RELEASED, RESERVE PARACHUTE EJECTED, RECOVERY AIDS ACTIVATED
*RETROPACKAGE NOT JETTISONED FOR MA-6 MISSION
**DROGUE WAS DEPLOYED AT SLIGHTLY HIGHER ALTITUDE IN MA-6 MISSION

Figure 9

SPACECRAFT PARACHUTE DEPLOYMENTS

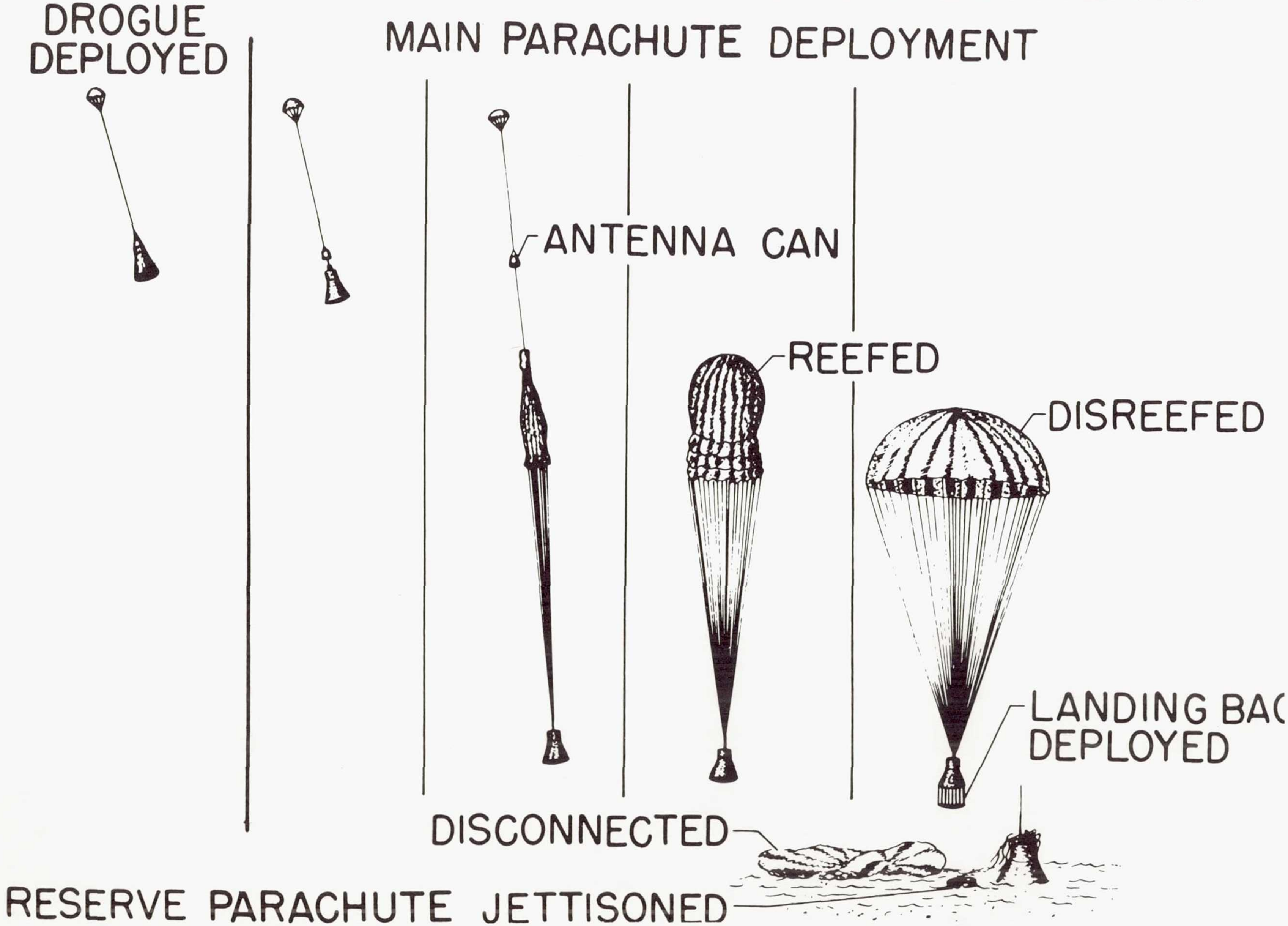

Figure 10

MA-6

CUTOFF CONDITIONS	ACHIEVED
ALTITUDE, FT	528,381
VELOCITY, FT/SEC	25,730
FLIGHT PATH ANGLE, DEG	-.0468
ORBIT PARAMETERS	
PERIGEE ALTITUDE, N. MI.	86.92
APOGEE ALTITUDE, N. MI.	140.92
PERIOD, MIN:SEC	88:29
INCLINATION ANGLE, DEG	32.54
MAXIMUM CONDITIONS	
EXIT, ACCELERATION, g UNITS	7.7
EXIT, DYNAMIC PRESSURE, LB/SQ FT	982
ENTRY, ACCELERATION, g UNITS	7.7
ENTRY, DYNAMIC PRESSURE, LB/SQ FT	472

Figure 11

Figure 12

Figure 13

Figure 14

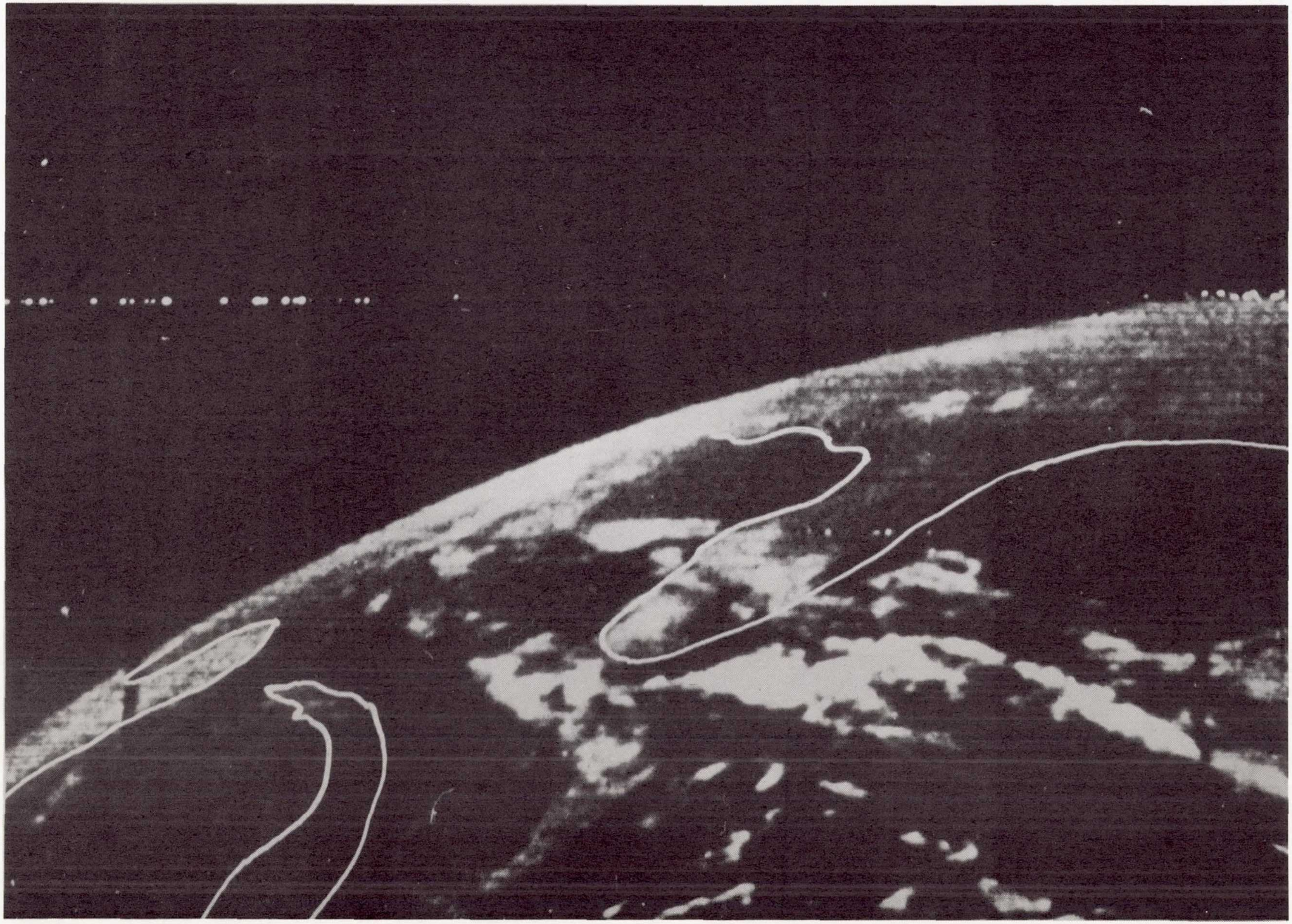

Figure 15

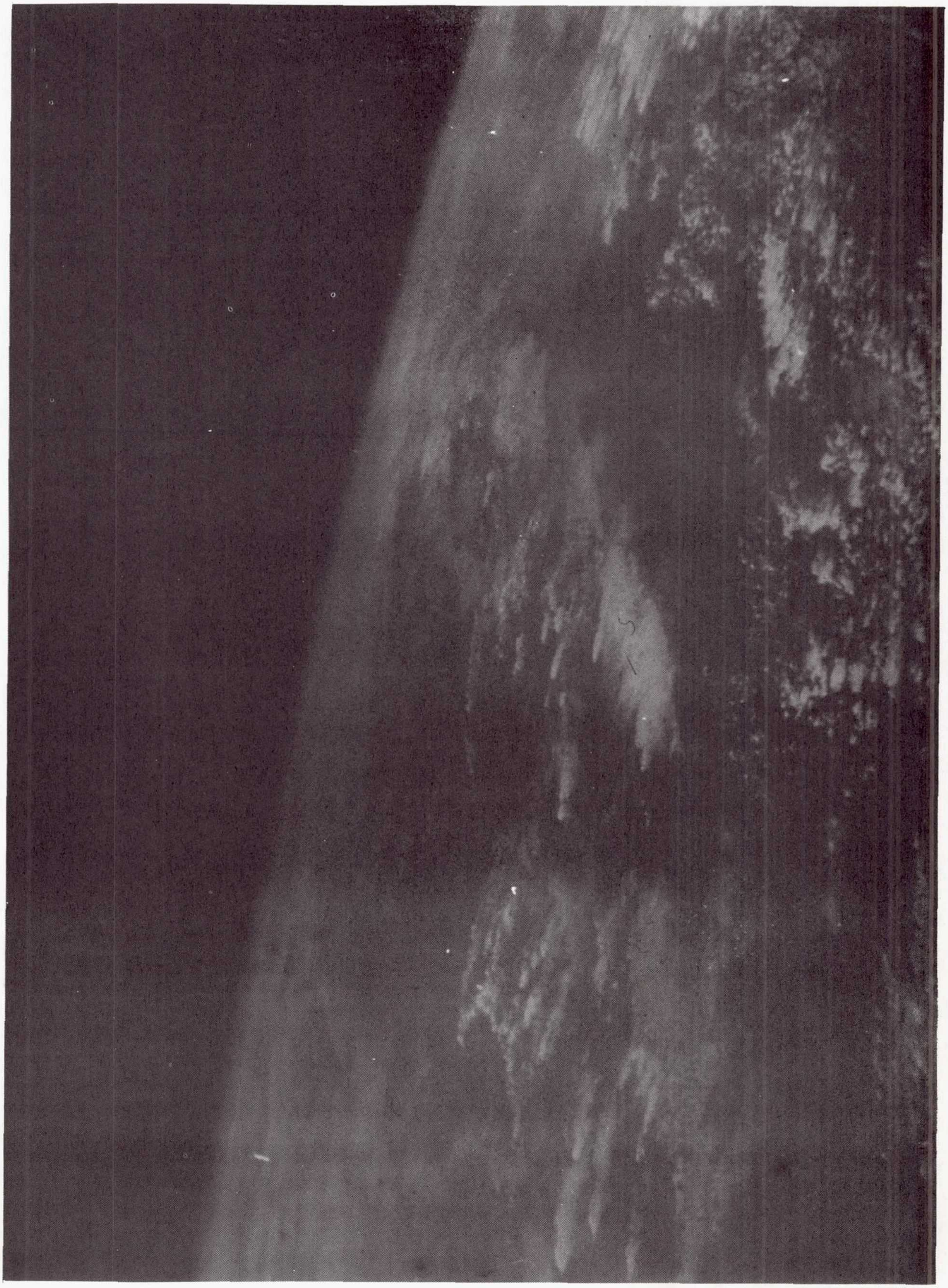

Figure 16

Figure 17

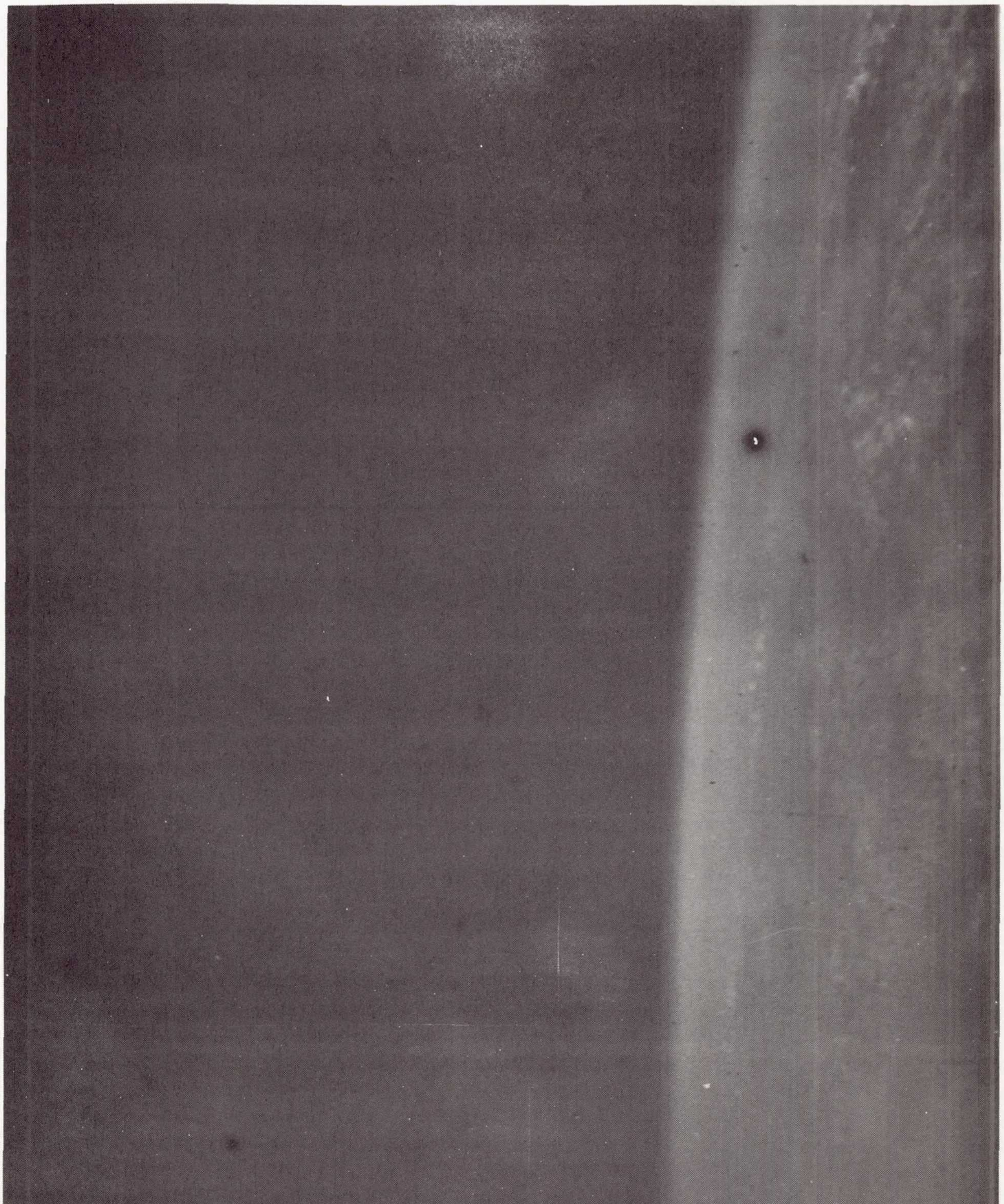

Figure 18

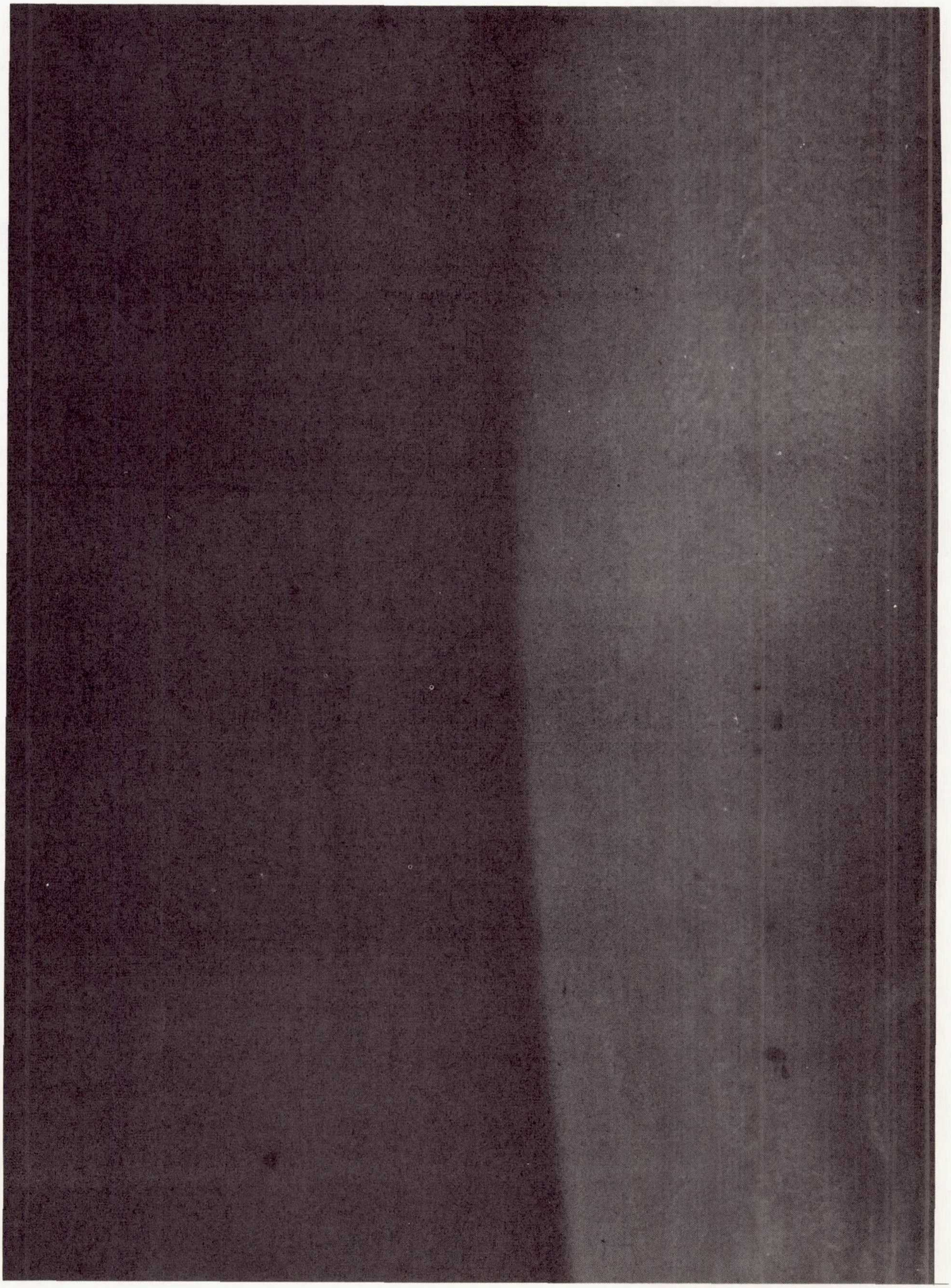

Figure 19

Figure 20

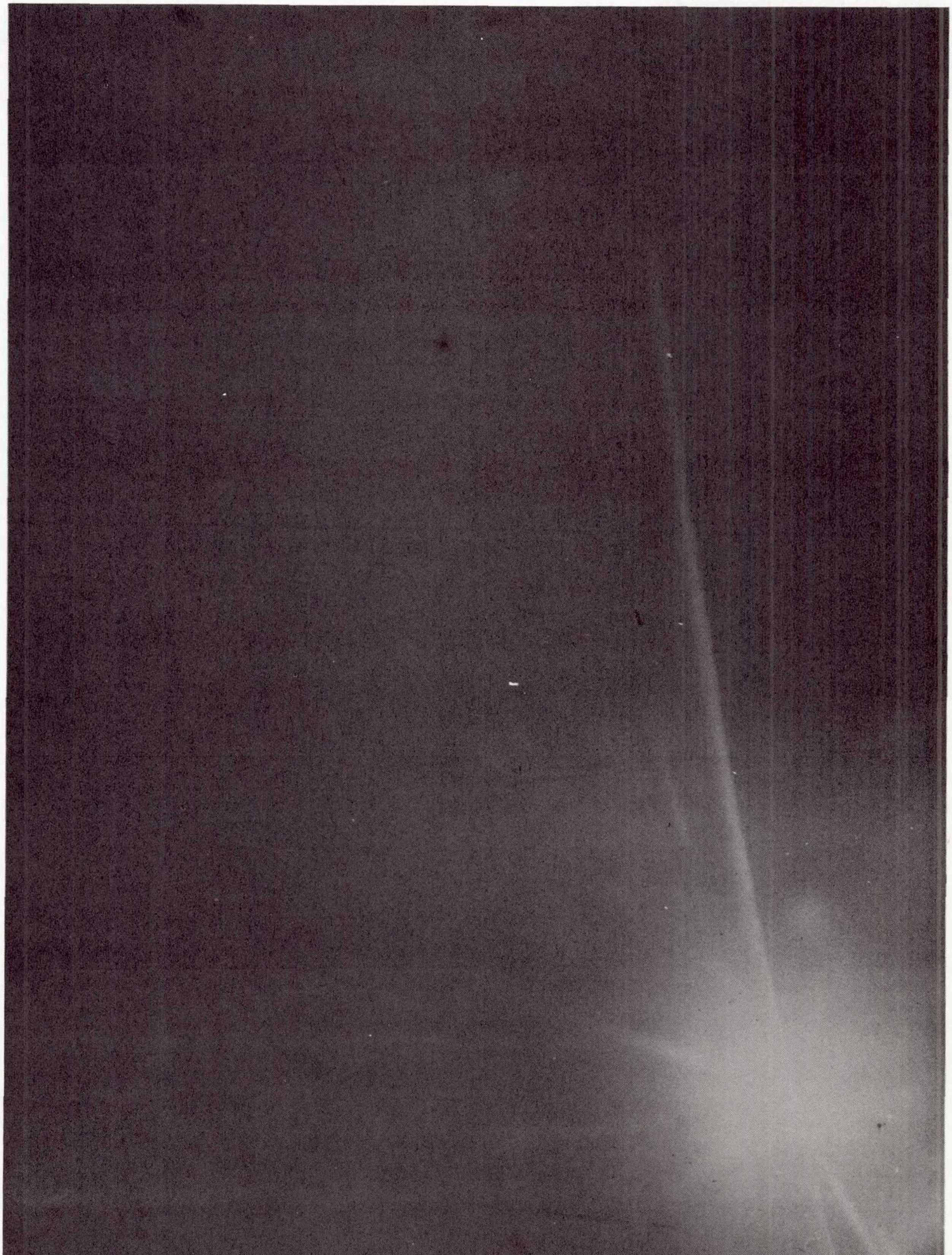

Figure 21

Figure 22

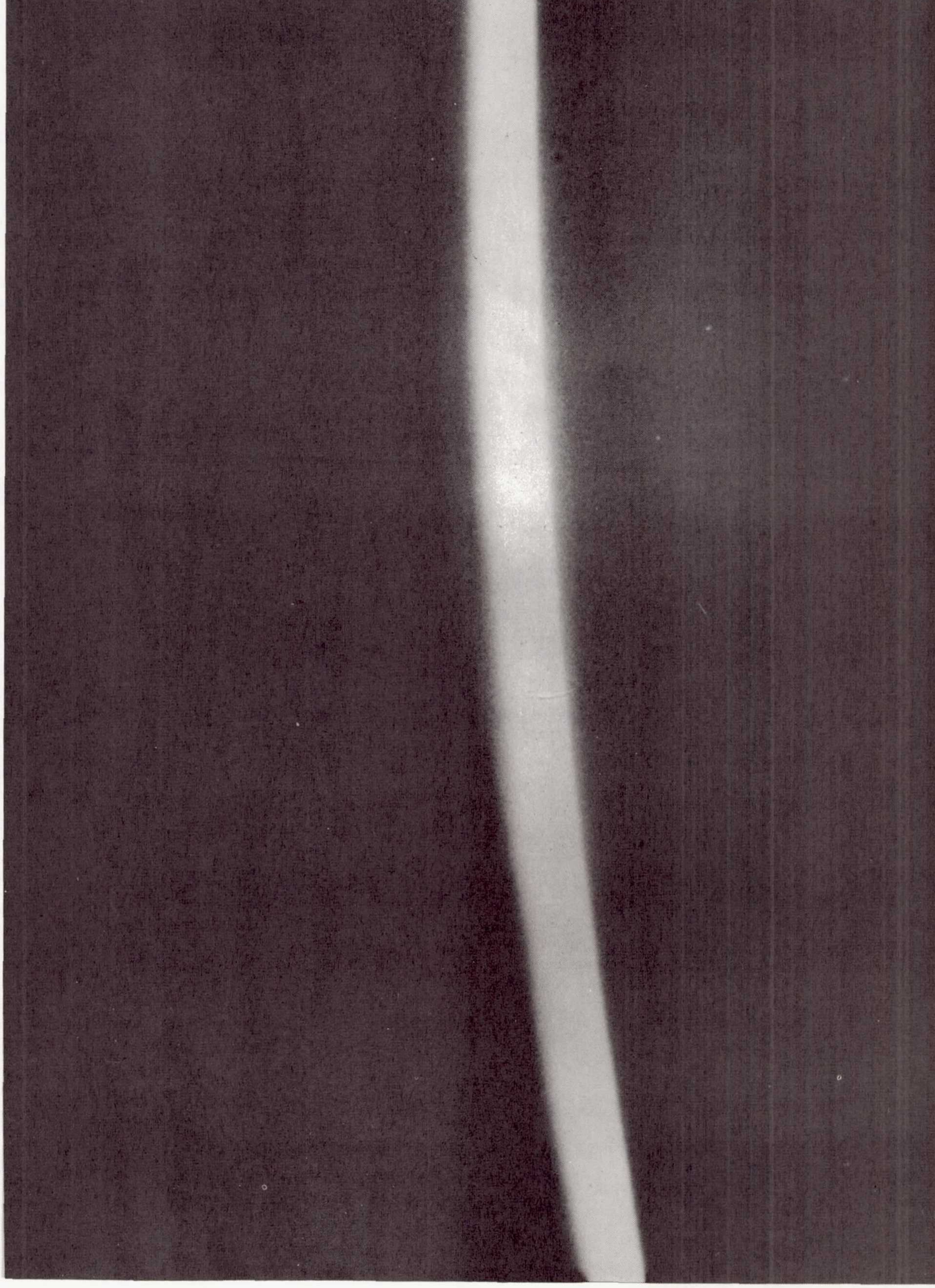

Figure 23

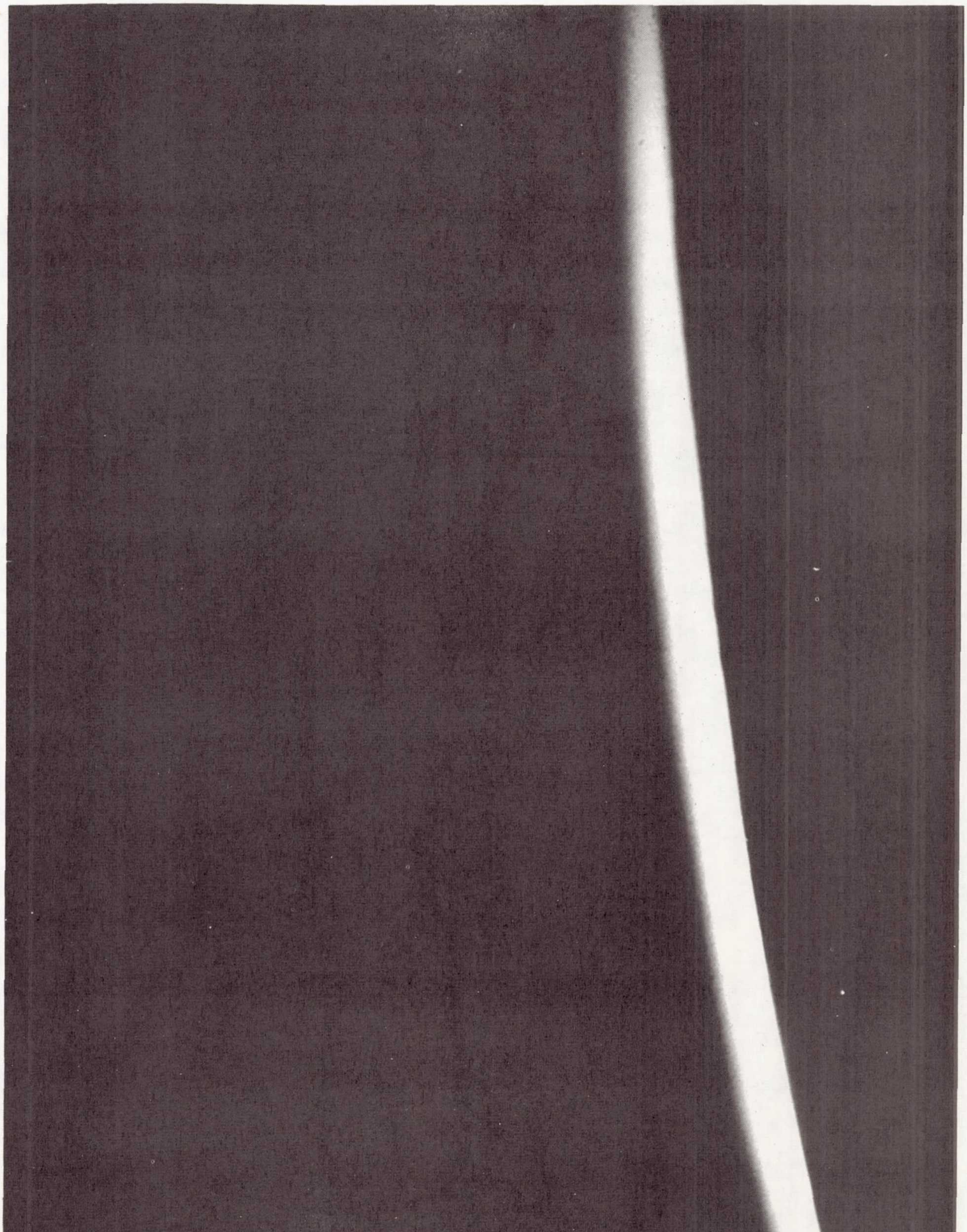

Figure 24

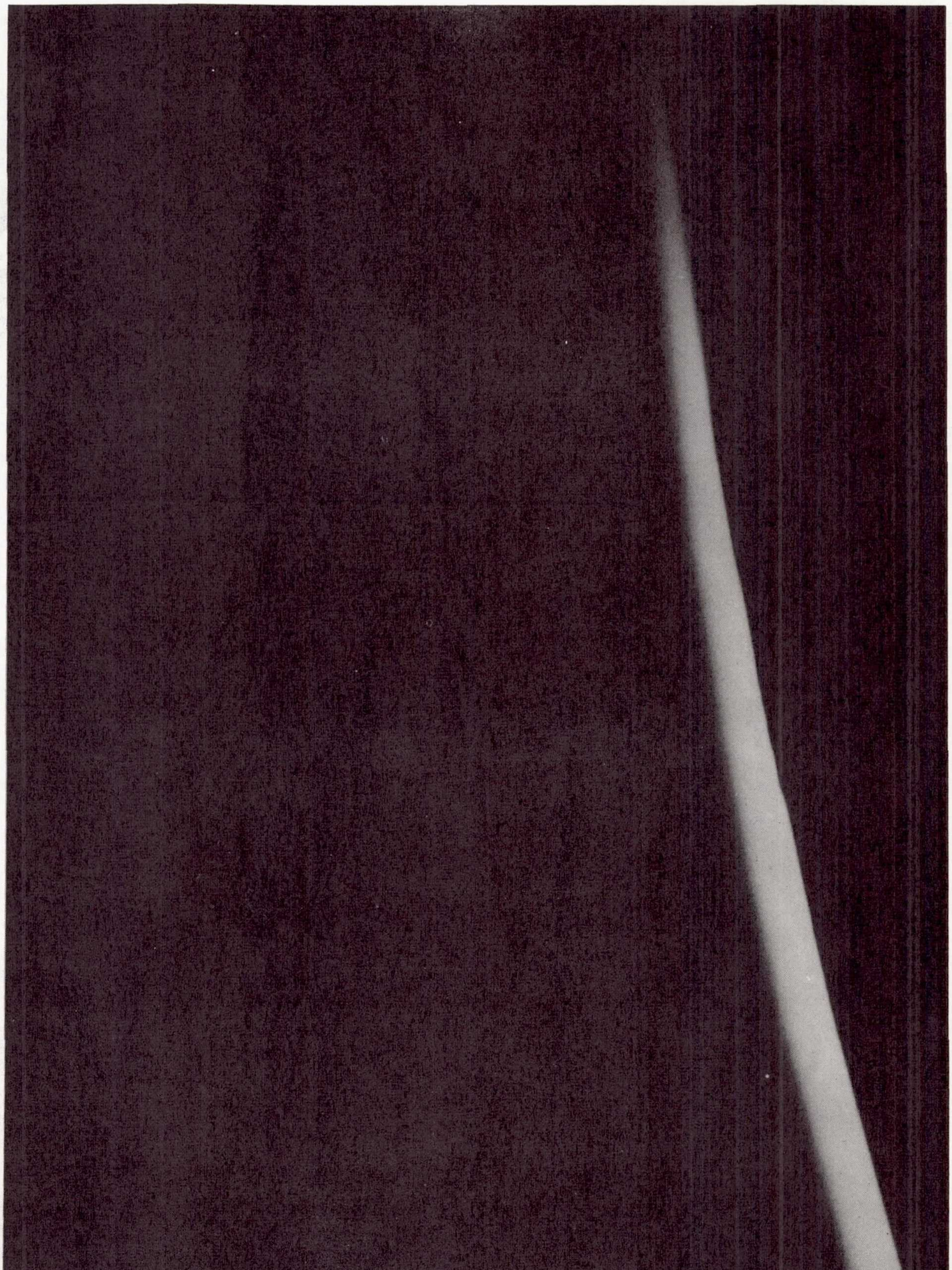

Figure 25

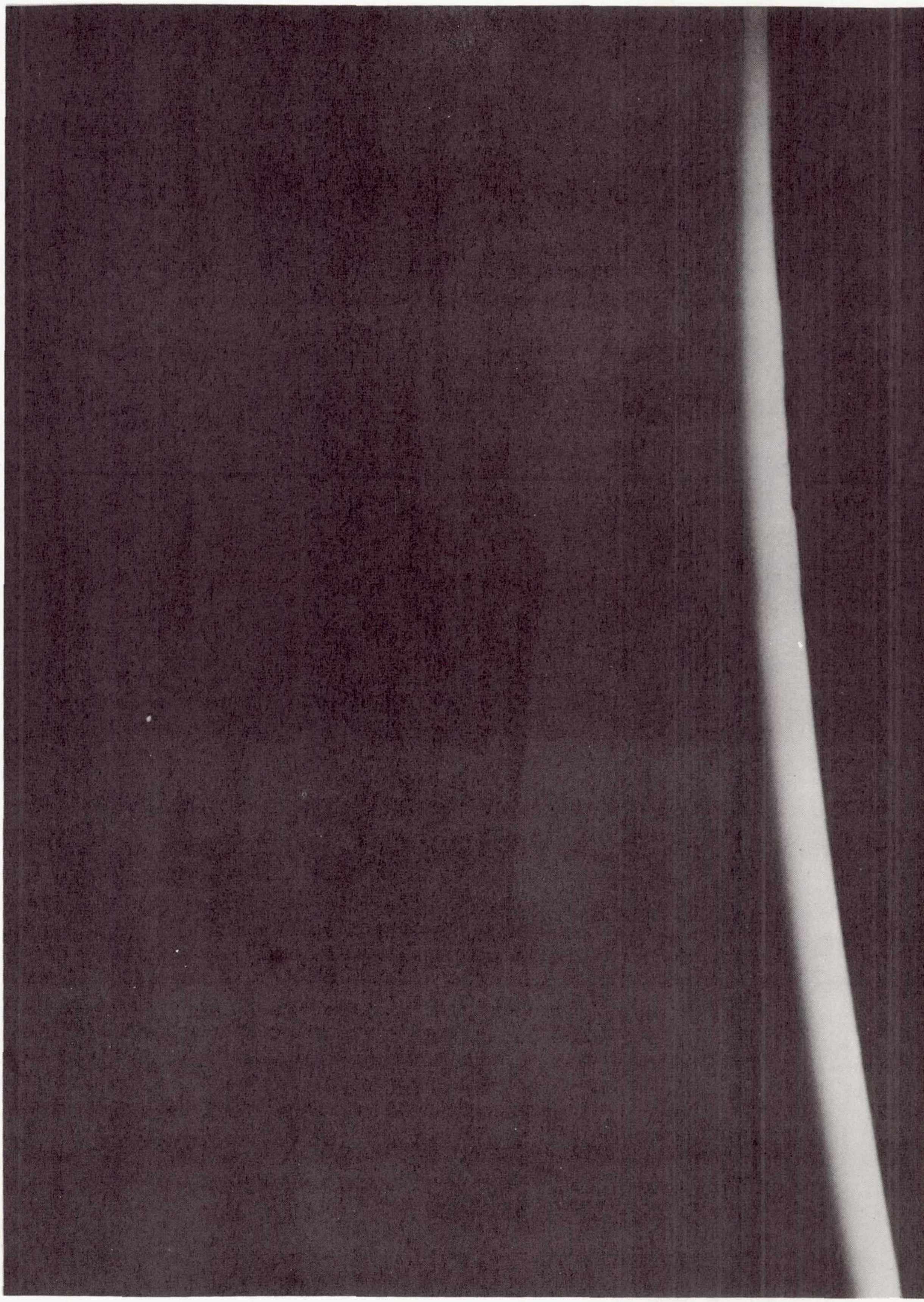

Figure 26

BLOOD PRESSURE TABLE

EVENT	NUMBER	MEAN B. P. MM HG	MEAN PULSE PRESS.	SYSTOLE RANGE, MM HG.	DIASTOLE RANGE MM HG
PHYS. EXAMS	14	110/66	44	98 TO 128	60 TO 80
TRAINER	15	121/76	45	110 TO 132	66 TO 87
3-ORBIT CENTR. SIMUL.	56	114/80	34	92 TO 136	68 TO 92
PAD TESTS	26	104/76	28	91 TO 125	64 TO 91
COUNT-DOWN	14	123/87	36	101 TO 139	83 TO 93
FLIGHT MA-6	10	129/70	59	119 TO 143	60 TO 81

Figure 27

COMPARISON OF PHYSIOLOGICAL DATA

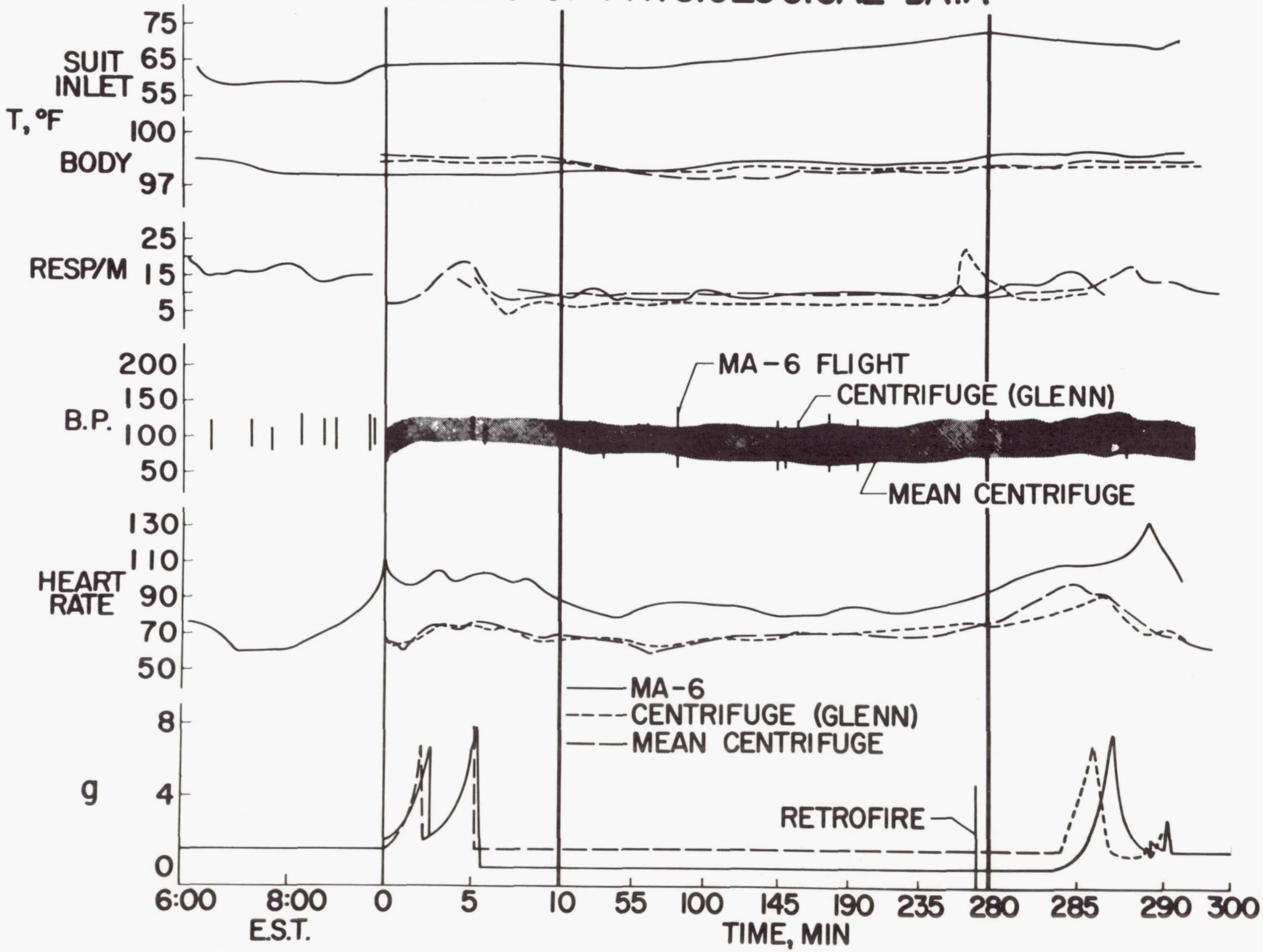

Figure 28

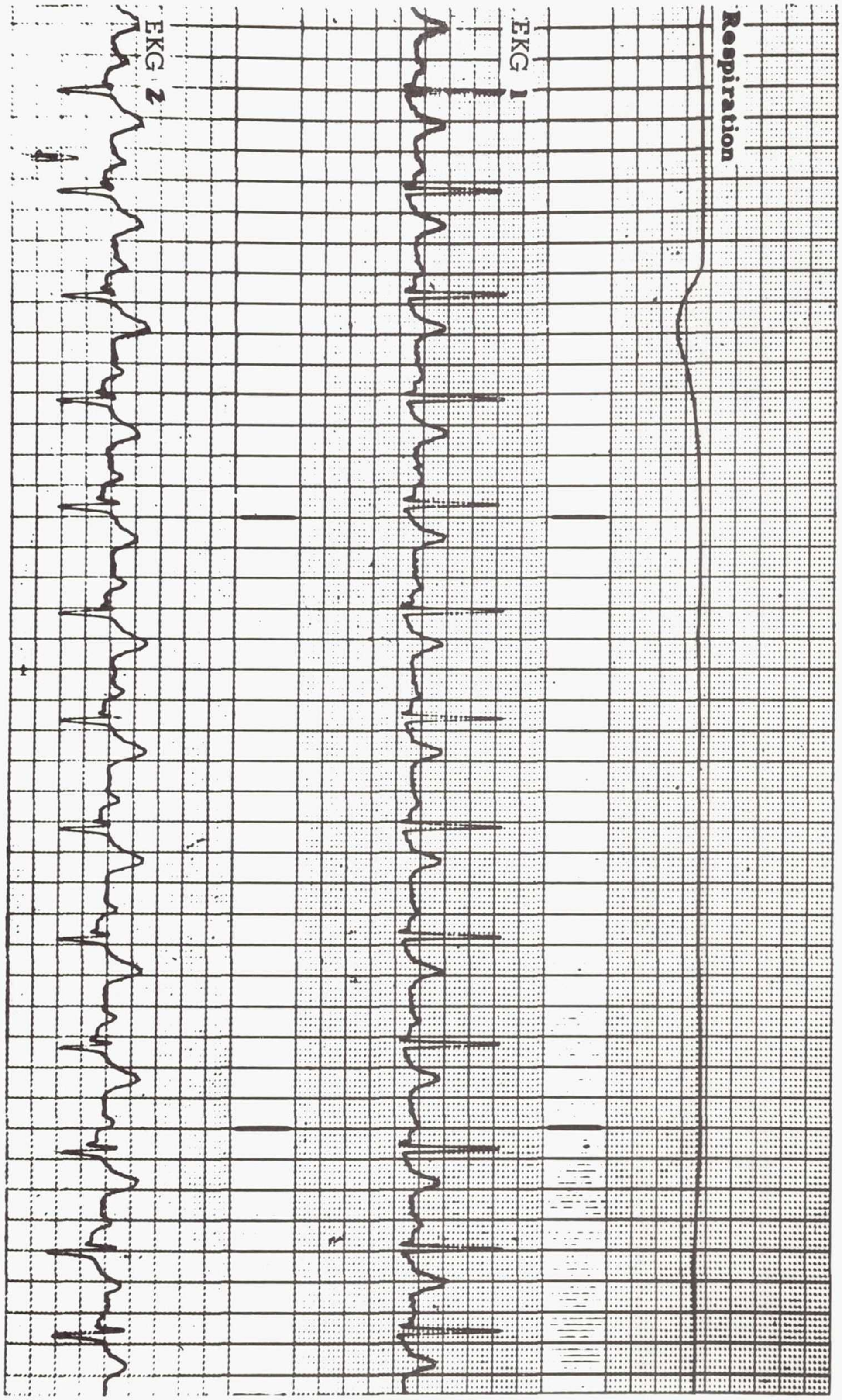

Figure 29