RESULTS OF THE SECOND U.S. MANNED ORBITAL SPACE FLIGHT, MAY 24, 1962

1. SPACECRAFT AND LAUNCH-VEHICLE PERFORMANCE

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[**1**] Summary

The performance of the Mercury spacecraft and Atlas launch vehicle for the orbital flight of Astronaut M. Scott Carpenter was excellent in nearly every respect. All primary mission objectives were achieved. The single mission-critical malfunction which occurred involved a failure in the spacecraft pitch horizon scanner, a component of the automatic control system. This anomaly was adequately compensated for by the pilot in subsequent inflight operations so that the success of the mission was not compromised. A modification of the spacecraft control- system thrust units were effective. Cabin and pressure-suit temperatures were high but not intolerable. Some uncertainties in the data telemetered from the bioinstrumentation prevailed at times during the flight; however, associated information was available which indicated continued well-being of the astronaut. Equipment was included in the spacecraft which provided valuable scientific information; notably that regarding liquid behavior in a weightless state, identification of the airglow layer observed by Astronaut Glenn and photography of terrestrial features and meteorological phenomena. An experiment which was to provide atmospheric drag and color visibility data in space through deployment of an inflatable sphere was partially successful. The flight further qualified the Mercury spacecraft systems for manned orbital operations and provided evidence for progressing into missions of extended duration and consequently more demanding systems requirements.

Introduction

The seventh Mercury-Atlas mission MA-7 was planned for three orbital passes and was a continuation of a program to acquire operational experience and information for manned orbital space flight. The objectives of the flight were to evaluate the performance of the man-spacecraft system in a three-pass mission, to evaluate the effects of space flight on the astronaut to obtain the astronaut's opinions on the operational suitability of the spacecraft systems, to evaluate the performance of spacecraft systems modified as a result of unsatisfactory performance during previous missions, and to exercise and evaluate further the pet performance of the Mercury Worldwide Network.

The Aurora 7 spacecraft and Atlas launch vehicle used by Astronaut Carpenter in successfully performing the second United States manned orbital mission (MA-7) were nearly identical to those used for the MA-6 flight. The Mercury spacecraft provided a safe and habitable environment for the pilot while in orbit, as well as protection during the critical flight phases of launch and reentry. The spacecraft also served as an orbiting laboratory where the pilot could conduct limited experiments which would increase the knowledge in the space sciences. The intent of this paper is to describe briefly the MA-7 spacecraft and launch vehicle...

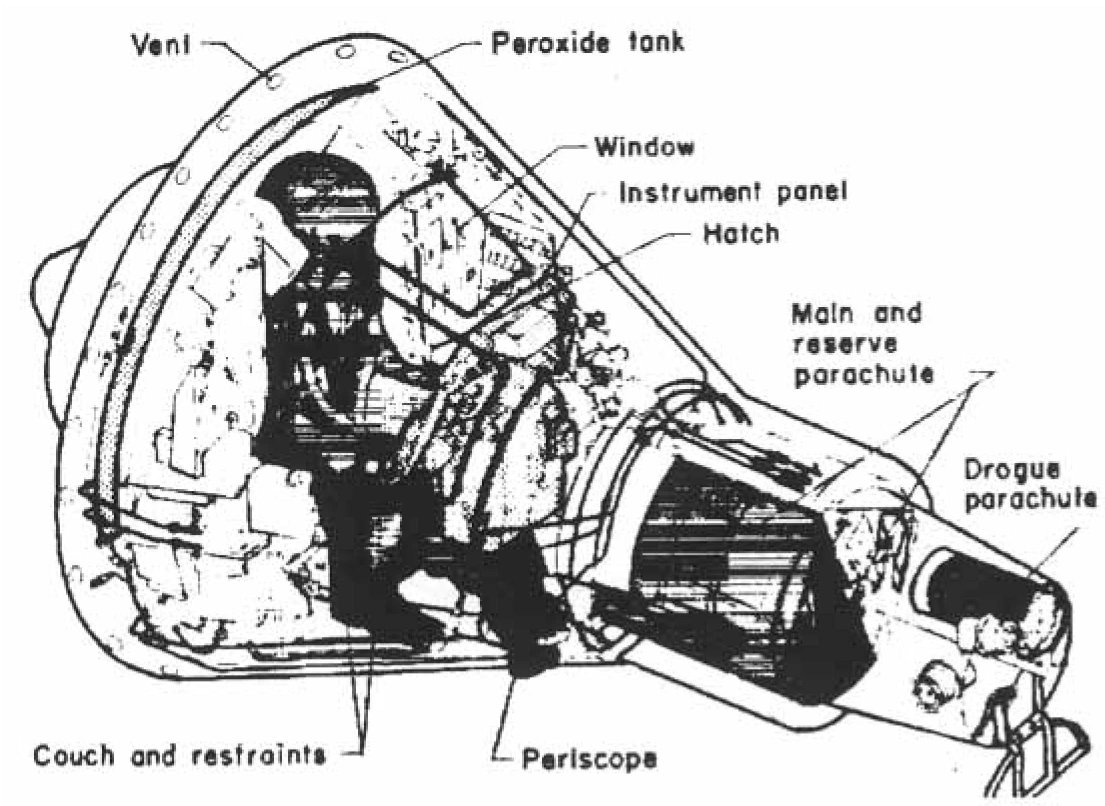


Figure 1-1.- Mercury spacecraft systems.

[**2**] ...systems and discuss their technical performance.

The many systems which the spacecraft comprises may be generally grouped into those of heat protection, mechanical and pyrotechnic, attitude control, communications, electrical and sequential, life support, and instrumentation. The general arrangement of the spacecraft interior is schematically depicted in figure 1-1. Although a very basic description of each system accompanies the corresponding section, a more detailed description is presented in reference 1.

Heat Protection System

During flight through the atmosphere at launch and reentry, the high velocities generate excessive heat from which the crew and equipment must be protected. The spacecraft must also be capable of withstanding the heat pulse associated with the ignition of the launch escape rocket. To provide this protection, the spacecraft afterbody is composed of a double-wall structure with thermal insulation between the two walls. The outer conical surface of the spacecraft afterbody is made up of high-temperature alloy shingles, and the cylindrical portion is protected by beryllium shingles. The spacecraft blunt end is fitted with an ablation-type heat shield which is constructed of glass fibers and resin. Additional description of the heat protection system can he found on pages 7 to 9 of reference 1.

Although the MA-7 reentry trajectory was slightly more shallow than for MA-6, the heating effects were not measurably different, as is evident in figure 1-2.

The performance of the MA-7 heat protection system was as expected and was quite satisfactory. .

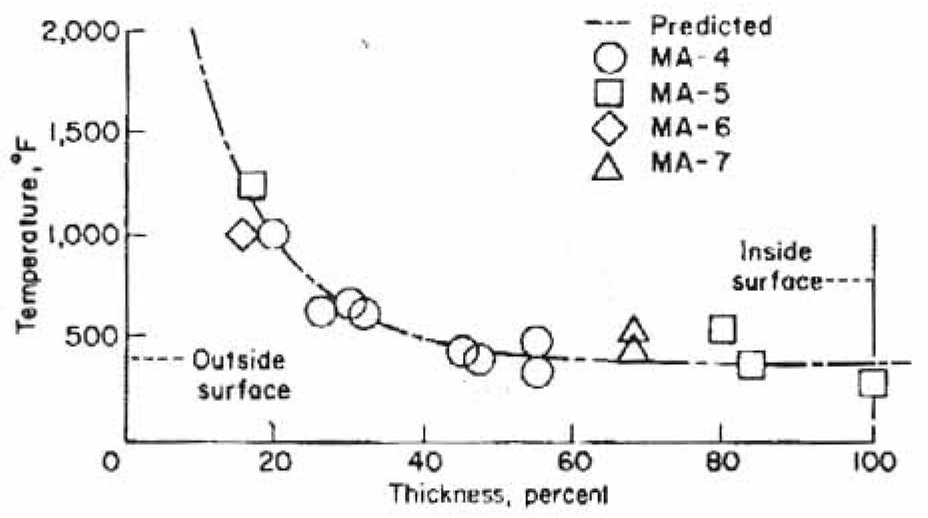


Figure l-2.- Maximum ablation-shield temperatures.

Two temperature measurements were made in the ablation shield, one at the center and the other approximately 27 inches from the center. The maximum recorded values are graphically and compared with previously obtained orbital reentry values in figure 1-2. The magnitude of these temperatures, as well as the ablation-shield weight loss during reentry, are comparable with previous flights. The supporting structure behind the ablation shield was found to be in excellent condition following the flight. A more complete temperature survey of points around the afterbody than on previous flights was conducted for MA-7 . This survey was made possible by the addition of a low-level commutator circuit. The data, which are shown in figure 1-3 were within expected ranges, and the integrity of the structure was not affected by the thermal loads experienced.

Mechanical and Pyrotechnic Systems

The mechanical and pyrotechnic system group consists of the separation devices, the rocket motors, the landing system, and the internal spacecraft structure. This entire group functioned satisfactorily during the mission. Performances of individual systems are discussed in the following paragraphs.

Separation Devices

Separation devices generally use explosive charges to cause separation or disconnection of components. The major separation points are at the interface between the spacecraft and launch vehicle between the spacecraft and the escape tower, at the heat shield, and around the spacecraft hatch. All separation devices worked properly during the mission. The explosive- actuated hatch was not used, since the pilot egressed through the top of the spacecraft after landing.

Rocket Motors

The rocket motor system consisted of three retrorocket motors, three posigrade motors, the launch escape rocket, and the small tower-jettison rocket. All of these motors are solid-propellant type. See page 9 of reference 1 for additional description of the rocket motor system. Nominal thrust and burning-time data are given in the following table:

Rocket motor	Number of motors	Nominal thrust each, lb	Approximate burning time each, sec
Escape	1	52,000	1
Tower jettison	1	800	1.5
Posigrade	3	400	1
Retrograde	3	1,000	10

Although ignition of the retrorocket motors was about 3 seconds later than expected, the [**3**] performance of the rocket motors was satisfactory. An analysis of radar tracking data for the flight yielded a velocity increment at retrofire which indicated that the retrorocket performance was 3 percent lower than nominal. This was acceptable and within the allowable deviation from nominal performance of ±5 percent.

Landing System

The landing system includes the drogue (stabilization) parachute, the main and reserve parachutes and the landing shock-attenuation system (landing bag). The latter system attenuates the force of lauding by providing a cushion of air through the deployment of the landing bag and heat shield structure, which is supported by straps and cables. The landing system can be actuated automatically, or manually by the astronaut. The landing system is described in greater detail on pages 28 to 30 of reference 1. The landing system performed satisfactorily and as planned.

The MA-7 landing system differed from the MA-6 system in the manner of arming the barostats (pressure-sensing devices). These units initiate automatic deployment of the parachutes when the spacecraft descends to the proper pressure altitude during reentry. In the MA-6 and prior missions, the barostats were armed when above the atmosphere during exit flight and thus were in readiness to initiate the parachute-deployment mechanisms when the barostats sensed the appropriate pressure during spacecraft descent through the atmosphere. This armed status of the barostats would of course permit deployment of a parachute during orbital flight if a certain type of barostat malfunction should occur. While such barostat malfunctions had not been detected in previous flights or during ground tests, it was believed that an additional safety margin would be desirable because of the unexplained early deployment of the drogue parachute during the MA-6 mission. Consequently, a control barostat was added to the automatic sequence circuit of the MA-7 spacecraft. This barostat sensed pressure in the cabin and...

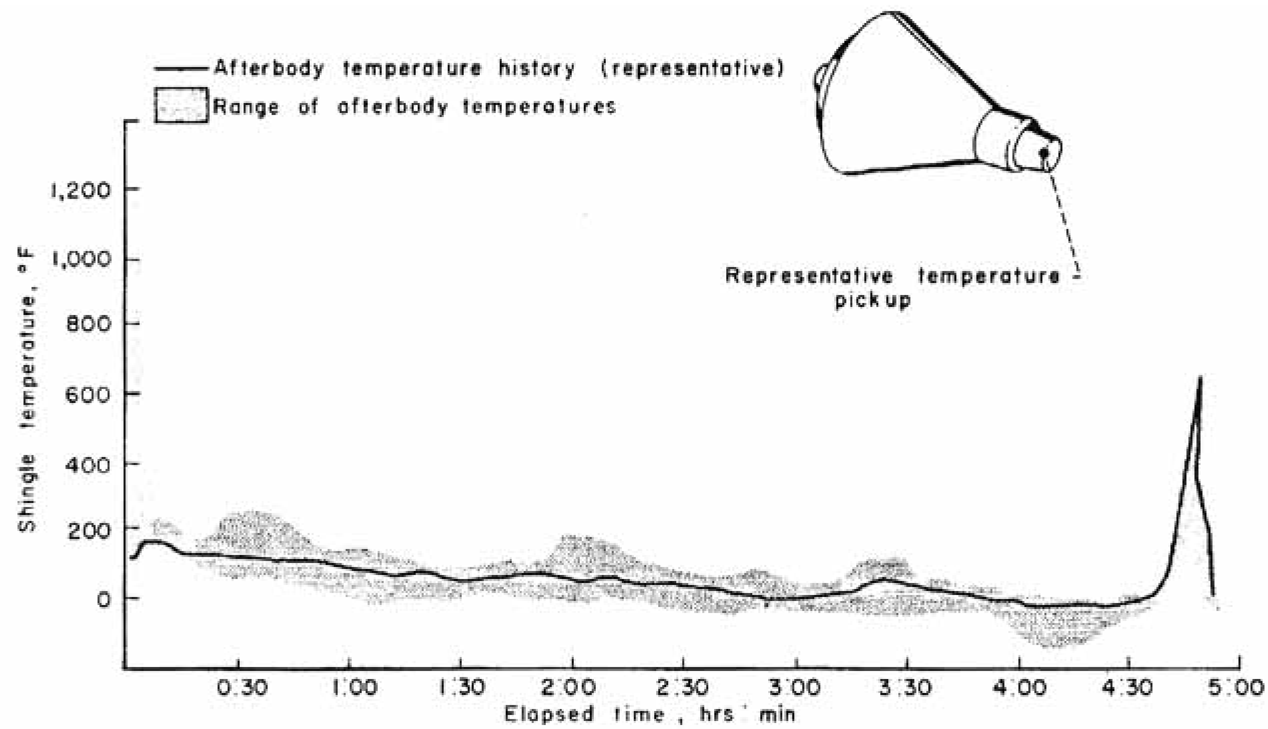


Figure 1-3.- Afterbody temperature from low-level commutator circuit.

[**4**] ...functioned in a manner intended to prevent automatic deployment of the parachutes until the spacecraft cabin pressure corresponded to an acceptable altitude. The control barostat did not alter the circuitry that was available to the pilot for manual deployment of the parachutes. In the MA-7 mission, it was planned for the pilot to deploy the drogue parachute manually at an altitude of 21,000 feet or higher if added spacecraft stabilization prior to automatic deployment of the drogue parachute was desired. Astronaut Carpenter felt the need for additional spacecraft stabilization and manually deployed the drogue parachute at an altitude of approximately 25,500 feet. The pilot also planned a manual deployment of the main parachute routinely at an altitude of about 10,000 feet, rather than waiting for automatic deployment at approximately 8,200 feet altitude; the data show that manual deployment was effected at about 9,500 feet.

After landing, the astronaut reported n severe list angle on the order of 60° from vertical, and postflight photographs of the spacecraft taken after egress of the pilot indicate approximately a 45° list angle. The time normally required for the spacecraft to erect to its equilibrium angle exceeds the period that Astronaut Carpenter used to initiate egress; therefore, this egress activity may have prevented the return to a more nearly vertical flotation attitude. Upon recovery, a considerable amount of sea water was found in the spacecraft, the majority of which is believed to have entered through the small pressure bulkhead when the pilot passed through the recovery compartment into the spacecraft. In addition, small leaks in the internal pressure vessel which probably occurred upon landing were disclosed during the normal postflight inspection; but accounting for the 6 hours prior to spacecraft recovery these leaks would have contributed only slightly to the water in the cabin. The pilot reported that at landing a small amount of water splashed onto the tape recorder in the cabin; it is believed that this resulted from a surge of water which momentarily opened a springloaded pressure relief valve in the top of the cabin.

Spacecraft Control System

The spacecraft control system is designed to provide attitude and rate control of the Mercury vehicle while in orbit and during reentry. Page 11 of reference 1 presents an additional description of the spacecraft control system. With the single exception of the pitch horizon scanner, all system components performed normally during the entire flight.

Table 1-1. Spacecraft Control System Redundancy and Electrical Power Requirements.

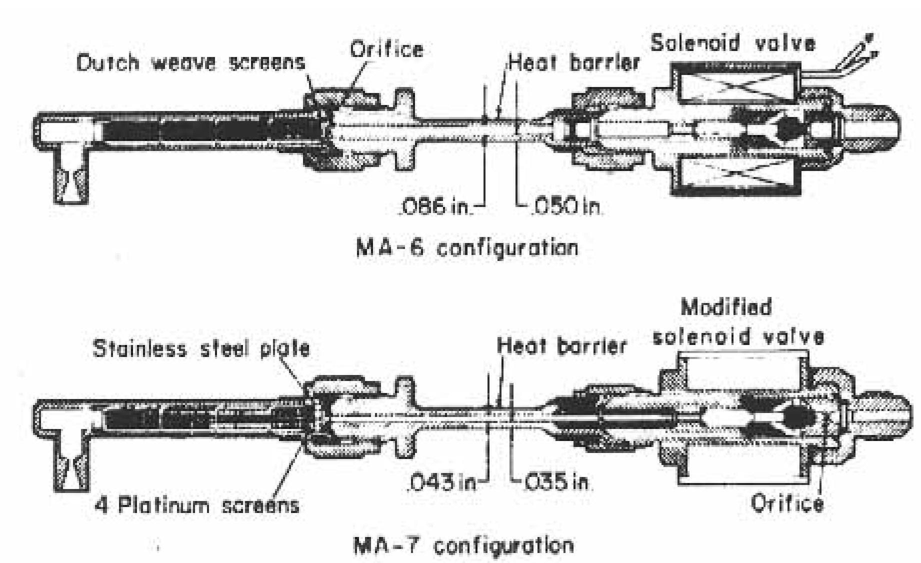
Control system modes	Corresponding fuel system (fuel supply, plumbing, and thrusters)	Electrical power required
ASCS - Automatic stabilization and control system	A	d-c and a-c
FBW - Fly-by-wire *	A	dc
MP - Manual proportional system *	B	None
RSCS - Rate stabilization control system *	B	dc and ac

*Controlled by pilot actuation of control stick

The attitude control system, at the discretion of the pilot, is capable of operation in the modes listed in table 1-1.

The spacecraft was equipped with two separate reaction control systems (RCS) shown as A and B in table 1-1, each with its own fuel supply and each independent of the other. Combinations of modes ASCS and FBW, FBW and MP, or FBW and RSCS were available to provide "double authority" at the choice of the pilot. A "maneuver" switch was added to the instrument panel for MA-7 and was included in the control circuitry to allow the astronaut to perform maneuvers without introducing errors in his attitude displays. Actuation of the switch effectively disabled the yaw reference slaving system and the automatic pitch orbital precession of 4°/min and thus prevented generation of erroneous gyro slaving signals during maneuvers.

The reaction control components were of the standard configuration, with the exception of the 1-pound and 6-pound thruster assemblies which had been slightly modified to correct deficiencies which occurred on earlier flights. The...



[5] Figure 1-4.-Comparison between MA-6 and MA-7 thrusters.

....modification to the 1-pound units involved replacing the stainless-steel fuel distribution (Dutch weave) screens (see fig. 1-4) with platinum screens and a stainless-steel fuel distribution plate, reducing the volume of the heat barriers of the automatic RCS and moving the fuel-metering orifice to the solenoid inlet. The only modification to the 0-pound units was the replacement of the stainless-steel screens with platinum screens. These changes proved to be effective, as all thrust units operated properly throughout the flight.

Horizon Scanners

The horizon scanners are employed to provide a correction reference for the spacecraft attitude gyros which is indicated in the basic schematic diagram shown in figure 1-5. An error introduced by the pitch horizon scanner circuit was present during launch and apparently remained to some degree throughout the flight. Since the scanners were lost when the antenna canister was jettisoned during the normal landing sequence, postflight inspection and analysis of these units were impossible; however the failure is believed to have been in the scanner circuit and was apparently of a random nature in view of the fact that the scanner system has been fully qualified on previous flights.

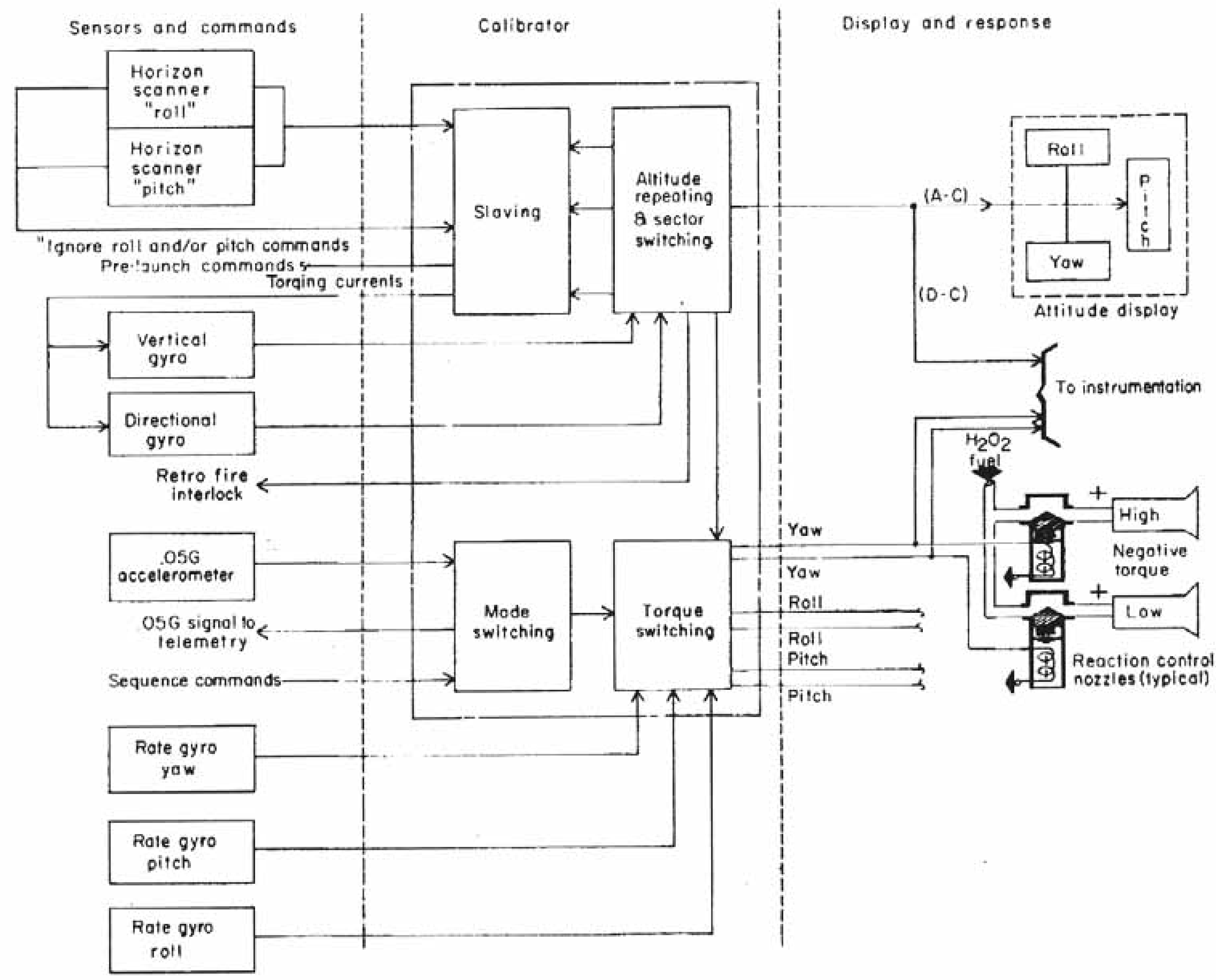
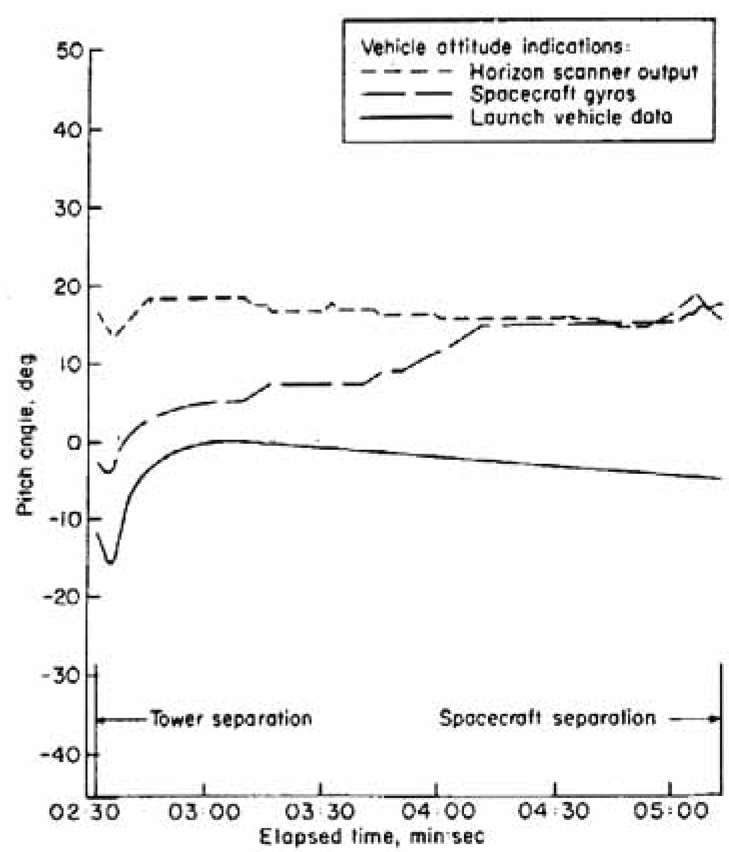


Figure 1-5.-Control system schematic diagram.



[**6**] Figure 1-6.- Spacecraft attitudes during launch.

Some 40 seconds after escape tower separation, the output of the pitch scanner indicated a spacecraft attitude of approximately 17°, which is graphically depicted in figure 1-6. Also shown is the attitude of the launch vehicle and spacecraft as determined from launch vehicle data a which is about-1° at this time indicating a scanner error of about 18° in pitch. This error apparently increased to about 20° at spacecraft separation. Radar tracking data at the time of retrofire provided the only additional independent information source and the radar data verify, in general, the scanner error. The thrust vector which produced the post retrograde velocity was calculated by using the radar measurements and since this vector is aligned with tire spacecraft longitudinal axis, a retrofire attitude of about -36° in pitch was derived. This calculated attitude was compared with a scanner-indicated attitude of-16° during retrofire, yielding a difference of 20°. Although these two independent measurements and calculations would support a theory that a constant bias of about 20° was present, the attitudes as indicated by instruments and compared with observations by the pilot disclose possible horizon scanner errors of widely varying amounts during the orbital flight phase. Because of the malfunctioning scanner which resulted in pitch errors in the spacecraft attitude-gyro system, the pilot was required to assume manual control of the spacecraft during the retrofire period.

Fuel Usage

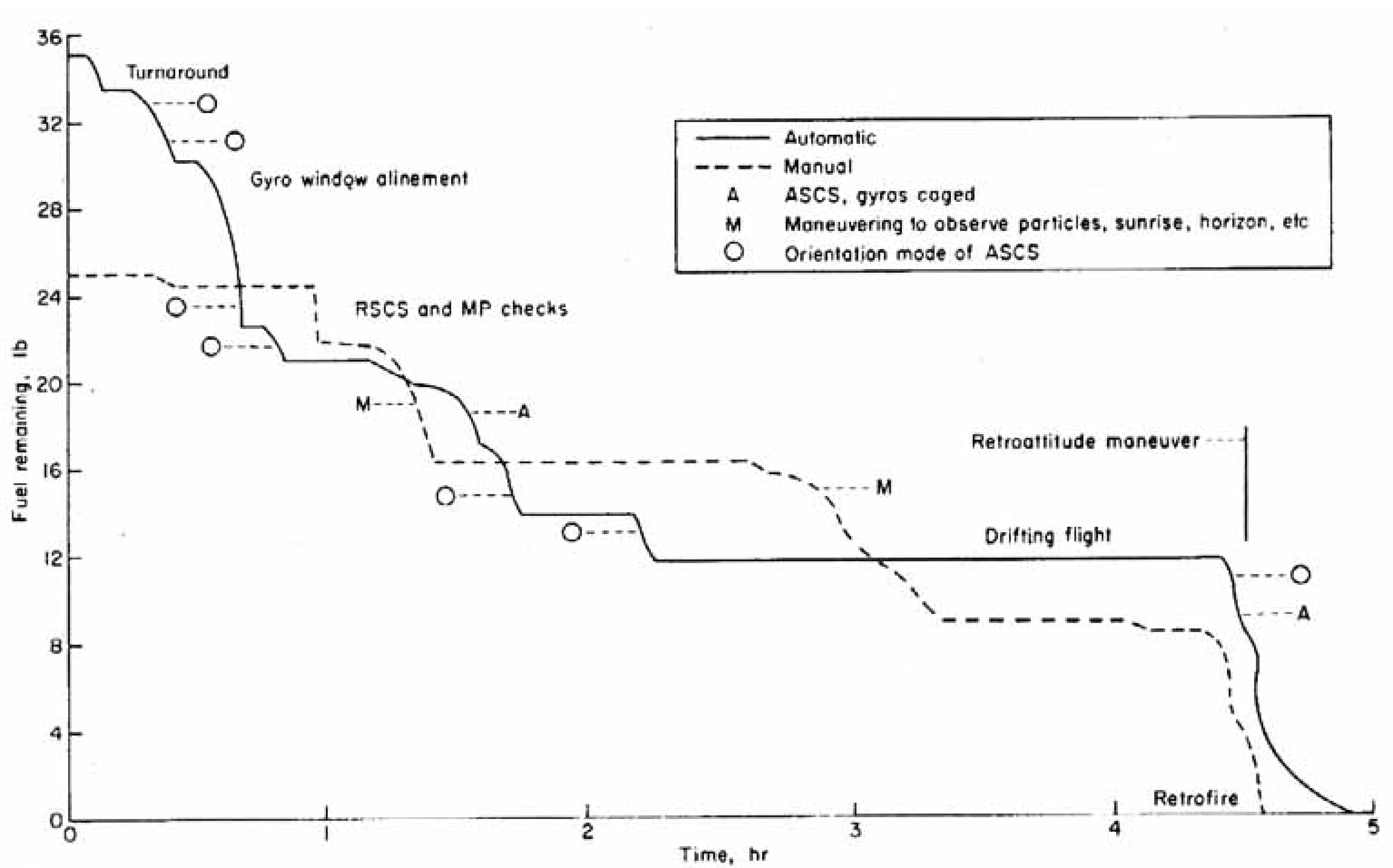
Double authority control was inadvertently employed at times during the flight, and the fly-by-wire high thrust units were accidentally actuated during certain maneuvers, both of which contributed to the high usage rate of spacecraft fuel indicated in figure 1-7. In addition, operation of the ASCS mode while outside the required attitude limits resulted in unnecessary use of the high thrust units. The manual-system fuel was depleted at about the end of the retrofire maneuver, and the automatic-system fuel was depleted at about halfway through the reentry period.

Because of the early depletion of automatic-system fuel, attitude control during reentry was not available for the required duration is a result, attitude rates built up after the ASCS became inoperative because of the lack of fuel, and these rates were not sufficiently damped, as expected, by aerodynamic forces. These oscillation; to diverge until the pilot chose to deploy the drogue parachute manually at an altitude of approximately 25,000 feet to stabilize the spacecraft.

In order to prevent inadvertent use of the high-thrust jets when using FBW mode of control, the MA-8 and subsequent spacecrafts will contain a switch which will allow the pilot to disable and reactivate the high-thrust units at his discretion. An automatic override will reactivate these thrusters just prior to retrofire. Additionally, a revision of fuel management and control training procedures has been instituted for the next mission.

Communication Systems

The MA-7 spacecraft communication system was identical to that contained in the MA-6 configuration with one minor exception. The voice power switch was modified to provide a mode whereby the astronaut could record voice on the onboard tape recorder without transmission to ground stations. Switching to the transmitting mode could be accomplished without the normal warm-up time, since the transmitter was maintained in a standby condition....



[7] Figure 1-7.-Fuel usage rates.

...when the switch was in the record position. The communications ions system is described in more detail beginning on page 12 of reference 1. The MA-7 communication system, with certain exceptions discussed below, performed satisfactorily.

Voice Communications

The UHF voice communications with the spacecraft were satisfactory. Reception of HF voice in the spacecraft was satisfactory; however attempts on the part of the astronaut to accomplish HF voice transmission to the ground were unsuccessful. The reason for the poor HF transmission has not been determined.

Radar Beacons

Performance of the C- and S-band beacons was entirely satisfactory, although slightly inferior to that of the MA-6 mission. Several stations reported some beacon countdown (missed pulses) and slight amplitude modulation on the C-band beacon. The amplitude modulation was possibly caused by the modulation presented by the phase shifter and the drifting mode of the spacecraft, which resulted in a less than optimum antenna orientation, as expected. Both beacons were rechecked after the mission and found to be essentially unchanged from their preflight status.

Location Aids

The recovery beacons employed as postlanding location aids include the SEASAVE (HF/DF), SARAH (UHF/DF), and Super SARAH (UHF/DF) units. Recovery forces reported that the auxiliary beacon (Super SARAH) and UHF/DF signals were received. The Super SARAH beacon was received at a range of approximately 250 miles. Both the SARAH beacon and UHF/DF transmitter were received at ranges of 50 miles from the spacecraft.

The SEASAVE rescue beacon (HF/DF) was apparently not received by the recovery stations.. The whip antenna used by this beacon was reported by the recovery forces to be fully extended and normal in appearance. The beacon was tested after the flight and found to be operating satisfactorily. The reason for lack of reception of this beacon has not been established but the large list angles of the spacecraft after landing placed the whip antenna near the surface of the water, and this may have been a contributing factor.

Command Receivers

[**8**] The two command receivers operated effectively during the MA-7 flight. One exercise was successfully accomplished with the emergency-voice-mode of the command system while over Muchea. The second exercise of this mode, attempted during reentry, was unsuccessful because the spacecraft was below the line-of-sight of the range

stations at this time.

Instrumentation System

The spacecraft instrumentation system was basically the same as that for the MA-6 mission which is described on page 19 of reference 1. Performance of the system was satisfactory except for those items discussed below.

The instrumentation system sensed information pertinent to over 100 items throughout the spacecraft. The biological parameters of the pilot, namely electrocardiogram (FOG) traces, respiration rate and depth, body temperature, and blood pressure, were of primary concern to flight control personnel. In addition, many operational aspects of spacecraft systems were monitored. These aspects included significant sequential events, control system operation and component outputs, attitudes and attitude rates, electrical parameters, ECS pressures and temperatures, accelerations along all three axes, and temperatures of systems and structure throughout the spacecraft. These quantities were transmitted to Mercury Network stations and recorded onboard the spacecraft. The system also included a 16-mm motion picture camera which photographed the astronaut and surrounding portions of the spacecraft. The instrumentation system had direct readouts on the MA-7 spacecraft display panel for many of the instrument parameters.

System Modifications

The changes made since the MA-6 flight included the incorporation of an additional, low-level commutator circuit which provided a more complete temperature survey, rewiring of the circuitry which monitored closure of the limit switches that sensed heat-shield release and the substitution of a semiautomatic blood pressure measuring system (BPMS) for the manual device used for MA-6. In addition, the earthpath indicator and the instrument-panel camera were deleted for MA-7.

Instrumentation Anomalies

A problem in the instrumentation system occurred just after lift-off when erroneous ECG signals were temporarily recorded. These extraneous signals were primarily attributed to rapid body movements of the pilot and possibly excessive perspiration during this period.

For a short period during the orbital phase, the instrumentation indicated that the astronaut s temperature had increased to 102° F. and this caused momentary concern. However, other medical information indicated that this 102° F. value was erroneous. The respiration rate sensor provided adequate preflight data, but the in-flight measurements were marginal because of the variations in head position and air density. This anomaly has been experienced on previous flights and was of little concern.

The data transmitted from the blood-pressure measuring system stem were questionable at times during the flight, primarily because of the magnitude of the data and the intermittency with which it was received. The intermittent signals were found to have resulted from a broken cable in the microphone pickup, shown in figure 1-8. This malfunction, however, could not have affected the magnitude of the transmitted information, since an intermittent short either sends valid signals or none at all. The BPMS was thoroughly checked during postflight tests in the laboratory-using actual flight hardware, with the exception of the microphone and cuff. Tests of the controller unit and amplifier were also conducted, and no component failure or damage in the BPMS has been detected to date. However, a number of uncertainties regarding the calibration and operation of the BPMS still...

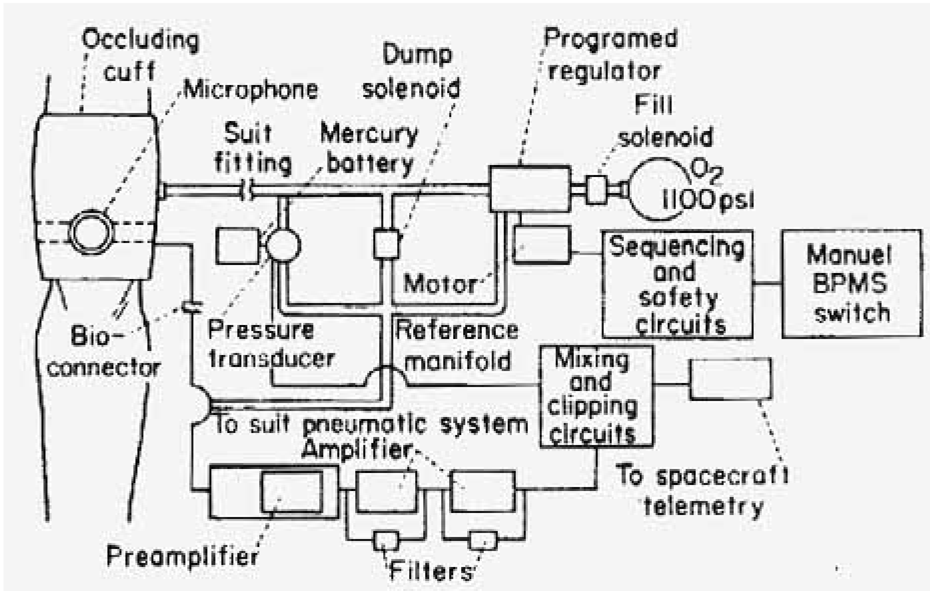


Figure 1-8.-Semiautomatic blood-pressure measuring system.

[**9**].... exist. Extensive testing is being conducted to correlate postflight and in-flight BPMS readings more accurately with clinically measured values.

The remainder of the instrumentation system performed satisfactorily, with the exception of a noncritical failure of one temperature pickup, a thermocouple located at the low clockwise automatic thruster. A brief indication of spacecraft crescent occurred on the rate-of-descent indicator toward the end of the orbital phase; but since this unit is activated by atmospheric pressure, the indication was obviously false. This indicator apparently operated satisfactorily during descent through the atmosphere and was found to be operating properly during postflight evaluation. The pilot-observer camera film suffered sea-water immersion after the flight, and its quality and usefulness were somewhat limited.

Life Support System

The life support system primarily controls the environment in which the astronaut operates, both in the spacecraft cabin and in the pressure suit. Total pressure, gaseous composition, and temperature are maintained at acceptable levels, oxygen is supplied to the pilot on demand, and water and food are available. Both the cabin and suit environmental systems operate automatically and simultaneously from common oxygen, coolant water, and electrical supplies. In-flight adjustment of the cooling system is provided for, and the automatic-supply function of the oxygen system has R manual override feature in case of a malfunction.

The suit and cabin pressures are maintained at 5.1 psia, and the atmosphere is nearly 100 percent oxygen. The environmental control system (ECS) installed in the MA-7 spacecraft, schematically shown in figure 1-9, differed from that for MA-6 in only two respects: The constant bleed of oxygen into the suit circuit was eliminated, and the oxygen partial pressure of the cabin atmosphere was measured, rather than that of the suit circuit. Pages 21 and 31 of reference 1 contain additional description of the life support system.

Higher-than-desired temperatures in the spacecraft cabin and pressure suit were experienced during the MA-7 flight, and these values...

[MISSING] Figure 1-9.-Schematic diagram of the environmental control system.

...are plotted in figures 1-10 and 1-11, respectively. In the same figures, the cabin and suit temperatures measured during the MA-6 mission are shown for comparison. The high temperatures were the only anomalies evident in the ECS during the flight.

The high cabin temperature is attributed to...

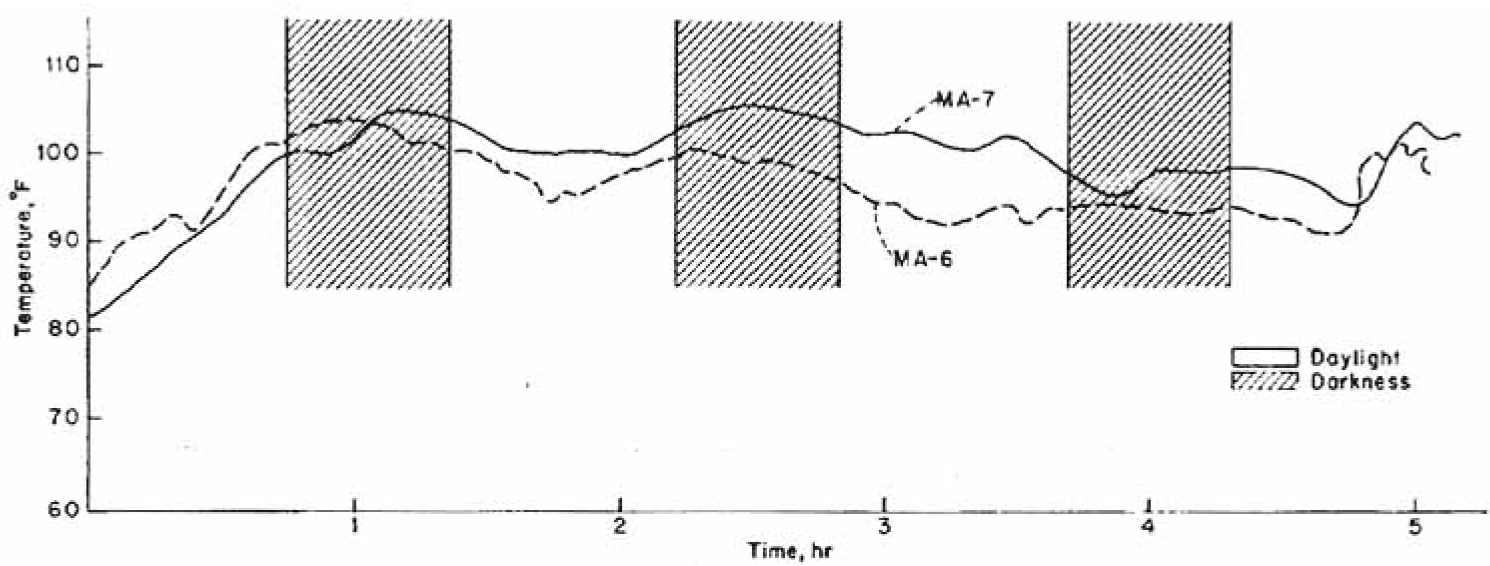
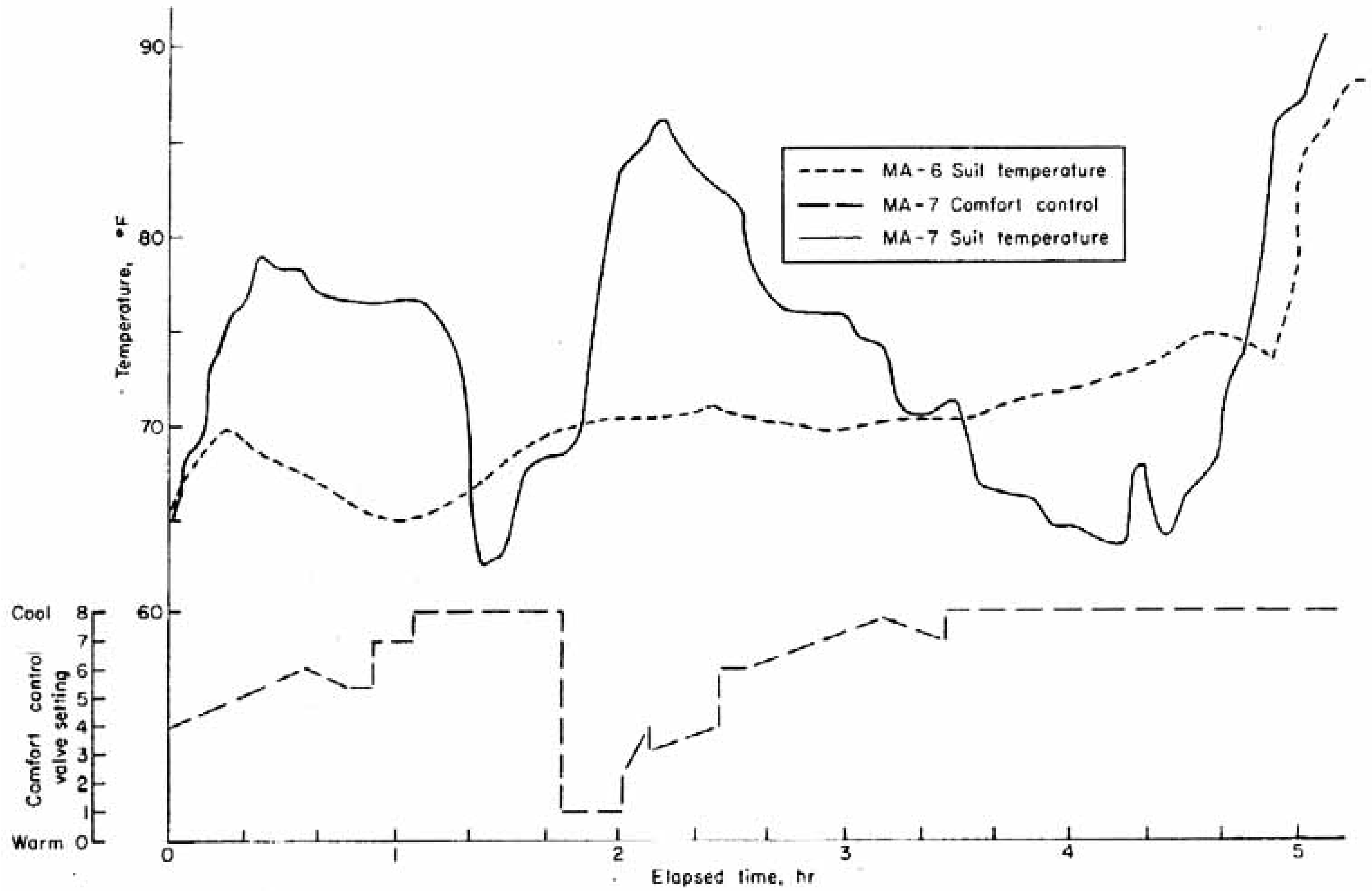


Figure 1-10. Cabin-air temperatures.



[**10**] Figure 1-11.-Suit-inlet temperature and comfort control valve setting.

....a number of factors, such as the difficulty of achieving high air flow rates and good circulation of air in the cabin and vulnerability of the heat exchanger to freezing-blockage when high rates of water flow are used. Tests are currently being made to determine if the cabin temperature can be lowered significantly without requiring substantial redesign of the cabin-cooling system.

In the case of the high suit temperatures, some difficulty was experienced in obtaining the proper valve setting for the suit-inlet temperature control, mainly because of the inherent lag at the temperature monitoring point with control manipulations. The comfort control valve settings are presented in figure 1-11, and a diagonal line reflects a lack of knowledge as to when the control setting was instituted. It has been further ascertained in postflight testing in the altitude chamber that the suit temperature did respond to control valve changes. Based on the satisfactory performance of the suit system in the MA-6 flight, it is believed that the suit-inlet temperature could have been maintained in the 60° to 65° F range for the MA-7 flight, had not the comfort control valve been turned down early in the flight The valve setting was reduced by the pilot during the first orbital pass when the cabin heat exchanger indicated possible freezing. It is believed that some freezing at the heat exchanger did occur during the flight which may have resulted in less efficient cooling but this is not the primary cause of the above-normal temperature.

A study of the metabolic rate associated with a manned orbital flight was conducted in this mission, and the results yielded a metabolic oxygen consumption of 0.07 22 pound/hour or 408 standard cubic centimeters (SCC) per minute. This level under weightlessness is comparable to that in a normal gravity field with similar work loads and is within the design specification of 500 sec/min for the ECS.

Electrical and Sequential System

The electrical power system for MA-7 was of the same type as that used for MA-6 . This system is described more fully on page 21 of reference 1. The MA-7 electrical power system performed satisfactorily during the MA-7 mission.

[**11**] The sequential system for MA-7 deviated only slightly from that used for MA-6, which is described in detail on pace 26 of reference 1. The major change involved the addition of a control barostat in the landing sequence circuit, which is discussed in a previous section. The MA-7 sequential system performed adequately during the mission. The one anomaly that was experienced is discussed subsequently.

Inverters

Temperatures of the inverters were, as in previous flights, above expected values. However a change in the coolant valve setting, by the astronaut later in the flight did decrease the rate of rise in the inverter temperatures.

Squib Fuses

As expected squib circuit fuses were found to be blown, including the number 1 retrorocket switch fuse which also had a small hole on the side of the ceramic housing. Postflight testing demonstrated that at the electric current levels experienced in flight, the casing of these fuses could be ruptured and significant quantities of smoke could be produced. It was confirmed by the astronaut during postflight tests, where he observed two similar fuses being blown, that these fuses produce a smoke having the same color and odor as that encountered in flight at the time of retrofire.

Sequential System

The differences between the MA-6, and MA-7 sequential systems included changing of the horizon scanner slaving signal from programmed to continuous and locking-in of the 1/4-g relay sustainer engine cutoff to prevent reopening by posigrade thrust.

One sequential system anomaly was indicated in the mission when retrofire was reported to have been delayed about 1 second after the pilot actuated the manual switch to ignite the retrorockets. Figure 1-12 shows schematically the retrosequence circuitry. Since the attitude gyro in pitch indicated that the spacecraft pitch attitude was not within ±12° of the nominal -34°, the attitude-permission circuitry couldn't pass the retrofire signal from the clock and thus, the automatic clock sequence could not ignite the retrorockets; this lack of permission was proper and indicated that sequential circuitry performance was according to design. After waiting for about 2 seconds, Astronaut Carpenter actuated the manual retrofire switch. He reported that an additional delay of about l second occurred red before the retrorockets actually ignited, which normally would take place instantaneously. No explanation is available for this additional 1-second delay, since exhaustive postflight testing has failed to reveal any trouble source in the ignition sequence circuitry.

Scientific Experiments

It was planned that a series of research experiments would be conducted by Astronaut Carpenter during the MA-7 mission. This series included a balloon experiment, a zerogravity study, a number of photographic exercises, a ground flare visibility experiment, and observations of the airglow layer witnessed by Astronaut Glenn. Results of the last experiment are presented in paper 4 and will not be discussed here. Most Mercury experiments were proposed and sponsored by agencies outside the Manned Spacecraft Center. Each was carefully evaluated prior to its approval for inclusion in the flight plan. Sponsoring agencies for the MA- 7 experiments are shown in the following table.

Experiment	Sponsoring Organization
Balloon	Langley Research Center
Zero-gravity	Lewis Research Center
Ground-flare visibility	Manned Spacecraft Center
Horizon definition	MIT Intrumentation Laboratory
Meteorological photography	U.S. Weather bureau
Airglow layer	Goddard Space Flight Center

Balloon Experiment

The objectives of the balloon experiment were to measure the drag and to provide visibility data regarding an object of known size and shape in orbital] space. The balloon was 30 inches in diameter, and was constructed of five equal-sized lunes of selected colors and surface finishes The sphere was constructed of a plastic and aluminum foil sandwich material, and...

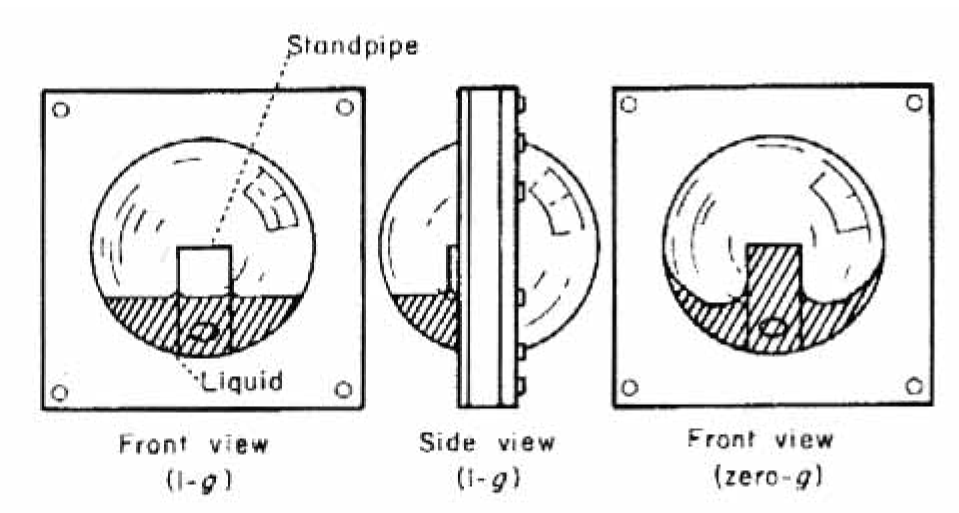
[**12**] Figure 1-12.- Retrosequence schematic diagram.

was to be inflated with a small nitrogen bottle immediately after release from the antenna canister at the end of the first orbital pass. In addition, numerous 1/4-inch discs of aluminized plastic were placed in the folds of the balloon and dispersed when the balloon was deployed.. is intended, the pilot observed the rate of dispersion and the associated visual effects of the "confetti."

The balloon was deployed at 01:38:00 ground elapsed time, but it failed to inflate properly. The cause has been attributed to a ruptured seam in the skin. Aerodynamic measurements were taken with the strain-gage pickup, but these are of little use since the actual frontal area of the partial inflated balloon is not known. The visibility portion of the experiment was also only partially successful because only two of the surface colors were visible, the orange and aluminum segments. While the balloon was deployed a series of spacecraft maneuvers evidently fouled the tethering line on the destabilizing flap located on the end of the cylindrical portion of the spacecraft, thus preventing the jettisoning of the balloon. No difficulty was encountered during retrofire and the balloon burned up during reentry.

Zero-Gravity Experiment

The objective of the zero-gravity experiment was to examine the behavior of a liquid of known properties in a weightless state using a particular container configuration. The apparatus consisted of a glass sphere containing a capillary tube which extended from the interior surface to just past the center, as shown in figure 1-13. A liquid mixture representing the viscosity- and surface tension of hydrogen peroxide was composed of distilled water, green dye, aerosol solution and silicon, and consumed about 20 percent of the internal volume. The diameter of the sphere was 3 3/8 inches. The application of the results of this experiment is primarily in the design of fuel tanks for....



[**13**] Figure 1-13.- Zero-gravity experiment.

....future spacecraft. The surface configuration of the liquid under zero-gravity was expected to assume the position indicated in the final view of figure 1-13. An astronaut report during the third pass over Cape Canaveral (see appendix) and a postflight analysis of the pilot- observer film verified the predicted behavior of the liquid. The results of the experiment showed that the liquid filled the capillary tube during weightless flight and during the low-acceleration portion of reentry.

Ground-Flare-Visibility Experiment

The major objective of the ground-flare-visibility experiment was to determine the capability of the astronaut to acquire and observe a ground-based light of known intensity and to determine the attenuation of this light source through the atmosphere. The earth-based apparatus consisted of ten 1,000,000-candle-power flares located at Woomera, Australia. The pilot was supplied with an extinction photometer with a filter variation from 0.1 neutral density to 3.8 neutral density (99.98-percent light reduction). The flares, with a burning time of about 1 1/2 minutes, were to be ignited approximately 60 seconds apart during passes over this station. The experiment was attempted and failed to yield results because of heavy cloud cover during the first pass. It was therefore discontinued for the remainder of the flight because of continuing cloud cover. This cloud cover, which was also experienced during a similar experiment in MA-6, was approximately eight-tenths at 3,000 feet. The exercise is scheduled to be repeated in future flight.

Photographic Studies

A series of photographic exercises were planned for the MA-7 flight, but since operational requirements assume priority over scheduled flight activities, some of these studies were not conducted. The Massachusetts Institute of Technology sponsored a study and supplied the necessary equipment to determine horizon definition as applied to the design of navigation and guidance systems. A few mosaic prints were derived from a series of exposures taken of the horizon. The MIT photographic study is discussed, and a sample photographic is shown in the Pilot Performance paper (paper 6).

A meteorological experiment involving a series of special photographs for the U.S. Weather Bureau was not accomplished because of the lack of time.

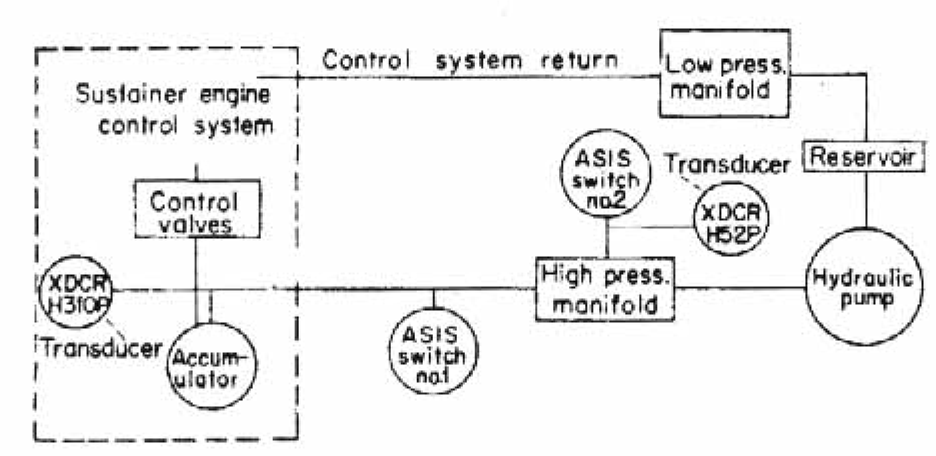
Astronaut Carpenter exposed an extensive series of general interest color photographs of subjects ranging from terrestrial features and cloud formations to the launch-vehicle tankage and the tethered balloon. Some of these photographs are displayed in the Pilot's Flight Report (paper 7).

Launch Vehicle Performance

The launch vehicle used to accelerate Astronaut Carpenter and his Aurora 7 spacecraft into orbit was an Atlas D missile modified for the Mercury mission. The MA-7 launch vehicle was essentially the same as that used for the MA-6 mission and is described in paper 4 of reference 1.

The differences between the Atlas 107-D (MA-7) and the Atlas 109-D used for MA-6 involved retention of the insulation bulkhead and reduction of the staging time from 131.3 to 130.1 seconds after liftoff The performance of the launch vehicle was exceptionally good, with the countdown, launch, and insertion conforming very closely to planned conditions. At sustainer engine cutoff (SECO), all spacecraft and launch-vehicle systems were go, and only one anomaly occurred during launch which requires mention.

Although the abort sensing and implementation system (ASIS) performed satisfactorily during the flight, hydraulic switch no.2 for the sustainer engine actuated to the abort position at 4:25 minutes after liftoff This switch and the pressure transducer H52P for the sustainer hydraulic accumulator are connected to a common pressure-sensing line as shown in figure 1-14. For an unknown reason this transducer was apparently faulty and showed a gradual....



[**14**] Figure 1-14. Launch vehicle hydraulic diagram.

....decrease in pressure from 2,940 psia to 0 between 190 seconds and 312 seconds after liftoff Another transducer located in the sustainer control circuit indicated that pressure had remained at proper levels throughout powered flight; therefore, this pressure switch did not actuate until the normal time after SECO. Since both of these switches must be activated to initiate an abort, the signal which would have unnecessarily terminated the flight was not generated.

Reference

1. ANON: Results of the First U.S. Manned Orbital Space Flight, Feb.20, 1962. NASA Manned Spacecraft Center.