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THE LIGHTWEIGHT TRANSOSONDE SYSTEM

J.W. Allen and G. Welch

Communications Branch
Radio Division

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THE LIGHTWEIGHT TRANSOSONDE SYSTEM

INTRODUCTION

A new concept of upper-air data collection has evolved from consideration of the use of controlled-altitude balloons by the Japanese during World War II. The concept is one of meteorological data collection from instrumented balloons controlled to float at a given constant-pressure surface in the atmosphere. This concept was first proposed in 1950 by Captain H. T. Orville, former head of Navy Aerology, as a means to fulfill the increasing requirements for more extensive weather information over remote ocean areas. Subsequent feasibility studies and field evaluations carried out by NRL established the technical and meteorological feasibility of a system implementing this concept. This system was called the transosonde. The system initially consisted of (a) a constant-volume, open-appendix (nonpressurized) balloon, (b) a balloon-borne telemetering station, and (c) a suitable network for determining periodically the position of the balloon. Wind speed and direction are derived from the positioning data obtained by this tracking network. Other meteorological parameters are telemetered to the ground stations as code modulations of the radio signals. This system acquired operational status in 1957 when the U. S. Navy began launchings of transosonde balloons from Japan. While the balloon borne equipment then employed was highly effective as a meteorological sounding device, maximum utilization and deployment of the system was seriously hampered by its size (39 ft diameter balloon, 5 cu ft instrumentation) and weight (approximately 600 lb).

With the development of fixed-volume plastic balloons (1958) capable of withstanding low-level pressurization, the concept of a small, lightweight transosonde airborne equipment became practical. In 1959 the transosonde program at NRL was directed toward the development of the small lightweight equipment. In accomplishing this task, 50 experimental research balloon flights were made. The purpose of these flights was to determine the potential of the new transosonde vehicle – the pressurized balloon – and to flight test and evaluate the capability of the lightweight instrumentation to be employed with a system utilizing the pressurized balloon. The equipment that evolved from this effort consisted of a spherical plastic balloon (12.5 ft diameter, weight about 20 lb) capable of withstanding 50 millibars of superpressure at 30,000 ft altitude and maintaining a superpressure level suitable for a sustained flight period of at least ten days; an instrumentation package (2 cu ft, 12 lb) which monitored ambient pressure, ambient air temperature, and balloon superpressure and was capable of delivering 50 transmission periods, each of three minutes duration with a radiated power of approximately 30 watts.

This report contains a compilation of data from the program of research flights conducted during the development of the small light weight equipment (Appendix A). Also presented is a detailed description of the function and operation of the lightweight instrumentation. A bibliography of pertinent or related articles is included at the end of the text.

FLIGHT-PROGRAM RESUMÉ

During the initial phases of the program, a cylinder-shaped balloon (75 ft long by 5 ft diameter, Fig. 1) was used. It was soon apparent that the launching and handling problems associated with the balloon size and configuration seriously hampered the optimum

utilization of the lightweight equipment. The large surface area also made testing and detection of balloon faults (poorly sealed seams, pinholes, fabrication defects, etc.) difficult, thus reducing reliability of the balloons.

Data collected from these early flights indicated that approximately a 50-millibar superpressure capability would be necessary in order for balloons to survive all possible environmental demands. Since existing balloons could not withstand an initial 50-millibar superpressure, it was necessary to install a ballast drop on the equipment so that balloon superpressure could be "recharged" when the occasion demanded.

By early 1960 the balloon manufacturer was able to produce spherically shaped balloons (12.5 ft diameter, Fig. 2). These provided a more favorable surface-area-to-volume ratio, thereby resulting in lighter and smaller balloons requiring less gas and greatly facilitating the inflation and launching procedures.

After several flights employing the new spherically shaped balloons, it was apparent that in order for them to be useful, improvements in sealing and quality control were necessary. A special development program, undertaken by the balloon manufacturer, jointly with NRL personnel, gradually resulted in an improved balloon.

By early 1961 the system capability had been thoroughly explored and occasionally demonstrated. Inconsistent balloon performance, however, still plagued the flight program. In April 1961, a balloon ground-testing program was initiated at NRL. Thereafter every balloon flown was thoroughly ground tested before flight. One of the main reasons for past inconsistent balloon performance was readily apparent soon after these tests were initiated. Practically all balloons had one or more pinholes in them. While difficult to locate, they were easily corrected by the application of a patch, made from the same material as the balloon, containing a clear, pressure-sensitive adhesive. In the future, this problem should be eliminated by the use of improved balloon material and material-inspection techniques, and better quality control of the balloon-fabrication process. From the time the balloon ground-testing procedure was initiated until the flight-test program was completed, balloon performance was excellent, with no flight failures being attributed to poor balloon performance.

The basic equipment design remained unchanged during this flight program. Numerous improvements were made and minor faults corrected. The major improvements consisted of the addition of a superpressure ballast control, a twofold increase in transmitter output power, and the development of an ambient-temperature encoder compatible with the existing keyer-encoder.

The final phase of this program showed that with proper balloon quality control and equipment preparation, this system could be utilized with a high degree of reliability.

BALLOON SUPERPRESSURE

On these flights the percentage free lift imparted to the balloon was the predominant factor in determining balloon superpressure, but it also was significantly affected by the balloon gas temperature. The effects of both the free lift and the balloon gas temperature were subject to change or modification by numerous factors, such as balloon type, balloon size, balloon-material "stretch" characteristics, balloon-material thickness and absorptance-emittance characteristics, and the balloon's thermal radiation environment. Because of the many varying factors playing a part in determining the balloon superpressure, it was difficult to predict exactly what it would be at any given time. From this data compilation, using only those flights where sufficient data were available to determine the maximum initial balloon superpressure upon reaching ceiling, free lift-superpressure data were tabulated (Table 1).

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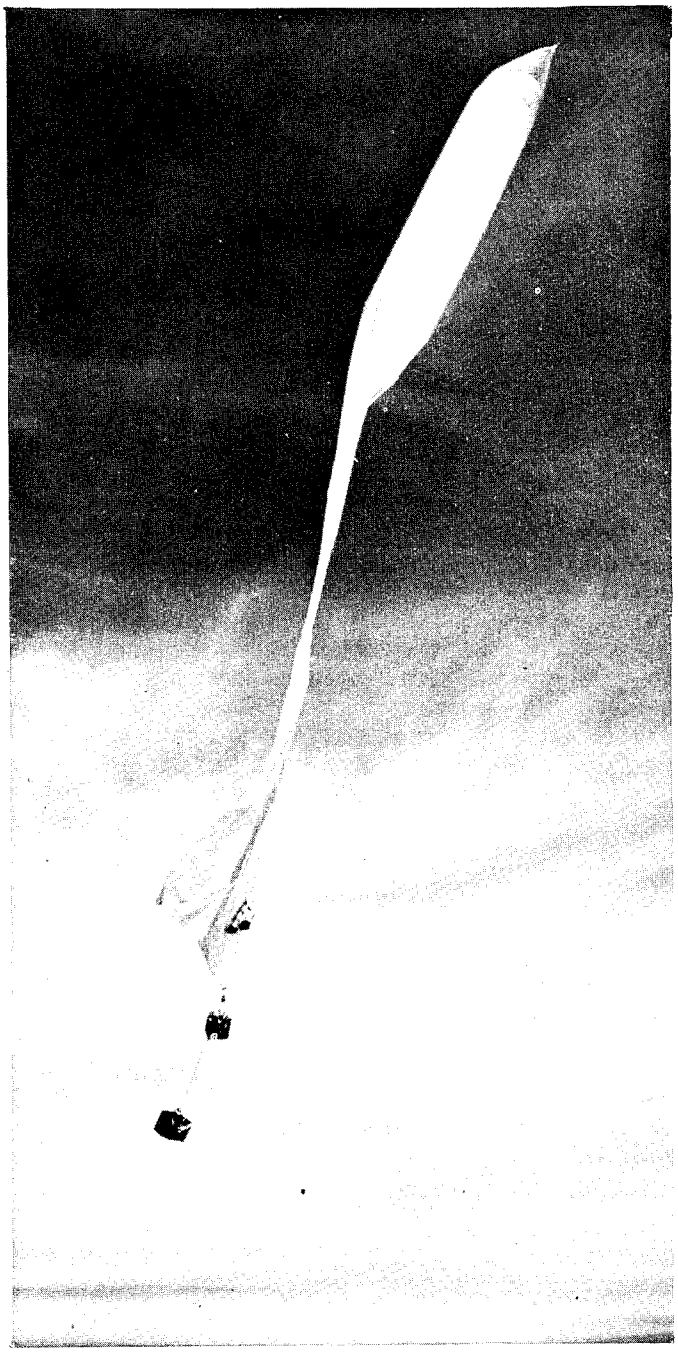

Fig. 1 - Cylindrical balloon

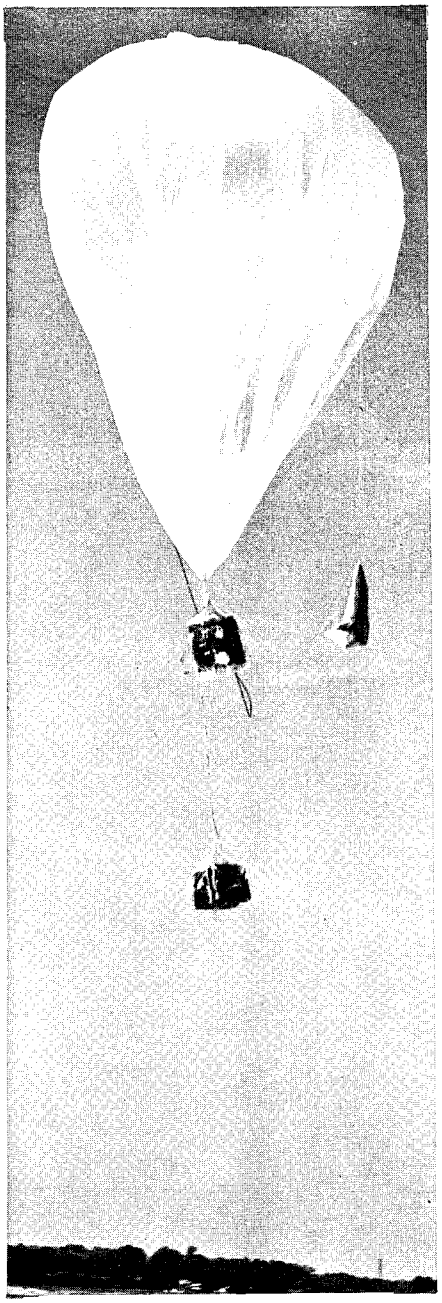

Fig. 2 - Spherical balloon

Table 1
Initial Free Lift-Superpressure Ratios

Balloons	Pressure per 1-percent Free Lift (millibars)		
	Maximum	Minimum	Average
Cylinder (13 flights)	3.8	2.4	3.2 ± 0.2
Spherical (17 flights)	4.2	3.1	3.5 ± 0.1

POSITIONING AND DATA COLLECTION

The positions of the balloons were determined periodically by the FCC high-frequency radio direction-finder network, with 18 stations located in the continental U.S., Alaska, and Hawaii. Each fix supplied by the network is assigned a rating in the form of a radius of a circle centered on the fix. The true fix is contained within this circle. Ratings are: Class A, 20-mile radius, Class B, 40-mile radius, Class C, 60-mile radius, and Class D, greater than 60-mile radius.

The FCC network also collected the data from these flights. The frequency of data transmission was determined by equipment capability and expected flight duration. For most flights, the transmissions were scheduled for one- or two-hour intervals.

FLIGHT EQUIPMENT

The flight assembly consisted basically of two thermally insulated instrument packages and a pressurized balloon. The balloons were made from Mylar plastic film (0.002 in. thick) with tape-sealed seams. The final model of the spherical balloon had 0.003-in.-thick material for the "end caps" and double-taped sealed seams.

The telemetering and balloon-control equipment was composed of five basic parts:

1. Transmitter
2. Keyer encoder
3. Power supply
4. Equipment housing
5. Programming and control

Figure 3 is a block diagram of the complete flight assembly.

Various modifications and improvements were adapted to the equipment during this flight-test period. On several flights, special instrumentation was necessary. During the latter portion of this program, a new ambient-temperature encoder compatible with existing equipment was flown on several flights. Whenever such modifications, improvements, or changes were employed, notation and explanation of them are included in the logs on the particular flights. The final model of the equipment was capable of delivering 50 transmission periods, each of three minutes duration, with a radiated power of approximately 30 watts.

Transmitter

The transmitter (Figs. 4 and 5) is a lightweight, dual-frequency unit allowing operation on two frequencies with a common set of tubes and components. It radiates 20 to 30 watts sequentially on each frequency with a minimum of component switching. The present model operates on frequencies of 6745.5 kc and 15,026.0 kc.

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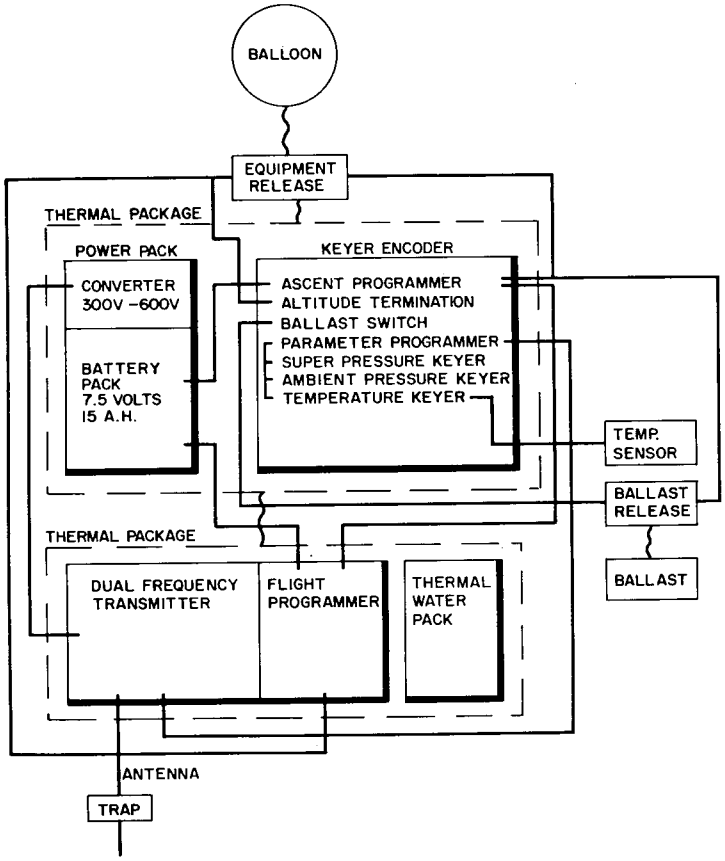

Fig. 3 - Block diagram of transosonde equipment

The oscillator section is a conventional electron-coupled Colpitts circuit. Frequency doubling is used for both frequencies to improve frequency stability. The plate circuit consists of two tank circuits in series, instead of a conventional circuit. One circuit is tuned to the low frequency and has a low L/C ratio. This circuit looks like a coupling capacitor to the high frequency. The other tank circuit is tuned to the high frequency and has a high L/C ratio. It looks like a small reactance to the low frequency.

The output circuit closely matches the antenna to the power output tube at both operating frequencies. The output tank circuit consists of a high-frequency trimmer capacitor, a high-frequency coil, a low-frequency coil, and a low-frequency trimmer coil. The antenna is connected in shunt with the low-frequency coils. A wave trap tuned to the high frequency is located one-half wavelength (high frequency) from one end of the antenna. The antenna feedpoint is in the center of this half-wavelength section, so it looks like 72 ohms to the high frequency. This 72 ohms shunts the low-frequency coils, which have a relatively high reactance (near 3000 ohms), and essentially excludes them from the circuit when operating at the high frequency.

The circuit L/C ratio is selected to have a parallel impedance around 2200 ohms (at the high frequency) with the 72-ohm antenna in the circuit. The plate resistance of the power-output tube closely matches this load.

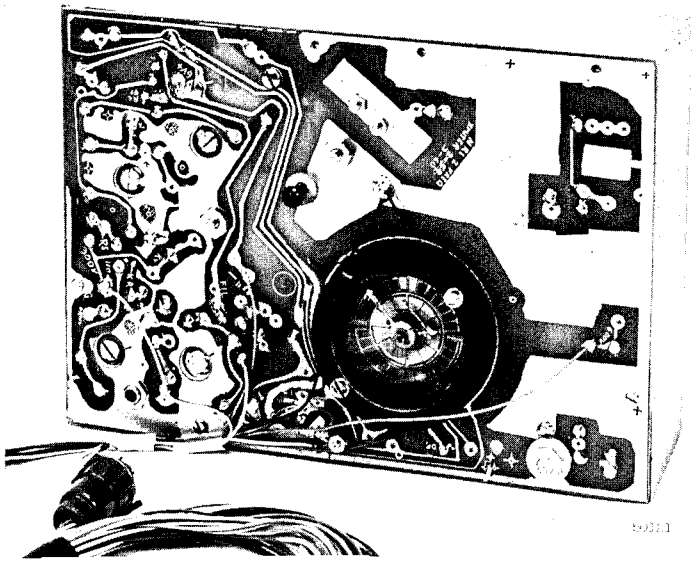

Fig. 4 - Transmitter, front view

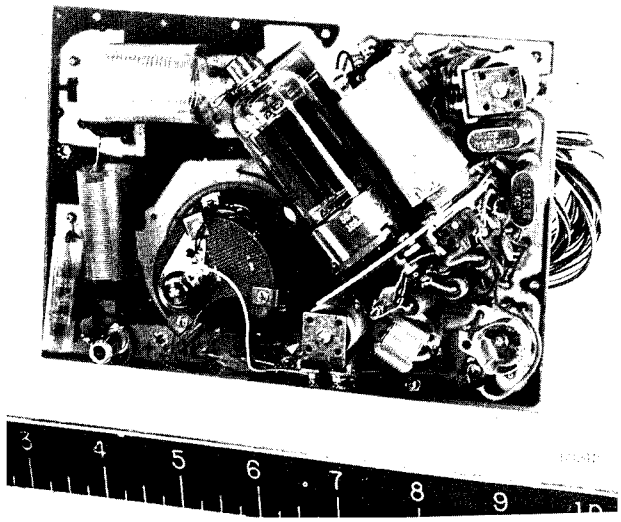

Fig. 5 - Transmitter, rear view

The total length of the antenna is one-half wavelength at the low frequency. The antenna feed point for the low frequency is off center, near one end. The impedance at this point is near 2200 ohms. In the output tank circuit the low- and high-frequency components are both active. At the low frequency, however, the high-frequency coil has little effect because of its relatively low inductance; thus the 2200-ohm antenna is essentially connected directly to the plate of the output tube. The low-frequency coils supply the needed inductance to resonate the tank circuit to the low frequency.

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A clock programming unit is included with the transmitter circuit. A common printed-circuit board supplies most of the circuits for the transmitter and its associated programmer. The programmer automatically energizes the transmitter on both frequencies at preset intervals selected from a variety of programmer circuits. The most commonly used programming sequence energizes the transmitter 1.5 minutes sequentially on each frequency every two hours. A 20-second continuous signal is included on both frequencies for use in obtaining radio bearings.

For transosonde use, the power to the converter is keyed, which results in the keying of the high voltage supplied to the transmitter. This is the most efficient mode of operation for transosonde use.

The power necessary to operate this unit is 600 volts at 66 ma, 300 volts at 27 ma, and 6.3 volts at 900 ma. The most efficient operation is obtained with 600 volts on the output and 300 volts on the driver.

Keyer-Encoder

The keyer-encoder (Figs. 6 and 7) programs and encodes all data and generates the appropriate Morse-code groups which are used to control keying pulses to the transmitter. In addition, it also provides means for accomplishing several flight-control functions. They are ascent programming, altitude termination, ballast control, and arming of ballast and termination release devices. These functions are fully described under Programming and Control.

Keying – Keying is provided by the code generated from two printed-circuit code disks on which code wiper contacts representing each parameter are positioned relative to the value and/or position of the sensors. The Morse-code signal thus generated activates a relay in the power converter which controls the high voltage to the transmitter. Thus the keying signal "keys" the converter, which in turn keys the transmitter.

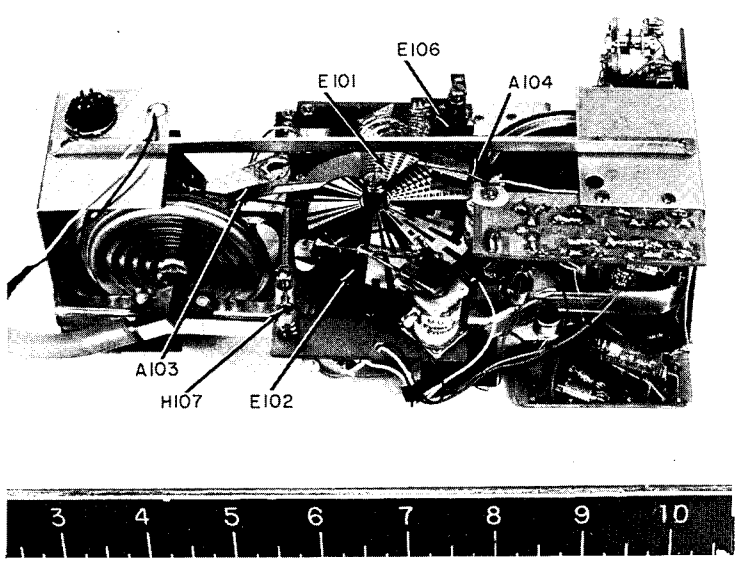

Fig. 6 - Keyer encoder, front view

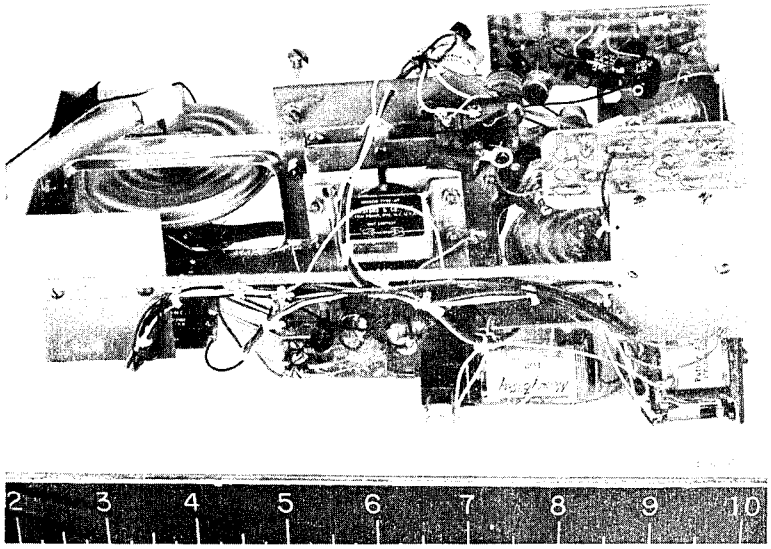

Fig. 7 - Keyer encoder, rear view

Morse-Code Generators – The code groups are generated from the printed circuits contained on two disks, the pressure-code disk and a special cam-shaped temperature-code disk. The pressure-code-disk printed circuit contains 256 code groups arranged radially on the disk with an average width of 0.0035 in. It is shaped so that the pressure-code wipers are making contact with the code disk only during the period the code is being generated. At all other times they are "free floating," thus eliminating the hysteresis effect caused by the friction of wiping contacts.

The temperature-code disk (Fig. 8) contains the same printed circuit as the pressure-code disk, except that the leading character of the code group has been modified so that all temperature-code groups begin with the letters E, I, or T, and thus are easily distinguishable from the pressure-code groups, which begin with the letters N, D, M, or U. It is slightly larger and contains approximately 200 code groups, with an average width of 0.005 in. per group. The disk is fabricated in the shape of a cam and is used to drive the servomechanism on the temperature encoder.

The contact wipers which generate the code have a controlled width of 0.0025 in., which prevents widening of the contact area due to wear, and subsequent variation of sensitivity. Thus degradation of the data during flight due to contact wear is eliminated.

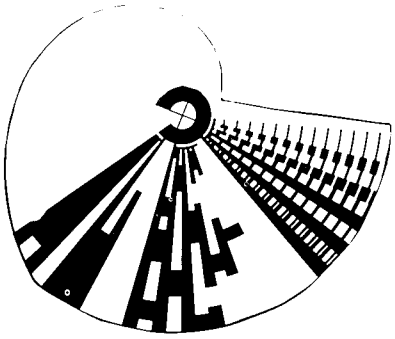

Fig. 8 - Temperature Morse-code disk

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The code groups are numbered sequentially as they appear on the code disks from center to circumference for ease in identification, and use with the calibration curves. Although these code groups appear in an alphabetically random sequence, they have been especially arranged with regard to adjacent Morse-code characters. This arrangement provides for generation of readable and usable code groups, even though some misalignment of code disks and wipers does exist.

Sensors – Three environmental parameters are telemetered. They are superpressure within the balloon, ambient pressure of the atmosphere, and ambient temperature of the atmosphere.

Similar aneroid cells and linkage systems are used as sensors for superpressure and ambient pressure. For superpressure, the aneroid cell is open and connected to the balloon by a rubber tube. The aneroid cells position captive pen arms on a printed-circuit Morse-code disk. The two units share a common code disk with the respective pen arms positioned 180 degrees apart. A change in pressure would effect a corresponding change in deflection of the respective aneroid cell, thereby causing the captive pen arm to be repositioned on the code disk, thus selecting the proper code group. The sensitivity of those units is linear over their respective operating ranges. For superpressure the sensitivity is 1 millibar per code group, and for ambient pressure it is 2 millibars per code group.

The temperature sensor is a bead thermistor with a diameter of 0.014 in. that has been aluminized to reflect solar heat. The small size of the thermistor and its reflective capabilities make it unnecessary to use shielding or ventilation during flight.

Each thermistor is associated with a special calibration curve, which shows a plot of resistance against temperature. These curves cannot be interchanged.

Temperature Encoder – Associated with the thermistor temperature sensor is an automatic servo-bridge device which selects Morse-code characters on the temperature code disk representing the resistance values of the bead thermistor. This servo-bridge is composed of four basic subassemblies; null detector, blocking oscillator, Wheatstone bridge circuit, and servomechanism. Because of the nonlinearity of the system, the sensitivity of this device varies over the temperature-measuring range. A typical calibration would have a range of -20°C to -55°C. The sensitivity at -25°C would be 0.3°C per code group, and at -50°C it would be 0.15°C per code group.

The null detector stops the movement of the servo device at a specific position representative of the thermistor resistance. Figure 9 shows an input transformer, T102, which matches the output of the bridge to the low impedance of the transistor input. The transistor amplifies the incoming spikes, which then pass through a second matching transformer and are rectified by a crystal diode. This rectified current produces a forward base bias which in turn is amplified in the transistor and results in a larger emitter current. The emitter current controls the moderately sensitive dc relay K101, which in turn controls the servo device through K103. In effect, the transistor amplifies the signal in an ac form and then again in a dc form. In doing this, a minimum of components are used, and full advantage is realized from the temperature-compensated circuit.

Good temperature stability of the null detector is achieved by including two thermistors in the circuit and selecting a transistor with a low I_{co} (collector saturation current). However, because the system is not perfectly compensated, temperature variations of the instrument from +40°C to -20°C can cause a null-point shift of approximately five code groups. In operation, this shift is measured by substituting a fixed temperature-compensated resistor in place of the bead; the resultant reading is used to modify the original calibration.

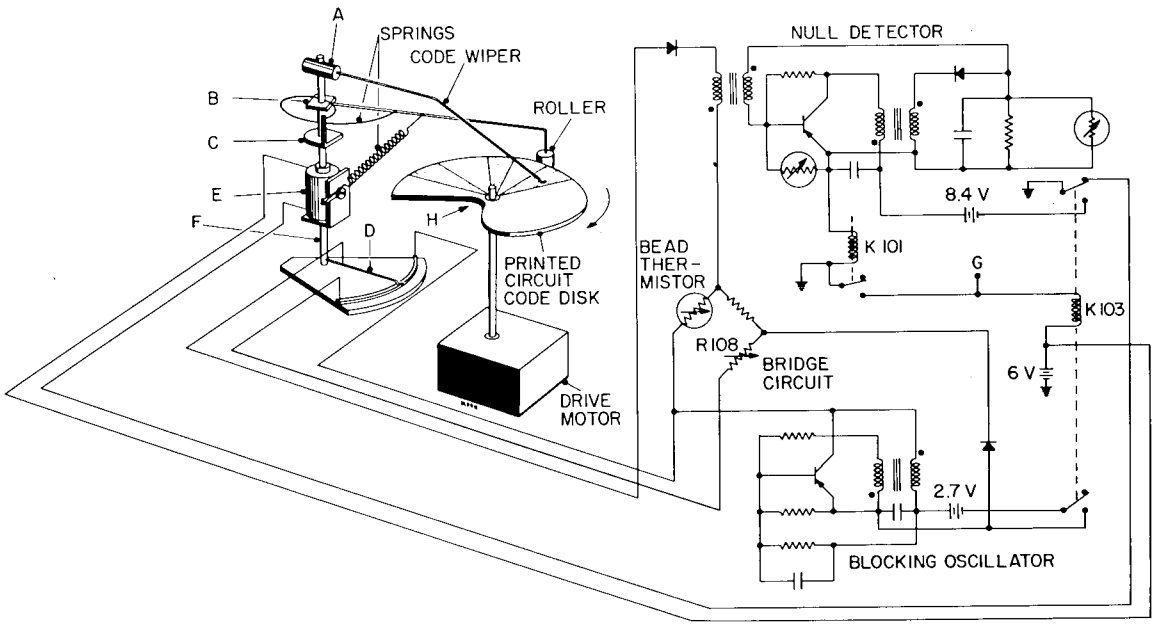

Fig. 9 - Temperature encoder schematic

The blocking oscillator supplies the measuring power to the bridge circuit in the form of sharp dc spikes that have a repetition rate near 4 kc and an amplitude near 12 volts. The low I_{co} of the transistor, the full on-and-off switching properties of the blocking oscillator, and the stability of the mercury cells provide an output waveform with negligible change over an operating range of -20°C to +40°C.

The bridge circuit's two active elements are the aluminized 0.0014-in.-diameter bead thermistor and the infinite-resolution potentiometer that is automatically positioned by the action of the servomechanism. The small size of the bead and its color allow accurate temperature measurements to be made without the use of sunshields or aspirators. The very narrow spikes generated by the oscillator cause less than 8 microwatts to be dissipated in the thermistor, which results in less than 0.2°C self heating. The thermistor is automatically disconnected during the periods when rf is being generated, which prevents induced voltages from circulating currents through the thermistor loop.

The servomechanism achieves the mechanical action required to operate the potentiometer in balancing the Wheatstone bridge and positioning the code-selecting wiper. The activating power is derived from the rotation of the cam-shaped Morse-code disk. Controlling signals from the null detector energize the electromagnetic brake when the null point is detected.

Typical Operation of the Temperature Encoder – Referring to the illustration, Fig. 9, code wiper arm A, relay armature C, and potentiometer wiper D are secured to the common shaft F. The roller arm B rotates freely on the shaft, which rotates freely in the electromagnetic brake E. The bridge circuit is in a balanced condition, and the Morse-code disk is in the middle of a cycle. The electromagnetic brake is locked, and all power has been removed from the transistor circuits.

As the code disk rotates, point H on the code disk will advance to the roller, at which time the "bridge return wiper contacts" ground point G through a conducting foil tab mounted on the bottom side of the code disk. This action releases the electromagnetic brake, allowing the roller to travel inward to the code-disk hub; this unbalances the bridge and energizing relays K101 and K103, which starts a new cycle.

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With relay K103 closed, the blocking oscillator generates a pulsating dc signal which is fed to the bridge circuit. With the potentiometer wiper unbalancing the bridge, positive pulses are fed to the null detector. Transformer T102 transforms the incoming signal to the proper impedance to match the transistor. The signal is amplified by the transistor and fed to the second matching transformer, where it is rectified into a forward base bias for the transistor. The bias is then amplified by the transistor and results in a sufficiently large emitter current to energize the null relay K101.

The null-relay contacts then control the main power relay, K103, holding it energized. As the code disk moves further, the bridge return wiper contacts controlling relay K103 are disconnected from ground, leaving the null relay in control.

With the brake no longer energized, members A, B, C, and D move together as the cam action of the code disk forces the roller away from the hub. At some position of the potentiometer the bridge will become balanced. At this time the input to the null detector will be zero, which will eliminate the rectified bias to the transistor. The emitter current is therefore greatly reduced, resulting in the null relay becoming deenergized. The main power relay K103 also becomes deenergized, which in turn energizes the brake (through normally closed contacts on K103). This action stops A, C, and D; however, the roller continues to move outward. Eventually the Morse-code wiper intercepts the Morse-code characters, generating the code groups which represent this particular null point.

Power Supply

The power supply (Fig. 10) consists of a 7.5-volt, 15-ampere battery pack and a lightweight transistorized dc-to-dc converter.

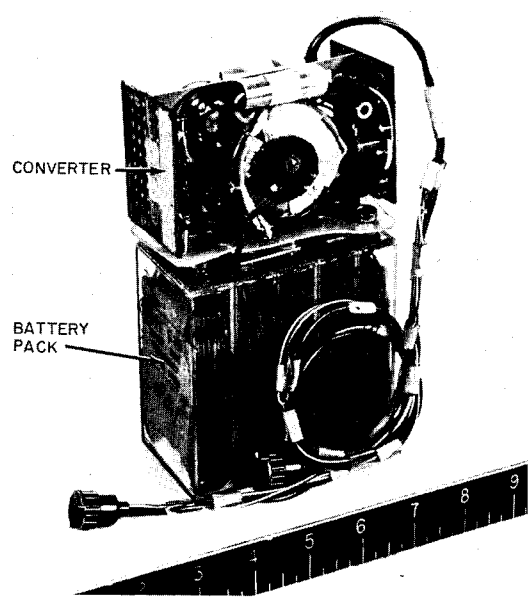

Fig. 10 - Power supply

Battery Pack – The battery pack is composed of five 1.5-volt, 15-ampere-hour silver-zinc cells connected in series.

Converter – The converter employs conventional transistorized circuits to convert the 7.5-volt battery voltage to high voltage for operating the transmitter. It consists of two 300-volt circuits which are connected in series, providing a total of 600 volts. In operation, it delivers 600 volts to the transmitter output tube and 300 volts to the driver.

Because of the severe weight limitation, a heat sink was not included in the design of the unit. Since the maximum requirement during flight for the converter is ten minutes operating time each hour, with approximately a 50-percent duty cycle, excessive heating is not a problem.

To achieve maximum system efficiency, the 7.5-volt battery voltage supplying the converter is controlled with the keying relay. This results in approximately a 50-percent duty cycle for all of the high-voltage circuits.

The keying relay, which is energized by the Morse-code intelligence signal supplied by the keyer, controls current to both emitters and bases of the two power transistors used in the converter. Both emitters and bases are keyed in order to suppress arcing on the relay contacts in the high-current emitter circuits.

Equipment Housing

The equipment is packaged for flight in two "thermal boxes." Since the equipment must operate in an extremely low-temperature environment, these thermal boxes must provide sufficient insulation so that a normal operating temperature is maintained on the equipment. The two boxes are the same in construction, although slightly different in size and configuration.

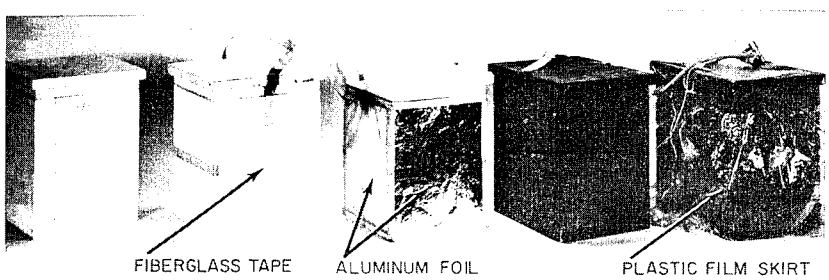

Fig. 11 - Thermal box

The thermal boxes (Fig. 11) are made of polyurethane foam insulating material of very low density (1.2 lb/ft^3), and constructed so that all pieces interlock together, thus avoiding the use of an adhesive. Fiberglass tape is added for additional strength and to provide a handle. The sections forming the inner liner which enclose the equipment are covered with a plastic film to prevent contamination of the equipment by breaking or flaking of the polyurethane material. In order to achieve a satisfactory temperature balance, it is necessary to enhance the heat-absorption characteristics of the thermal package by utilizing a black outer surface. Since paint attacks the polyurethane material, it is necessary to cover the surface before painting it. Panels of aluminum foil attached with Mylar or other suitable tape are used as a covering. The aluminum foil also acts as a heat sink, distributing the heat evenly over the surface and thus preventing the occurrence of "hot spots" which could melt the polyurethane material.

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To further enhance the temperature balance, the thermal boxes are enclosed in loose-fitting plastic film bags, or "skirts," which produce a greenhouse effect. This retains heat and reduces conductive cooling of the boxes.

PROGRAMMING AND FLIGHT CONTROL

Programming and flight control are considered together, since they are closely interrelated. Program functions provided are two-hour transmission programming, ascent transmission programming, and parameter programming. Flight-control functions provided are time termination, ballast drop, altitude termination, and ascent time period. The main programming and control functions (the transmission programming, ascent transmission programming, and time termination) are provided by a clock movement installed in the transmitter housing. All other program and control functions are initiated by the keyer-encoder.

Clock Programmer Functions

The program clock is included as an integral part of the transmitter assembly in order to simplify packaging of a delicate mechanism and to provide sufficient heat to maintain it at a reasonable operating temperature. It provides control for a three-minute programmed transmission period every two hours, a 30-second transmission period every four minutes during the ascent period, and a preset flight-time termination.

The two-hour transmission program is controlled through a control relay which, when energized by the appropriate clock contacts, supplies power to the transmitter filaments and the keyer-encoder. The two-hour transmission program is provided by the minute hand and associated contacts (contacts 1, 2, and 3 on the printed-circuit clock face, Fig. 12), which give 1.3 minutes of data transmission followed by a 20-second continuous cw signal repeated sequentially on the two frequencies.

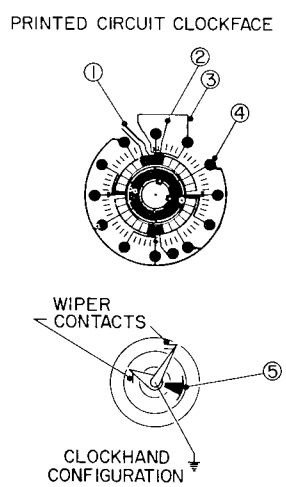

Fig. 12 - Printed-ciruit clock face

Since this is a one-hour clock movement, a circuit is provided to prevent transmissions during the off hours. This circuit is controlled by the hour hand and the associated contacts (circuit 5, Fig. 12) on the printed circuit. The hour hand during the off hour grounds the base of a transistor, which prevents it from conducting; thus the control relay, which is in series with the transistor, cannot operate. During the "on" hour, the hour-hand contact is open, the transistor conducts freely, and the control relay operates normally when energized by the appropriate minute-hand contacts.

The ascent program, consisting of a 30-second data-transmission period on a single frequency every four minutes during the ascent period of flight, is provided by the minute hand and associated contacts (circuit 4, Fig. 12). These four-minute-interval contacts are connected to the low-frequency-transmission contact (contact 1, Fig. 12) through a relay which is controlled by the ascent timer. This ascent-program circuit energizes the control relay and thereby provides ascent transmissions in addition to the regular transmissions during this period. This ascent-transmission program is terminated, after a predetermined period of time, by the ascent timer.

The flight-time termination control is provided by a subassembly mounted on the program clock movement. After a predetermined period of time this subassembly closes

a switch, energizing the termination release device. This device severs the load line between balloon and equipment, thus terminating the flight. This subassembly, composed of a printed-circuit star gear, with appropriate contacts, is advanced by a spring drive pin mounted on the hour-hand drive gear of the program clock; thus it advances one count (notch) each revolution of the hour-hand gear (twelve-hour period). Since the gear contains 17 notches, it can count up to 17 twelve-hour periods, or a total time of 8-1/2 days.

Keyer-Encoder Programming and Control Functions

The keyer-encoder provides for parameter programming, ascent-time period, ballast drop, and altitude termination. The parameters measured by this unit are superpressure of the balloon, ambient air pressure, ambient air temperature, and a reference temperature. The proper program sequence for these parameters is determined by the alignment of the two code disks, the pressure wiper arms, the parameter switch which controls switching between pressure and temperature parameters, and the stepping spring which drives the parameter switch (Fig. 13). The stepping spring is flexible, so the parameter switch is prevented from jamming the motor if it is inadvertently misaligned at any time.

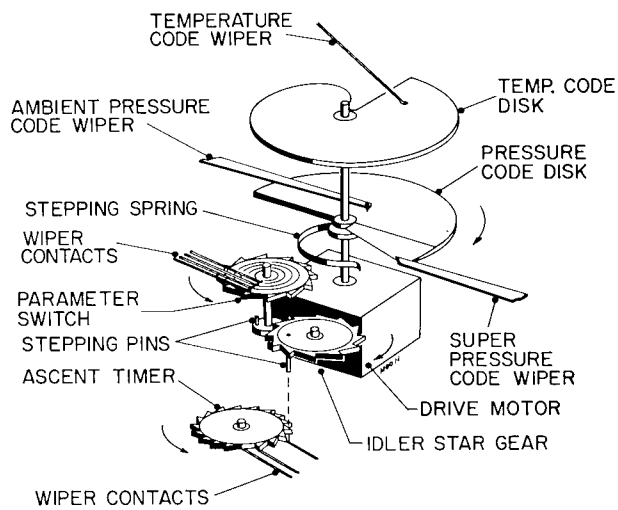

Fig. 13 - Ascent timer and parameter programmer

The two code disks and the stepping spring are mounted directly on the shaft of a 12-rpm miniature timing motor; thus for each revolution of the motor the parameter switch is advanced 1/12 revolution by the stepping spring. These discrete steps of the parameter switch are arranged so as to provide keying from the pressure wipers for one revolution of the timing motor, followed by keying from the temperature wiper for three revolutions of the timing motor; the sequence is then repeated. During the pressure keying revolution, code groups representing ambient pressure and superpressure are generated. During the temperature keying period, one code group is generated during each revolution of the motor. The first group is the reference, followed by two temperature code groups. A blank period is necessary at the beginning of each revolution during the temperature keying period, in order to allow time for bridge balancing to occur before code generation is initiated.

The ascent time period is provided by a small stepping gear train mounted on the back of the keyer-encoder. It is composed of two printed-circuit ratchet type gears

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(idle gear and ascent timer gear) and associated contacts. This assembly is positioned so that the stepping-pin assembly mounted on the parameter-switch shaft can engage and advance the idler gear one increment (1/12 revolution) for each revolution of the parameter switch. The idler gear also contains a stepping pin which engages and drives the ascent-timer-circuit gear, advancing it one increment for each revolution of the idler gear. Thus, the ascent timer is directly linked to the 12-rpm timing motor and is advanced one increment for each 144 revolutions (12 minutes operating time) of the motor. The ascent timer contains 18 positions; thus it can count up to eighteen 12-minute periods, or a total on time of 216 minutes (3 hours, 36 minutes).

Termination of the ascent period requires that a switching action be initiated which will deenergize the ascent relay controlling the four-minute program cycle on the clock and arm the termination-release and ballast-release circuits. To accomplish this, a tooth is cut from the ascent timer gear. The printed circuit of the ascent timer and the associated contacts are then aligned so that the appropriate switching will occur as the stepping pin on the idler gear advances the ascent timer the last increment prior to that adjacent to the missing gear tooth. Thereafter, since there is no tooth for the stepping pin to engage on its next revolution, the ascent timer will remain in this "stop" position.

As a safety factor for the balloon, provisions for a ballast drop are included which will allow recharging of the balloon's superpressure if for any reason it drops below a preset minimum level. To provide this control, a pen-arm assembly is linked to and positioned by the superpressure aneroid cell to make electrical contact with an adjustable screw, if for any reason the superpressure drops below three millibars. This electrical contact energizes the ballast-release mechanism; this reduces equipment weight, causing the balloon to seek a higher altitude and thereby recharging balloon superpressure as the balloon ascends. This circuit is also controlled by the ascent timer, which arms the ballast-release mechanism at the end of the ascent period. Thus no ballast drop can be made during the ascent period.

To prevent the balloon and equipment from becoming a hazard by floating at other than the preselected flight levels, an altitude termination control is included which effects flight termination if the unit descends below, or levels off below, a predetermined altitude. To provide this control, a pen-arm assembly is linked to and positioned by the ambient-pressure aneroid cell and makes electrical contact with an adjustable printed circuit if for any reason the balloon descends to or remains below 300 millibars. This electrical contact energizes the termination-release mechanism, which severs the load line and thus terminates the flight.

It is obvious that for a portion of the ascent the condition calling for termination (below 300 millibar level) exists; therefore it is necessary to bypass this control during the ascent period. The ascent timer accomplishes this by delaying the arming of the termination-release mechanism until the end of the ascent period. If at that time the balloon is still below the 300-millibar altitude level, termination will occur.

SETTING OF TIMING CONTROLS

Prior to any proposed flight, the controls (clock programmer, termination timer, ascent timer) for the various time functions must be set. To accomplish this a flight schedule for the launch time, ascent period, transmission cycle, and flight duration must first be determined. A typical flight schedule would be:

Launch Time – 1900 GMT (1/20/62)
Ascent Period – 100 minutes
Transmission Cycle – 15 minutes after the odd hour - GMT
Flight Duration – 100 hours.

To avoid confusion, all times are normally expressed in terms of Greenwich Mean Time (GMT).

Ascent-Timer Setting

The ascent-timer unit contains a ratchet-type gear train which is driven directly by the 12-rpm keyer-encoder motor. The gear train contains two printed-circuit ratchet gears, the idler gear, and the ascent time gear (Fig. 13). The gear train is arranged so that for each 144 revolutions (12 minutes operating time) of the keyer-encoder motor, the idler is advanced twelve counts (notches), which in turn advances the ascent timer gear one count.

During the ascent period the keyer-encoder motor is energized for fourteen 30-second transmissions plus one regular three-minute transmission each hour, or an "on time" of ten minutes per hour. Thus, for a 100-minute ascent period, total transmission time would be 16.7 minutes (including one regular transmission period). Normally, at least three 30-second transmission periods are added to this total to allow for final transmission checks; thus total on time would be 18+ minutes. This on period would account for 18 counts on the idler gear and 1.5 counts on the ascent timer.

To set up 1.5 counts on the ascent timer, the ascent timer gear should be set on count 3 and the idler gear advanced by manually rotating parameter switch gear, six counts past the point where the idler-gear stepping pen engages the ascent-timer gear. The ascent timer is then on count 2 and will provide three 30-second test transmission periods, plus a 100-minute ascent period with a normal ascent transmission cycle.

Termination Timer and Clock Programmer Setting

The clock programmer is a standard 12-hour dc clock movement with contacts mounted on hour and minute hands which wipe over a printed-circuit clock face containing the control circuits for the various time functions. The termination timer is a small subassembly mounted in the clock programmer (Fig. 14) and driven by the hour-hand gear of the clock programmer. As such it is an integral part of the clock programmer, causing their respective time functions to be interrelated. Consequently, their time-setting procedures are also interrelated and must be carried out at the same time and in the proper sequence.

The contact which starts the normal transmission cycle is located on the clock face two minutes before the 12-o'clock position; thus to program a transmission at any particular time during the hour, the minute hand must always be set with respect to the position of this contact. For example, suppose that the transmission period was to occur at 15 minutes after the hour. This would mean that the minute hand must be set so that it reaches the contact position (two minutes before 12 o'clock) at 15 minutes after the hour, or that the minute hand must be set 17 minutes slow.

Under the hour hand on the printed circuit face are two circuits which connect together the odd- and even-hour periods respectively. Only the odd-hour circuit is used. It is so arranged that the minute hand can energize the normal transmission circuit only during the period when hour hand is making contact with the odd-hour circuit. Thus, two-hour programming is achieved.

The termination timer is advanced one increment every 12-hour period as the hour hand of the clock programmer passes through the 12 o'clock position. Thus, each count on the termination timer printed-circuit gear, except for the first count to be run off, represents a 12-hour period. The first count to be run off may represent a 12-hour

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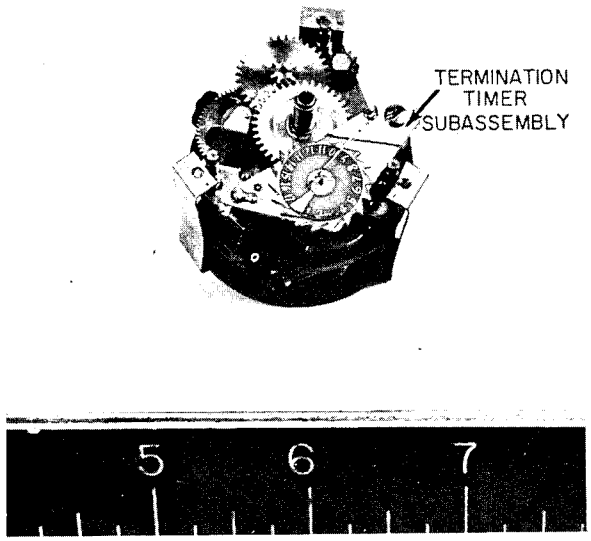

Fig. 14 - Clock programmer with termination timer subassembly

period or any portion thereof. For example, suppose the termination timer was set on count 6 at 1900 GMT. At 2400 GMT the timer would be advanced to count 5; thus count 6 (the first to be run off) would represent only five hours, or the time it takes the hour hand to advance from the position at which it was set to the 12-o'clock position. Thereafter each count represents a 12-hour period.

Typical Setting Procedure for Clock Programmer and Termination Timer

The termination timer and clock programmer must be set prior to initiation of final launch procedure. Assuming that it takes place 24 hours prior to launch, then using the flight schedule previously cited as an example, the setting procedure would take place at approximately 1900 GMT (1/19/62). The clock programmer must be set to provide transmissions 15 minutes after the hour, which means that the minute hand must be set 17 minutes slow.

The total elapsed time that must be accounted for on the termination timer is 124 hours (100 hours flight duration plus 24 hours). This is equal to ten 12-hour periods plus four hours.

After proper settings have been determined, the following procedural sequence should be followed, using the previously cited example, at approximately 1855 GMT (1/19/62).

1. Set termination timer on count 12.

2. Manually advance clock programmer until termination counter is switched to position (count) 11. This action assures proper alignment between the hour-hand gear and the termination-timer gear.

3. Continue to advance the clock programmer until the 7-o'clock position is reached.

4. At exactly 1900 GMT, manually advance the clock programmer to the 0743 position (17 minutes before the hour).

The termination timer and clock programmer are now set. The termination timer should be on count 11, and the hands of the clock programmer should be at the 0743 position.

If for some reason it becomes necessary to switch transmission programming from odd to even hour, simply advance or set back the position of the hands of clock programmer by one hour. This action will switch programming with respect to time (GMT) and also will either subtract or add respectively one hour to flight duration.

FLIGHT PREPARATION OF TRANSOSONDE EQUIPMENT

Before preparations for a launch can proceed, several steps must be taken in order to prepare the equipment for flight.

Keyer-Encoder Alignment and Calibration

Before flight it is necessary to calibrate and/or check the settings of all controls to assure proper flight performance and to calibrate all sensors in order to be able to interpret correctly the code groups transmitted during the flight. To accomplish this calibration and control check, it is necessary to have a vacuum chamber or bell jar (12 in. diameter minimum) system, a power supply (6 vdc), a code practice oscillator setup, a decade resistance box (5 k to 80 k), and a contact-pressure measuring device. The vacuum chamber must have means for external electrical connections, a fine pressure-regulating control, and also means for exposing the superpressure aneroid cell to ambient pressure (through the hose connections) during its calibration run. Since superpressure measurement is a differential pressure, it is calibrated by using ambient pressure as a reference.

For the calibration runs, the power supply can be connected directly across the keyer-encoder motor. The code practice oscillator must be driven from a sensitive keying relay (coil resistance greater than 500 ohms with a shunt, spark-suppressing diode) which is connected between the 6-volt supply and the parameter-switch main contact. It is not necessary to connect the decade resistance box to the temperature encoder during the pressure-calibration runs.

Before any calibration runs can be made, it is necessary to check the alignment of code disks, wipers, and parameter switch, including the contact pressure of the wiping contacts. The alignment can be checked (after connection of test instruments) simply by listening to the code sequence and noting if the sequence is correct and whether there is any overlapping, breaking, or omission of code groups. If alignment is not correct, then it should be rechecked by following procedure (Fig. 15).

Contact pressure should be checked with wipers resting on code disks. For the superpressure and ambient-pressure wipers, contact pressure should be between three and four grams. For the temperature wiper, contact pressure should be six to eight grams.

Since the pressure units share a common code disk, their operating ranges are set up so that no overlapping will occur; thus ambiguity among code groups is avoided. The normal arrangement is for the ambient pressure to occupy the outer portion of the code disk (last 100 code groups, approximately Nos. 150 to 256, Fig. 16) and for the superpressure to occupy the inner portion of the code disk (first 150 code groups).

Figures 17 and 18 are typical pressure and temperature calibration charts, showing calibration and control check points. Normally two "runs" are made on each parameter

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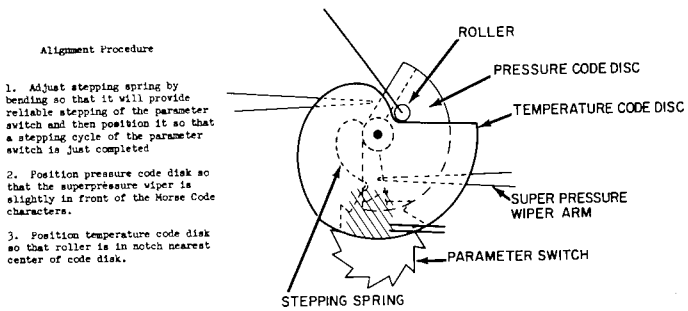

Fig. 15 - Keyer-encoder alignment

an initial calibration run during which all points are checked, and a reference check run in which only calibration reference points are checked. The reference run can be made immediately after the calibration run is completed, or it can be delayed until a later date. If there is a long delay between calibration and use of equipment, then another reference check run should be made when equipment is finally prepared for flight. The pressure readings are checked for both increasing and decreasing pressure during the calibration run. This provides a check on hysteresis. If there is consistently more than plus or minus one code group difference between the readings, then the diaphragm assembly responsible should be repaired or replaced. Also, if there is any significant change or shift in calibration from one calibration run to the next, the diaphragm assembly responsible should be repaired or replaced.

Calibration and setting of the pressure-control switches are usually accomplished during the calibration reference check run. During all pressure-calibration runs, the rate of change of pressure of the vacuum system should be less than 5 millibars per minute, in order to prevent errors in calibration introduced by lag in the equipment diaphragm assemblies and/or the pressure-measuring instrument.

Ambient-Pressure Calibration and Altitude-Termination Setting – The operating range should be checked before a calibration run is started. In order to check it, the keyer-encoder unit must be installed in the vacuum chamber, the necessary connections (power supply and code practice oscillator) made, and the pressure reduced to the operating level, which is normally 250 millibars. The code group corresponding to this level should fall between the 175th and 200th code groups on the code disk. If this is not the case, then the unit must be removed from the vacuum chamber and the position of the wiper readjusted, by unlocking and rotating the aneroid cell. After each adjustment the unit must be replaced in the vacuum chamber and the results checked. This sequence should be repeated until the code group for the 250-millibar operating level does fall in the correct range.

Once the operating range has been set, the calibration run can be started. The pressure should be decreased slowly to the values for the various check points, as listed on the calibration chart, and the appropriate code groups noted and recorded. When the lowest pressure check point is reached, the cycle should be reversed and readings taken at each check point as pressure is slowly increased to 300 millibars. After completion of this run the vacuum chamber should be opened and a 6-volt test lamp (100 milliamps max) connected across the termination circuit. The wiper pen arm should then be manually advanced to a position on the code disk corresponding to the 295-millibar pressure level. While holding it in that position, the adjust screw on the termination contact should be advanced until the test lamp becomes energized. The termination adjustment screws should then be locked and the calibration reference check run made. During descent (increasing pressure), the point at which the test lamp is energized should be observed

1	NBB	53	NAL	104	DFS	155	MWM	206	UDG
2	NBK	54	NAR	105	DGN	156	MWU	207	UDO
3	NBV	55	NAA	106	DGD	157	MWF	208	UDX
4	NBW	56	NAS	107	DGM	158	MWG	209	UMB
5	NBL	57	NSN	108	DGU	159	MWO	210	UMK
6	NBR	58	NSD	109	DGF	160	MWX	211	UMV
7	NBA	59	NSM	110	DGG	161	MLB	212	UMW
8	NBS	60	NSU	111	DGO	162	MLK	213	UML
9	NKN	61	NSF	112	DGX	163	MLV	214	UMR
10	NKD	62	NSG	113	DOB	164	MLW	215	UMA
11	NKM	63	NSO	114	DOK	165	MLL	216	UMS
12	NKU	64	NSX	115	DOV	166	MLR	217	UUN
13	NKF	65	NNB	116	DOW	167	MLA	218	UUD
14	NKG	66	NNK	117	DOL	168	MLS	219	UUM
15	NKO	67	NNV	118	DOR	169	MRN	220	UUU
16	NKX	68	NNW	119	DOA	170	MRD	221	UUF
17	NVB	69	DNL	120	DOS	171	MRM	222	UUG
18	NVK	70	DNR	121	DXN	172	MRU	223	UUO
19	NVV	71	DNA	122	DXD	173	MRF	224	UUX
20	NVW	72	DNS	123	DXM	174	MRG	225	UFB
21	NVL	73	DDN	124	DXU	175	MRO	226	UFK
22	NVR	74	DDD	125	DXF	176	MRX	227	UFV
23	NVA	75	DDM	126	DXG	177	MAB	228	UFW
24	NVS	76	DDU	127	DXO	178	MAK	229	UFL
25	NWN	77	DDF	128	DXX	179	MAV	230	UFR
26	NWD	78	DDG	129	DBB	180	MAW	231	UFA
27	NWM	79	DDO	130	DBK	181	MAL	232	UFS
28	NWU	80	DDX	131	DBV	182	MAR	233	UGN
29	NWF	81	DMB	132	DBW	183	MAA	234	UGD
30	NWG	82	DMK	133	MBL	184	MAS	235	UGM
31	NWO	83	DMV	134	MBR	185	MSN	236	UGU
32	NWX	84	DMW	135	MBA	186	MSD	237	UGF
33	NLB	85	DML	136	MKS	187	MSM	238	UGG
34	NLK	86	DMR	137	MKN	188	MSU	239	UGO
35	NLV	87	DMA	138	MKD	189	MSF	240	UGX
36	NLW	88	DMS	139	MKM	190	MSG	241	UOB
37	NLL	89	DUN	140	MKU	191	MSO	242	UOK
38	NLR	90	DUD	141	MKF	192	MSX	243	UOV
39	NLA	91	DUM	142	MKG	193	MNB	244	UOW
40	NLS	92	DUU	143	MKO	194	MNK	245	UOL
41	NRN	93	DUF	144	MKX	195	MNV	246	UOR
42	NRD	94	DUG	145	MVB	196	MNW	247	UOA
43	NRM	95	DUO	146	MVK	197	UNL	248	UOS
44	NRU	96	DUX	147	MVV	198	UNR	249	UXN
45	NRF	97	DFB	148	MVW	199	UNA	250	UXD
46	NRG	98	DFK	149	MVL	200	UNS	251	UXM
47	NRO	99	DFV	150	MVR	201	UDN	252	UXU
48	NRX	100	DFW	151	MVA	202	UDD	253	UXF
49	NAB	101	DFL	152	MVS	203	UDM	254	UXG
50	NAK	102	DFR	153	MWN	204	UDU	255	UXO
51	NAV	103	DFA	154	MWD	205	UDF	256	UXX
52	NAW								

Fig. 16 - Morse-code group list

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SUPERPRESSURE 9/8/61

Barometer Reading (Millibars)	Super Pressure	Calibration Run #1			Calibration Run #2			Comments
		Decreasing Pressure	Increasing Pressure	Code Group Numbers	Decreasing Pressure	Increasing Pressure	Code Group Numbers	
1020.6	0	DFV	DFV	99	DFV	DFV	99	
1017.6	3	DFR	DFA	102-103				
1015.6	5	DFS	DGS	104	DFS	DGN	104-105	
1010.6	10	DGF	DGF	109	DGF	DGF	109	
1005.6	15	DOV	DOV	115	DOA	DOA	119	
1000.6	20	DOA	DOA	119				
995.6	25	DXF	DXF	125	DXF	DXF	125	
990.6	30	DBV	DBV	131				
985.6	35	MKS	MKN	136-137	MKS	MKN	136-137	
980.6	40	MKU	MKU	140				
970.6	50	MVR	MVR	150	MVR	MVR	150	

AMBIENT PRESSURE 9/8/61

Pressure (Millibars)	Calibration Run				Reference Run		Comments
	Decreasing Pressure	Code Group Numbers	Increasing Pressure	Code Group Numbers	Increasing Pressure	Code Group Numbers	
400	DUM	91					Garbled code group at 295 mbs.
350	DXM	123					
300	MVB	145	MVK	146	MVK	146	
290	MVA	151	MWS	152			
280	MWO	159	MWO	159	MWO	159	
270	MLW	164	MLL	165			Termination Contact - 296 mbs.
260	MRD	170	MRM	171	MRM	171	Ground Reading Code group - DNR(70)
250	MAV	179	MAV	179			
245	MAR	182	MAR	182	MAR	182	
240	MSN	185	MSD	186			
230	MNK	194	MNK	194	MNK	194	

LEAKAGE CHECK – SUPERPRESSURE TUBE

Time and Date	Ambient Pressure	Code Group	Code Group No.	Room Temperature	Comments
9:30 AM 9/11/61	1016.0 mb	MSO	191	72°F.	
12:30 PM 9/11/61	1016.0 mb	MSM	187	71°F.	O.K.

Fig. 17 - Pressure-calibration sheet, keyer No. 49

Resistance	Code Groups	Code Group Numbers	Resistance	Code Groups	Code Group Numbers
14K	EAS	56	40K	EAA	55
	ERN	41		IFX	96
	ERD	42		IFX	96
16K	EAS	56	42K	EAA	55
	ERG	46		IFW	100
	ERG	46		IFW	100
18K	EAS	56	44K	EAA	55
	EAK	50		IFS	104
	EAK	50		IFA	103
20K	EAS	56	46K	EAS	56
	EAS	56		IGM	107
	EAA	55		IGM	107
22K	EAS	56	48K	ESS	56
	ESF	61		IGO	111
	ESF	61		IGO	111
24K	EAS	56	50K	EAA	55
	ENK	66		IOK	114
	ENK	66		IOK	114
26K	EAS	56	55K	EAA	55
	INL	69		IXD	122
	INR	70		IXD	122
28K	EAA	55	60K	EAA	55
	IDN	73		IBX	128
	IDD	74		IBX	128
30K	ESS	56	65K	EAA	55
	IDG	78		TBA	135
	IDG	78		TBA	135
32K	EAA	55	70K	EAA	55
	IMK	82		TKG	142
	IMK	82		TKG	142
34K	EAA	55	75K	EAA	55
	IML	85		TVW	148
	IMR	86		TVW	148
36K	EAA	55	80K	EAS	56
	IUN	89		TWN	153
	IUN	89		TWD	154
38K	EAA	55	83K	EAA	55
	IUF	93		TWD	154
	IUU	92		TWM	155

Fig. 18 - Temperature-encoder calibration sheet

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and recorded; this should be between 295 and 300 millibars. If not, then the preceding sequence must be repeated for termination contact setting. After completion of the reference check run, the vacuum chamber should be opened, the test lamp removed, and the ground reading (code group) of the ambient pressure wiper recorded.

Superpressure Calibration and Ballast Drop Setting – To check the superpressure range, simply note the code group for zero superpressure. This code group should fall between the 40th and 100th code groups on the disk. If this is not the case, then the position of the wiper should be changed by unlocking the aneroid cell and rotating it until the wiper is in the correct range.

It is essential that the atmospheric pressure remain essentially constant during superpressure calibration. Thus, before initiation of the calibration run, the ambient-pressure reading should be observed for a short period of time (10 to 15 min) to make certain that it is not changing rapidly enough to affect the calibration run. If ambient pressure is stable, then the keyer-encoder unit can be installed in the vacuum chamber, proper connections made, and the calibration run initiated. The pressure should be carefully and slowly adjusted to the values for check points as listed on the calibration sheet, and the proper code groups noted and recorded. After this run is completed, the ballast contact should be set by adjusting the contact screw so that it makes contact at the 3-millibar reading. This can be done by advancing contact screw until the superpressure wiper reads the code group associated with the 3-millibar superpressure level. The contact screw should then be locked in place.

When making the calibration reference check run, a 6-volt test lamp should be connected across the ballast circuit in order to check the ballast contact setting. During the run, while "decreasing" pressure, the point at which the lamp is energized should be noted and recorded. This contact point should occur at 3 millibars ± 1 millibar. If not, the sequence for setting the ballast contact should be repeated.

Also included with the alignment and calibration procedure for super pressure is a leakage check for the superpressure tube and diaphragm assembly. This check can be carried out immediately after completion of the calibration runs. The test consists of pressurizing the superpressure tube to approximately 50 millibars, closing it off, and observing the shift in code groups over several hours. Since changes in temperature and ambient pressure will greatly affect this test, they must be monitored closely and taken into account when analyzing the results.

Ambient-Temperature Calibration and Reference Check – The operation of the temperature encoder should be checked before starting calibration. This can be done by noting the temperature code groups, first with the thermistor circuit shorted and then with it open. With the thermistor circuit shorted, the code group generated should be on the inner extreme edge of the code disk. With it open, the code group generated should be on the outer extreme edge of the code disk. If code groups are garbled or incorrectly located, the alignment and range of the temperature encoder should be checked and readjusted.

After completion of this check, the code group representing the reference resistance value should be noted and recorded. The decade resistance box can then be connected to the thermistor contact points and the temperature-calibration run initiated. Appropriate code-group sequences for check points should be noted and recorded, as indicated in Fig. 18. At least one complete code-group sequence (reference, temperature 1, and temperature 2) are recorded for each check point. The reference reading should not change more than one code group during calibration.

After completion of calibration checks, all adjusting screws, lock nuts, etc., should be sealed with an appropriate sealing compound. Care should be taken not to contaminate the surfaces of the code disks.

Calibration Curves – Use and Interpretation – Figure 19 is a graph showing typical calibration curves plotted for the three parameters and the control points noted for reference, ballast, and termination. To illustrate the use of these calibration curves, suppose that the following typical code-group sequence had been received: superpressure DOS, ambient pressure MAL, reference EAW, temperature 1 IUM, temperature 2 IUM. First, the code-group number should be identified from Fig. 16. Following this, the correct values for the pressure-code groups can be obtained from the graph (Fig. 19) by finding the appropriate code-group number along the abscissa (bottom of graph) and from the intercept of it and the proper curve determining the correct value (in millibars) from the plotted values along the ordinate of the graph. In this particular case the values for the pressures are: superpressure (DOS) 20.0 millibars, and ambient pressure (MAL) 248.6 millibars.

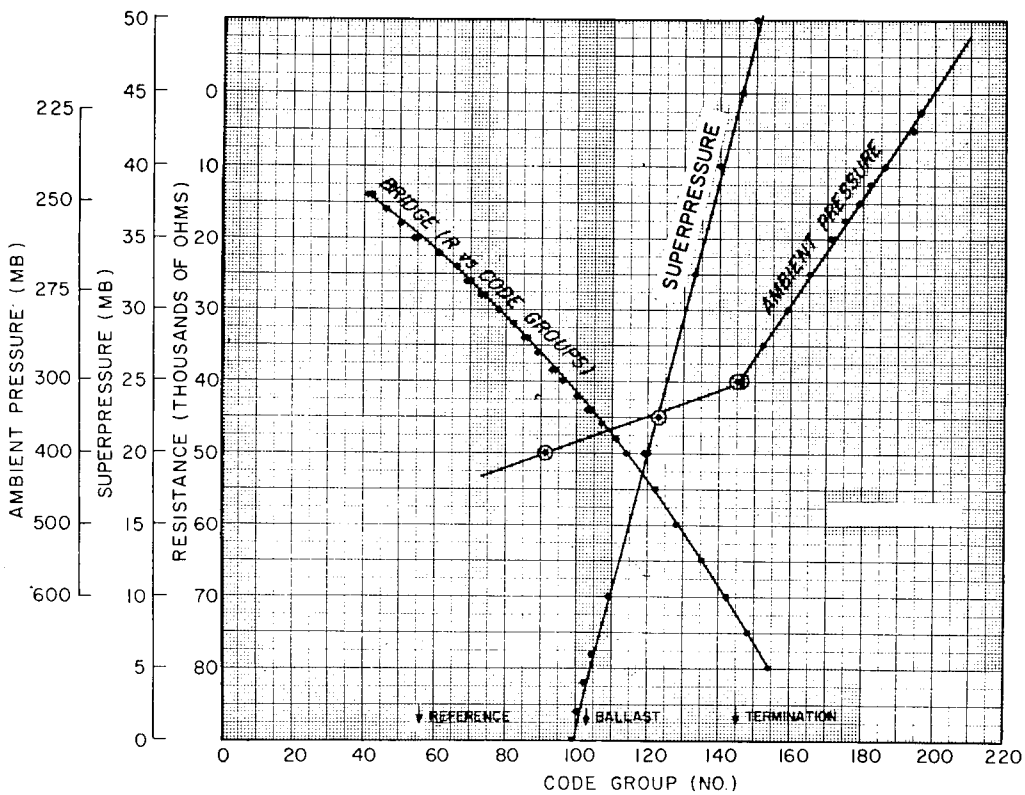

Fig. 19 - Keyer-encoder calibration graph

To simplify this process, a pressure-calibration sheet can be made after the calibration curves have been plotted, by obtaining the proper values for the respective pressure-code groups in their operating range and recording them directly on the code-identification sheet (Fig. 16). Thereafter, the values for the pressure-code groups can be read directly from this sheet.

A check on the reference-code group (EAW) cited in the above sample code-group sequence shows that a shift (numerical decrease) of four code groups has occurred, which means that environmental factors have caused the bridge zero point to shift. All temperature-code groups are thereby shifted an equivalent amount in the same direction. To obtain a correct temperature reading, this calibration shift must be taken into account by adjusting the temperature-code group. This can be accomplished by shifting the temperature-code

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group reading a number of code groups equivalent to the calibration shift (same number of code groups as reference shift). Thus in the example cited, the temperature-code group IUM (91) would be shifted by four code groups to IUO (95). The following example further illustrates this use of the reference-code group in correcting for the calibration shift.

CODE-GROUP NUMBER	CODE GROUP	
51	EAV	
52	EAW	— Telemetered reference-code group
53	EAL	
54	EAR	
55	EAA	
56	EAS	— Original reference calibration
89	IUN	
90	IUD	
91	IUM	— Telemetered temperature-code group
92	IUU	
93	IUF	
94	IUG	— Corrected temperature-code group. It is obtained by moving up four code groups from the telemetered reading. This reading is used with the charts to obtain the correct temperature.
95	IUO	
96	IUX	

Once the calibration shift has been accounted for, Fig. 19 can be used to obtain a resistance value for the correct temperature-code group. This resistance value represents the thermistor resistance. Then to obtain a temperature reading, Fig. 20 must be used. This figure is a thermistor calibration graph associated with the particular thermistor used. Each thermistor as it comes from the manufacturer will be accompanied by a similar calibration chart.

Following the procedure outlined above, the values for the temperature-code group cited in the example are:

Telemetered code group IUM (91)

Corrected code group IUO (95)

Resistance value (Fig. 19), 38,750 ohms

Ambient temperature (Fig. 20), -44.2°C

Transmitter

To insure proper operation of the transmitter unit, the regulation of the clock programmer, transmitter tuning, and antenna-trap tuning should be checked.

Clock-Programmer Regulation – Several weeks prior to flight, the clock-programmer regulation should be checked to insure accurate flight programming. To accomplish this check, a 6-volt test battery should be connected across the clock movement and its timing

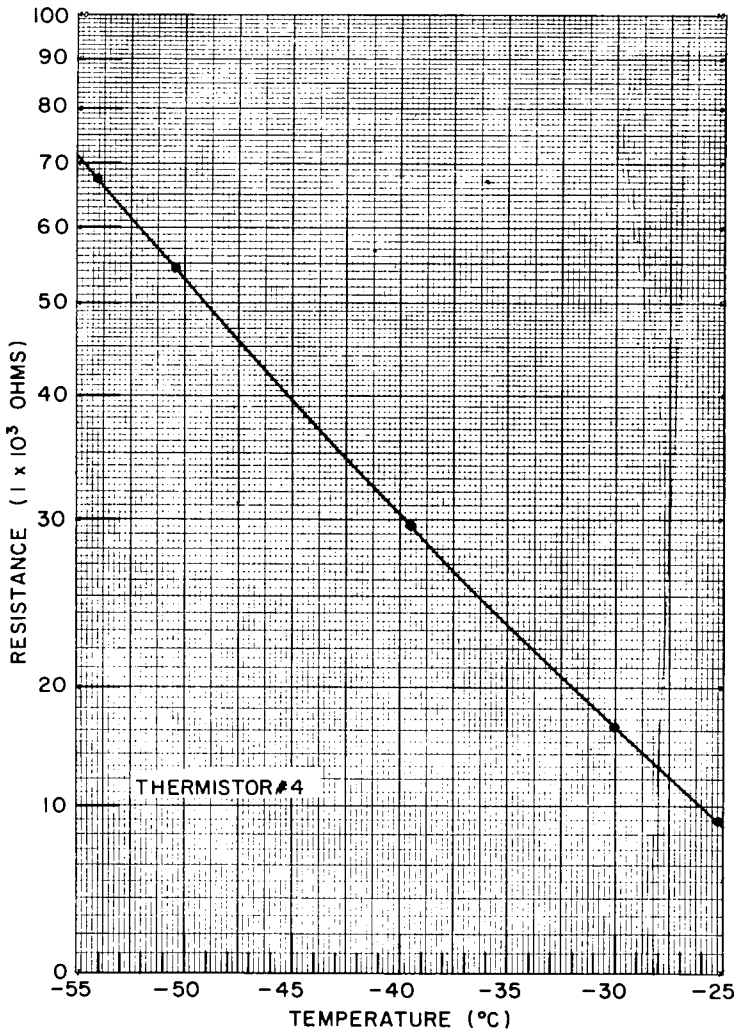

Fig. 20 - Thermistor calibration graph

accuracy checked against some standard (WWV), over a two- to three-day period. Minimum acceptable accuracy is ±1 minute in 48 hours. If clock accuracy does not meet this requirement, then clock regulation should be adjusted (according to manufacturer's instructions) until such accuracy is achieved. If the minimum acceptable accuracy cannot be achieved, then the transmitter unit should not be used until the clock movement can be replaced.

Transmitter Tuning – To check transmitter tuning, the following instruments are necessary: ammeter, 0-15 amps dc, milliammeter, 0-5 ma with grid-drive plug attached, insulated tuning tool, and a spare transosonde power supply. The procedural sequence for tuning the transmitter is outlined below. To understand better the operation of the transmitter and the steps in the tuning procedure, reference should be made to Fig. 21 and to the transmitter description included earlier in this report.

1. Plug the milliammeter into the grid-drive jack. Connect the ammeter in series with the battery feeding the converter and connect the transmitter. CAUTION: 600 and 300 volt terminals are exposed on the printed-circuit face of the transmitter.

2. With the 600-volt lead disconnected, adjust the low-frequency drive for maximum grid drive (above 1.5 ma). Adjust the low-frequency crystal trimmer to the assigned

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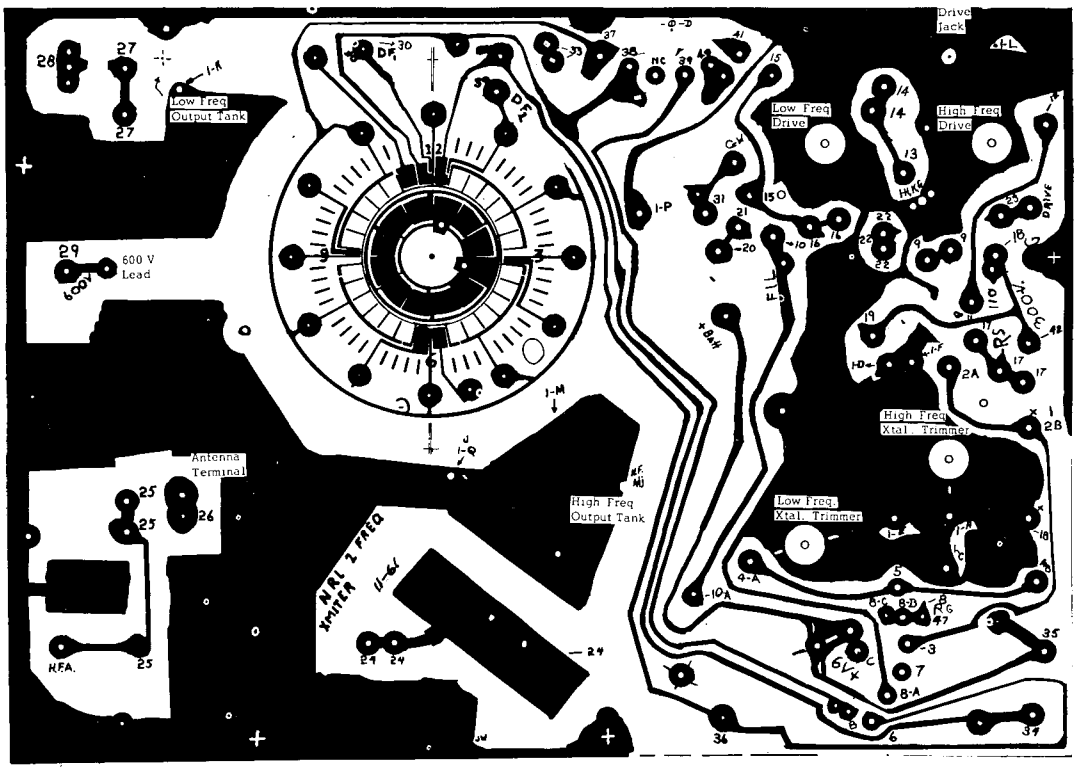

Fig. 21 - Transmitter printed circuit

operating frequency. Adjust the high-frequency drive for maximum grid drive (above 1.5 ma) and adjust the high-frequency crystal trimmer to the assigned operating frequency. The transmitter is switched from high to low frequency by manually advancing the clock programmer to the appropriate contacts.

3. With the 600-volt lead connected and the antenna terminal shorted directly to ground through less than one inch of wire, adjust the high-frequency output tank for lowest dip in the converter, battery current (about 4.5 amp).

4. With the 600-volt lead connected and the antenna terminal completely disconnected from ground and antenna, adjust the low-frequency output tank for lowest dip in battery current (about 4.5 amp). Alignment will be effective only when the above procedure is followed in the exact order described. Use appropriate sealant on the adjustment points after tuning is completed.

Antenna-Trap Tuning – To check antenna-trap (Fig. 22) tuning, the following instruments are necessary: crystal-controlled oscillator, tuned to high frequency with plate-current and/or grid-current meter. The procedural sequence for tuning the antenna trap is outlined below.

1. Disconnect antenna leads from both ends of the trap.

2. Place the trap in the rf field of the crystal-controlled oscillator tuned to the high frequency.

3. Tune trap for resonant dip in oscillator grid current or plate current.

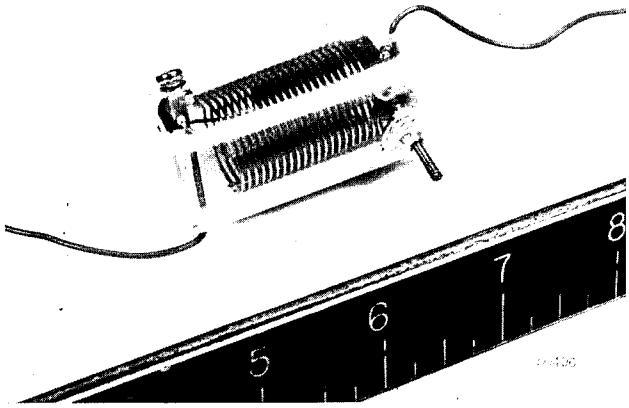

Fig. 22 - Antenna trap

Do not tune the trap while connected to antenna or any other circuit. Use appropriate sealant on adjustment points after tuning is completed.

Power Supply – Assembly

After completion of the charging cycle according to manufacturer's instructions, the cells should be assembled in a pack (five cells in each pack) with the lugs and nuts furnished by manufacturer. Battery-pack voltage (before use) should be greater than 8.5 volts. A converter unit should then be installed on top of the battery pack, taking care to insure good contact between nuts retaining the converter unit and battery lugs.

No specific checks other than a battery-pack voltage check and a visual check for obvious faults (cracked cells, contaminated lugs, etc.) is necessary. Operation of the battery pack and converter is checked during equipment operational performance check.

Equipment Operational Performance Check

After all components (keyer-encoder, transmitter, and power supply) have been tuned, aligned, and/or calibrated, they should be assembled and an operational performance check made. The equipment necessary for this check is a communications receiver (6 to 20 Mc) equipped with a beat-frequency oscillator, and two 6-volt test lamps. The procedure for accomplishing this check is outlined below.

1. Check battery voltages:

   Main battery pack voltage (BT1) 8.5 v minimum

   Keyer-Encoder Unit (BT2) 8.4v minimum

   (BT3) 2.7v minimum.

   If voltage readings are below these minimum values, replace batteries.

2. Interconnect components (keyer-encoder, transmitter, power supply) and install 6-volt test lamps on termination and ballast circuits. Either one or both test lamps could be energized at this point, depending on the position of the various ballast- and termination-circuit controls. The plug connection between the transmitter and power supply can be used as an on-off switch control.

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3. Check operation of the termination circuits. Since there are three controls (termination timer, altitude-termination switch, and ascent timer) on this circuit, they must be checked in sequence.

a. Make certain that both termination timer and altitude-termination switch are not in position to energize the termination circuit.

b. Manually advance the ascent timer to its "stop" position. At this point the termination test lamp should not be energized.

c. Check altitude-termination switch by manually rotating the ambient-pressure pen-arm assembly to make contact with the circuit on the printed-circuit board. The termination test lamp should be energized when this occurs.

d. Check the time termination switch by manually adjusting it to "zero" position. The termination test lamp should be energized when the termination switch reaches this position.

e. With the termination switch in its "zero" position and the termination test lamp energized, manually advance the ascent timer to a "run" position. This should deenergize the termination test lamp.

4. Check operation of ballast circuit. There are two controls (ballast switch and ascent timer) on this circuit that must be checked.

a. Manually advance the ascent timer to its "stop" position. The ballast test lamp should be energized at this point.

b. Manually advance the superpressure pen-arm assembly. This action should break the ballast switch contact and deenergize the ballast test lamp.

c. With the ballast-switch contact closed and ballast test lamp energized, manually advance the ascent timer to a "run" position. The ballast test lamp should now be deenergized.

If at any time the test lamps do not function in the manner described after prescribed adjustment of proper controls, then a continuity check should be made on the circuits to determine the trouble.

CAUTION: Whenever any adjustment or check involves the advancement or manipulation of a pen-arm assembly, extreme care should be taken to see that the stylus is not bent or damaged in any manner.

5. Check transmission programming sequence and keying. During the first three steps of this check, the ascent transmission schedule should be eliminated. This can be accomplished by manually adjusting the ascent timer to its "stop" position.

a. Connect meters (see Transmitter Tuning for details), and tune receiver to high frequency.

b. Manually rotate the clock programmer until contact is made with a high-frequency control circuit. The unit should now be energized and a signal heard on the receiver (after a 9 to 10 second warmup period). During the transmission period the following should be monitored:

Code group sequence - (Compare with calibration)

Transmission Period - 1.2 to 1.5 minutes duration

Continuous (cw) signal duration – 15 to 30 seconds

Grid current – should be between 1.5 & 2.5 ma (key down)

Battery current - 9 to 11 amp (key down)

c. Return receiver to low frequency, rotate clock programmer until low-frequency circuit is energized, and repeat the procedure described above.

d. To check ascent transmission programming, advance the ascent switch to a "run" position and rotate the clock programmer until contact is made with the ascent program circuit. The unit should now be energized and a signal received after an 8 to 10 second warmup period. While transmission is in progress, manually advance the ascent timer to its "stop" position. This action should deenergize the unit and cut off transmission.

Any component that does not perform as prescribed during operational performance check should be replaced.

Final Prelaunch Preparation

Approximately 24 hours prior to an anticipated launching, final prelaunch preparations should begin. The procedural sequence for this period is outlined below in the order in which it would normally be carried out. The time listing for the various procedures is necessarily approximate, since it is to some extent determined by the manpower available, the launching facilities, availability of the launching site, launching technique, etc. Approximately 24 hours prior to anticipated launch:

1. Flight-time schedule (flight transmission period, flight duration, and the launch time) should be determined.

2. Ascent timer should be set. See section titled Ascent Timer Setting for details.

3. Equipments should be installed in thermal boxes (Figs. 23 and 24). Care should be taken to insure that the superpressure tube does not become pinched off during installation.

4. The thermistor should be installed on the thermistor support and the antenna attached to the transmitter.

5. Equipments should be plugged together and a transmission check made to determine if they are functioning normally (see Equipment Operational Performance Check, step 5). Disconnect equipment after completion of check.

6. The clock programmer and time-termination unit should be set (see Termination Timer and Clock Programmer Setting).

7. Equipment weight should be determined and ballast bag made up and installed on the thermal box. The equipment-weight figure is needed by the balloon handler in determining balloon weigh-off and ballast weight. Ballast is usually very fine iron shot which must be enclosed in a weatherproof plastic bag.

Approximately one hour prior to scheduled launch, the following steps are usually performed at, or immediately adjacent to, the launch area.

1. Tune the receiver to low frequency. Connect the equipment and monitor one 30-second transmission, during which keying quality is noted and code-group sequence is recorded and checked against the calibration curves.

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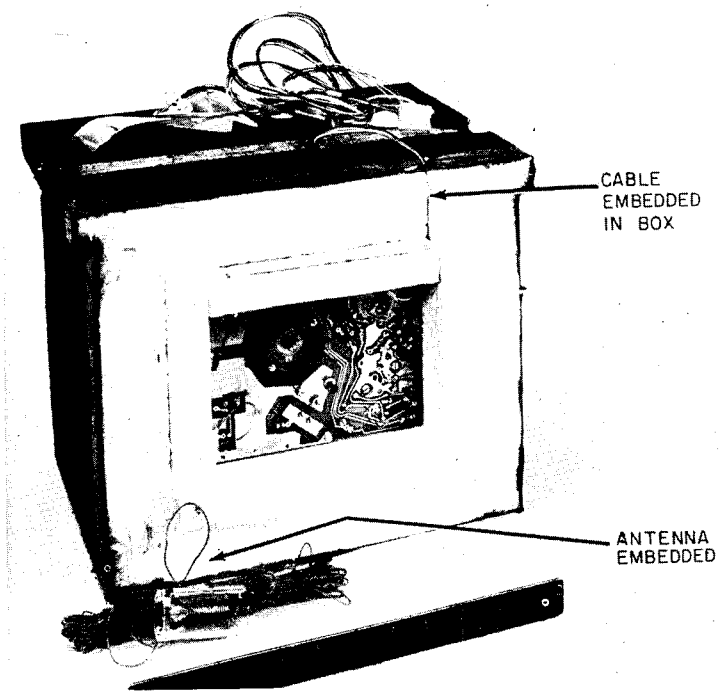

Fig. 23 - Transmitter installed in thermal box

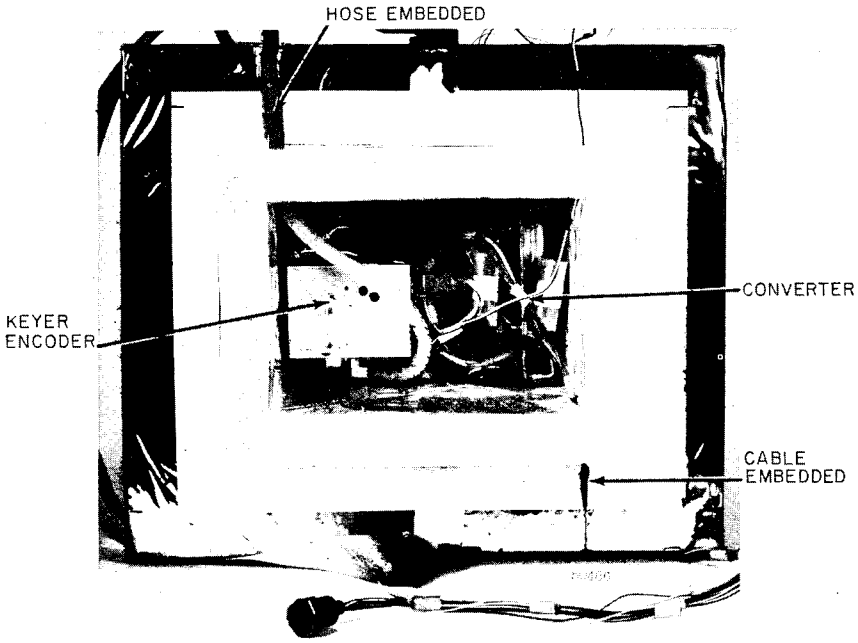

Fig. 24 - Keyer-encoder, power supply installed in thermal box

2. Launch time should be confirmed and the clock programmer checked. Readjustment of setting should be made, if necessary.

3. After a final visual check of the package interior, package doors should be installed and sealed with tape. Load lines and rigging should be installed (see Figs. 25 and 26).

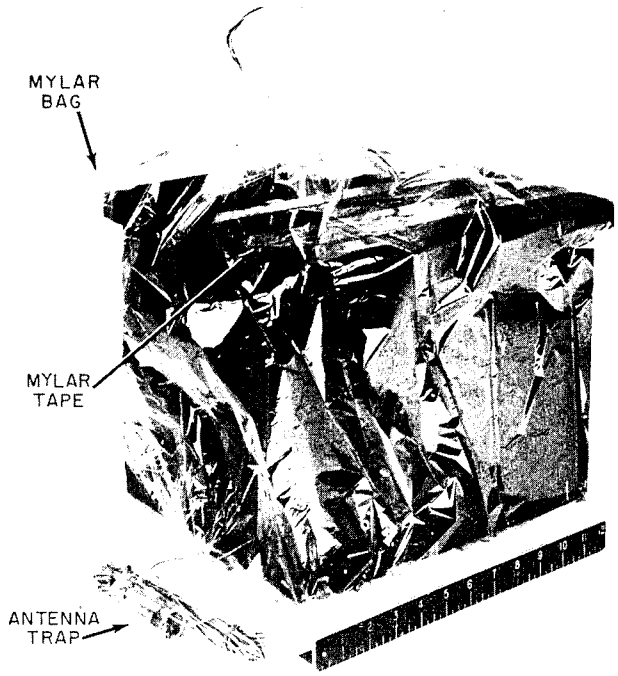

Fig. 25 - Complete transmitter thermal package

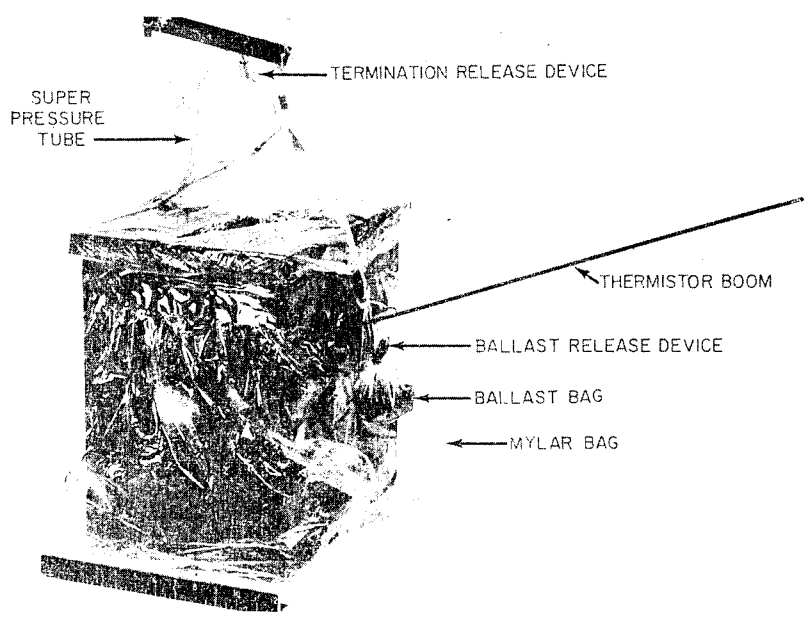

Fig. 26 - Complete keyer-encoder, power supply thermal package

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Approximately 15 minutes prior to scheduled launch (after balloon inflation and weigh-off is completed):

1. Attach load lines to balloon load rings and install Mylar parachute (Fig. 27).

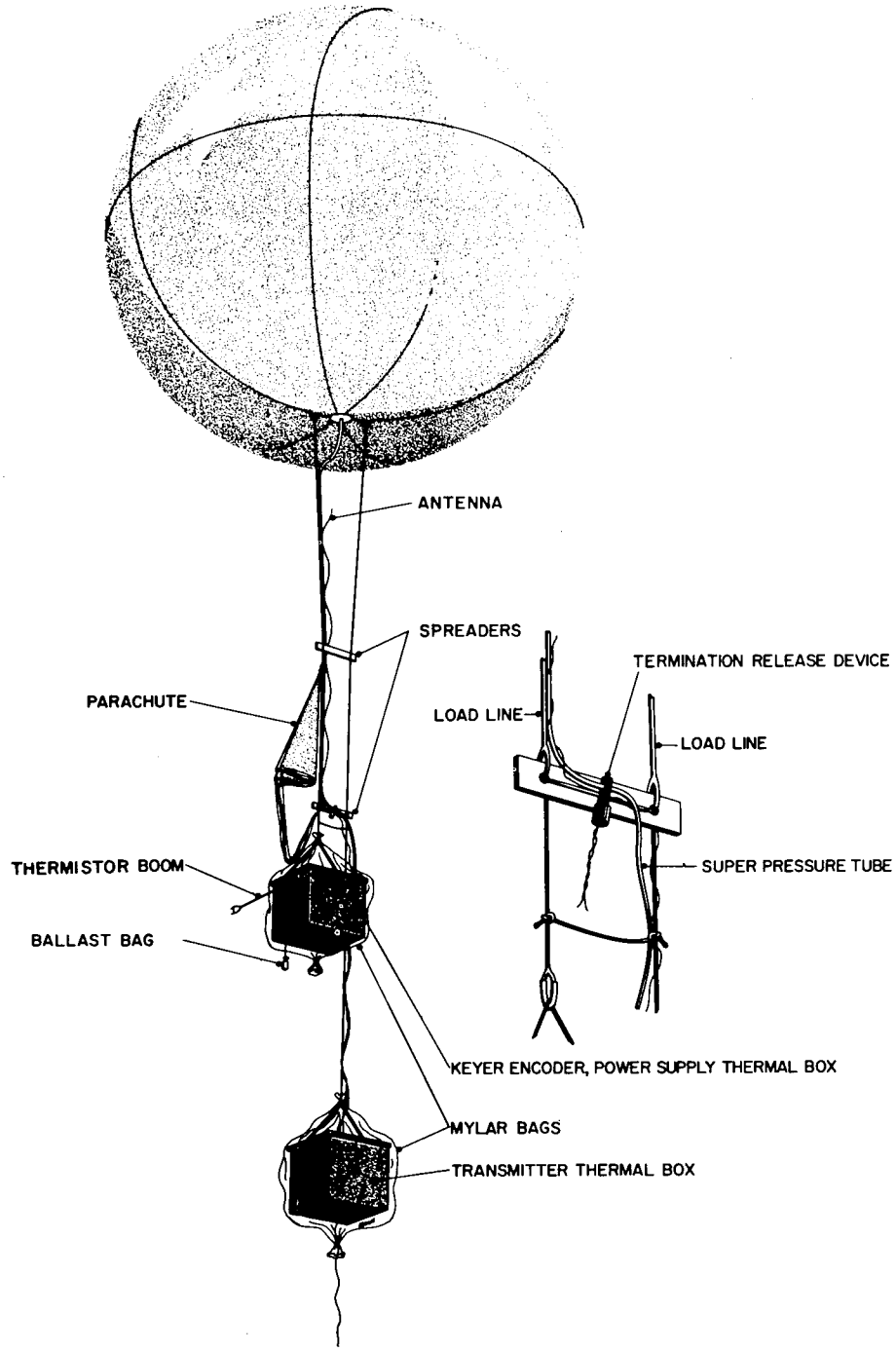

Fig. 27 - Rigging assembly

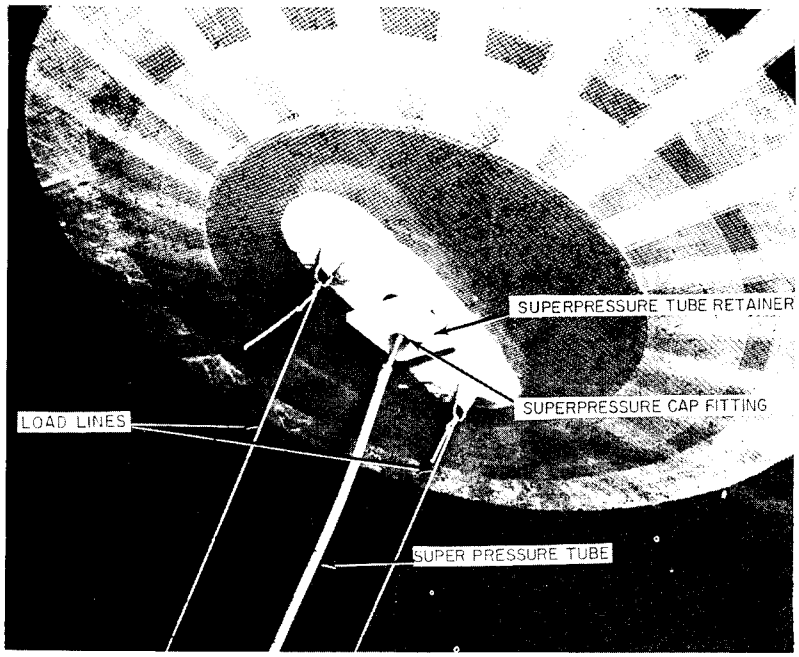

Fig. 28 - Balloon rigging

2. Install superpressure hose retainer and attach superpressure hose on balloon inflation fitting (Fig. 28). CAUTION: Do Not let air be pulled into balloon during attachment of superpressure hose.

3. Make continuity checks of ballast and termination circuits and connect squibs to proper circuits.

4. Install thermistor boom.

Approximately five minutes prior to scheduled launch:

1. Connect equipment together (starting plug) and monitor one 30-second transmission, checking keying and code groups.

2. Roll out antenna.

3. Prepare for launch. Make certain that equipment load line, parachute, and superpressure hose are not entangled.

During launch, care should be taken to assure that equipment does not receive any shock or unusual vibration. A complete schematic is shown as Fig. 29.

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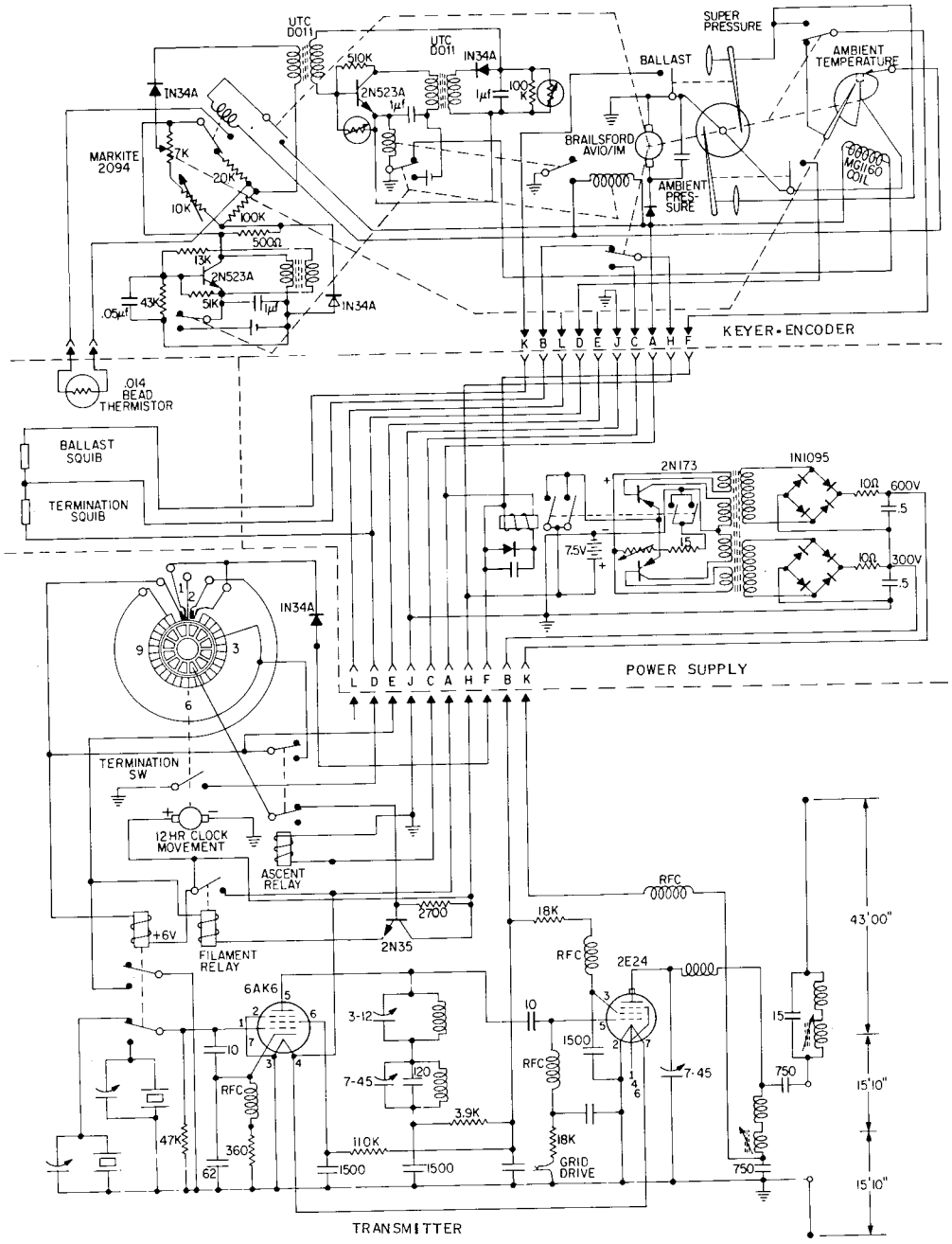

Fig. 29 - Equipment schematic

CONCLUSIONS

The instrumentation that evolved during this program is unique and versatile. Although designed as an expendable piece of gear, it exhibits very good reliability. It could easily be adapted to monitor other parameters, to provide various radiated power levels, and to control various timing functions, in other balloon-borne systems.

The maximum flight duration during this program was limited to five days in order to avoid involving air space over foreign countries. The balloon and instrumentation, with proper preparation, is capable of much longer flight durations (10 to 15 days).

The flight program contributed greatly to the development of the spherical superpressure balloon. The flight data collected helped delineate the balloon's major faults and problem areas, and the flight program served as a testing ground for new and improved balloon models. Finally, this program demonstrated that a reliable transosonde system can be implemented utilizing a small constant-volume superpressure balloon and compact lightweight equipment.

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APPENDIX A

FLIGHT LOGS AND DATA
FLIGHTS NR 1 THROUGH NR 50

These data are a compilation from the research-flight program conducted during the development of the small, lightweight equipment. Fifty flights were launched from Webster Field, Patuxent Naval Air Station, Maryland, between August 1959 and December 1961. The flight data consists of a flight log – a plot of ambient pressure at balloon floating level and superpressure of balloon – and a trajectory plot, including fix data provided by the Federal Communications Commission. On those flights on which ambient-temperature encoding equipment was flown, a plot of the ambient-temperature data is included.

All pressure data are presented in millibars, temperature data in degrees Centigrade, and time in GMT. Superpressure is represented by a filled circle and the ambient pressure by an open circle. Sunrise and sunset are designated by arrows pointing up and down, respectively. In the flight log the free-lift figure is given as a percentage of the gross load weight (balloon and equipment). The resulting balloon superpressure is measured in terms of millibars of pressure above ambient pressure. FCC tracking data varies in quality due to variation in flight trajectory and propagation conditions. In order to present a clear picture of the flight trajectory and yet avoid clutter, some FCC fix data have been omitted from the trajectory plots. Complete tabulation of FCC fix data is included with each flight. Copies of the originals of the flight data are available to qualified persons upon request. Direct inquiries to Director, U.S. Naval Research Laboratory, Code 5414, Washington, D.C. 20390.

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Table A1
Flight Summary

Flight No.	Balloon Type	Date Time (GMT)	Expected Flight Duration (hr)	Data Period (hr)	Probable or Actual Duration (hr)	Free Lift (percent)	Flight Disposition
NR 1	Cyl.	8/6/59 2225	60	10	Unknown	7.4	Equipment malfunction; clock battery
NR 2	Cyl.	9/15/59 2127	100	7	199	9	Equipment malfunction; clock battery
NR 3	Cyl.	9/18/59 2059	50	29	29	9	Superpressure loss; insufficient
NR 4	Cyl.	9/23/59 2129	120	6.5	7	10	Balloon leak
NR 5	Cyl.	10/5/59 1930	105	105	105	9	Time termination
NR 6	Sphere	10/28/59 2120	60	30	31	8	Superpressure loss; reason unknown
NR 7	Sphere	11/19/59 2050	60	18.5	221	11	Equipment malfunction; clock failure
NR 8	Cyl.	11/30/59 2115	60	28.5	Unknown	11	Superpressure loss reason unknown
NR 9	Sphere	12/9/59 2030	100	1	1	9	Balloon rupture
NR 10	Cyl.	1/25/60 2212	60	1/2	1/2	14	Balloon rupture
NR 11	Cyl.	2/3/60 2212	60	1/2	1/2	10	Balloon rupture
NR 12	Sphere	2/12/60 2115	100	54	54	8	Unknown
NR 13	Cyl.	2/16/60 2130	60	11	11	10	Balloon leakage
NR 14	Cyl.	2/25/60 2200	50	0	0	10	Balloon lost during launching in high winds
NR 15	Cyl.	3/23/60 2200	50	33	Unknown	10	Battery exhaustion
NR 16	Cyl.	3/29/60 2200	70	54	Unknown	10	Communications blackout; Sunspot activity
NR 17	Cyl.	4/7/60 2230	60	4	4	10	Balloon leakage
NR 18	Cyl.	4/14/60 2200	100	11	Unknown	8	Equipment malfunction; internal short

Table A1 (Continued)
Flight Summary

Flight No.	Balloon Type	Date Time (GMT)	Expected Flight Duration (hr)	Date Period (hr)	Probable or Actual Duration (hr)	Free Lift (percent)	Flight Disposition
NR 19	Cyl.	4/19/60 2300	99	99	99	10	Time termination
NR 20	Cyl.	4/25/60 2315	119	24	24	10 + 3	Balloon leak; excess superpressure
NR 21	Sphere	6/1/60 2030	72	1-1/2	1-1/2	10	Balloon rupture
NR 22	Sphere	6/16/60 2030	50	1-1/2	1-1/2	7	Balloon rupture
NR 23	Sphere	6/20/60 2030	60	26	26	5	Balloon leakage
NR 24	Sphere	7/13/60 2144	100	1-1/2	1-1/2	7	Balloon rupture
NR 25	Cyl.	8/10/60 2100	74	49	49	7	Superpressure loss; reason unknown
NR 26	Sphere (3 mil cap mono-tape)	9/1/60 2045	105	105	105	6	Time termination
NR 27	Sphere	9/2/60 2125	144	47	Unknown	7	Signal lost; extreme range
NR 28	Sphere	9/10/60 1434	147	21	Unknown	7	Equipment malfunction; keying relay
NR 29	Sphere	9/14/60 2100	46	18	Unknown	7	Equipment malfunction; keying relay
NR 30	Sphere (3 mil cap-bi-tape)	9/23/60 2150	120	47	47	7	Superpressure loss; reason unknown
NR 31	Sphere	9/27/60 2028	100	9	Unknown	7	Probable equipment mal-function; battery connection
NR 32	Sphere	10/10/60 2100	60	93	Unknown (93 + hr)	7	Equipment malfunction; battery connection
NR 33	Sphere	10/17/60 2030	120	21	Unknown	7.3	Unknown
NR 34	Sphere	11/2/60 2203	58	53	58	8	Time termination

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Table A1(Continued)
Flight Summary

Flight No.	Balloon Type	Date Time (GMT)	Expected Flight Duration (hr)	Data Period (hr)	Probable or Actual Duration (hr)	Free Lift (percent)	Flight Disposition
NR 35	Sphere	11/21/60 2103	50	1	1	15	Balloon rupture
NR 36	Sphere Bi-tape seal (NRL specs)	1/10/61 1957	20	20	20	16.9 (in 3 steps)	Time termination
NR 37	Sphere	2/27/61 2030	48	31	Unknown	8 + 4	Signal lost; poor propagation
NR 38	Sphere	2/27/61 2122	52	1	1	15	Balloon rupture
NR 39	Sphere	3/7/61 2045	24	12	Unknown	8	Battery failure; low temperature
NR 40	Sphere	3/20/61 2035	11	2	2	8 + 5.5	Balloon rupture
NR 41	Sphere	3/27/61 2127	80	12	12	8	Balloon leakage
NR 42	Sphere	5/4/61 1958	50	50	50	7	Time termination
NR 43	Sphere	5/25/61 2126	100	16	100	8	Equipment malfunction; transmitter failure
NR 44	Sphere	6/30/61 2100	100	123	123	8	Time termination; equipment malfunction
NR 45	Sphere	7/17/61 2123	100	100	100	8	Time termination
NR 46	Sphere	8/10/61 2155	100	2-1/2	2-1/2	8	Flight lost in thunderstorm
NR 47	Sphere	9/11/61 2027	100	8	Unknown	8	Unknown
NR 48	Sphere	10/5/61 2020	50	50	50	8	Time termination
NR 49	Sphere	10/27/61 2010	264	18	Unknown	8	Equipment malfunction
NR 50	Sphere	11/6/61 2042	48	48	48	8	Time termination

FLIGHT NR 1

Launched	2225, 8/6/59
Balloon Type	Cylinder
Free Lift	7.4 percent
Expected Flight Duration	60 hr
Probable or Actual Duration	Unknown
Data Period	10 hr

Comments

Failure of programming clock batteries caused program clock to stop functioning after 10 hours; thus transmissions ceased. Balloon performance looked good, although superpressure dropped off more than anticipated

DATE/TIME	FIX		CLASS
070012	37.0°N	75.7°W	A
0210	36.5	74.8	C
0413	35.0	72.5	A
0612	34.1	70.5	B
0812	33.4	69.0	B

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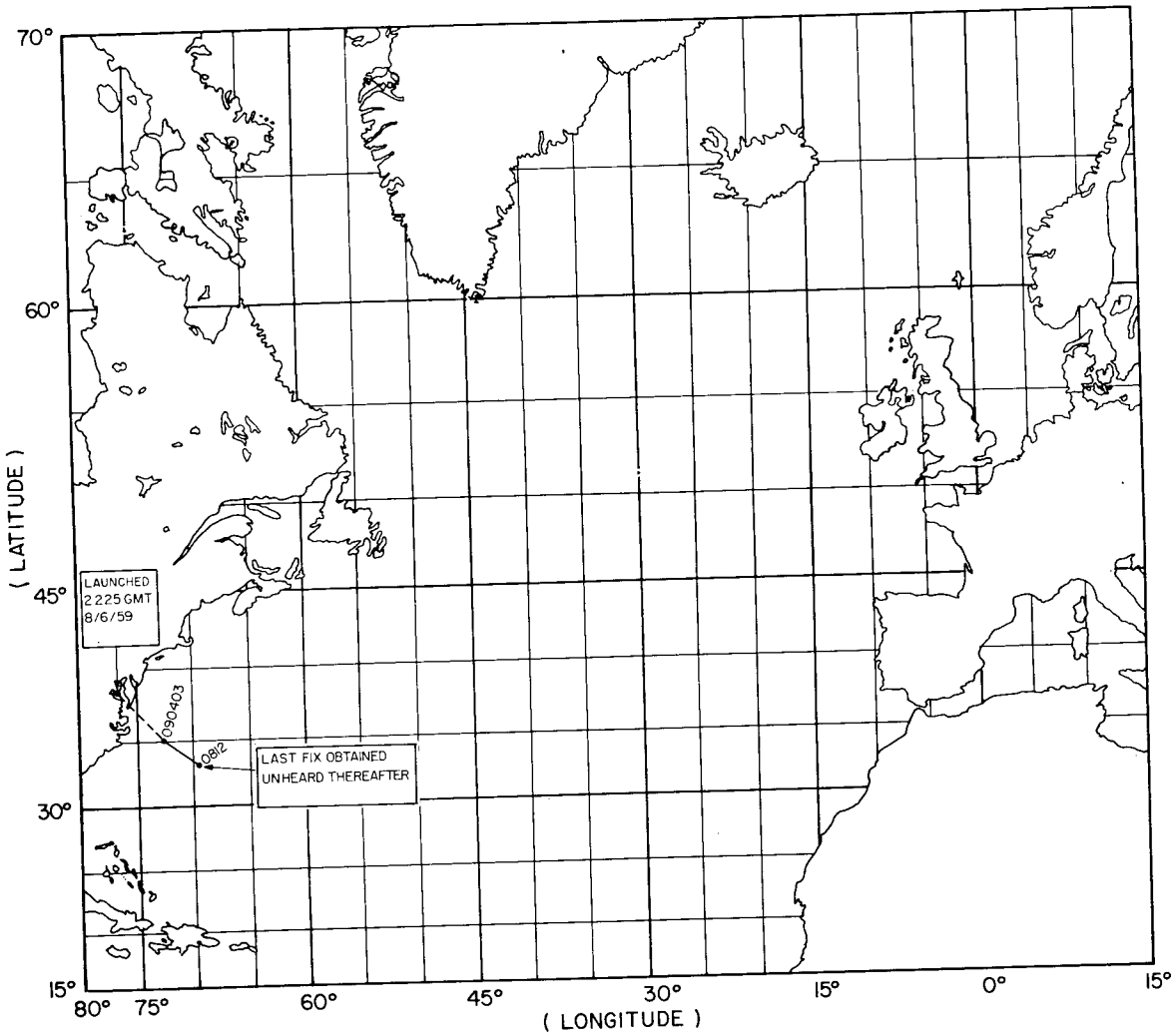

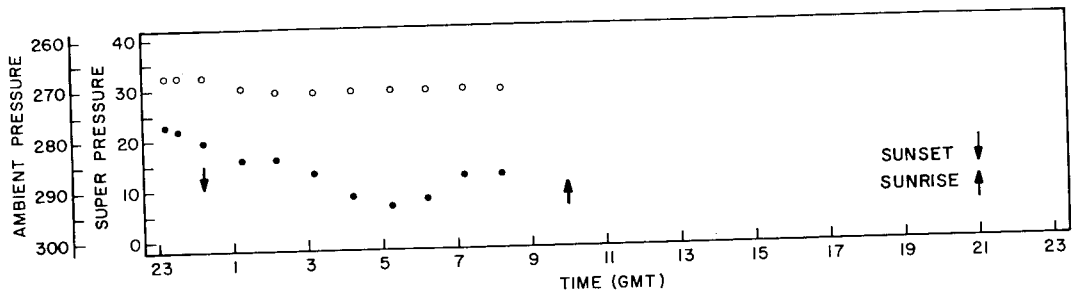

FLIGHT NR 2

Launched	2127, 9/15/59
Balloon Type	Cylinder
Free Lift	9 percent
Expected Flight Duration	100 hr
Probable or Actual Duration	199 hr; seen descending in Spain
Data Period	7 hr

Comments

Equipment recovery allowed postflight examination which showed that transmission termination after 7 hr was caused by failure of clock battery pack, thus substantiating synopsis on flight NR 1. Flight duration indicated substantial balloon capability. Equipment was recovered in Spain.

DATE/TIME	FIX		CLASS
160014	39.3°N	70.5°W	C
0215	39.0	68.3	C
0412	39.6	71.1	C

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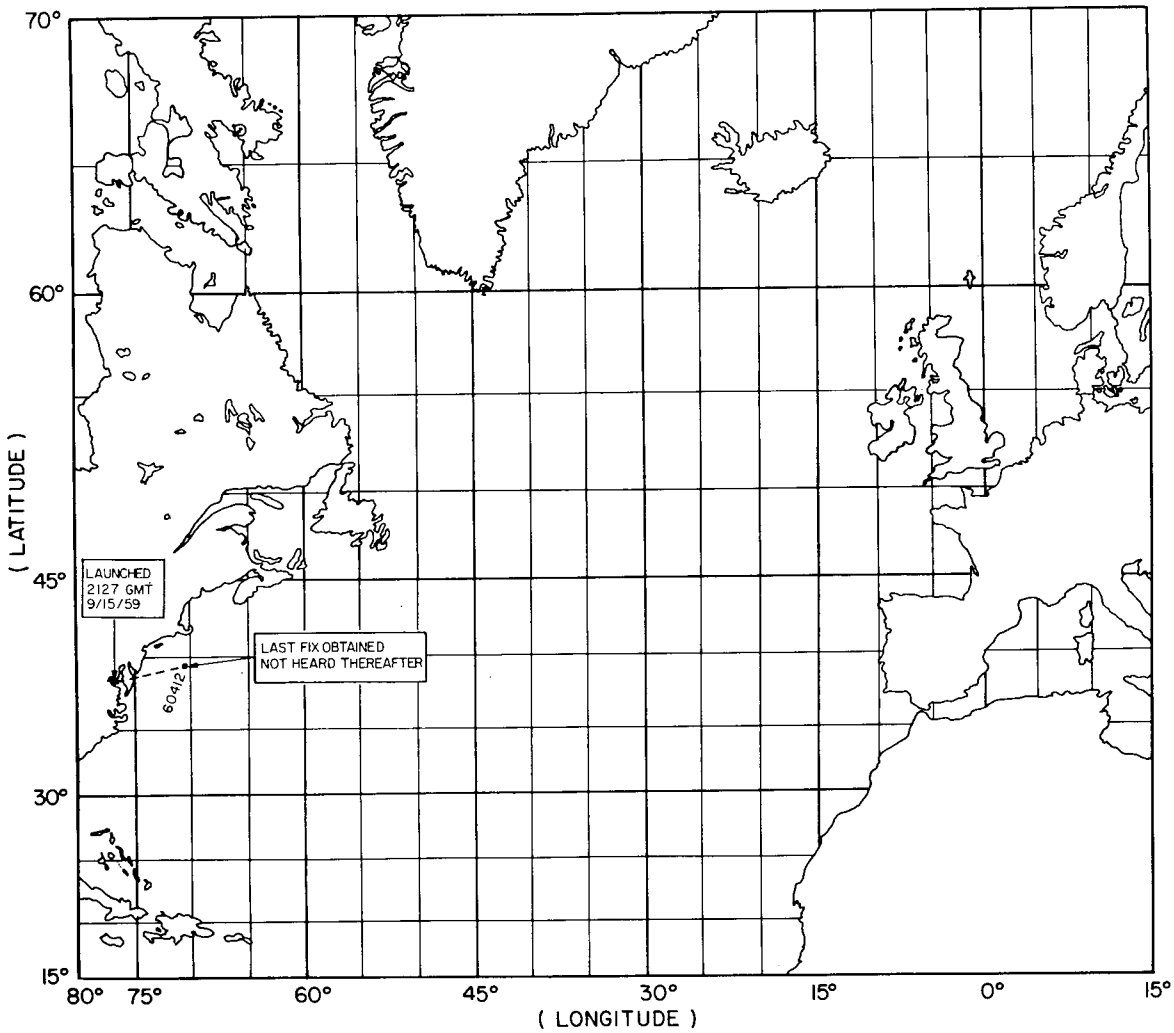

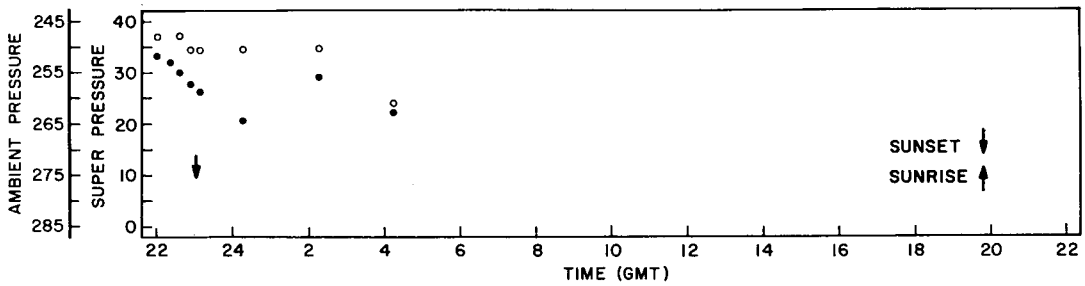

FLIGHT NR 3

Launched	2059, 9/18/59
Balloon Type	Cylinder
Free Lift	9 percent
Expected Flight Duration	50 hr
Probable or Actual Duration	29 hr
Data Period	29 hr

Comments

New clock battery pack installed on this equipment. Performance was satisfactory. Transmission schedule was set up to deliver a 30-sec transmission every four minutes on alternate frequencies. While providing excellent data coverage, it was an extremely difficult signal on which to obtain reliable bearings; thus only one position "fix" was obtained during flight. Early flight termination was due to loss of superpressure, which suggests need for ballast drop. Poor propagation conditions caused loss of signal during early morning on second day.

DATE/TIME	FIX		CLASS
190210	40.0°N	67.2°W	C

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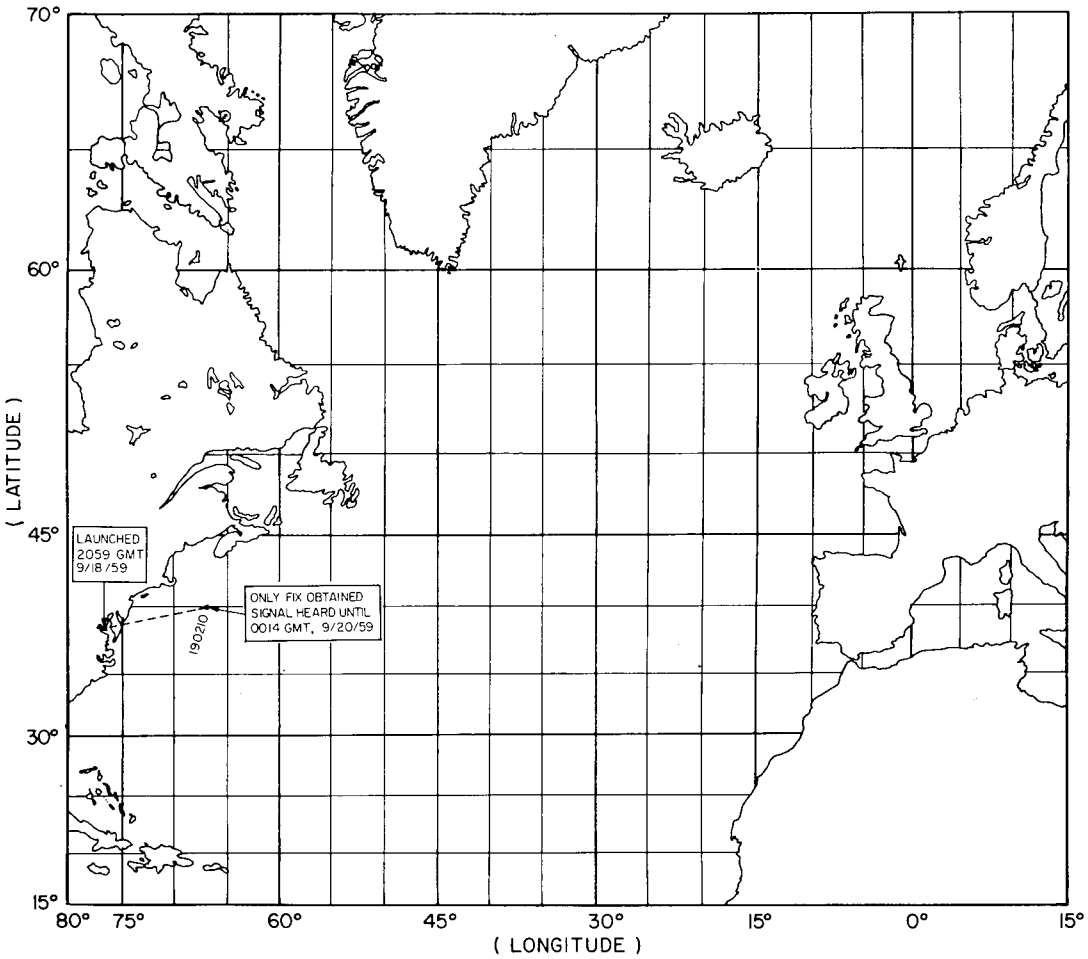

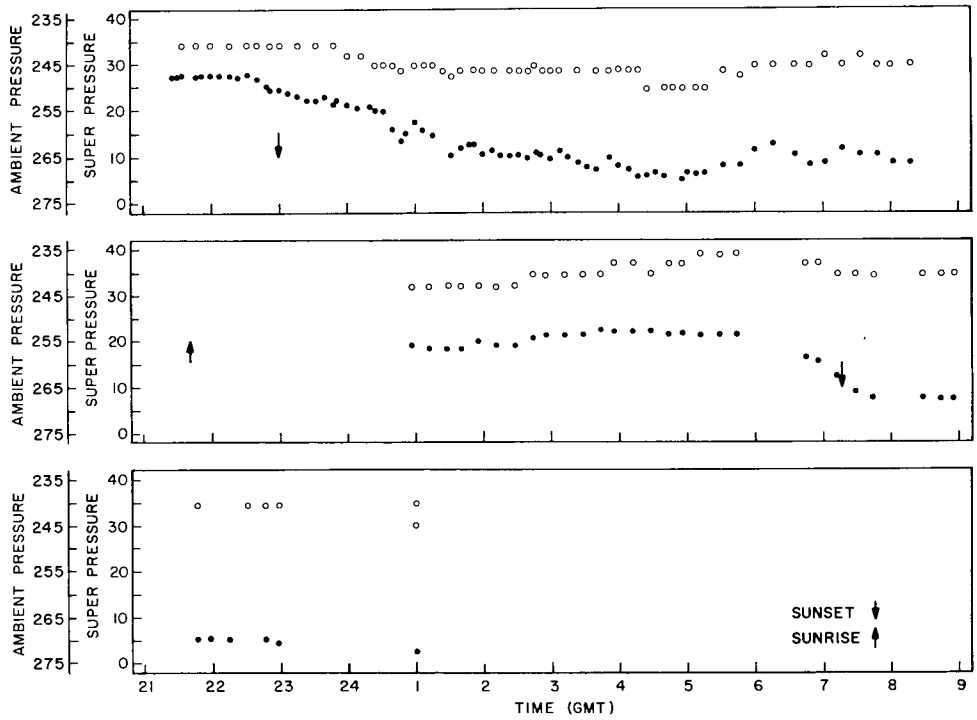

FLIGHT NR 4

Launched	2129, 9/23/59
Balloon Type	Cylinder
Free Lift	10 percent
Expected Flight Duration	120 hr
Probable or Actual Duration	7 hr
Data Period	6.5 hr

Comments

Balloon leak caused loss of superpressure and subsequent flight termination after 7-hr flight duration. Loss of superpressure could not be attributed to any specific cause, although it is possible that an initial 10 percent free lift is excessive for this balloon.

DATE/TIME	FIX		CLASS
240013	38.4°N	74.8°W	D-100
0213	38.7	73.9	C
0410	38.5	72.2	C

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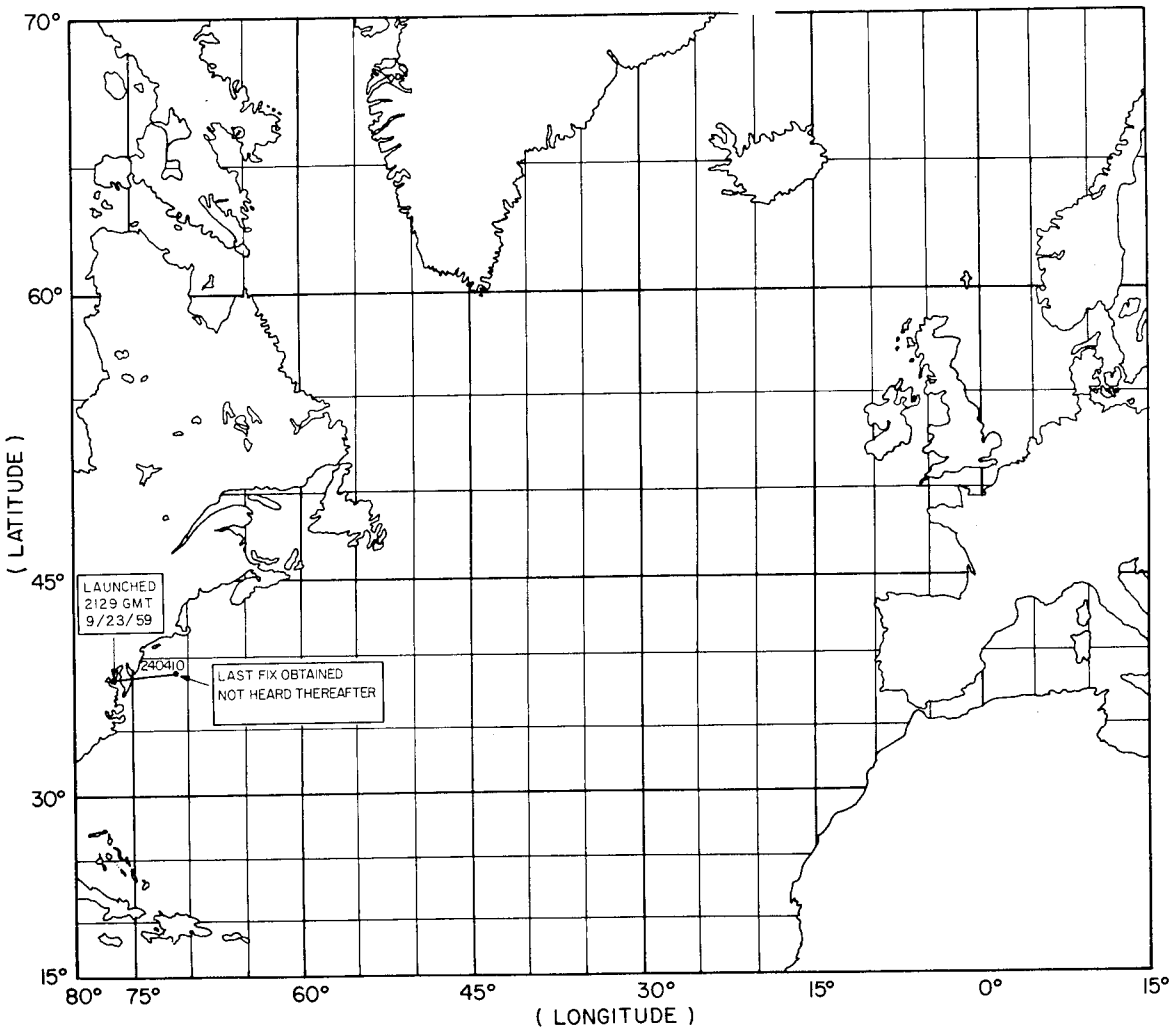

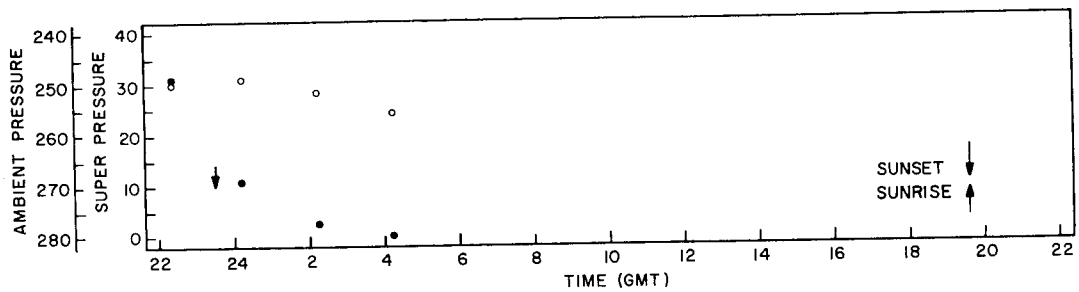

FLIGHT NR 5

Launched	1930, 10/5/59
Balloon Type	Cylinder
Free Lift	9 percent
Expected Flight Duration	105 hr
Probable or Actual Duration	105 hr
Data Period	105 hr

Comments

Excellent flight. Time termination. Equipment operation normal. Poor-quality fixes toward end of flight indicate need for higher transmitted power. Double convection shield was used on thermal packages. No apparent effect on internal package temperature. Superpressure appeared satisfactory. Data indicates some day, night cyclic affect on the ambient pressure level. This is probably due to stretching of balloon material, caused by superpressure variation, thereby allowing increased balloon volume.

DATE/TIME	FIX		CLASS	DATE/TIME	FIX		CLASS
052311	38.3°N	76.5°W	C	1314	40.3°N	57.0°W	C
060114	38.8	76.3	B	1514	40.3	57.0	B
0312	39.2	76.0	C	1714	39.9	55.9	B
0511	39.5	74.8	B	1914	39.8	55.0	A
0711	39.6	74.5	C	2114	39.8	54.3	C
0911	40.1	73.9	C	2314	40.0	53.0	C
1111	40.2	73.5	B	080115	39.3	52.3	B
1313	39.8	73.5	B	0513	39.3	49.1	C
1513	40.0	73.0	B	0712	38.8	44.0	C
1713	40.3	71.9	A	1715	35.8	42.5	D/150
1913	40.5	71.3	A	2114	35.8	38.5	C
2113	40.8	70.0	B	2314	34.0	35.0	C
2313	41.1	68.1	A	090314	33.5	33.7	C
070113	41.4	67.4	A	0515	33.0	30.8	C
0313	41.3	66.2	B	0713	33.8	28.8	C
0512	41.5	64.0	C	1315	37.5	27.4	D/200
0712	41.3	61.5	C	1515	39.8	27.0	D/200
0912	40.8	57.0	C	1715	40.3	23.3	D/100
1112	40.8	55.0	C	2115	40.8	22.0	C

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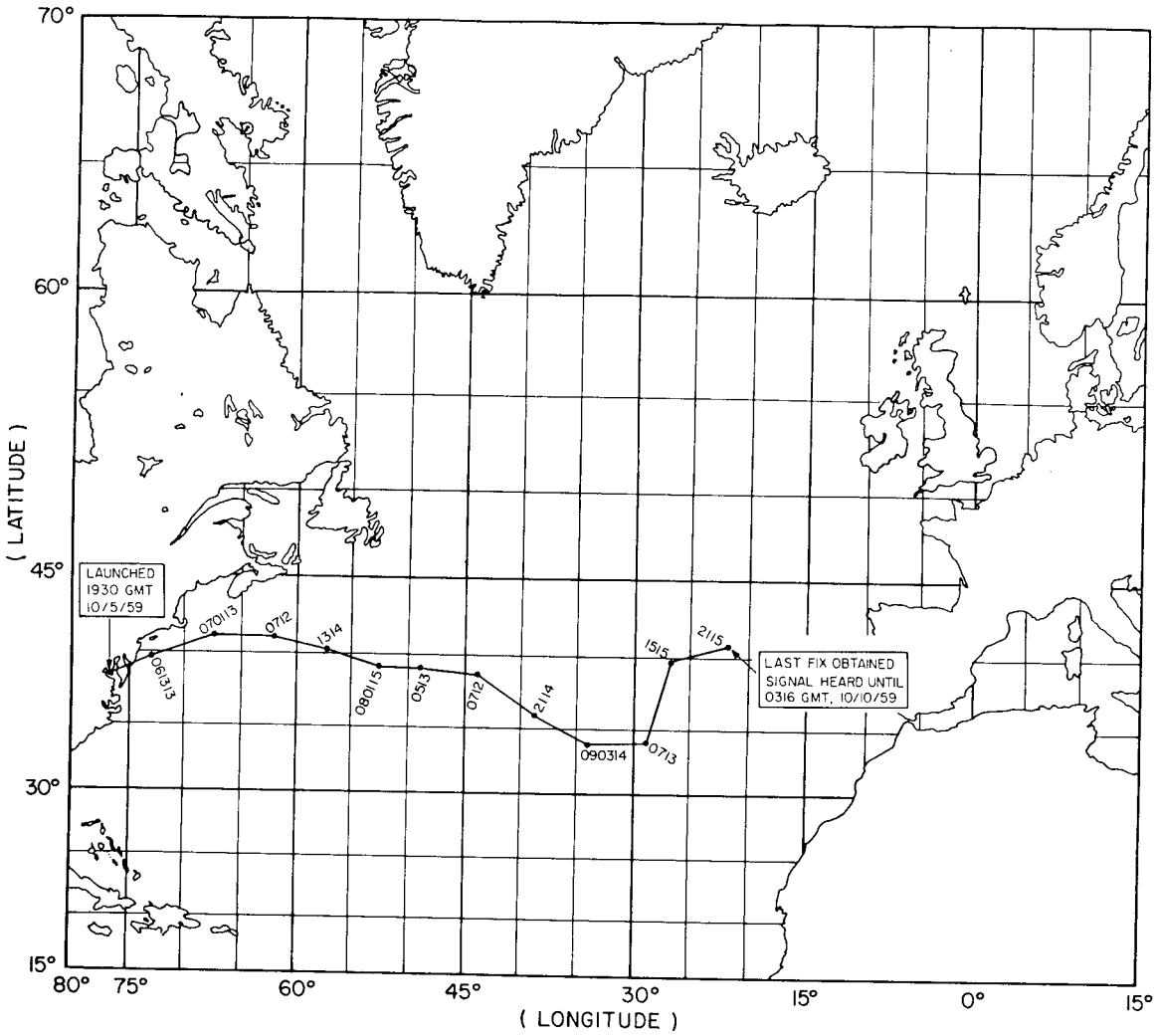

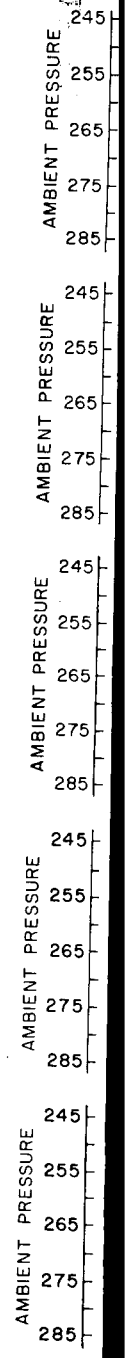

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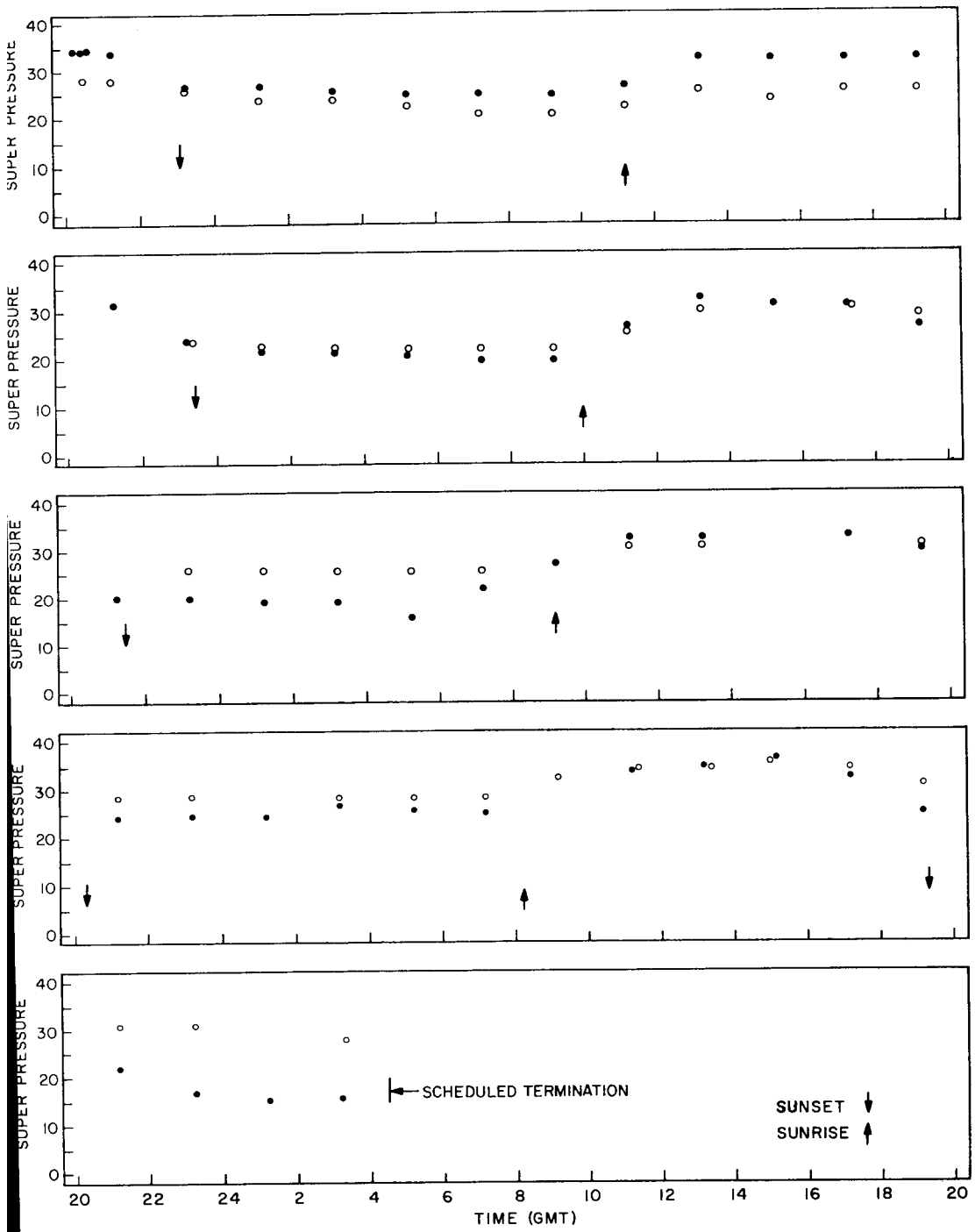

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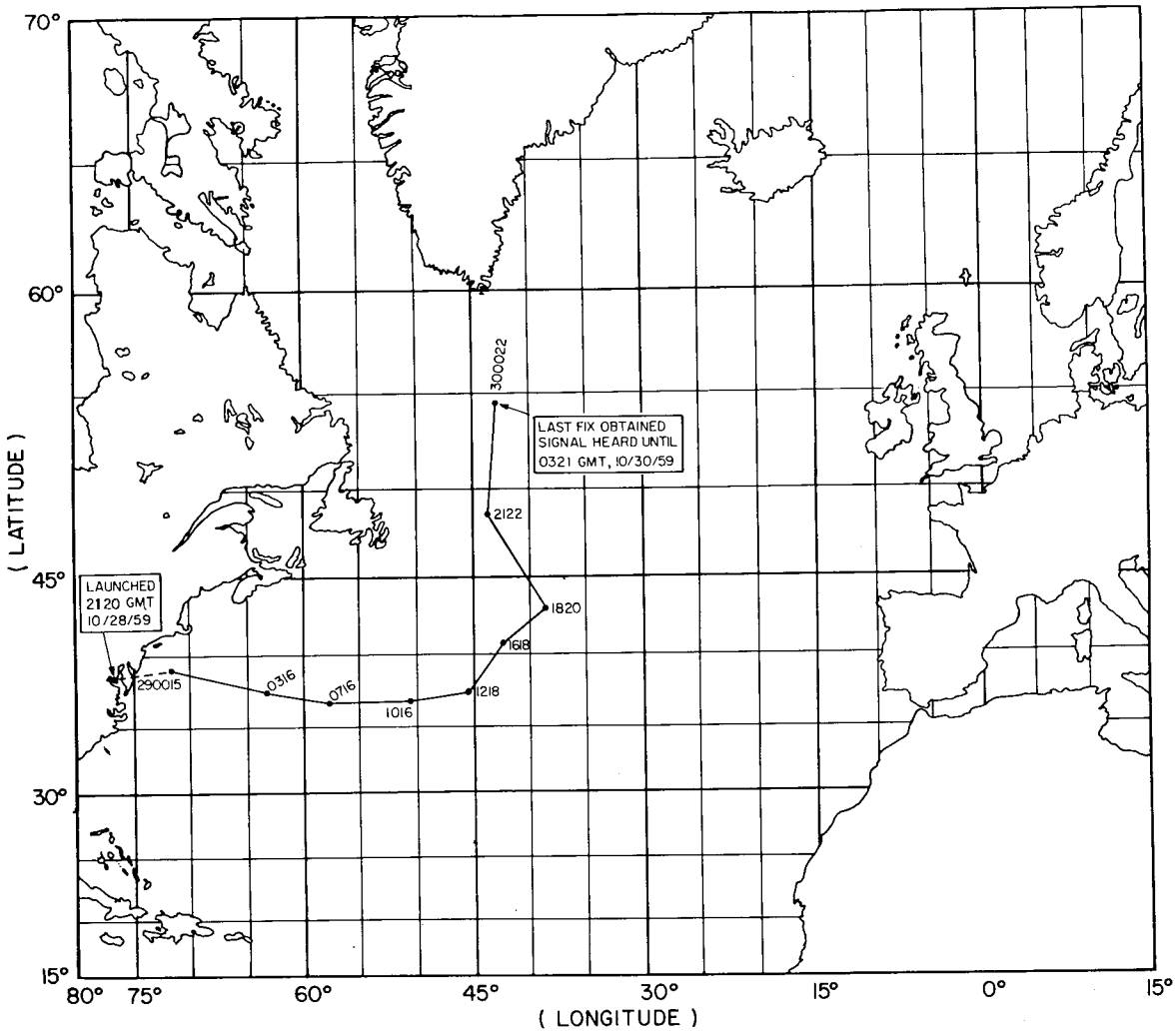

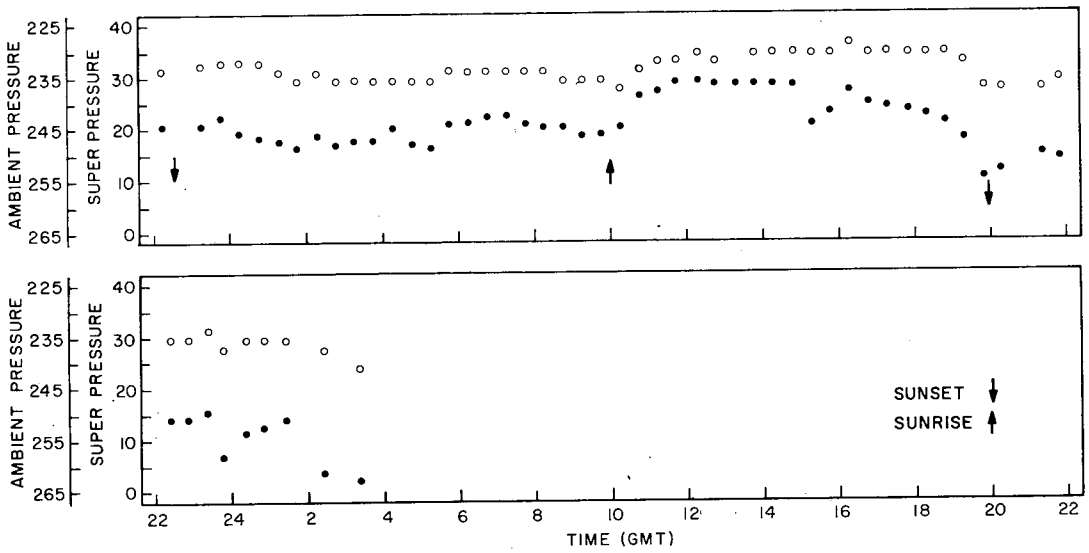

FLIGHT NR 7

Launched	2050, 11/19/59
Balloon Type	Sphere
Free Lift	11 percent
Expected Flight Duration	60 hr
Probable or Actual Duration	221
Data Period	18.5 hr

Comments

Transmission schedule was every 1/2 hr. The equipment was recovered in Japan ten days after launching, indicating that balloon performance and durability were good. Obviously 10-percent free lift was not excessive for this balloon. The second experimental spherical balloon was employed on this flight.

Postsynopsis of equipment revealed that early transmission termination was due to a defective clock mechanism. A small 2-in.-diameter code disk was employed on this equipment, allowing a twofold increase in sensitivity of the pressure sensors.

A "taped-skirt" thermal convection shield was used on this equipment. Data indicated its performance was satisfactory, with no unusual variation from normal noted in internal package temperature.

DATE/TIME	FIX		CLASS
192318	38.2°N	73.8°W	C
200016	37.8	73.0	C
0116	37.0	71.0	C
0216	38.2	68.3	C
0316	38.5	66.3	D/100
0416	38.8	63.3	C
0516	38.4	60.5	B
0616	37.5	58.5	B
0716	37.8	57.4	C
0816	38.0	55.5	B
0916	38.0	54.3	C
1016	38.3	53.4	C
1116	38.3	51.0	C

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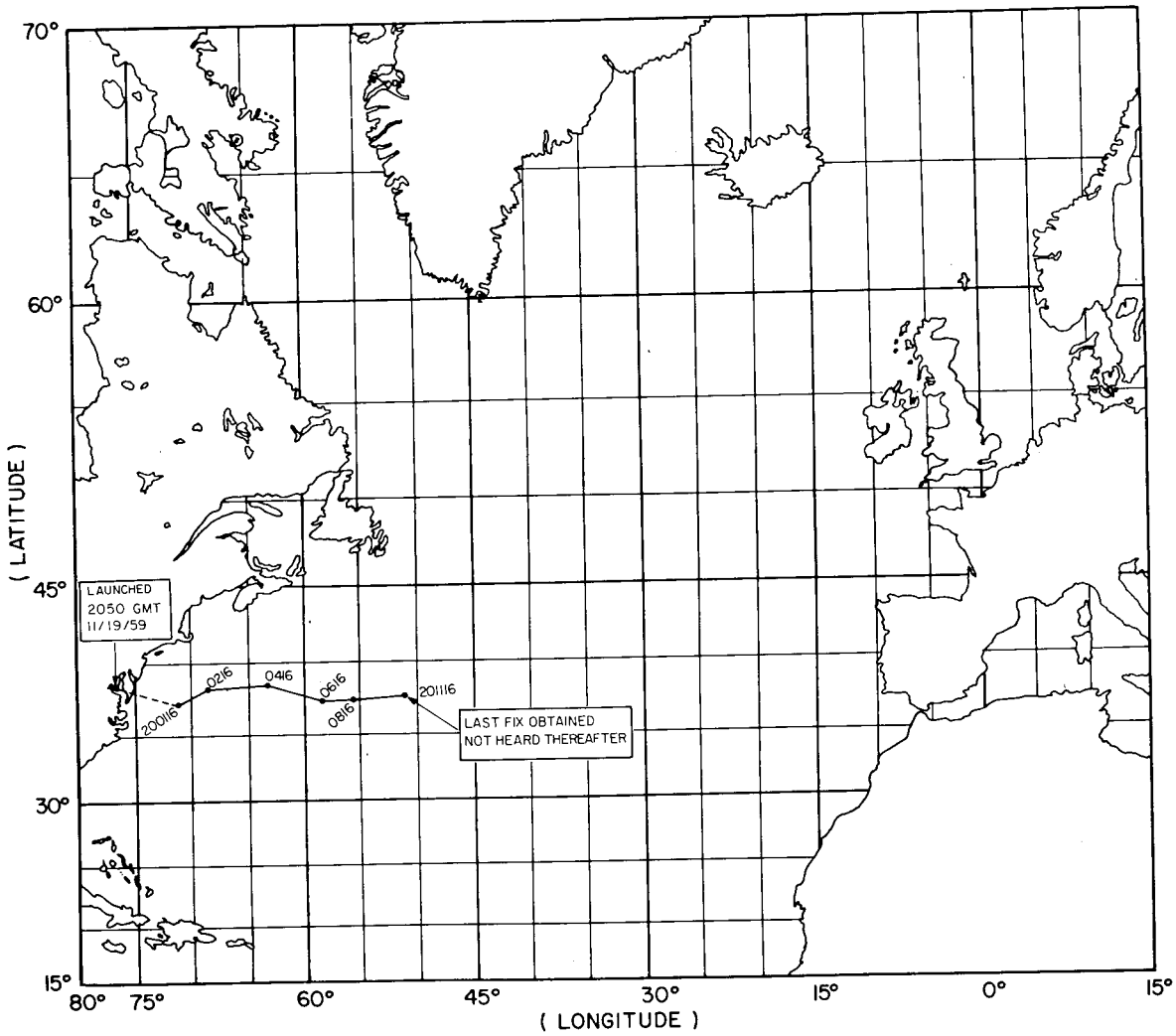

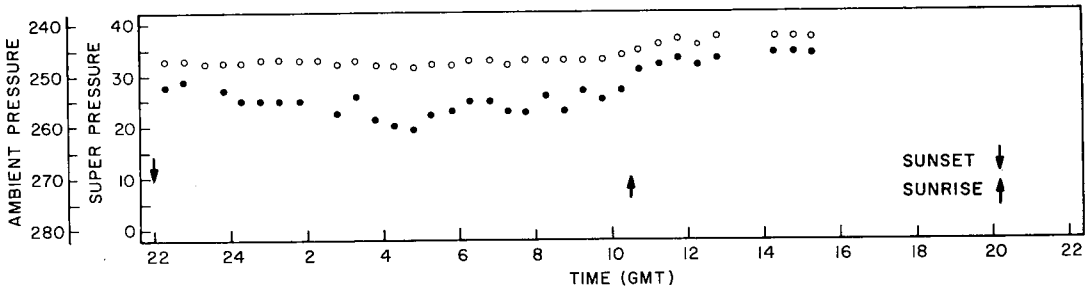

FLIGHT NR 8

Launched	2115, 11/30/59
Balloon Type	Cylinder
Free Lift	11 percent
Expected Flight Duration	60 hr
Probable or Actual Duration	Unknown
Data Period	28.5 hr

Comments

Transmission schedule was every 1/2 hr. Early flight termination was due to loss of superpressure. Unable to determine whether balloon leaks or environmental changes caused this loss. This was the highest percentage free lift attempted to date.

DATE/TIME	FIX		CLASS
302218	38.0°N	75.3°W	C
2319	38.0	74.3	B
010019	37.9	73.5	B
0119	37.6	72.3	B
0220	38.0	71.5	C
0318	38.2	70.4	C
0418	38.0	69.2	C
0518	38.3	69.1	C
1320	44.3	56.5	A
1520	48.0	44.0	D/100
1620	48.3	40.4	D/150
1922	51.0	40.0	D/150
2022	51.5	42.3	D/200

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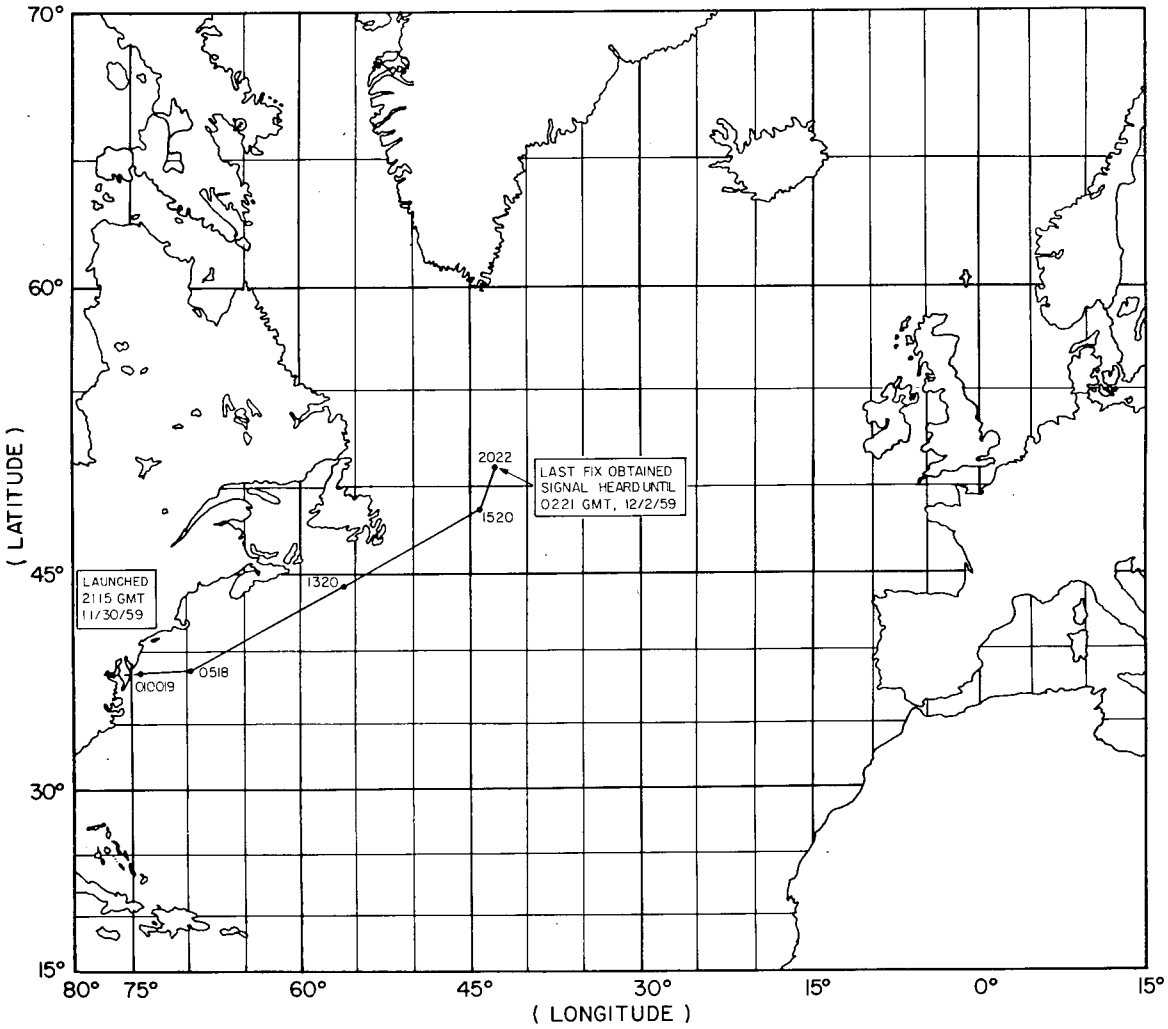

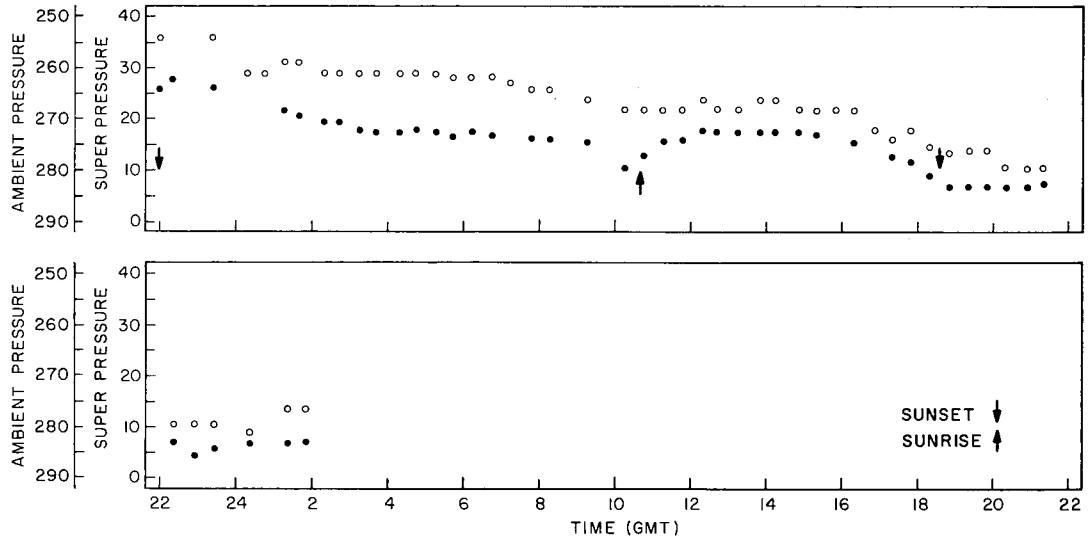

FLIGHT NR 9

Launched	2030, 12/9/59
Balloon Type	Sphere
Free Lift	9 percent
Expected Flight Duration	100 hr
Probable or Actual Duration	1 hr
Data Period	1 hr

Comments

No significant data obtained. The balloon apparently burst at low altitude. This was the third flight on which an experimental spherical balloon was flown. This particular spherical balloon was one of the first to be built and had never been tested prior to this flight. Provision for a ballast drop was first incorporated on this equipment, using ambient pressure to activate ballast switch at 285 millibars.

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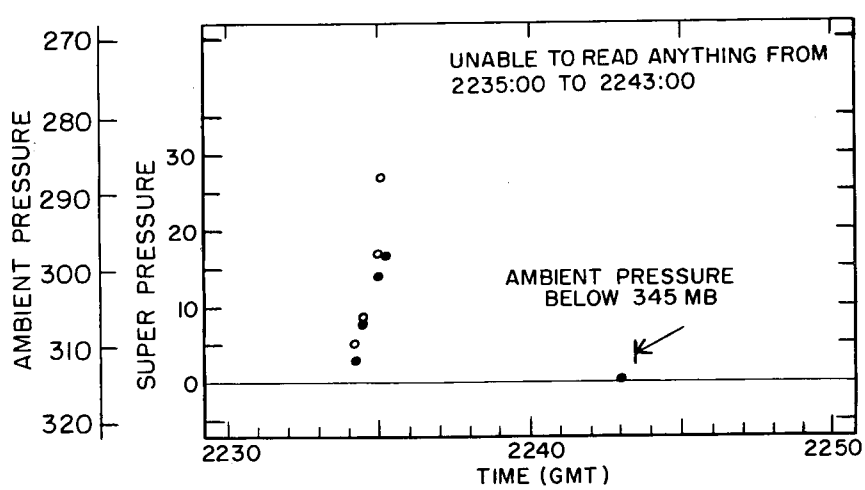
FLIGHT NR 10

Launched	2212, 1/25/60
Balloon Type	Cylinder
Free Lift	14 percent
Expected Flight Duration	60 hr
Probable or Actual Duration	30 min
Data Period	30 min

Comments

Balloon burst upon reaching ceiling, causing termination of flight. Excessive superpressure, due to high initial free lift (14 percent) was probable cause for balloon failure.

Keying became intermittent shortly after launching; thus only sporadic data were obtained thereafter. The equipment was recovered on Eastern Shore, Md., in good condition. Laboratory examination of equipment revealed an intermittent short in keyer circuit, which caused loss of keying during flight. To improve transmitted power, another trap was added to the antenna to provide better impedance match with transmitter.

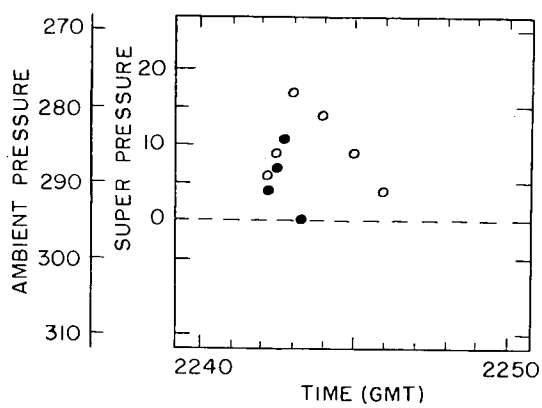


FLIGHT NR 11

Launched	2212, 2/3/60
Balloon Type	Cylinder
Free Lift	10 percent
Expected Flight Duration	60 hr
Probable or Actual Duration	30 min
Data Period	30 min

Comments

Balloon failed at ceiling. No obvious reason for failure. Equipment was recovered in Virginia. Means for providing continuous telemetering during last stages of ascent were first employed on this flight. Also, an improved ambient pressure diaphragm was employed on this equipment, allowing 1 millibar sensitivity.



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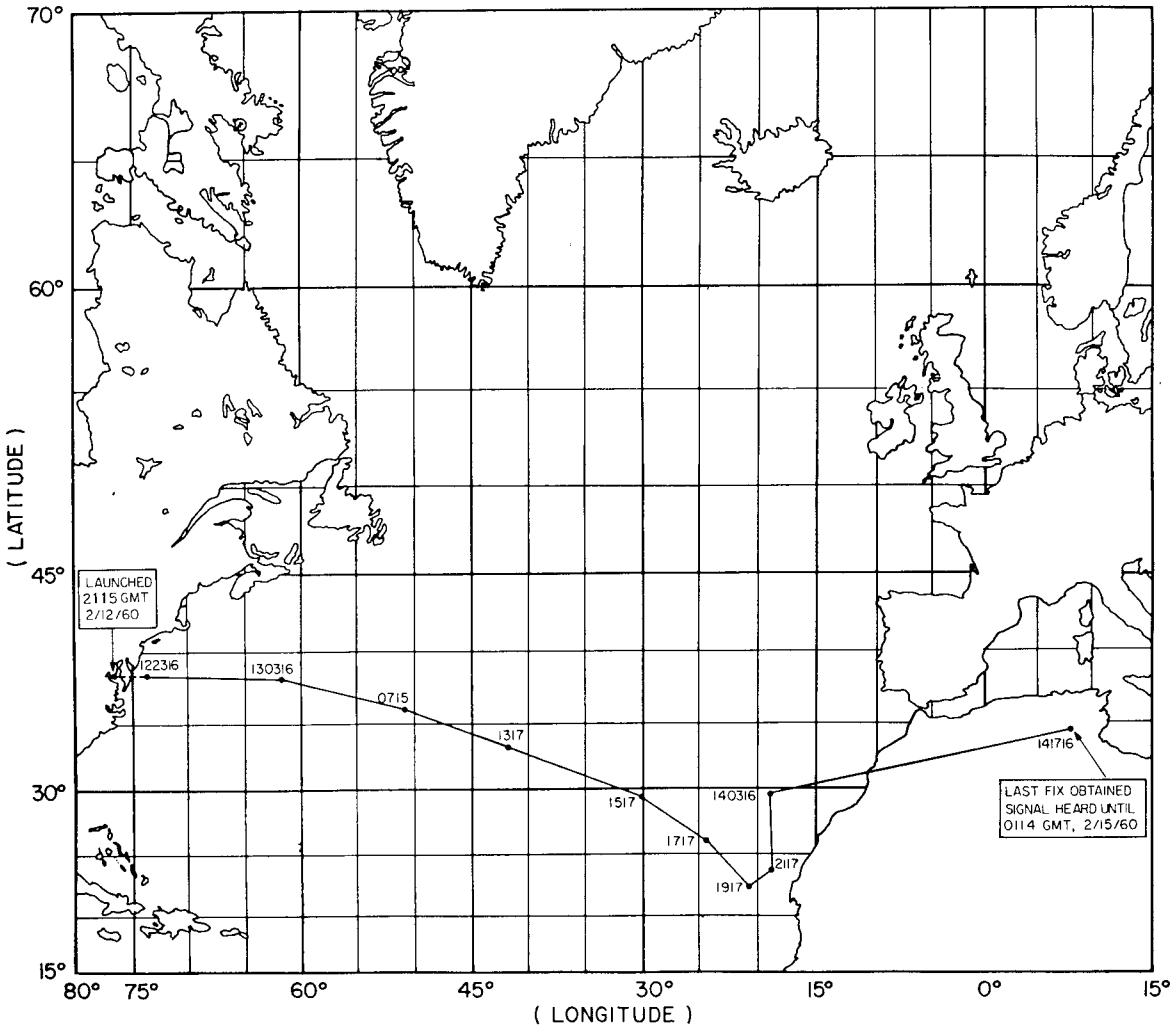

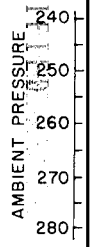

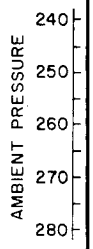

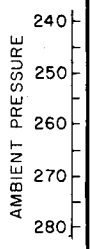

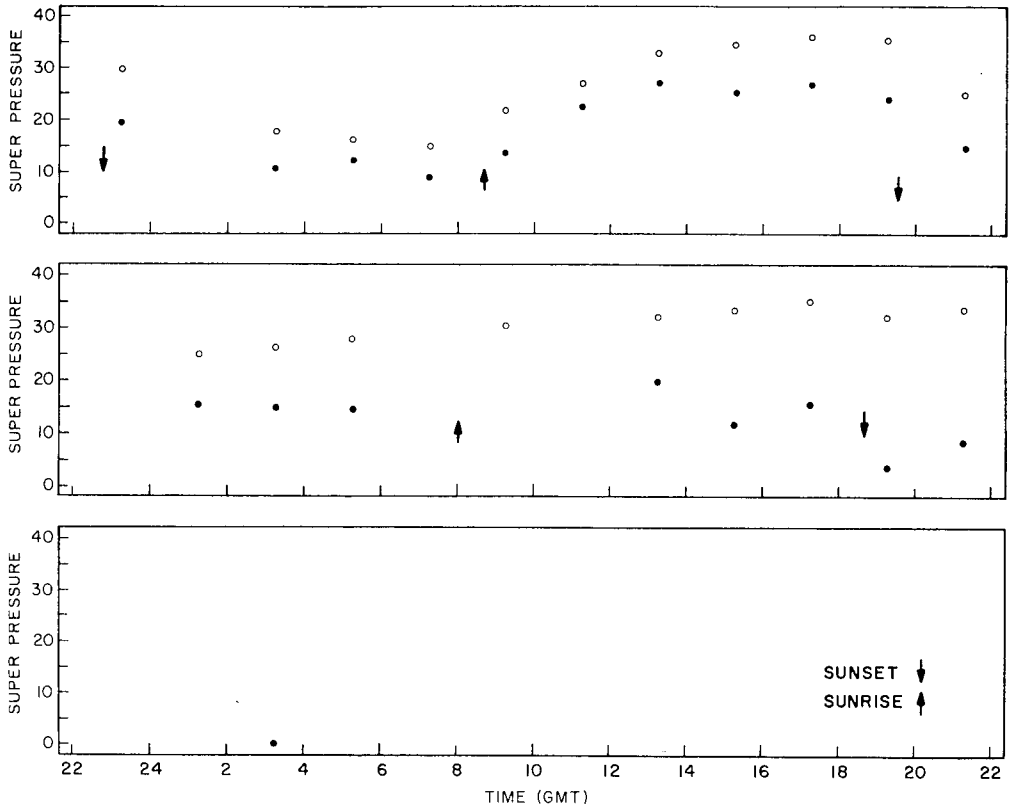
SUPER PRESSURE
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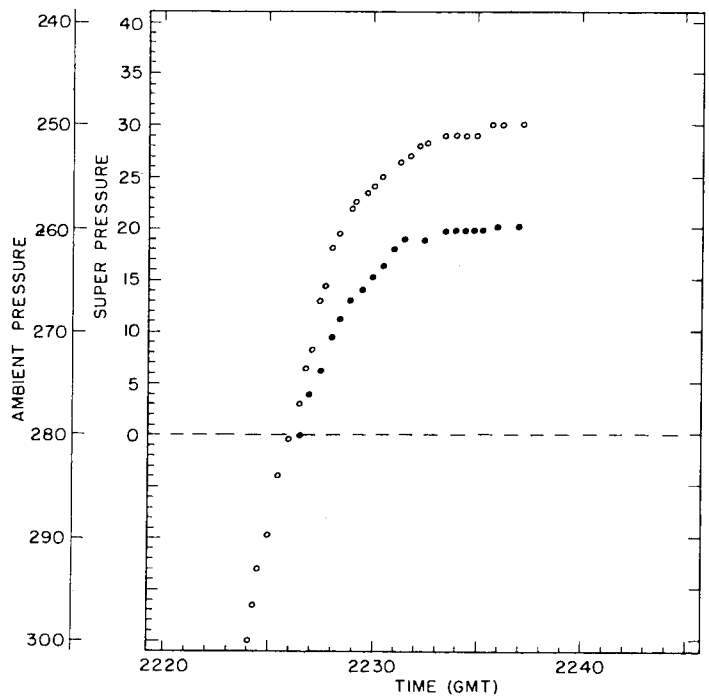
AMBIENT PRESSURE
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FLIGHT NR 12

Launched	2115, 2/12/60
Balloon Type	Sphere
Free Lift	8 percent
Expected Flight Duration	100 hr
Probable or Actual Duration	54 hr
Data Period	54 hr

Comments

This was the fourth flight on which an experimental spherical balloon was employed. Balloon performance during the early portion of the flight was good. Due to high wind velocity the balloon quickly reached an extreme range (2500 miles), making tracking and data reception difficult during the latter portions of the flight; thus a complete balloon-performance evaluation is not possible. The last data reading, obtained before termination occurred, indicated zero superpressure. No definite conclusion could be reached as to the cause for this loss of superpressure. There was no indication of ballast drop. The ballast-drop control has been ineffective when installed to work off of ambient pressure, as on this flight. In the future the ballast control will be operated by balloon superpressure. It was also determined that the addition of an extra trap to the antenna, as was used on the previous flight, is not necessary. Also included with the data for this flight is a graph showing superpressure and ambient-pressure curves during ascent. The difference between the two curves is a good indication of how much stretching of material occurs when balloon is being pressurized.

The equipment from this flight was recovered in Turkey on 2/17/60.

DATE/TIME	FIX		CLASS
122316	38.3°N	73.7°W	B
130316	38.3	61.9	B
0516	35.3	49.1	C
0715	36.0	50.8	C
0915	36.3	48.8	C
1317	33.5	41.8	C
1517	29.6	30.0	B
1717	26.0	24.5	D/100
1917	22.5	20.7	C
2117	23.5	19.0	D/100
2317	24.8	18.4	D/150
140316	29.8	18.9	D/150
1716	33.8	07.7°E	D/200
1916	33.0	09.6	D/200

FLIGHT NR 13

Launched	2130, 2/16/60
Balloon Type	Cylinder
Free Lift	10 percent
Expected Flight Duration	60 hr
Probable or Actual Duration	11 hr
Data Period	11 hr

Comments

Termination was due to balloon leakage. Transmissions were scheduled every 1/2 hr. This is the second flight on which an obvious balloon leak caused termination.

DATE/TIME	FIX		CLASS
170012	38.5°N	73.7°W	A
0112	38.4	73.2	B
0214	38.1	71.8	B
0312	38.3	70.7	B
0413	39.5	69.2	A
0512	39.9	66.8	B
0613	38.9	66.8	B
0712	39.3	65.8	A
0813	39.7	65.3	A

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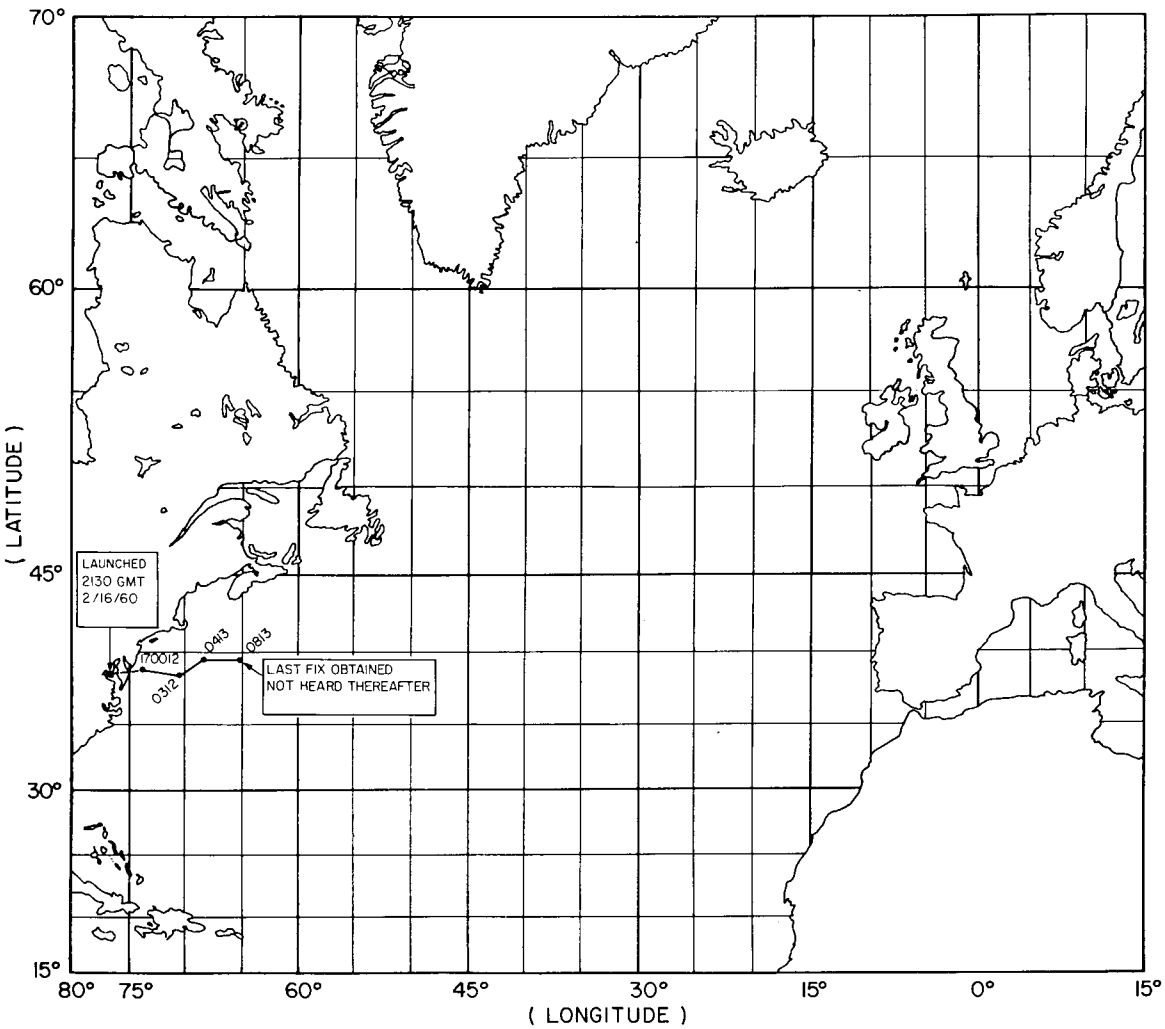
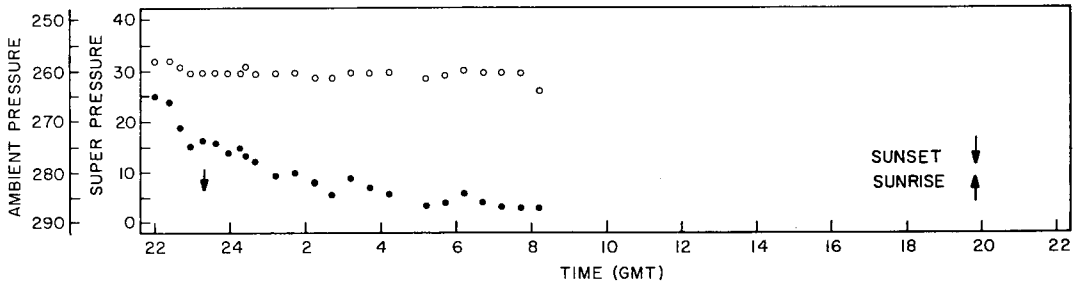




FLIGHT NR 14

Launched	2200, 2/25/60
Balloon Type	Cylinder
Free Lift	10 percent
Expected Flight Duration	50 hr
Probable or Actual Duration	0
Data Period	0

Comments

Balloon and equipment were lost during attempted launching due to high ground winds (20 knots). The package containing batteries and coding unit was torn off and recovered. Equipment included means for measuring external temperature. This consisted of a "black-ball" arrangement containing the ambient temperature sensor, hanging approximately 6 ft below the equipment. Also, this was the first unit on which maximum sensitivity of 3/4 millibar ambient pressure and 1/4 millibar superpressure was achieved.

The loss of this balloon and equipment dramatically illustrates one of the major problems associated with employment of the cylinder balloon with the transosonde equipment. The size of the balloon makes handling in high winds extremely difficult and in this case contributed directly to its loss during the attempted launching.

UNCLASSIFIED

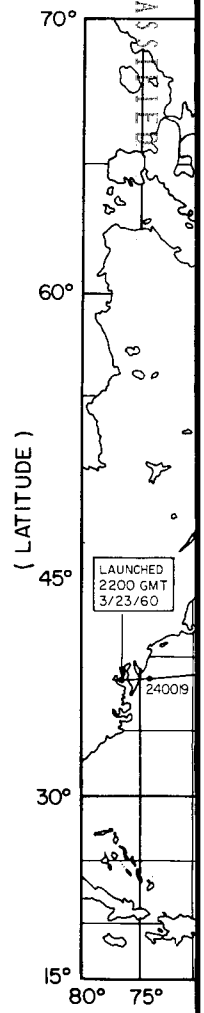
FLIGHT NR 15

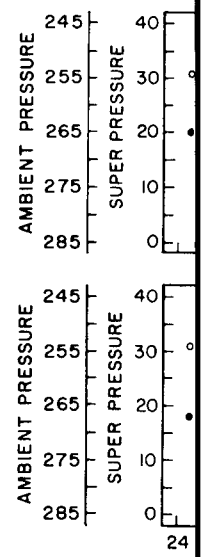
Launched	2200, 3/23/60
Balloon Type	Cylinder
Free Lift	10 percent
Expected Flight Duration	50 hr
Probable or Actual Duration	Unknown
Data Period	33 hr

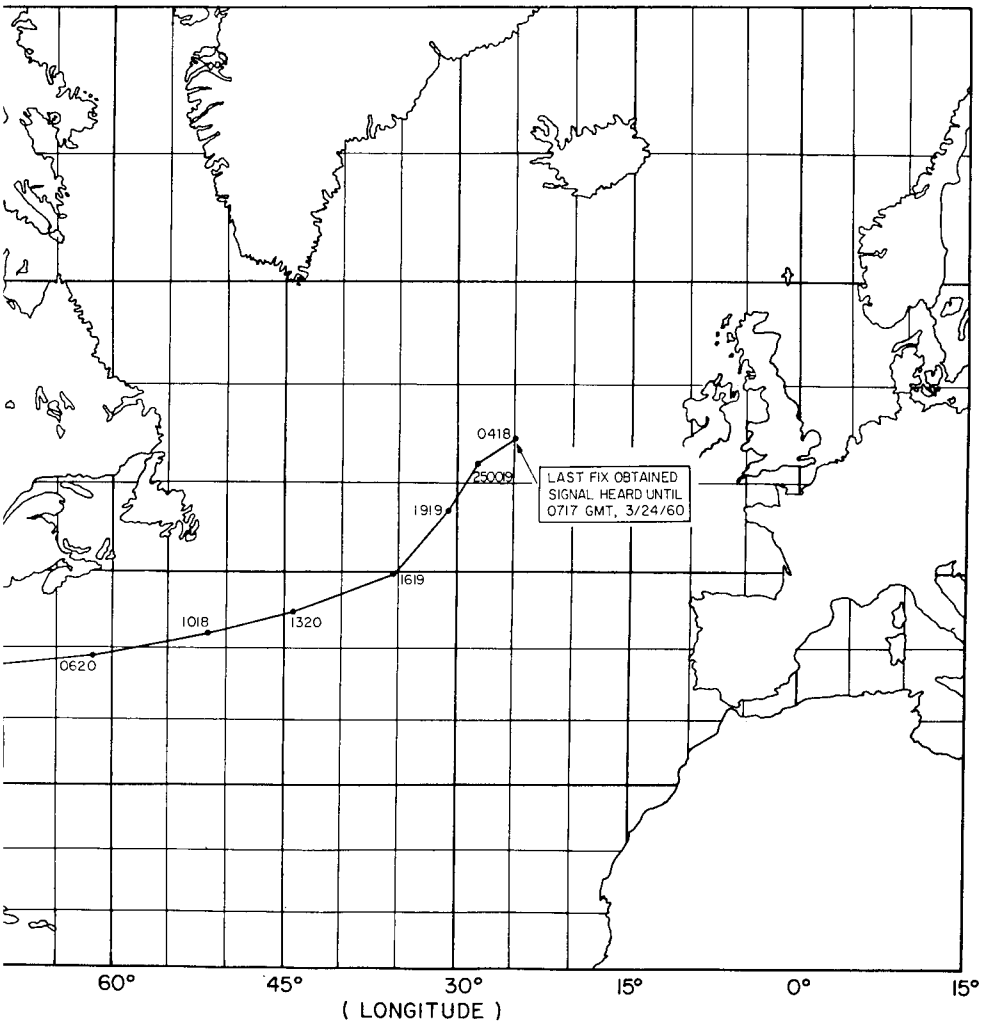
Comments

A new converter configuration allowed the radiated power to be doubled on this flight. This placed a severe load on the batteries, which caused their early exhaustion; transmissions ceased after 33 hr. The increased power greatly aided the df network in obtaining bearings, which is reflected in the much better quality fixes obtained on this flight. Means for including this converter and correcting battery deficiencies on future flights were pursued as quickly as possible. This equipment also included a ballast drop which was controlled by the superpressure level. The control level was 3 to 4 millibars superpressure. This arrangement will be included on all future equipments. After approximately 31 hr of flight the ballast control was activated and for the first time a ballast drop was observed which effectively recharged balloon superpressure and prolonged flight duration.

DATE/TIME	FIX		CLASS
240019	38.3°N	74.2°W	C
0115	38.2	73.7	C
0217	38.0	72.8	B
0318	38.2	72.4	C
0418	38.3	70.3	C
0620	39.0	62.3	C
0718	40.3	57.7	B
0818	40.5	56.0	B
1018	41.0	52.5	B
1119	41.5	50.6	B
1220	42.3	46.3	B
1320	42.9	43.9	B
1419	43.7	41.0	B
1519	44.3	37.9	B
1619	44.9	35.4	A
1719	46.0	34.9	B
1819	47.0	33.0	B
1919	48.3	31.0	B
2019	48.7	29.3	C
2319	50.7	27.7	B
250019	51.3	27.7	C
0117	51.4	27.0	C
0219	51.3	26.3	C
0319	51.7	26.0	C
0418	52.0	25.0	C






0418
2500Z
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LAST FIX OBTAINED
SIGNAL HEARD UNTIL
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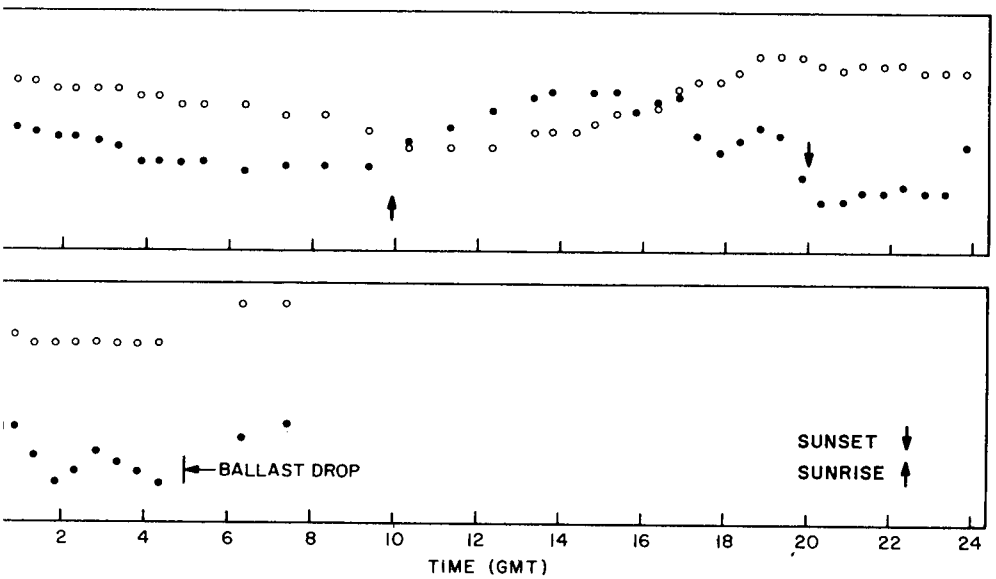
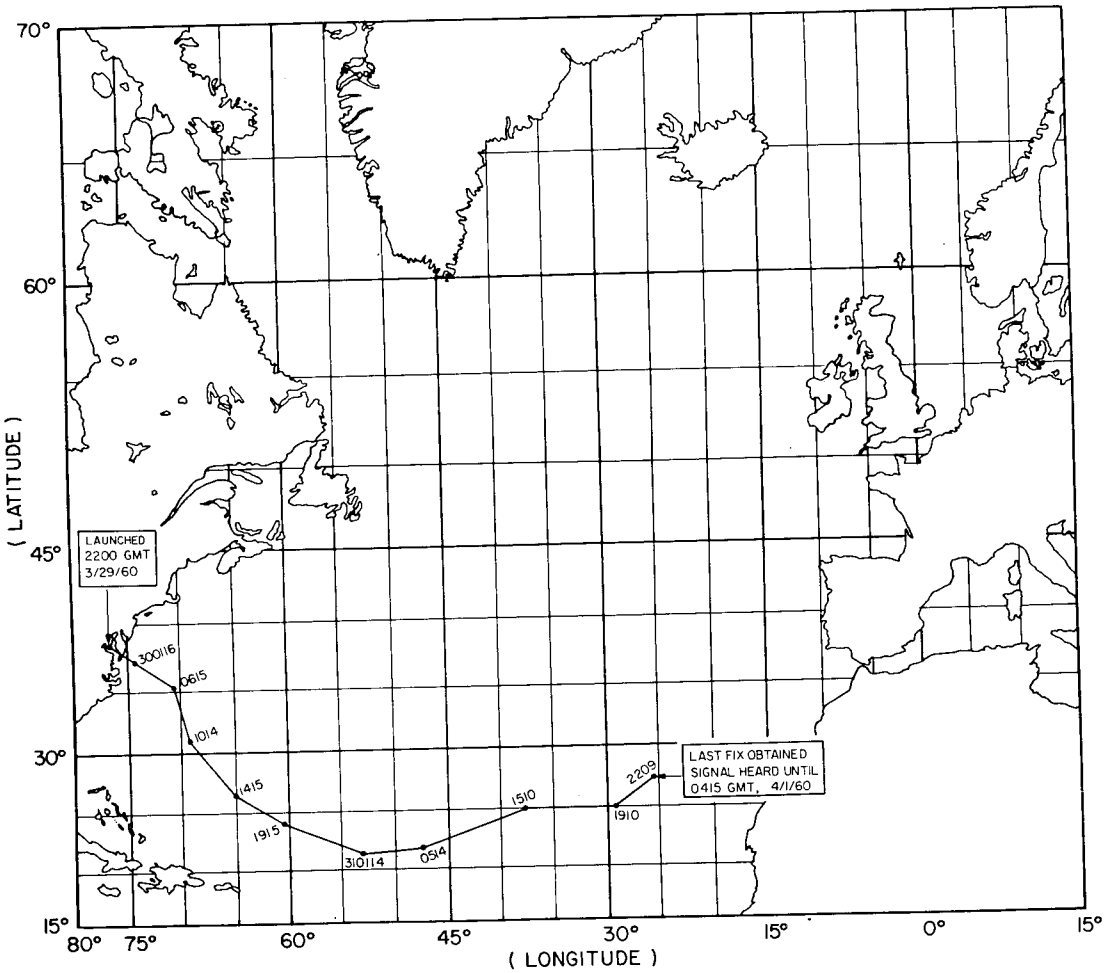
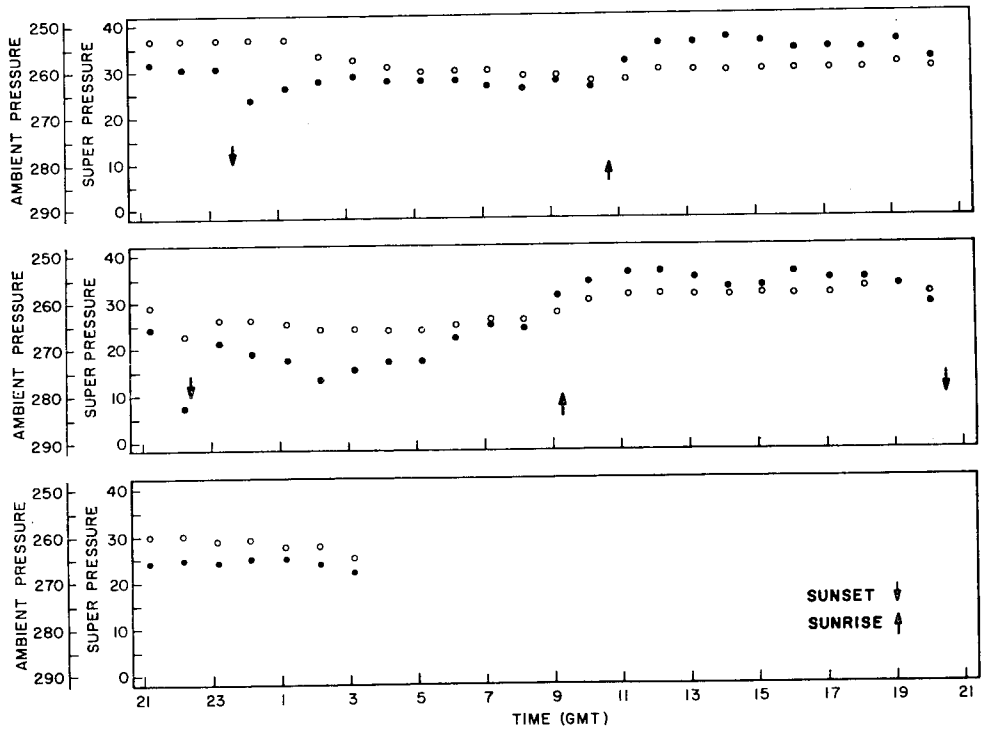
15°
(LONGITUDE)


BALLAST DROP
SUNSET
SUNRISE
2
4
6
8
10
12
14
16
18
20
22
24
TIME (GMT)

UNCLASSIFIED





FLIGHT NR 17

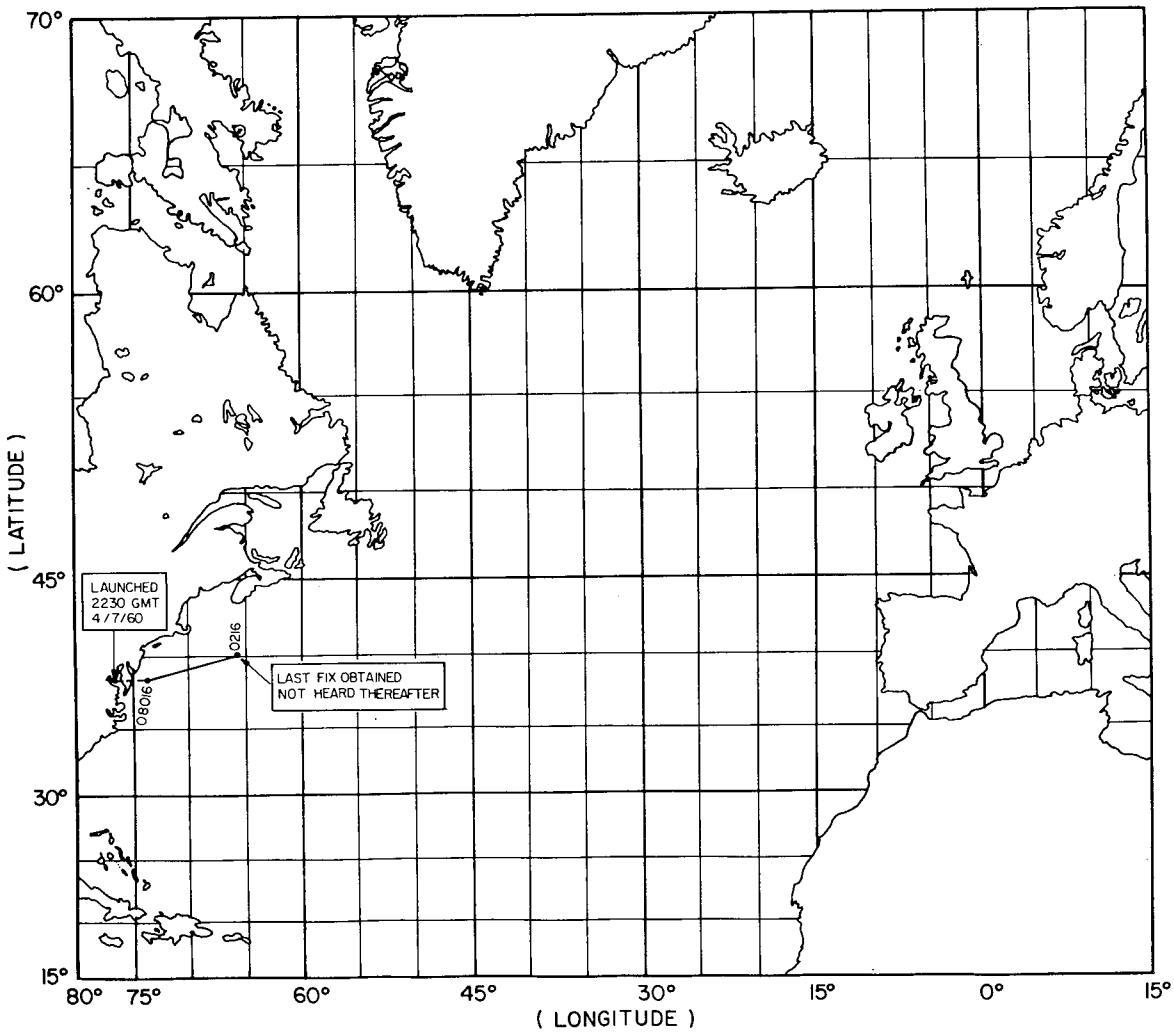
Launched	2230, 4/7/60
Balloon Type	Cylinder
Free Lift	10 percent
Expected Flight Duration	60 hr
Probable or Actual Duration	4 hr
Data Period	4 hr

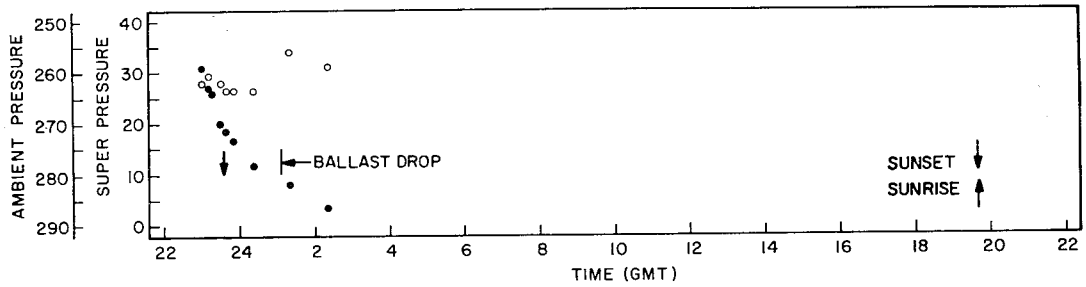
Comments

This flight terminated after 4 hr duration because of balloon leak. The ballast circuit was activated after 2-1/2 hr, thus prolonging flight another 1-1/2 hr. A new program sequence was tried on this flight. Frequency switching occurred on each revolution of the code disk; thus a transmitted code sequence appeared on each frequency at approx. 6-sec intervals. FCC had no trouble in receiving and tracking the signal. This program sequence allowed a shorter "on-time" period to be used, thereby conserving power. The only drawback to this program schedule is that it requires two receivers in operation simultaneously in order to monitor all data. The new converter was also employed on this flight, allowing radiated power to be doubled.

DATE/TIME	FIX		CLASS
080016	38.5°N	72.8°W	B
0116	39.7	70.0	B
0216	40.0	66.0	C

UNCLASSIFIED





FLIGHT NR 18

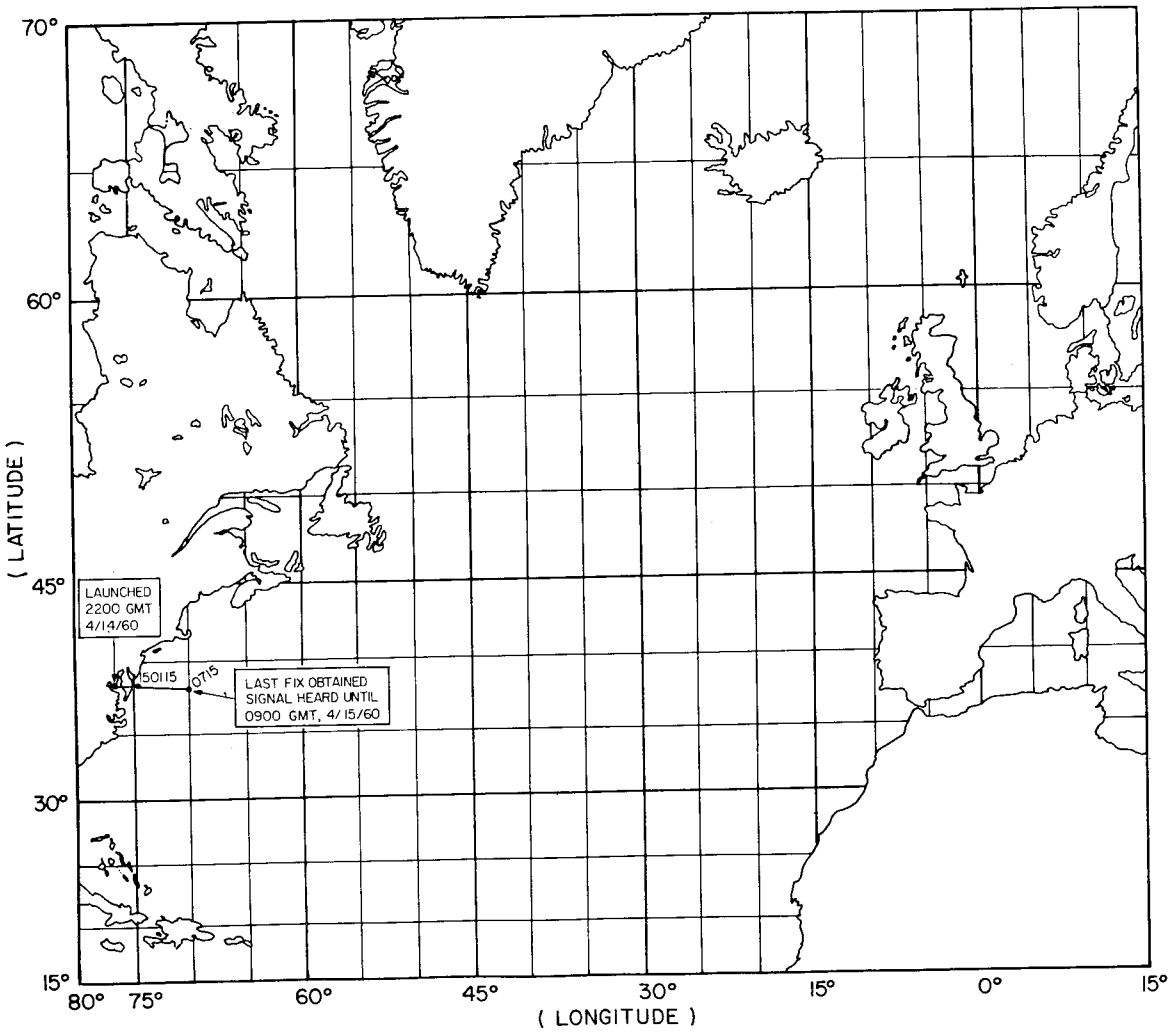
Launched	2200, 4/14/60
Balloon Type	Cylinder
Free Lift	8 percent
Expected Flight Duration	100 hr
Probable or Actual Duration	Unknown
Data Period	11 hr

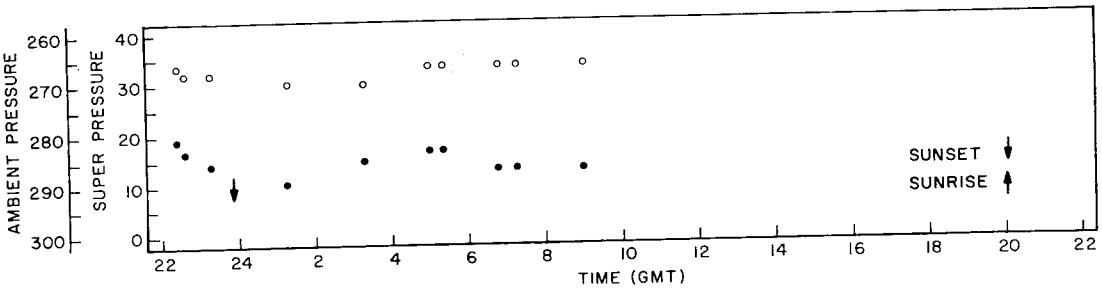
Comments

Internal temperature data (battery package) indicated a short circuit in equipment, which caused premature exhaustion of the batteries; thus transmissions ceased after 11 hours. Balloon performance was normal during this restricted flight-data period.

DATE/TIME	FIX		CLASS
150115	38.9°N	75.3°W	B
0317	38.5	73.0	B
0516	38.3	71.2	B
0715	38.0	70.4	A

UNCLASSIFIED





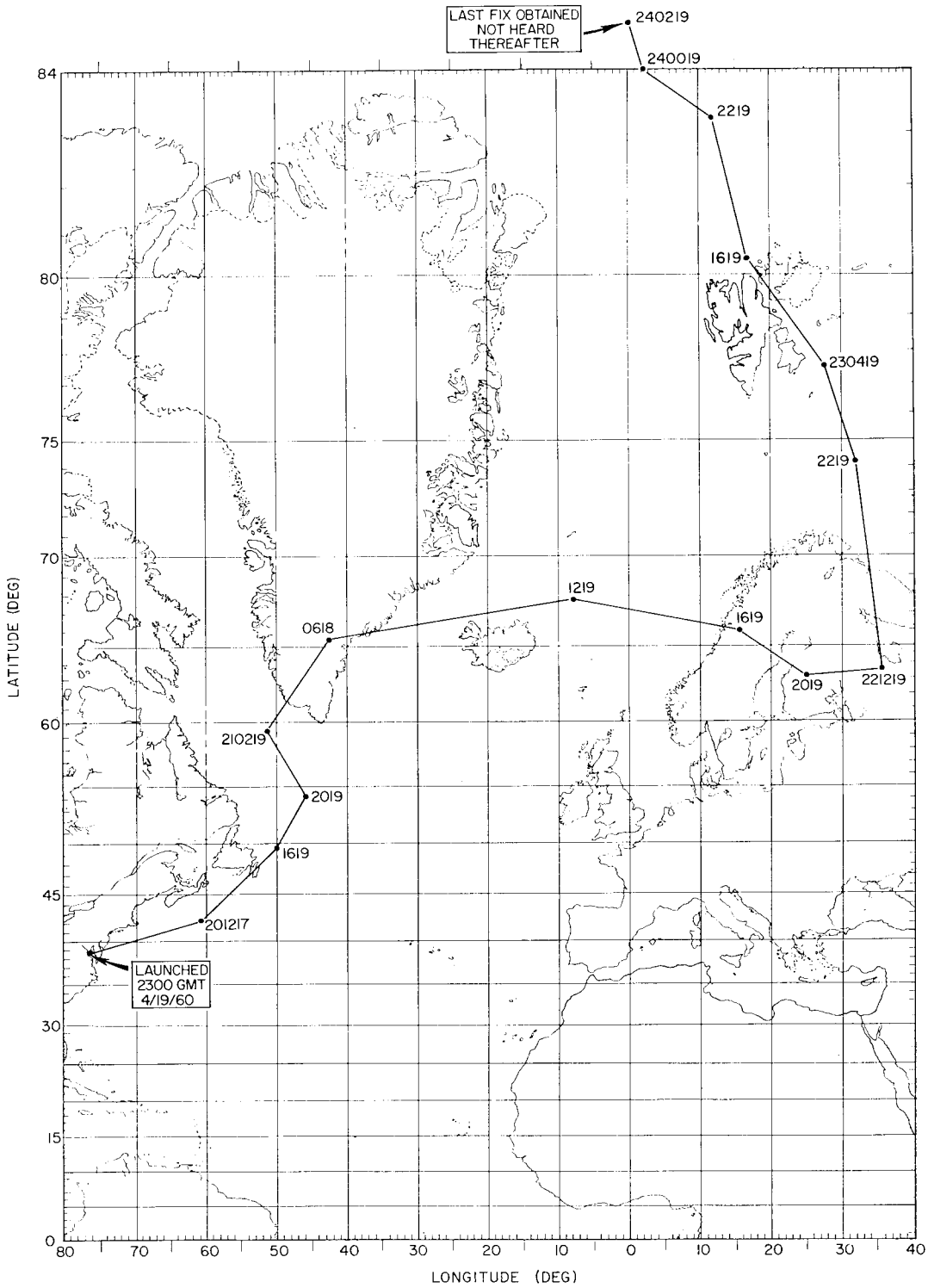
FLIGHT NR 19

Launched	2300, 4/19/60
Balloon Type	Cylinder
Free Lift	10 percent
Expected Flight Duration	99 hr
Probable or Actual Duration	99 hr
Data Period	99 hr

Comments

Excellent flight, programmed termination. The unusual flight trajectory took it above 80°N latitude. No sunset was observed on the balloon during last 24 hr of flight. Although this balloon traversed approx. 40° of latitude, there was no indication of drop off in superpressure. Data reception and tracking were good, except during latter portion of flight, when due to extreme range and location of balloon, tracking became difficult.

DATE/TIME	FIX		CLASS
200016	38.7°N	76.3°W	B
0216	38.3	74.2	C
0417	38.0	72.5	B
0617	38.4	68.8	B
0817	40.0	66.4	B
1016	41.3	64.1	C
1217	43.0	60.7	B
1419	45.8	57.0	B
1619	49.3	50.0	B
1819	51.6	45.5	B
2019	54.0	46.1	C
2219	55.3	51.5	C
210019	58.5	51.5	B
0219	59.5	51.8	B
0419	61.0	52.0	C
0618	65.3	40.9	C
1219	67.3	08.0	D/250
1419	65.6	03.0°E	C
1619	66.0	16.1	C
1819	63.7	19.3	C
2019	62.6	24.8	D/100
220219	63.7	28.0	C
1219	63.8	35.0	D/250
1819	73.7	24.0	D/200
2019	73.0	30.0	C
2219	74.0	31.5	A
230019	75.0	30.0	C
0219	75.7	25.0	C
0419	77.4	29.0	B
1419	81.3	12.5°W	C
1619	80.6	18.0	D/150
1819	80.7	02.0	D/100
2019	82.0	10.0	D/100
2219	83.0	01.0	C
240019	84.0	01.1	C
0219	85.5	00.0	C


LAST FIX OBTAINED
NOT HEARD
THEREAFTER
240219
240019
2219
1619
230419
2219
1219
1619
0618
2019
221219
210219
2019
1619
201217
LAUNCHED
2300 GMT
4/19/60
LATITUDE (DEG)
LONGITUDE (DEG)
84
80
75
70
60
45
30
15
0
80
70
60
50
40
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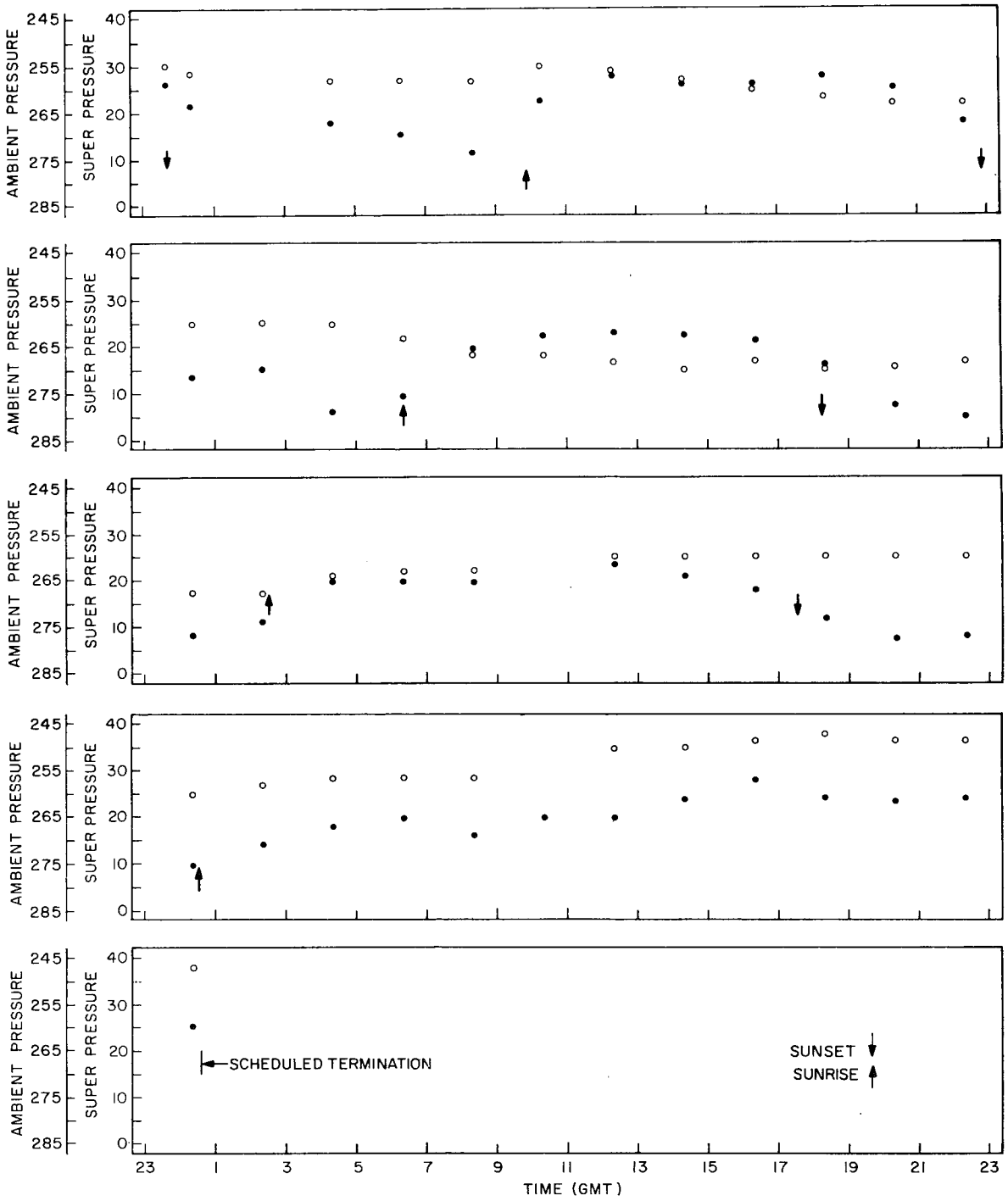
10
0
10
20
30
40

UNCLASSIFIED



FLIGHT NR 20

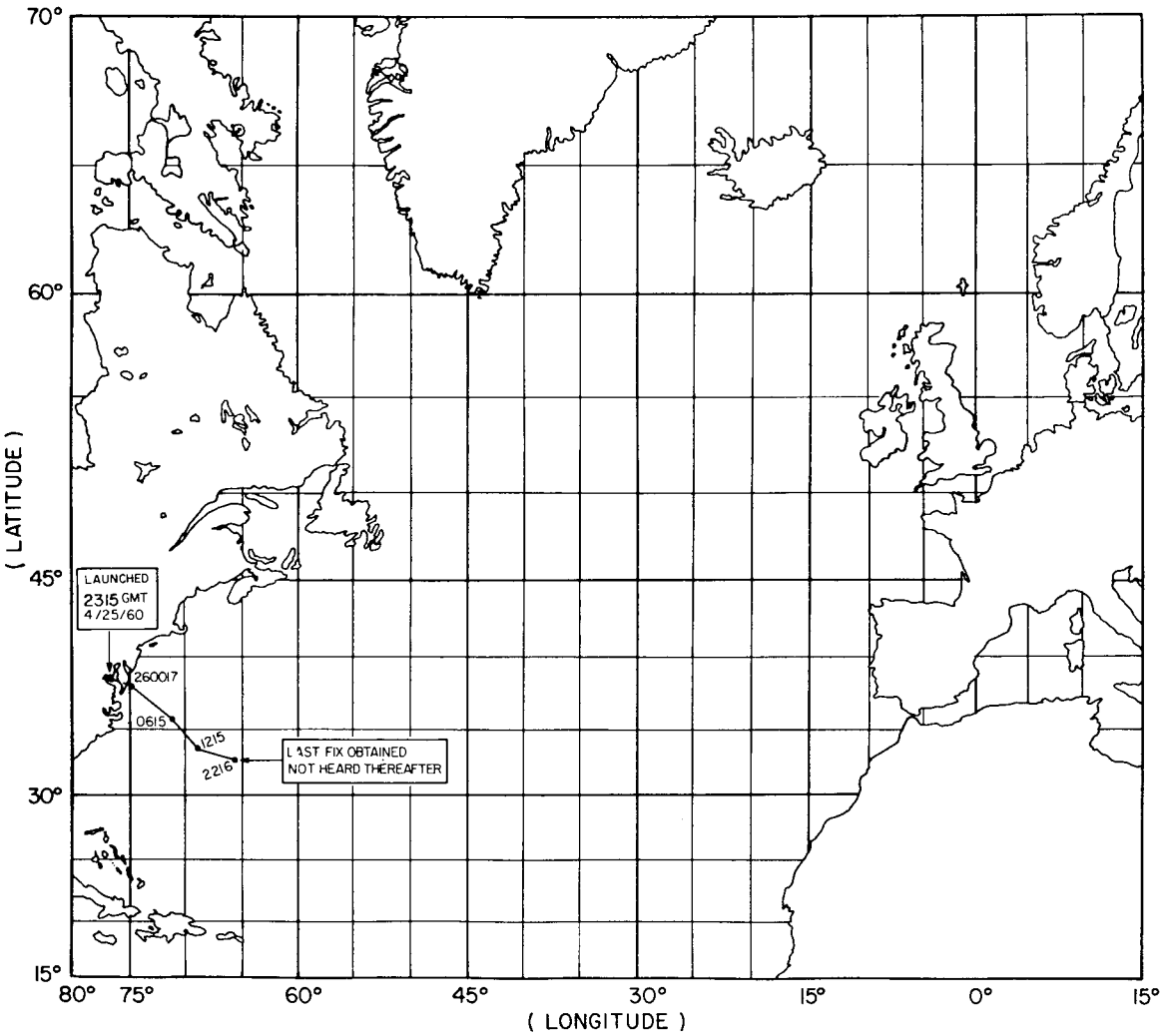
Launched	2315, 4/25/60
Balloon Type	Cylinder
Free Lift	10 percent + 3 percent
Expected Flight Duration	119 hr
Probable or Actual Duration	24 hr
Data Period	24 hr

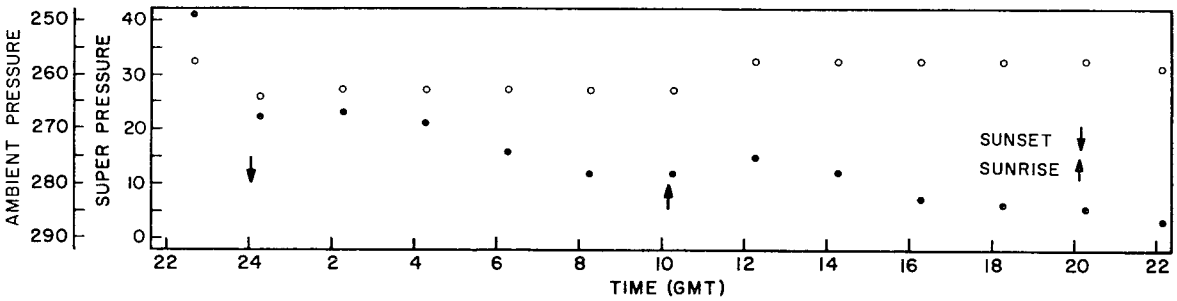
Comments

Termination of flight after 24 hr was due to loss of superpressure caused by balloon leak. During ascent, an apparent short circuit (momentary) in the ascent timer caused ballast circuit to be energized, thereby dropping ballast and delivering added superpressure to the balloon. Total superpressure was 13 percent. This caused superpressure to exceed its normal range by a considerable margin, and probably was responsible for balloon leak occurring.

DATE/TIME	FIX		CLASS
260017	37.7°N	75.0°W	C
0216	37.1	73.9	B
0416	36.7	72.8	B
0615	35.3	71.9	B
0815	35.3	69.1	B
1215	33.6	68.7	C
1417	33.2	67.7	B
1815	33.1	68.0	C
2016	33.0	67.5	C
2216	32.8	66.0	B

UNCLASSIFIED



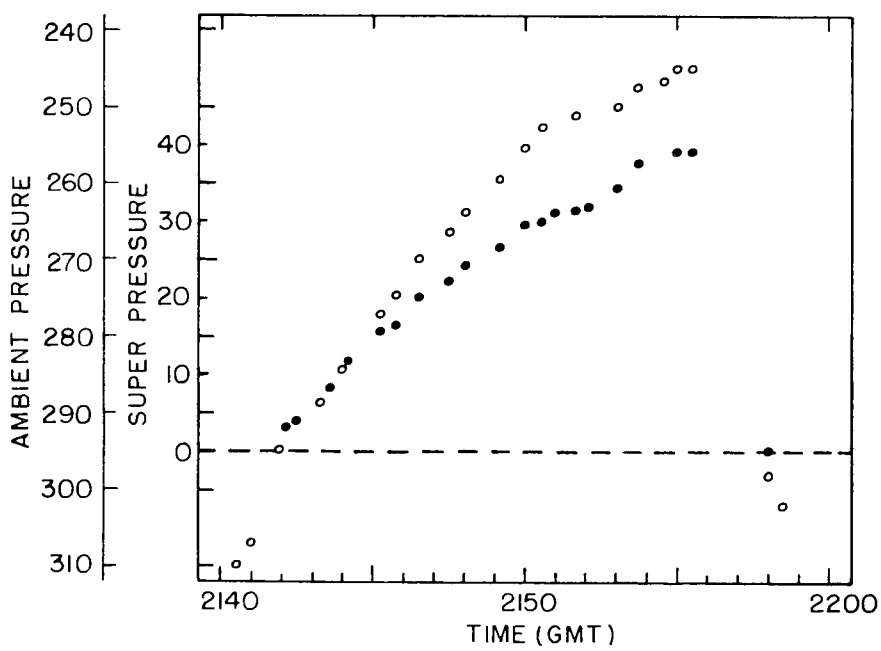


FLIGHT NR 21

Launched	2030, 6/1/60
Balloon Type	Sphere
Free Lift	10 percent
Expected Flight Duration	72 hr
Probable or Actual Duration	1-1/2 hr
Data Period	1-1/2 hr

Comments

Balloon ruptured when it reached ceiling. Equipment was recovered in good condition in Chincoteague, Va. This was the first flight on which one of a new series of spherical balloons was employed. It is quite possible that 10 percent free lift is more than this type balloon can withstand.



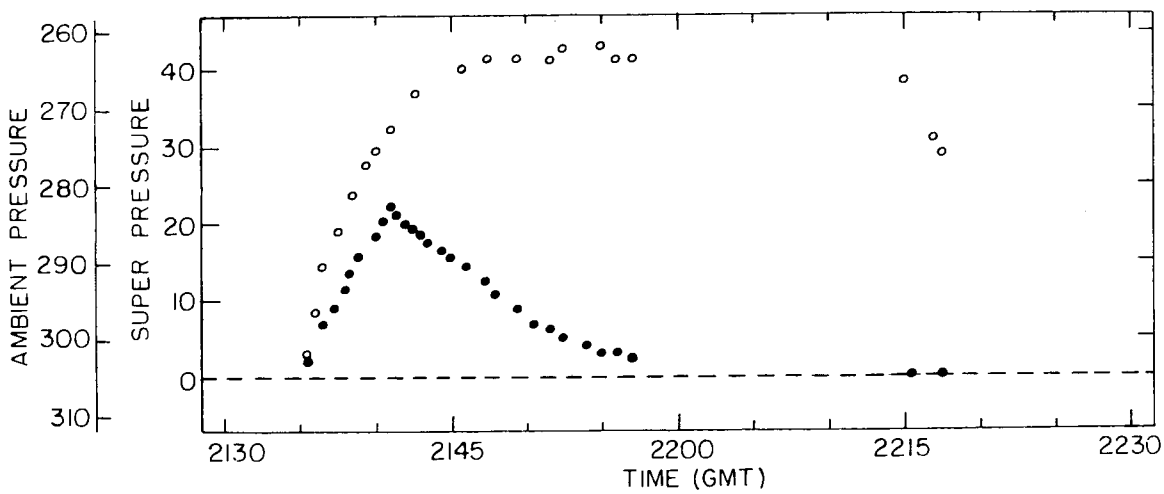
UNCLASSIFIED

FLIGHT NR 22

Launched	2030, 6/16/60
Balloon Type	Sphere
Free Lift	7 percent
Expected Flight Duration	50 hr
Probable or Actual Duration	1-1/2 hr
Data Period	1-1/2 hr

Comments

Balloon failed at ceiling. Superpressure reached 22.2 millibars, then immediately began falling off. Continued to ballast drop contact. At end of 100-min period, ballast squib was energized, releasing ballast (2159.00). This drop maintained balloon at altitude for only a few minutes. Sixteen minutes later (2215.00), during regular transmission, superpressure was at zero and balloon was descending. No obvious reason for balloon failure. Equipment was recovered ten days later, in the ocean, 30 miles off the coast of New Jersey.



FLIGHT NR 23

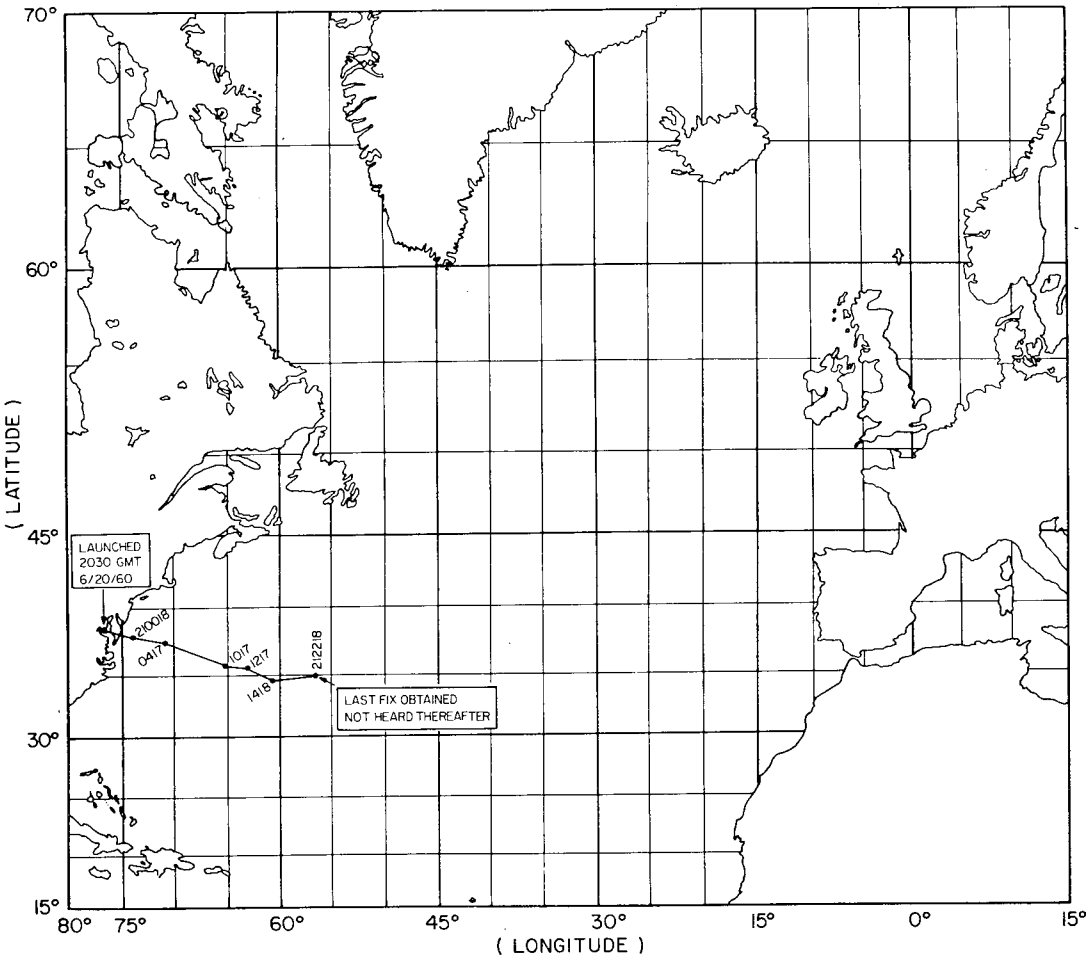
Launched	2030, 6/20/60
Balloon Type	Sphere
Free Lift	5 percent
Expected Flight Duration	60 hr
Probable or Actual Duration	26 hr
Data Period	26 hr

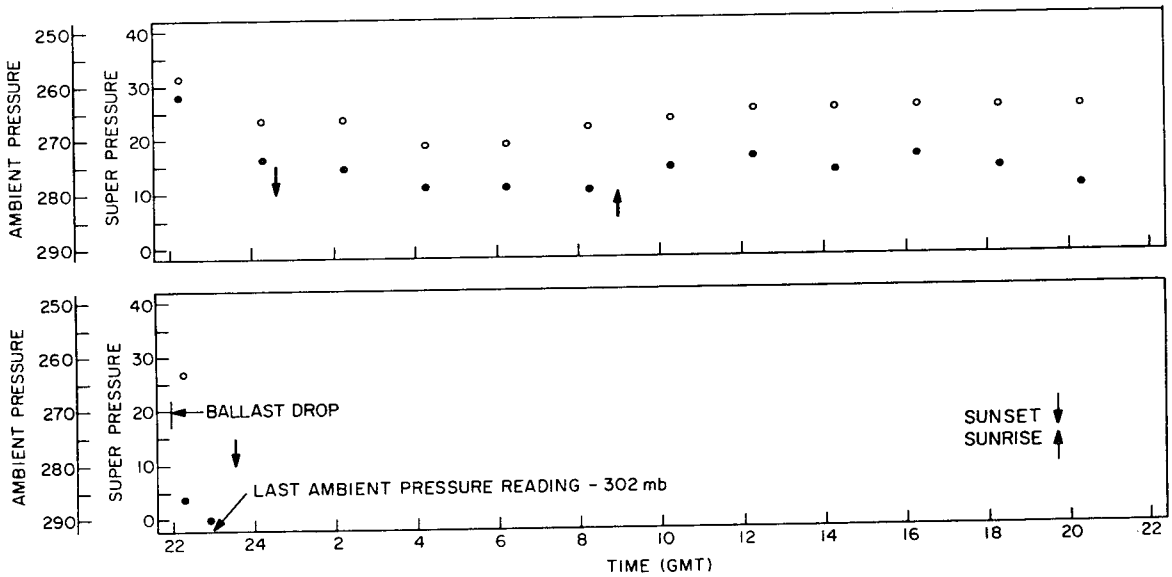
Comments

Termination due to loss of superpressure caused by balloon leak. Ballast drop had very little effect.

DATE/TIME	FIX		CLASS
202218	37.6 °N	74.7 °W	A
210018	37.1	74.1	A
0217	36.9	72.6	A
0417	37.2	70.5	B
1017	35.6	65.2	C
1217	35.5	63.3	A
1418	34.7	61.0	A
1618	34.5	60.0	A
1818	34.8	59.1	B
2018	34.7	59.0	B
2218	35.0	57.2	A

UNCLASSIFIED



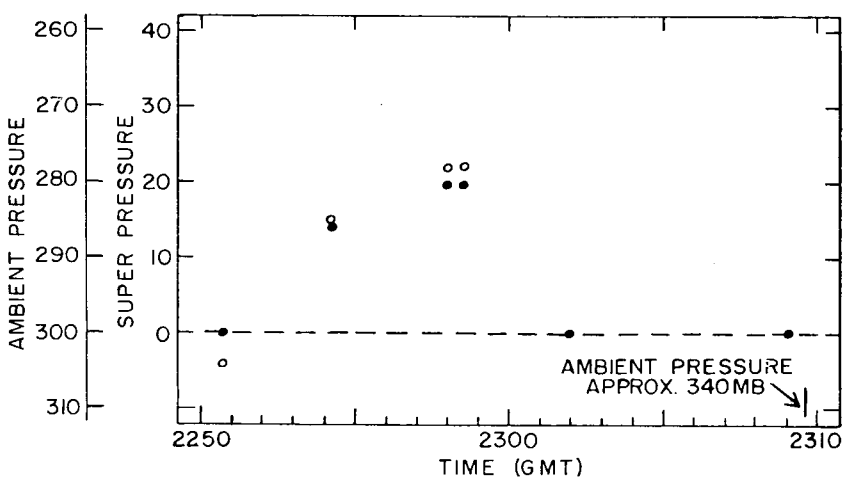


FLIGHT NR 24

Launched	2144, 7/13/60
Balloon Type	Sphere
Free Lift	7 percent
Expected Flight Duration	100 hr
Probable or Actual Duration	1-1/2 hr
Data Period	1-1/2 hr

Comments

Balloon ruptured at ceiling. Equipment included first model of ambient-temperature encoder using a ventilated thermistor. Equipment was recovered in Princess Anne Co., Md. This is the fourth successive flight on which termination has been due to balloon rupture and/or leakage. Such performance indicates inferior or faulty balloons. The manufacturer has initiated a more thorough testing and evaluation program in order to assure improved balloon performance; thus future models of the spherical balloon should show better flight reliability.



CLASSIFIED

FLIGHT NR 25

Launched	2100, 8/10/60
Balloon Type	Cylinder
Free Lift	7 percent
Expected Flight Duration	74 hr
Probable or Actual Duration	49 hr
Data Period	49 hr

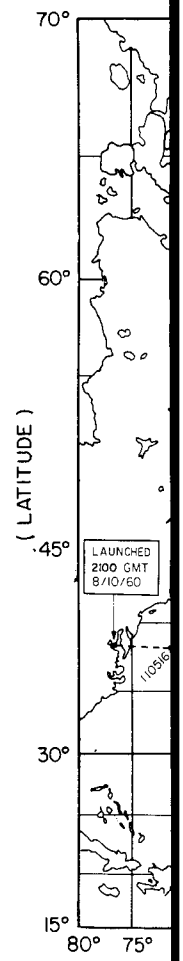
Comments

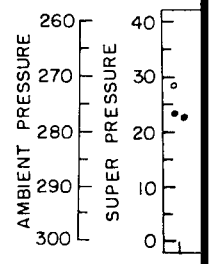
Termination was due to loss of superpressure. Although the ballast circuit was energized during the second sunset, the ballast was not dropped. Consequently, during the third sunset termination occurred. The reason for the loss of superpressure and ballast drop failure, is unknown. This balloon was an old-model cylinder balloon which had been accidentally punctured while undergoing tests at NRL. It was subsequently patched and ground tested prior to use on this flight.

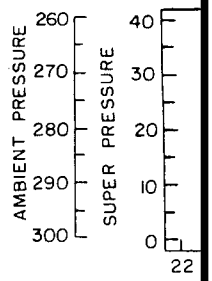
The equipment included means for telemetering ambient air temperature. This was the first flight from which significant amount of ambient-air-temperature data were obtained, but due to discontinuity in recording data, what was obtained was of little value, since it was impossible to completely identify and interpret it.

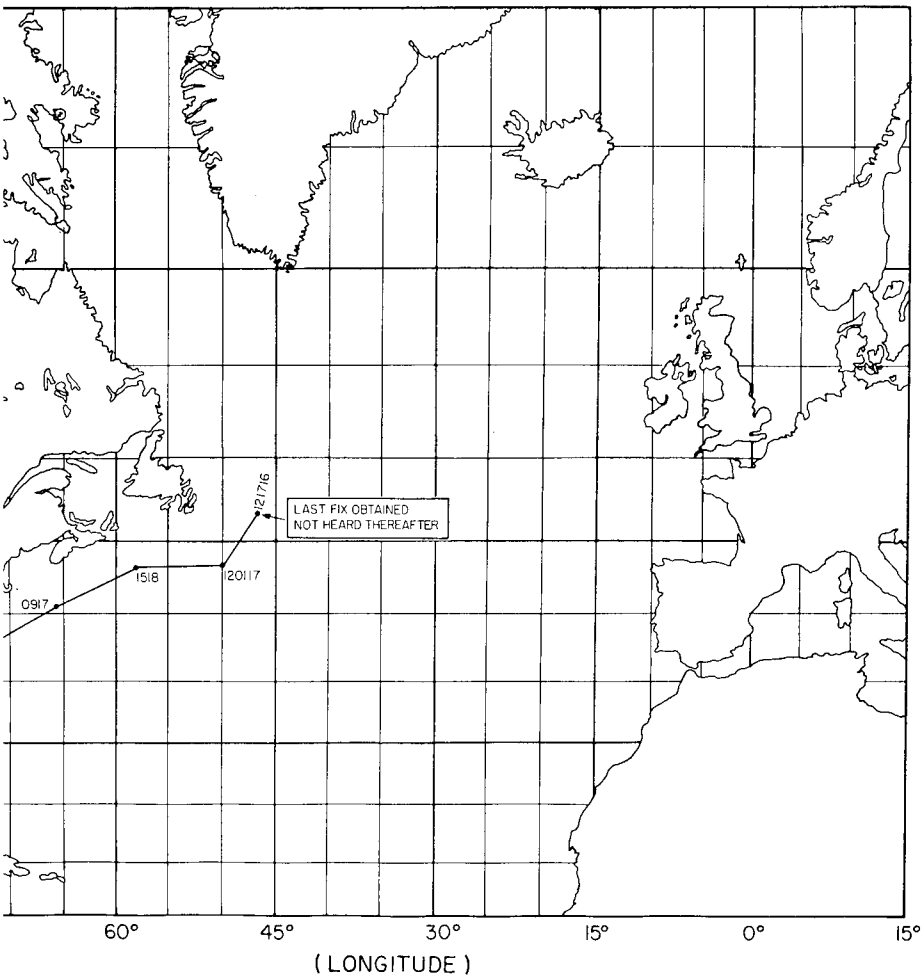
Some faulty keying was noted during portions of this flight. A laboratory check of the keying circuit used on this flight revealed no specific reason for this occurrence.

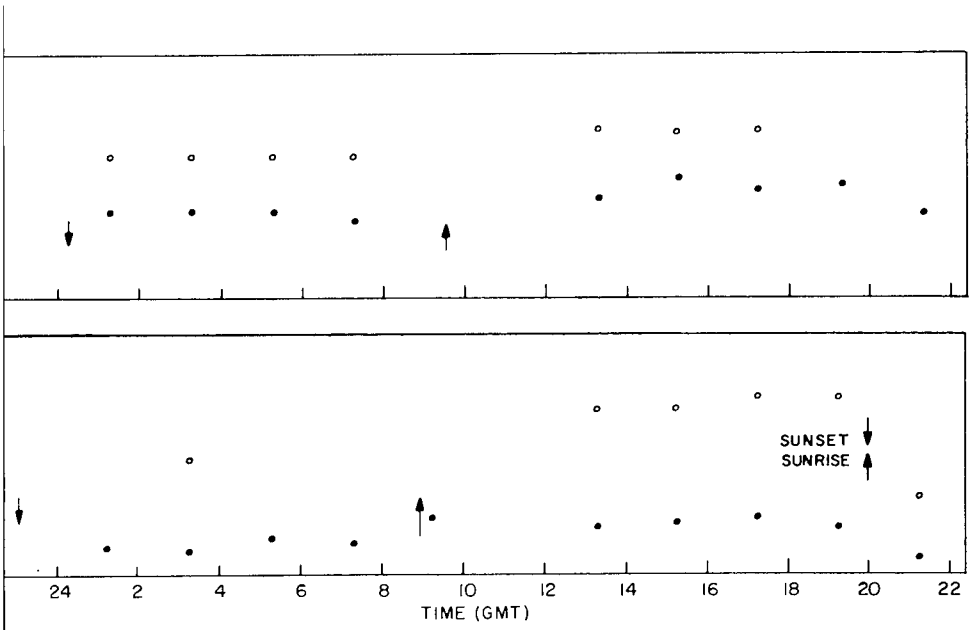
DATE/TIME	FIX		CLASS
110516	38.3°N	71.3°W	D/100
0717	39.7	67.8	C
0917	40.6	65.7	B
1318	41.5	62.2	C
1518	42.9	58.0	C
1918	43.3	55.2	B
2118	43.9	53.8	C
120117	43.2	50.0	C
121716	46.8	46.6	D/100



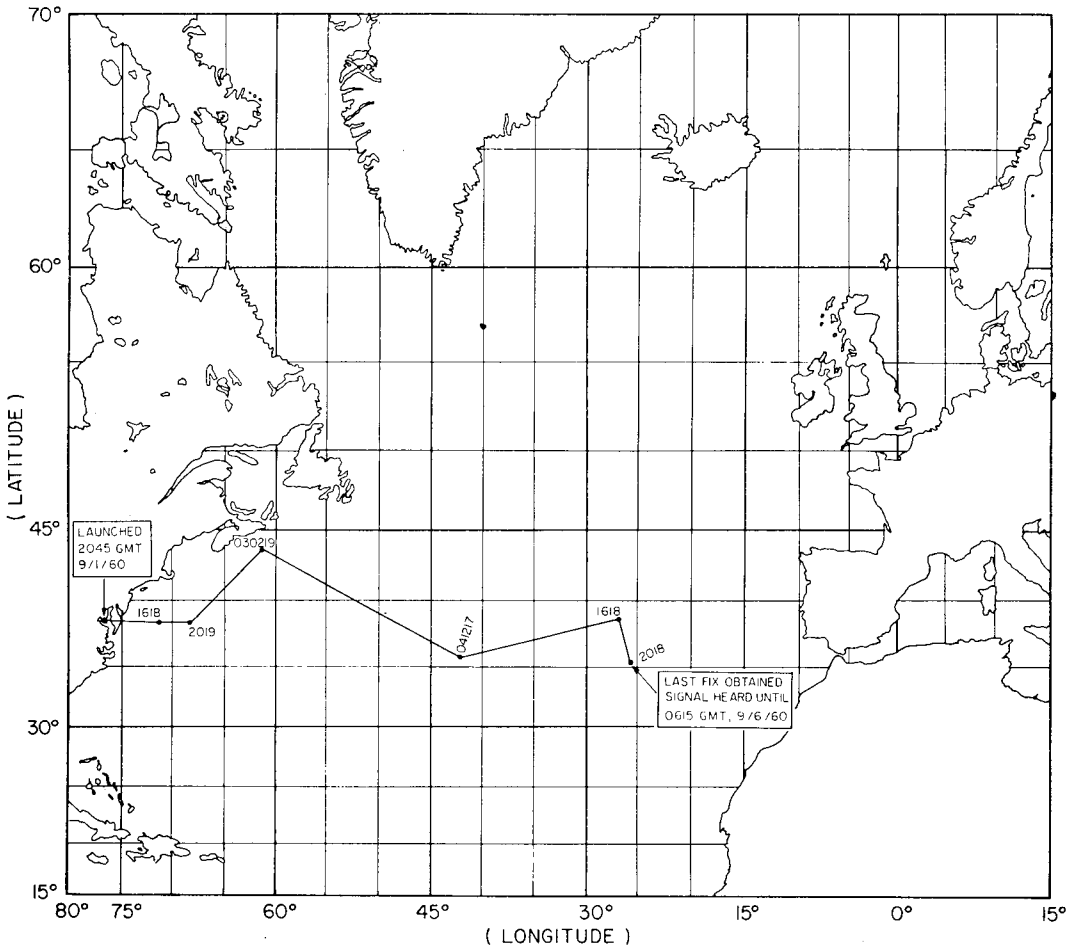


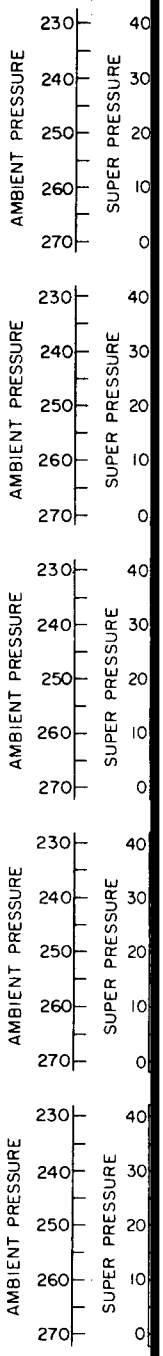


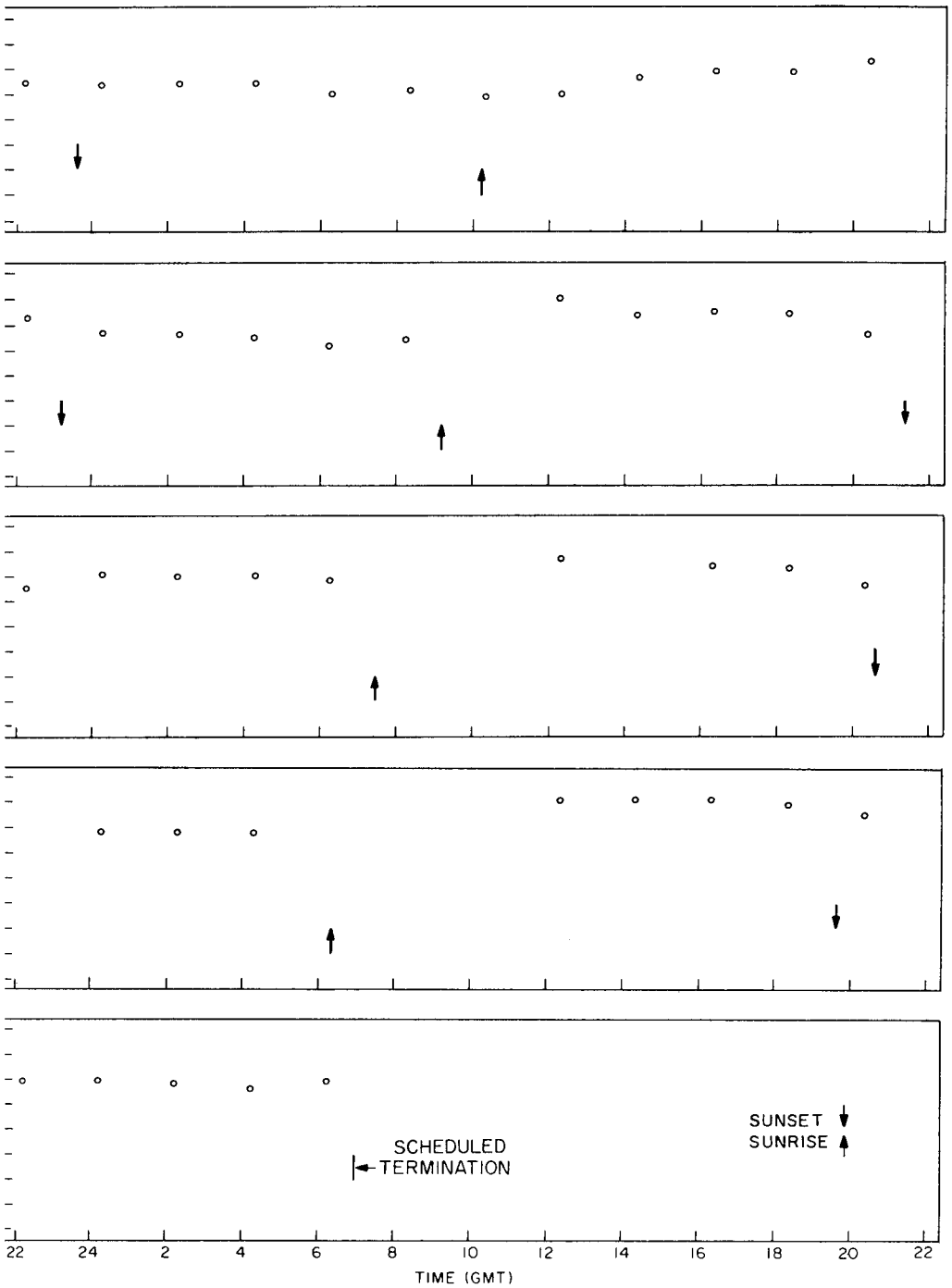

LAST FIX OBTAINED
NOT HEARD THEREAFTER
121716
120117
1518
0917
60°
45°
30°
15°
0°
15°
(LONGITUDE)


SUNSET
SUNRISE
24
2
4
6
8
10
12
14
16
18
20
22
TIME (GMT)

UNCLASSIFIED







was launched
transmission
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ıve occurred
:omplete loss
after 24 hrs,
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:r allowing
used on
ıll future

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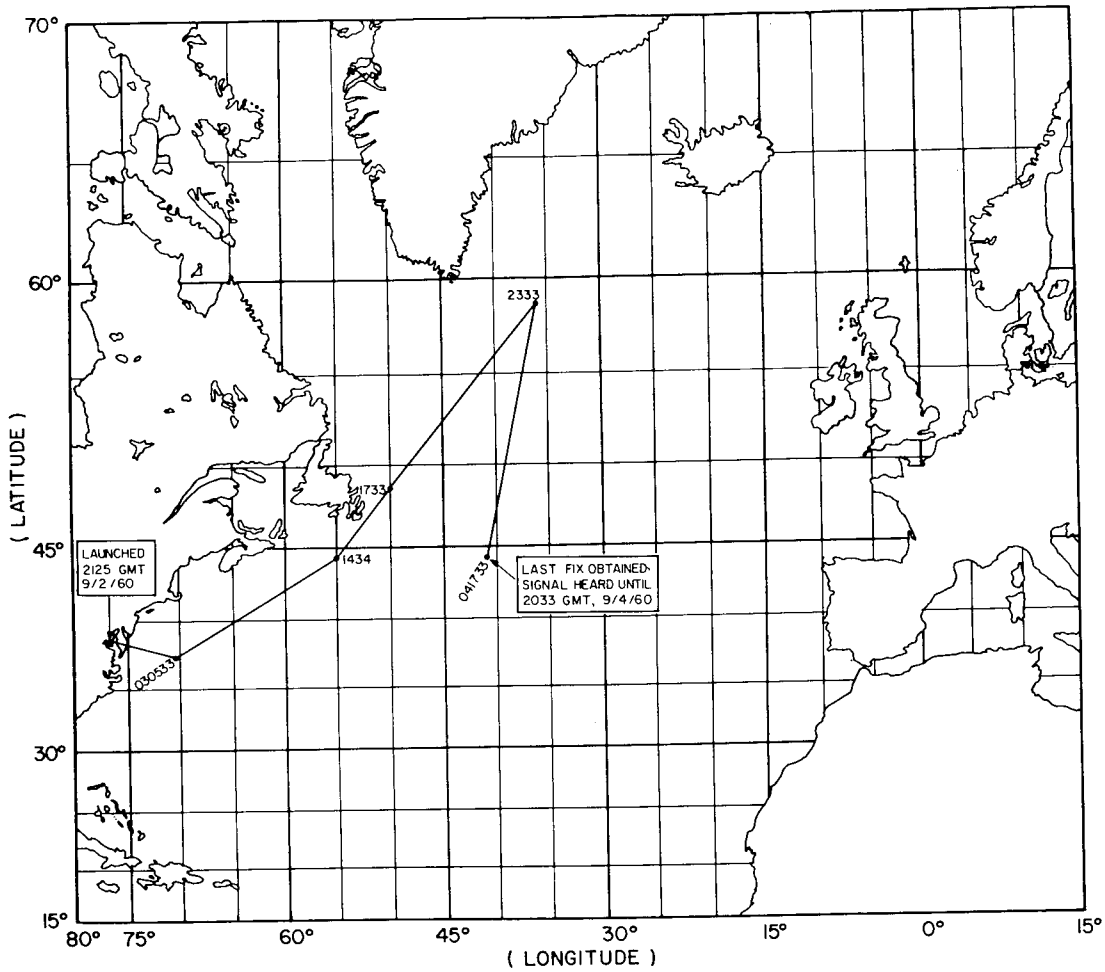
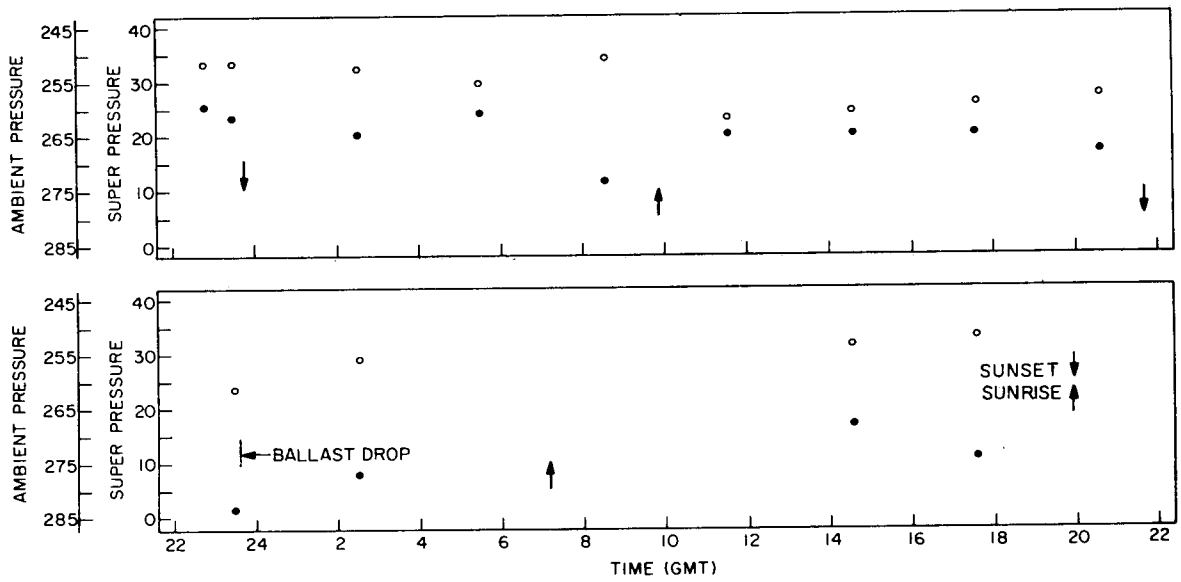




FLIGHT NR 28

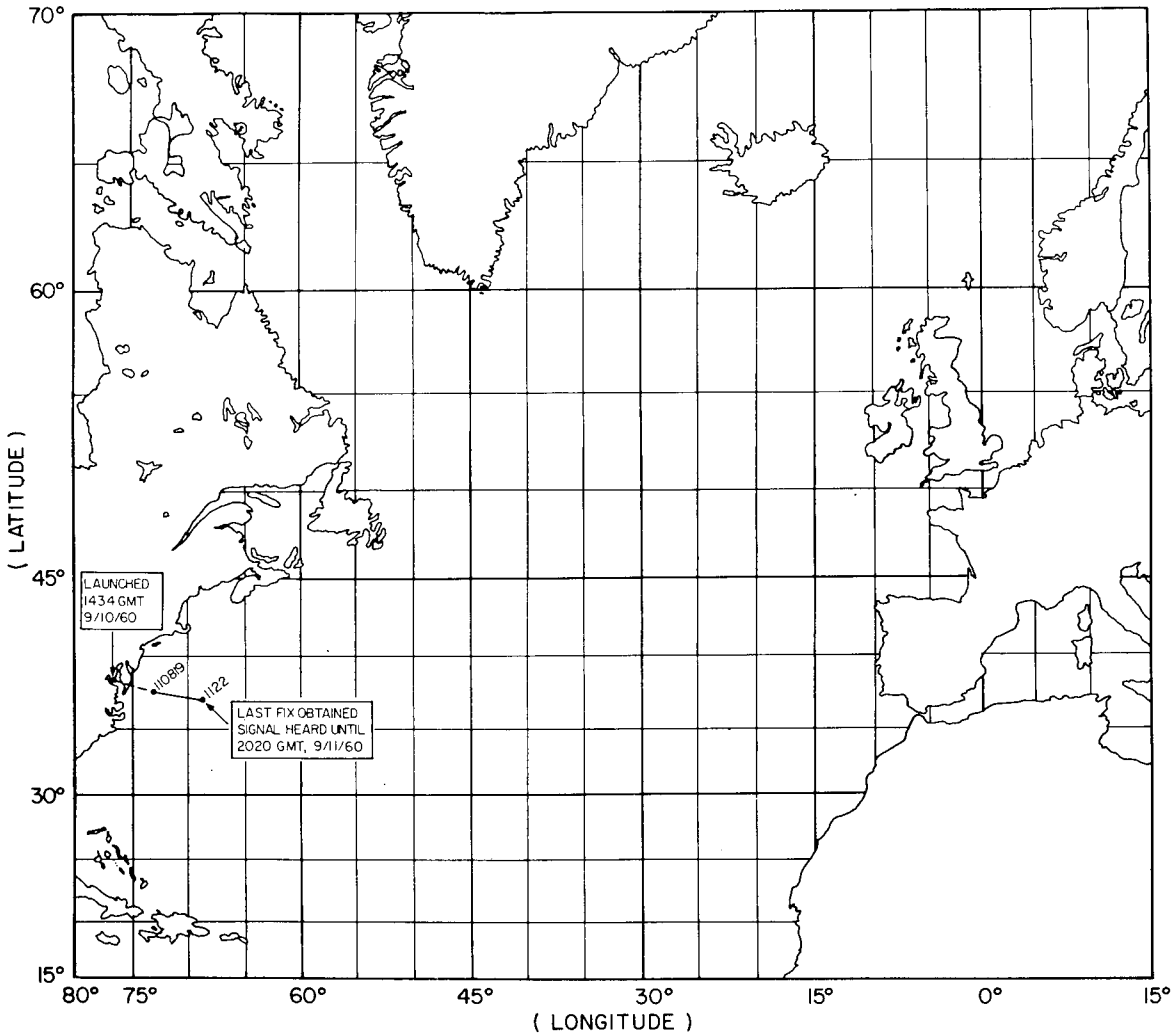
Launched	1434, 9/10/60
Balloon Type	Sphere
Free Lift	7 percent
Expected Flight Duration	147 hr
Probable or Actual Duration	Unknown
Data Period	21 hr

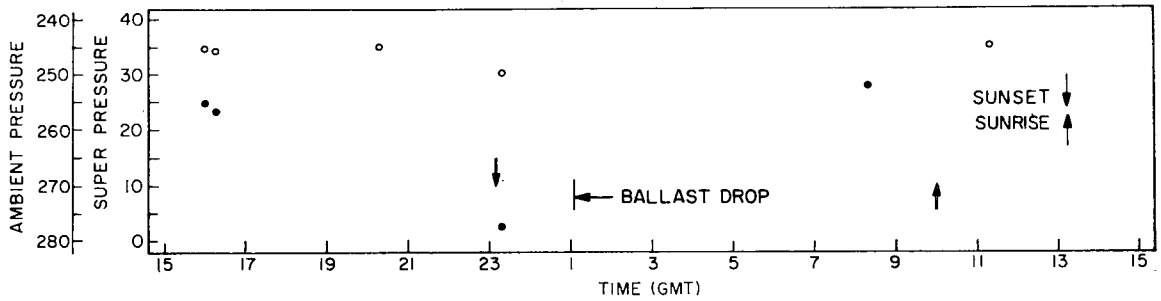
Comments

Defective keying was noted during ascent period and continued through flight. A thorough check of similar equipment at NRL showed that the keying circuit used on this and several preceding flights could cause intermittent operation and at times place excessive drain on the battery pack, causing premature exhaustion of batteries. From data received, it seems probable that such was the case on this flight. Ballast was dropped after approx. 10 hr, indicating possibly a leaky balloon. Lack of data prevented a complete analysis of balloon performance.

DATE/TIME	FIX		CLASS
102020	39.1°N	74.8°W	B
2320	37.5	71.0	B
110819	37.3	73.2	C
1122	37.0	68.3	B

UNCLASSIFIED





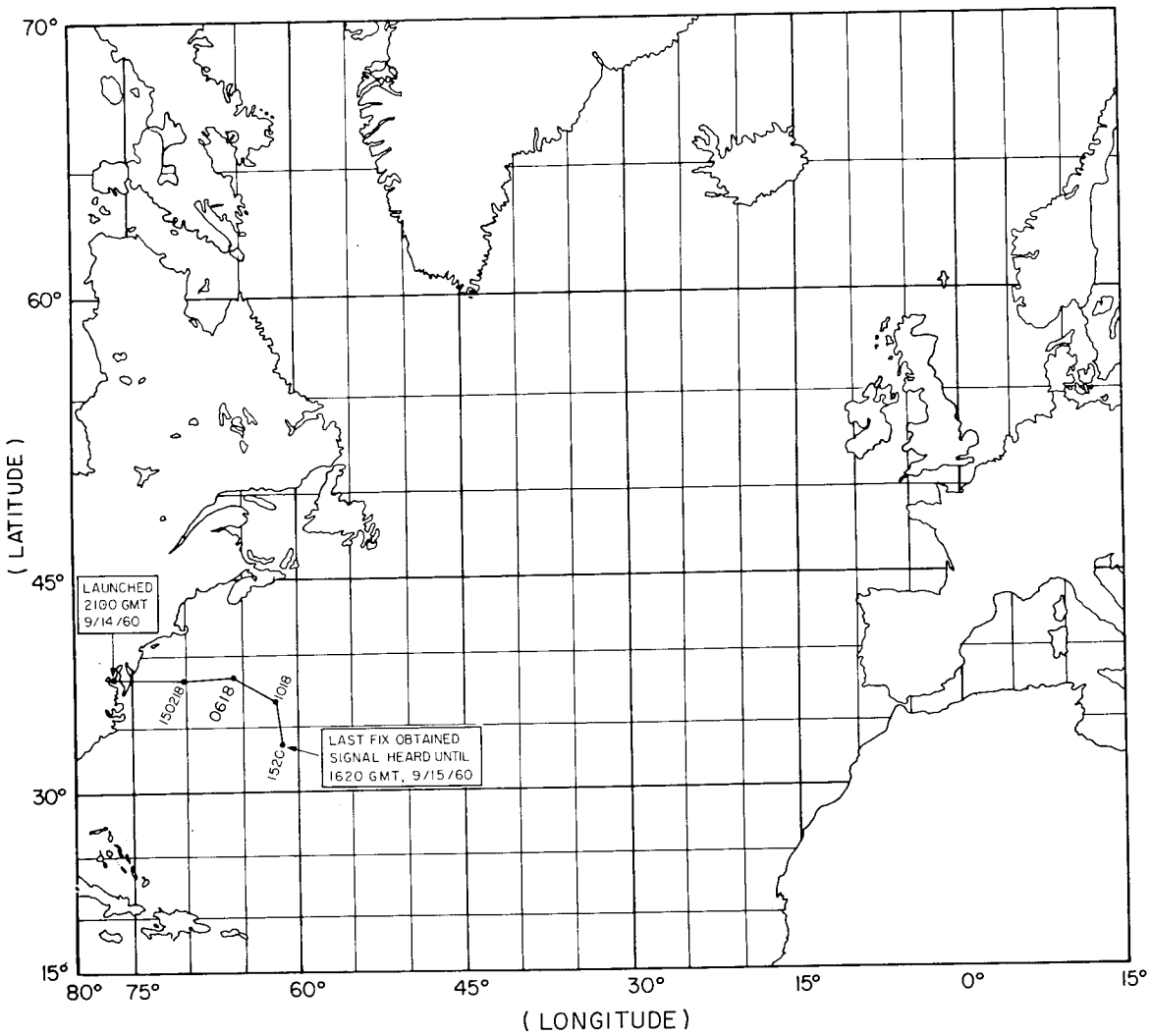
FLIGHT NR 29

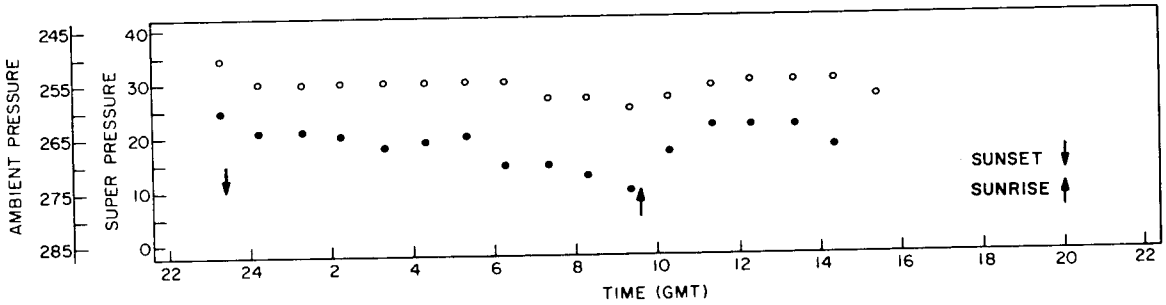
Launched	2100, 9/14/60
Balloon Type	Sphere
Free Lift	7 percent
Expected Flight Duration	46 hr
Probable or Actual Duration	Unknown
Data Period	18 hr

Comments

Examination of data from this flight showed an abnormal increase in battery-pack temperature during last two transmission periods, indicating excessive battery load which would have prematurely exhausted the batteries. Probable reason for this was a faulty keying circuit which placed excessive drain on batteries (similar to NR 28). Balloon performance was normal.

DATE/TIME	FIX		CLASS
142220	38.0°N	75.3°W	A
2320	38.1	74.4	B
150019	38.8	73.3	C
0118	38.8	72.0	C
0218	38.5	70.3	C
0318	39.0	69.9	C
0420	38.0	69.3	C
0517	38.4	68.3	C
0618	38.6	66.5	C
0717	37.0	63.3	D/200
0817	37.0	63.3	C
0918	36.8	63.1	D/150
1018	36.4	62.0	C
1118	35.4	62.0	C
1218	34.6	62.0	B
1320	33.9	61.6	C
1420	33.6	61.5	B
1520	33.5	61.3	C


70°
60°
45°
30°
15°
(LATITUDE)
80° 75° 60° 45° 30° 15° 0° 15°
(LONGITUDE)
LAUNCHED
2100 GMT
9/14/60
1502/8
0618
1018
1520
LAST FIX OBTAINED
SIGNAL HEARD UNTIL
1620 GMT, 9/15/60


AMBIENT PRESSURE
245
255
265
275
285
SUPER PRESSURE
40
30
20
10
0
22 24 2 4 6 8 10 12 14 16 18 20 22
TIME (GMT)
SUNSET
SUNRISE

FLIGHT NR 30

Launched	2150, 9/23/60
Balloon Type	Sphere (First bi-tape balloon)
Free Lift	7 percent
Expected Flight Duration	120 hr
Probable or Actual Duration	47 hr
Data Period	47 hr

Comments

An unknown factor (possibly circuit short causing ballast drop) caused substantial change in altitude after approx. 40 hr. The resulting change in superpressure evidently ruptured balloon. Superpressure immediately decreased and continued decreasing until it reached zero approx. 6 hr later. An improved balloon with double tape sealed seams was used on this flight. Similar balloons will be used on all future flights.

DATE/TIME	FIX		CLASS
232319	37.9°N	76.1°W	B
240117	37.3	76.0	C
0317	37.6	75.8	C
0517	37.0	75.4	C
0717	37.3	75.2	C
1119	36.1	74.5	C
1317	35.3	74.0	C
1517	34.7	73.4	B
1718	34.3	72.5	C
2117	33.0	71.5	B
2317	32.1	71.3	A
250117	31.6	70.1	A
0317	31.3	68.2	B
0516	30.6	67.0	B
0717	30.8	65.1	C
0917	30.4	64.3	C
1116	30.0	62.6	C
1318	30.5	60.0	C
251518	30.8	60.3	C
1718	31.8	60.5	C
1918	33.0	60.8	C
2118	33.9	59.9	B

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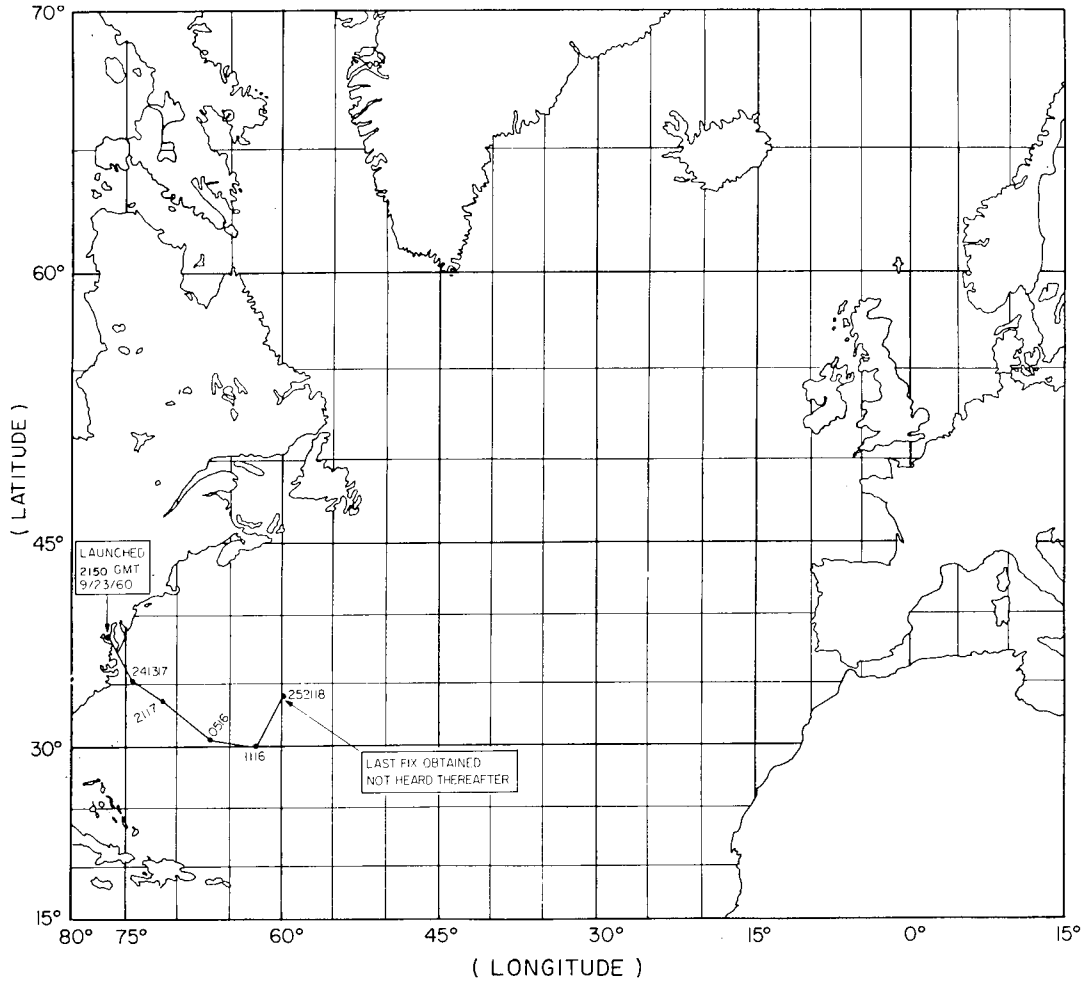

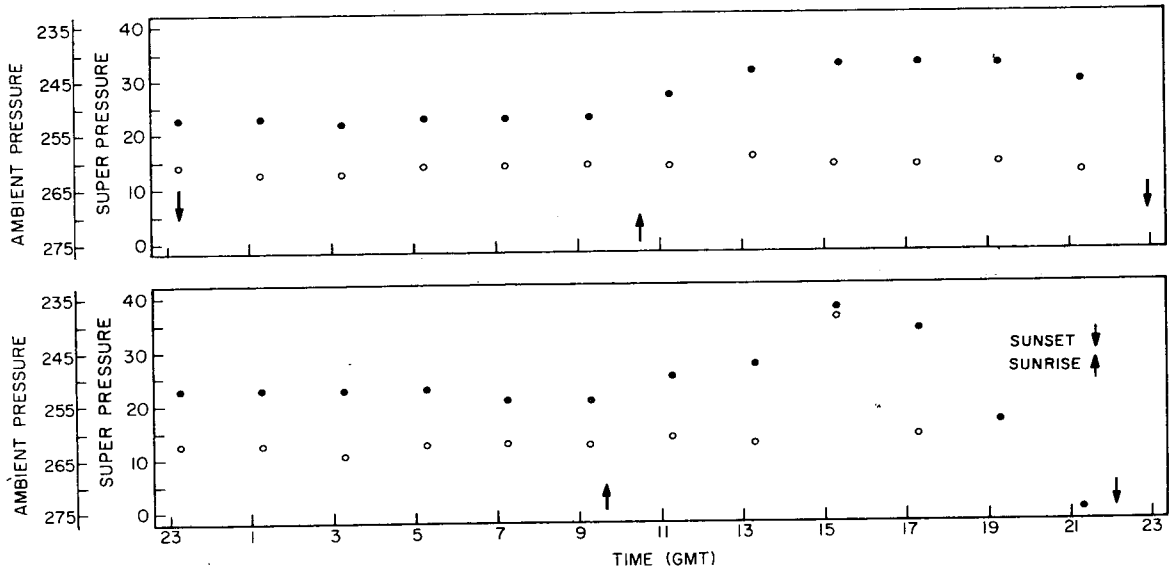

FLIGHT NR 31

Launched	2028, 9/27/60
Balloon Type	Sphere
Free Lift	7 percent
Expected Flight Duration	100 hr
Probable or Actual Duration	Unknown
Data Period	9 hr

Comments

Review of the data and equipment performance indicated a possible equipment malfunction. Laboratory tests indicated probable cause for malfunction was a faulty battery connection, which could cause complete loss of signal or operation. Instrumentation on this flight included an improved ambient-temperature encoder. Mechanical performance of this unit was good, but excessive drift of reference with change in temperature made evaluation of the data difficult.

DATE/TIME	FIX		CLASS
272319	38.1°N	70.9°W	B

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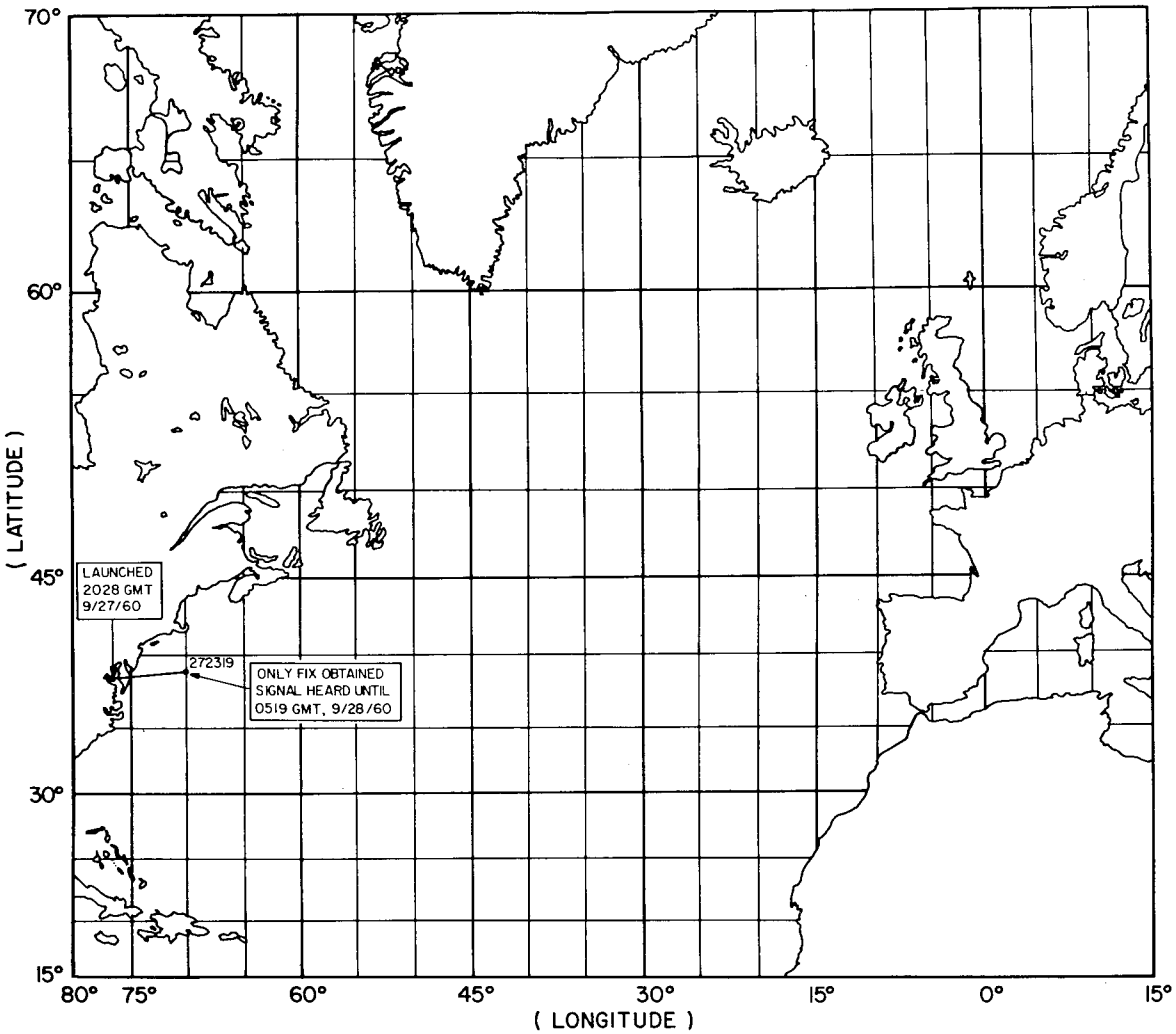

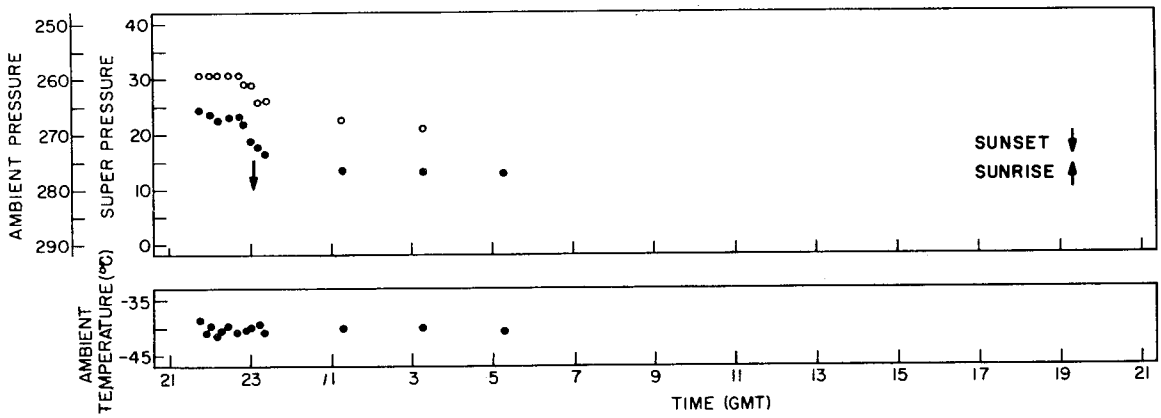

FLIGHT NR 32

Launched	2100, 10/10/60
Balloon Type	Sphere
Free Lift	7 percent
Expected Flight Duration	60 hr
Probable or Actual Duration	Unknown
Data Period	93 hr

Comments

Signal was lost four hours after launch. Signal was heard again 48 hours later and monitored for an additional 45 hours until too weak to be heard. The ballast circuit was energized some time during this off period, but the pressure data do not indicate any ballast drop until time of scheduled termination. At that time ballast was dropped, causing an approximate 15-millibar change in altitude. Scheduled termination after 60 hours did not occur due to malfunction of superpressure tube release. Equipment thereafter was supported by superpressure tube, which resulted in superpressure encoder being thrown far off scale. Laboratory check of similar equipment indicated that probable cause for loss of signal was a faulty battery connection (similar to NR 31). Also, a check on the ballast-release circuit showed that the ballast-release squib did not always cut the ballast-retaining string cleanly. When this occurs, the ballast will not separate from the equipment unless it experiences some jolt or shock such as would occur during termination.

The balloon performance looked very good during the portion of the flight for which superpressure data were available.

DATE/TIME	FIX		CLASS
102218	37.0°N	76.2°W	C
2318	37.3	76.6	D/150
122220	41.3	43.0	B
2321	41.2	40.8	C
130021	41.8	39.8	D/100
0121	42.8	37.3	D/150
0221	43.5	34.8	D/150
0620	43.5	34.8	D/200
1121	44.5	25.5	D/150
1321	47.0	23.8	D/100
1722	42.0	25.0	D/150
1822	41.0	20.5	D/150
2121	37.0	16.5	D/200
2221	35.5	14.0	D/200
140122	32.8	05.0	D/250
0222	31.4	02.3	D/250

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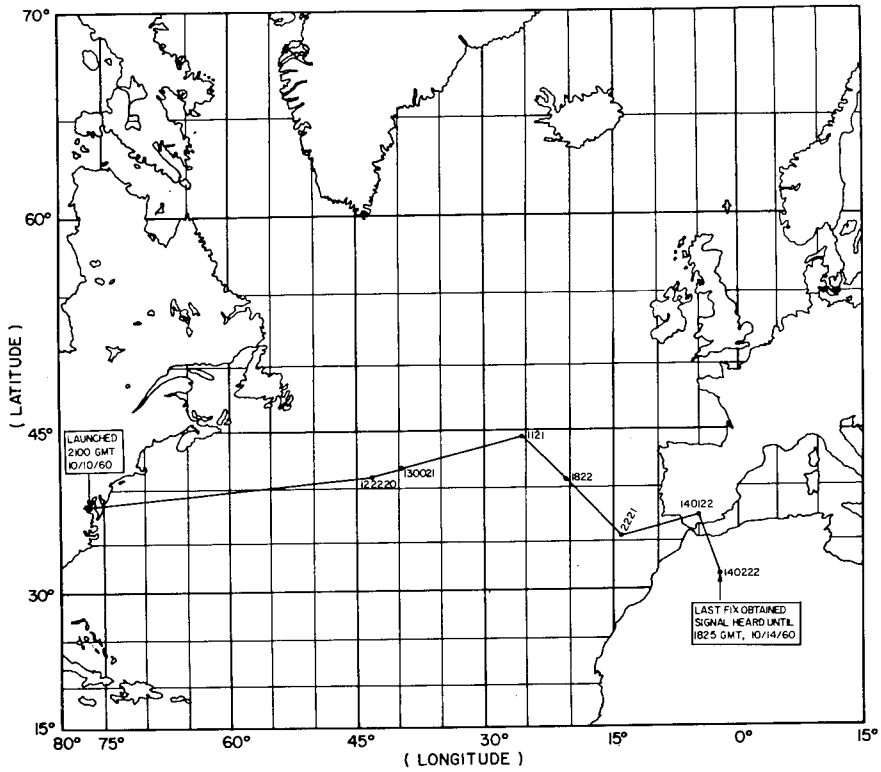

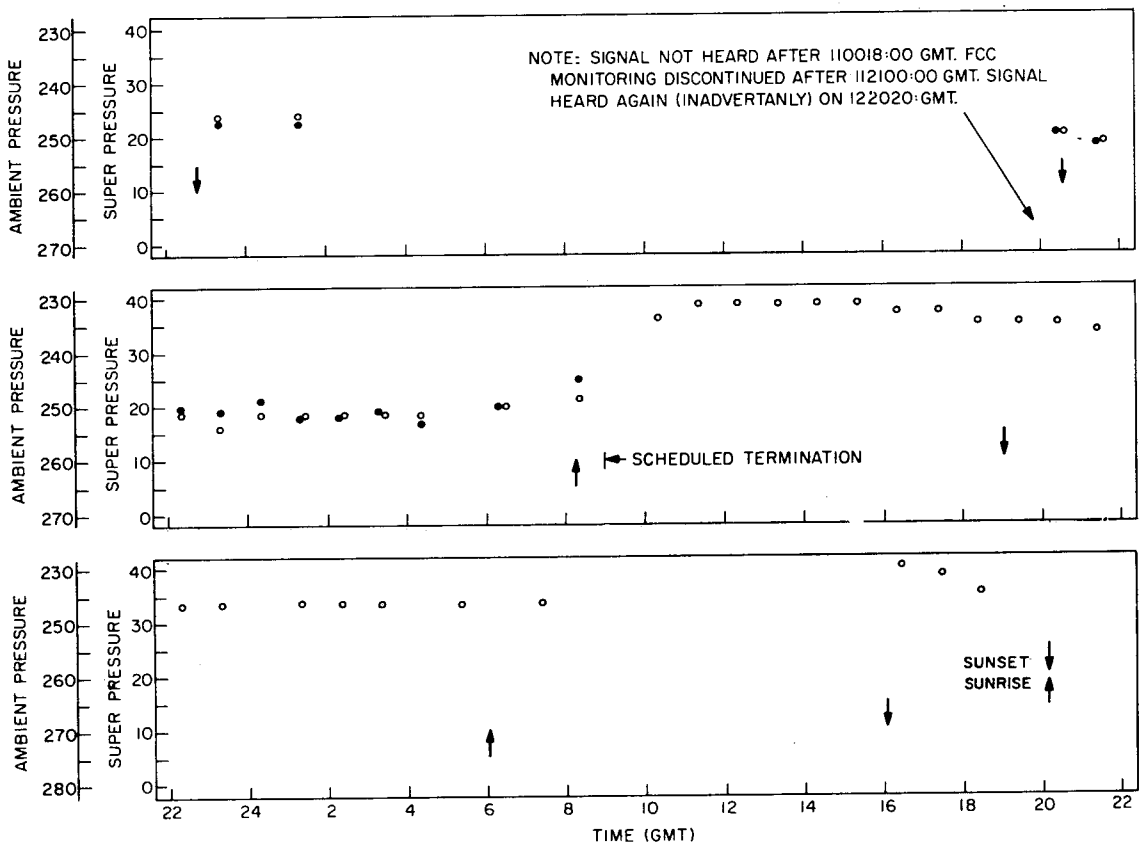

FLIGHT NR 33

Launched	2030, 10/17/60
Balloon Type	Sphere
Free Lift	7.3 percent
Expected Flight Duration	120 hr
Probable or Actual Duration	Unknown
Data Period	21 hr

Comments

The superpressure tube pinched off during launching due to an improper load-harness arrangement; thus no superpressure data were obtained during flight. Reason for early transmission termination unknown, although it could have been a faulty battery connection. A thorough check of a similar equipment indicated that such was the probable cause of intermittent operation on flights NR 31 and NR 32. This flight equipment was the same as was used on those flights.

DATE/TIME	FIX		CLASS
172316	38.5°N	76.0°W	C
180118	39.3	75.8	C
0518	41.8	72.9	C
0717	41.6	71.4	C
1318	49.1	58.0	B
1517	50.5	59.0	C
1718	53.2	56.1	D/200

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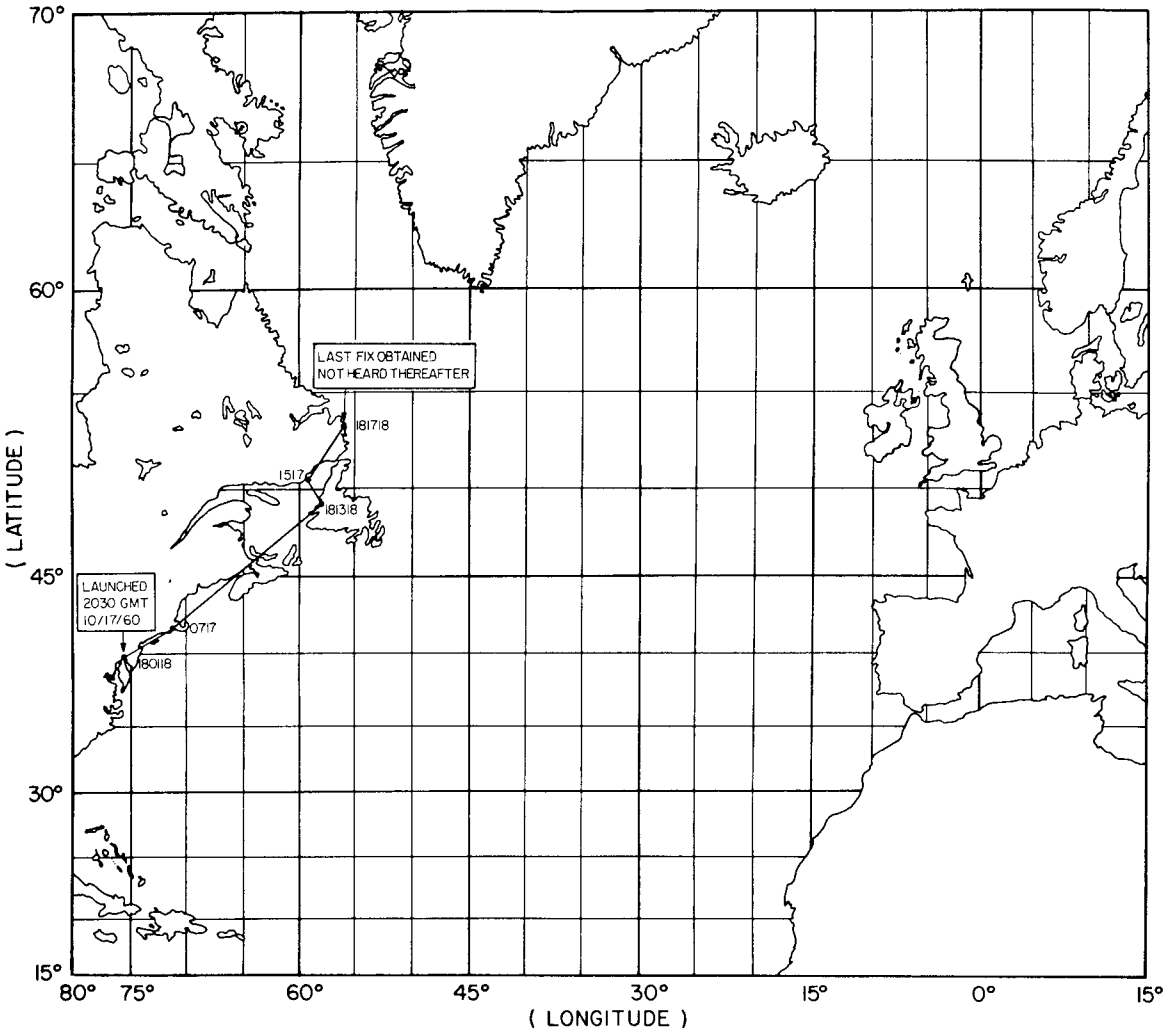

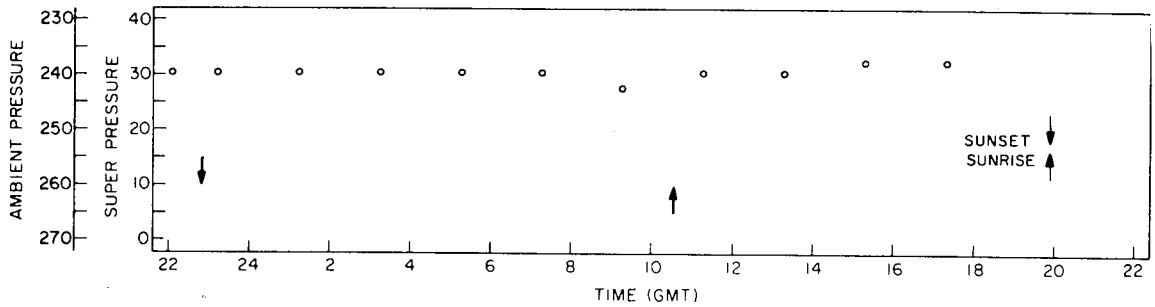

FLIGHT NR 34

Launched	2203, 11/2/60
Balloon Type	Sphere
Free Lift	8 percent
Expected Flight Duration	58 hr
Probable or Actual Duration	58 hr (probable)
Data Period	53 hr

Comments

This flight probably reached time termination. A combination of bad propagation, extreme range, and weak signal made reception extremely difficult during some portions of this flight, and thus termination could not be confirmed. A periodic shift in transmission programming, caused by the binding of the clock-termination counter gear, added to the difficulty. An improved model of temperature encoder, with ambient-air and balloon-gas temperature sensors, was employed on this flight. The data indicate some radiant-heating effect on both sensors. Also, reference drift was still excessive. The balloon performance was normal, although the initial superpressure level was lower than had been anticipated.

DATE/TIME	FIX		CLASS
022230	38.9°N	73.9°W	C
031603	52.1	60.0	D/150
1704	53.1	56.7	D/200
1904	55.1	50.3	D/200
2003	54.5	45.2	D/200
2103	53.7	40.5	D/200
2203	53.0	30.0	D/200
2303	51.8	25.5	D/200

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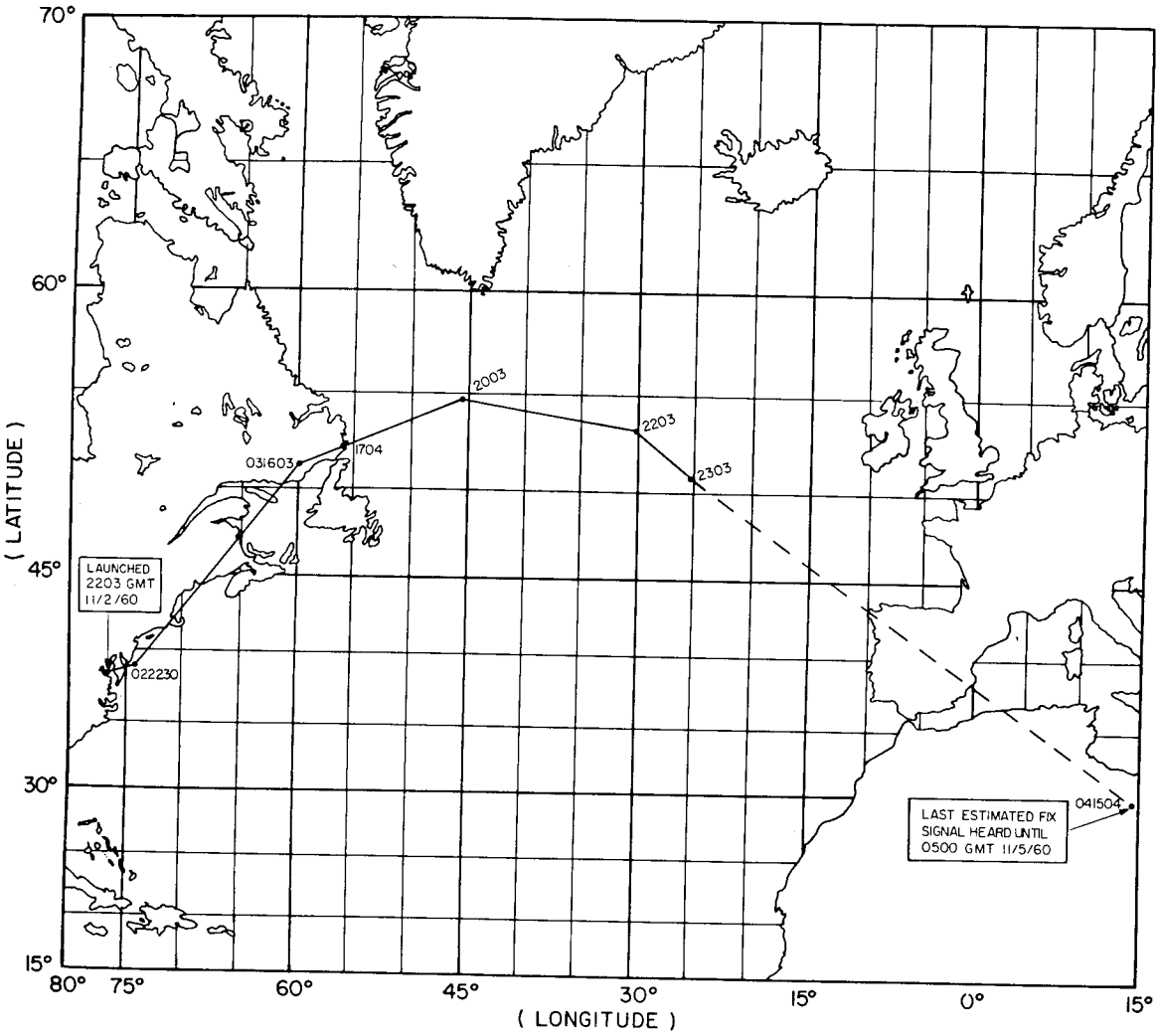

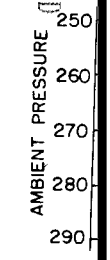

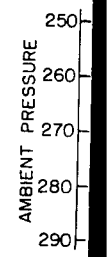

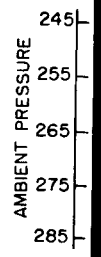

1/60

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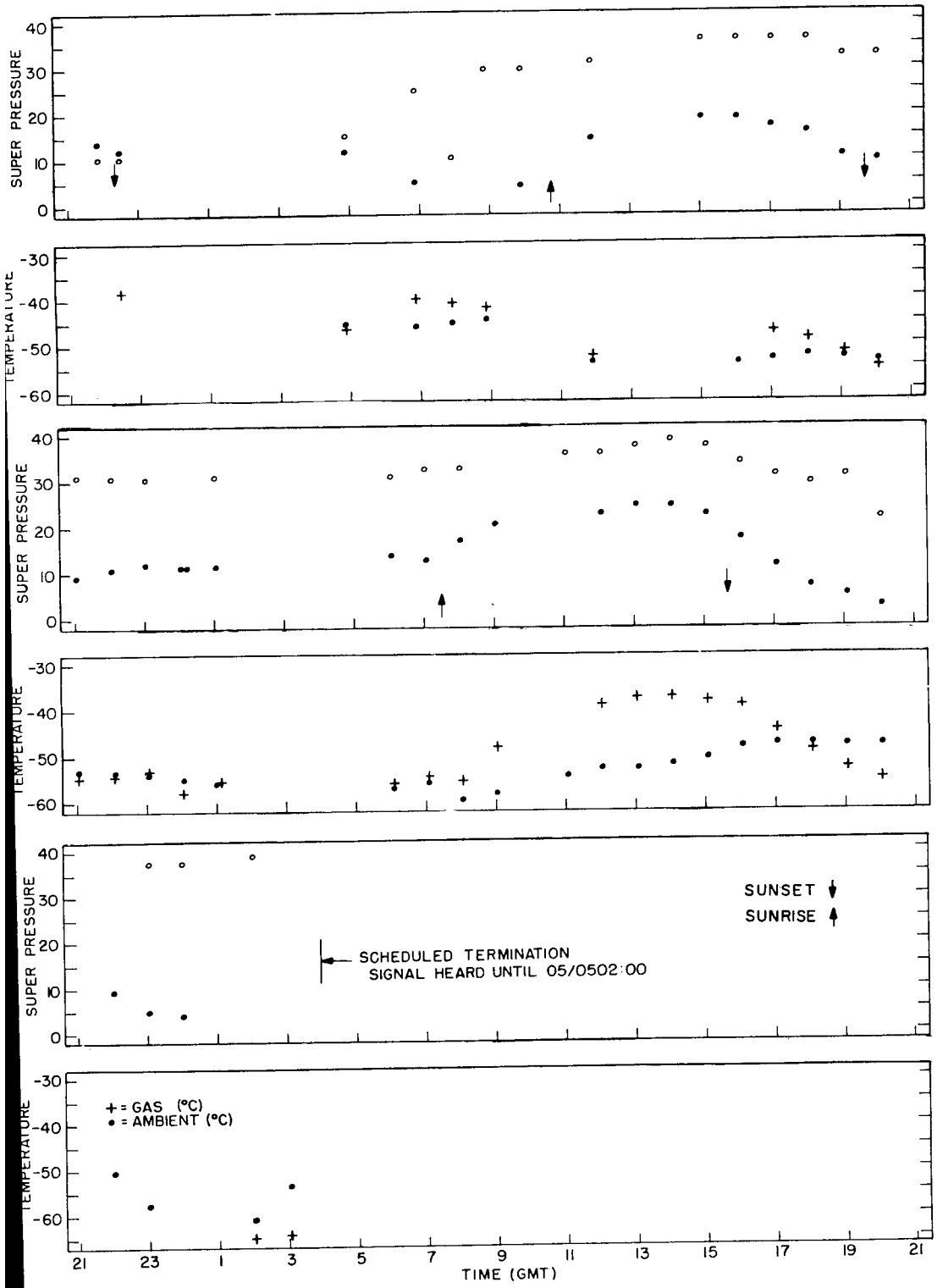

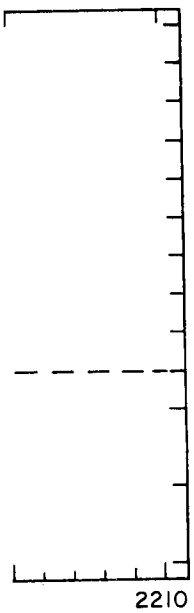

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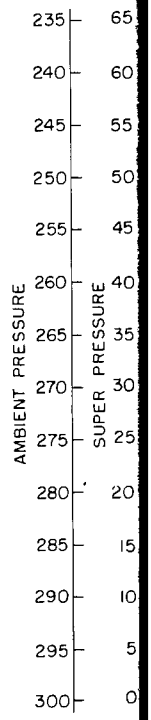
FLIGHT NR 36

Launched	1957, 1/10/61
Balloon Type	Sphere
Free Lift	16.9 percent (8% + 2.6% + 2.7% + 3.6%)
Expected Flight Duration	20 hr
Probable or Actual Duration	20 hr
Data Period	20 hr

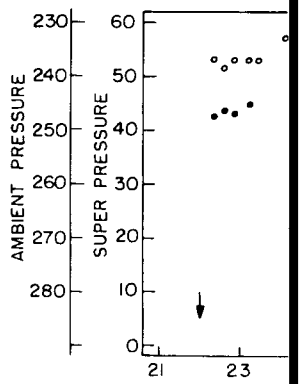
Comments

In order to alleviate the problem experienced on the preceding flight, this flight was arranged so that the superpressure would be increased in increments (above initial superpressure), thereby making less severe whatever momentary stresses the balloon may experience during pressurization. This was accomplished by programming three ballast drops to be made approximately 15 minutes apart after the balloon had reached ceiling. Due to error of timer setting all ballast drops occurred approximately 1/2 hour early; thus the first ballast drop occurred during ascent, the second just as the balloon was reaching ceiling, and the third approximately five minutes after the balloon had leveled off (see data plot of ascent and ballasting period).

Because of early ballast drops, the free lift experienced upon reaching ceiling initially was approximately 10.6 percent. Highest superpressure ever achieved with this type of balloon (51.1 mb) was recorded during latter part of this flight, indicating that a good balloon is capable of approaching its theoretical limit under normal flight conditions. Additional programming was added to this equipment to provide a 30-second transmission every four minutes for duration of flight.



DATE/TIME	FIX		CLASS
102119	37.6°N	76.1°W	D/100
2319	38.0	73.8	D/100
110018	38.4	73.6	D/100
0217	38.4	72.0	D/100
0617	38.8	62.3	C
0717	38.4	60.7	C
0817	38.1	57.8	C
0918	38.0	58.5	D/100
1018	37.5	59.5	D/100
1619	37.5	53.0	D/200



FLIGHT NR 37

Launched	2030, 2/27/61
Balloon Type	Sphere
Free Lift	8 + 4 percent
Expected Flight Duration	48 hr
Probable or Actual Duration	Unknown
Data Period	31 hr

Comments

This flight was equipped with a single ballast drop which was activated at end of the 100-minute ascent period (after balloon had reached ceiling), thereby providing a "step" function which boosted superpressure to a relatively high level (12 percent) at the beginning of the flight. No other auxiliary in-flight ballast drop was provided.

A 12-percent equivalent superpressure should be sufficient to maintain balloon superpressure during all the environmental conditions a balloon would experience during a normal flight (4 to 5 days duration in temperate latitudes). Assuming a good balloon that does not leak, and thus does not require further ballasting action to recharge superpressure after initial pressurization at the beginning of the flight has been achieved, then a simple ballast drop control, such as was used on this flight, is all that is necessary.

The programming necessary for this ballast drop was provided by a very simple modification of the existing 100-minute timer in the flight-control unit. This allowed elimination of the superpressure control circuit used for auxiliary in-flight ballast control; thus, balloon control was simplified, requiring less ground preparation (setting and calibration).

A temperature encoder (same model as on NR 34) employing two thermistor temperature sensors was used on this flight. Two thermistors were flown to determine whether a difference of orientation with respect to the sun would cause a change in their heat absorption rate. There was no significant difference in the readings of the two thermistors. (The difference was less than the accuracy of the system, 0.5°C.) Reference drift of the temperature sensor was still excessive, although usable. Because of noisy radio conditions transmission reception was very bad. The signal was completely lost after 31 hours.

Balloon performance was excellent during the flight-data period.

DATE/TIME	FIX		CLASS
272219	38.1°N	72.4°W	C
2319	38.3	71.5	B
280019	38.0	70.5	C
0119	37.9	69.6	C
0916	33.3	56.7	D/100
1517	25.8	50.0	D/100
1615	25.0	49.5	C
1715	25.3	48.5	D/150
1817	25.8	48.3	D/100
1917	25.0	47.0	D/150
2218	23.3	42.0	C
2318	22.0	41.0	C

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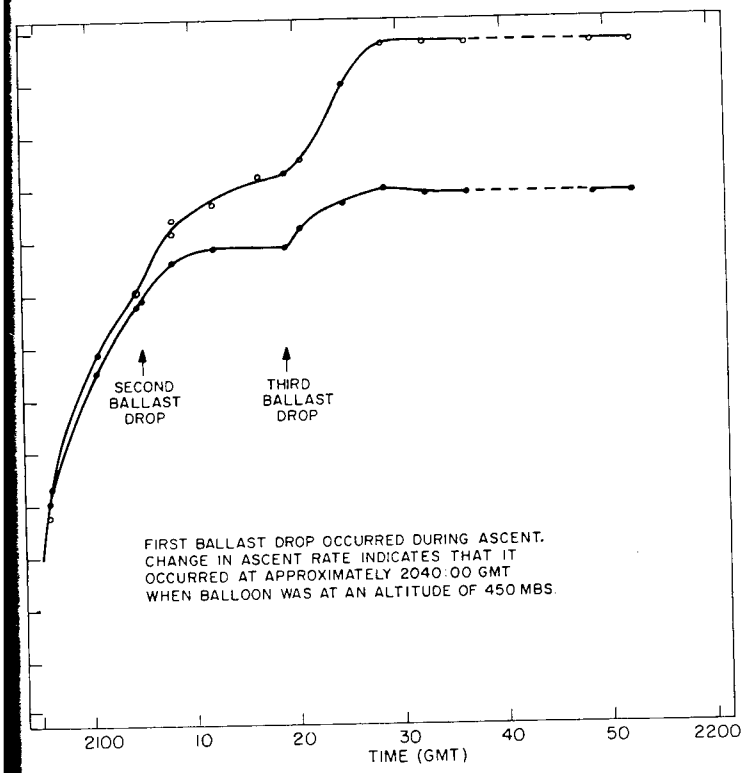

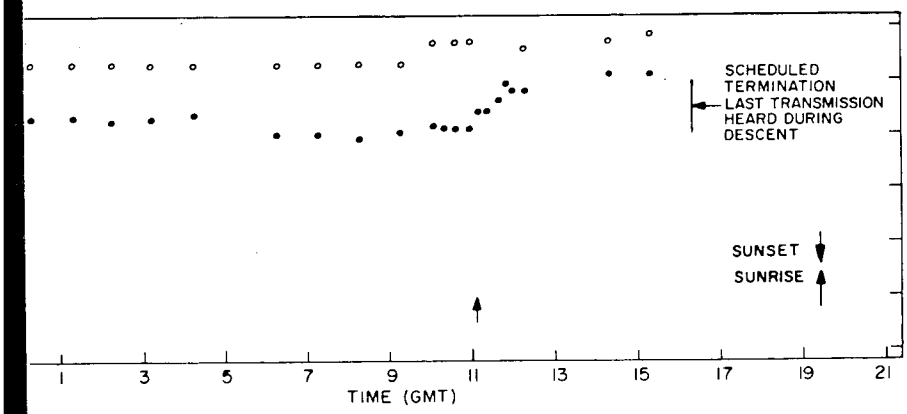

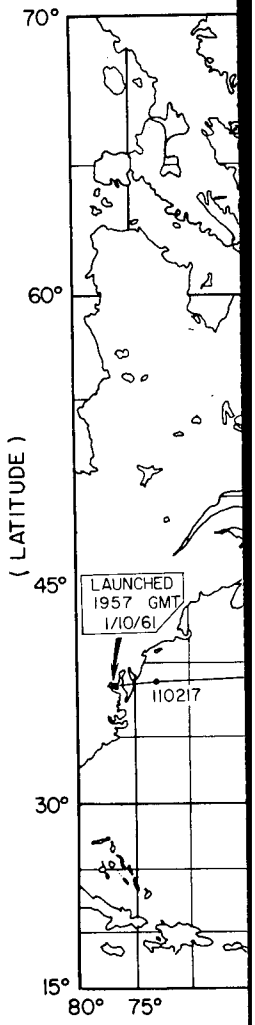

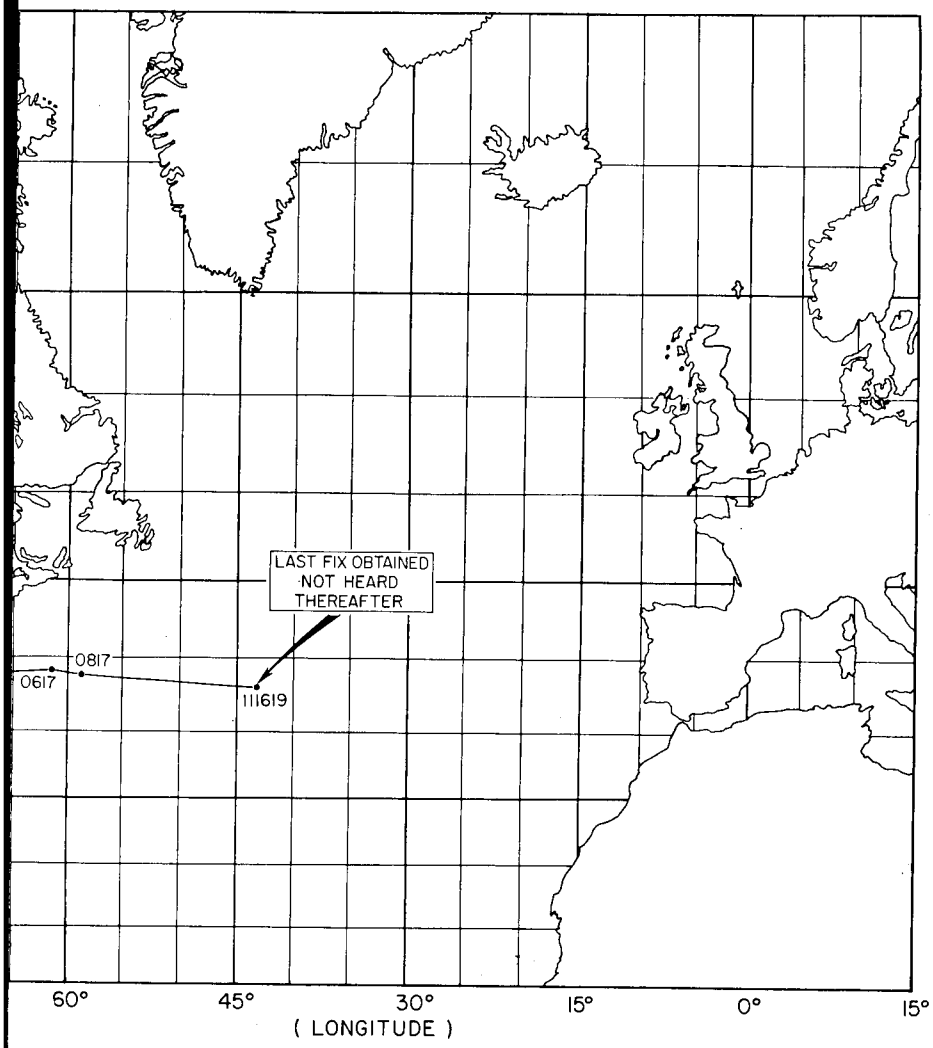
LAST FIX OBTAINED
NOT HEARD
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0617
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(LONGITUDE)

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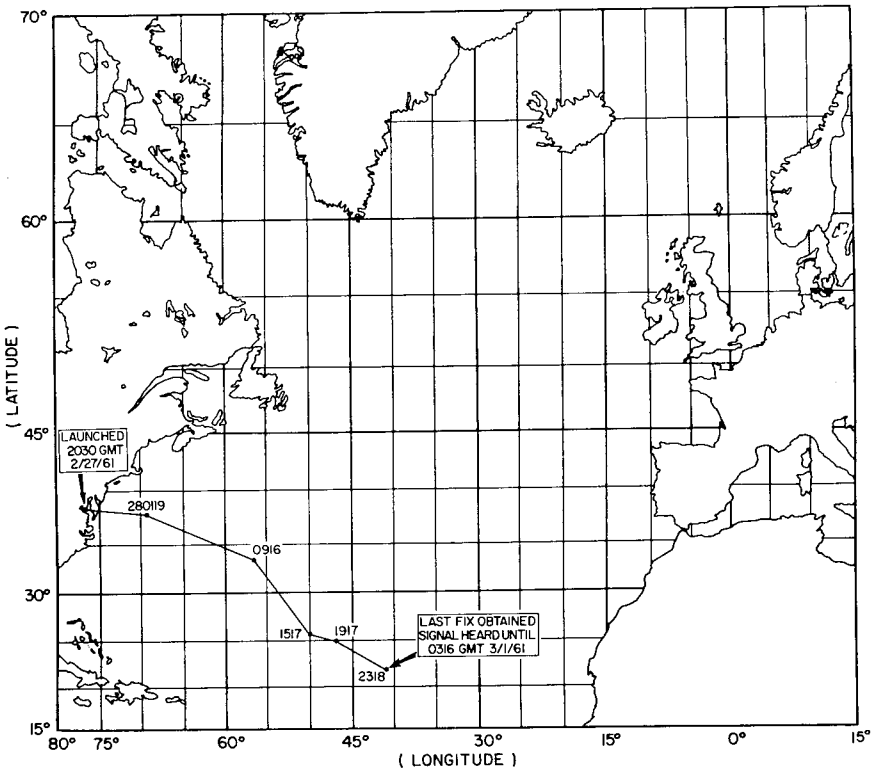

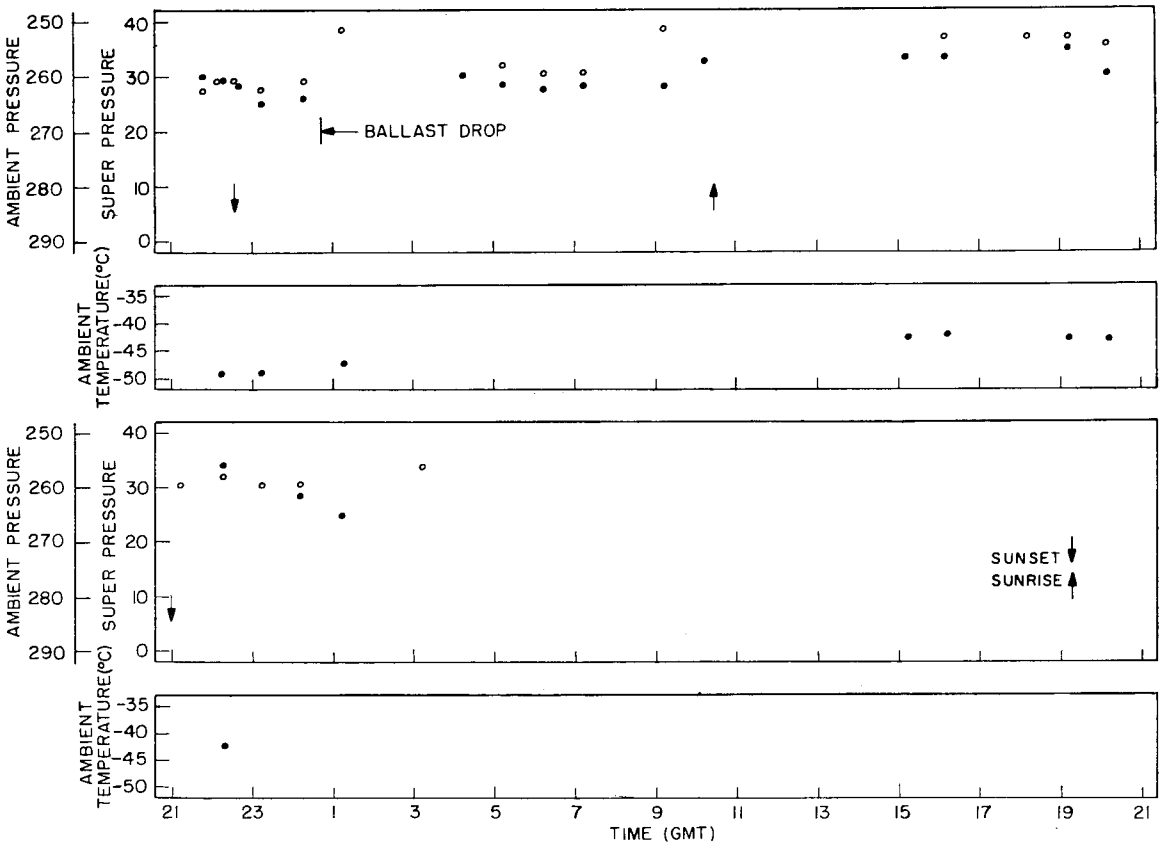

FLIGHT NR 38

Launched	2122, 2/27/61
Balloon Type	Sphere
Free Lift	15 percent
Expected Flight Duration	52 hr
Probable or Actual Duration	1 hr
Data Period	1 hr

Comments

To further investigate the results experienced on NR 35, an initial free lift of 15 percent was again attempted on this flight.

This balloon had been tested by the manufacturer to a pressure above that equivalent to the 15-percent free lift used on this flight. It was also visually checked just prior to the flight for any flaws or imperfections, particularly in end caps and seams.

The balloon apparently ruptured as it reached ceiling. Due to noisy propagation and interference, it was impossible to copy all data. The last readings obtained indicated an altitude of 270 millibars and a superpressure of 34.8 millibars.

The results of this flight and flight NR 35 seem to indicate definitely a relation between high initial free lift (below theoretical limits of the balloon) and subsequent balloon rupture, as was surmised on NR 35.

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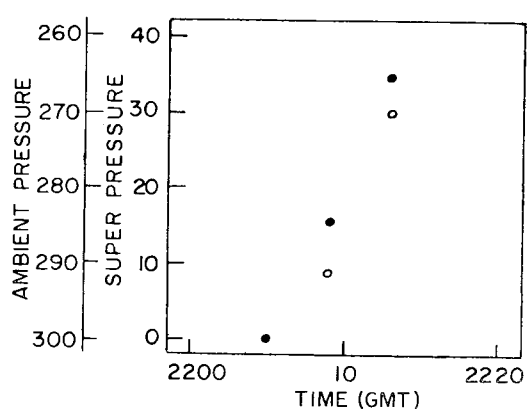
Assuming that this is true, then the only safe manner in which to approach this problem is to employ a conservative initial free lift (6 to 10 percent) together with subsequent ballast drops after reaching ceiling to boost superpressure to the proper level. These ballast drops may be used to boost superpressure to a high level at the beginning of the flight or on a demand basis, where they are used to recharge balloon superpressure whenever it reaches some minimum value. Both methods have been explored in previous flights.

The equipment from this flight was recovered near Ocean City, Maryland, on Dec. 4, 1961.



FLIGHT NR 39

Launched	2045, 3/7/61
Balloon Type	Sphere
Free Lift	8 percent
Expected Flight Duration	24 hr
Probable or Actual Duration	Unknown
Data Period	12 hr

Comments

In addition to a regular equipment, a completely independent high-frequency transmitter unit was sent on this flight in order to check the radiated power of the regular transmitter. The extra unit used a single-frequency transmitter with a half-wave center-fed antenna and was suspended completely below the antenna of the regular equipment. It was thoroughly checked for maximum radiated power before the flight. No appreciable difference was noted in signal strength of the two transmitters during the flight; thus, the matching network between power amplifier and antenna of the regular transmitter is assumed to be satisfactory and the radiated power normal.

A small battery pack was used with these units. Because of the reduced heat capacity, the battery pack became considerably colder than normal (-35°C). Also, on the next-to-the-last transmission a 10-mb drop in ambient pressure was noted. Unfortunately no superpressure readings were obtained during this period; thus it was impossible to determine the reason for this 10-mb change in altitude. No definite conclusions could be reached for early transmission termination. Possible causes could have been low battery-pack temperature resulting in premature battery failure, or loss of superpressure due to balloon failure and/or environmental changes.

DATE/TIME	FIX		CLASS
072118	38.3°N	76.5°W	B
2126	38.3	76.5	C
2218	38.2	75.0	C
2318	38.1	73.8	C
080018	38.1	72.3	C
0118	37.8	70.5	C
0219	37.1	66.5	D/100
0317	36.8	64.5	C
0417	36.4	61.5	D/100
0517	36.0	59.5	C
0617	35.4	57.0	C
0717	34.3	54.3	C

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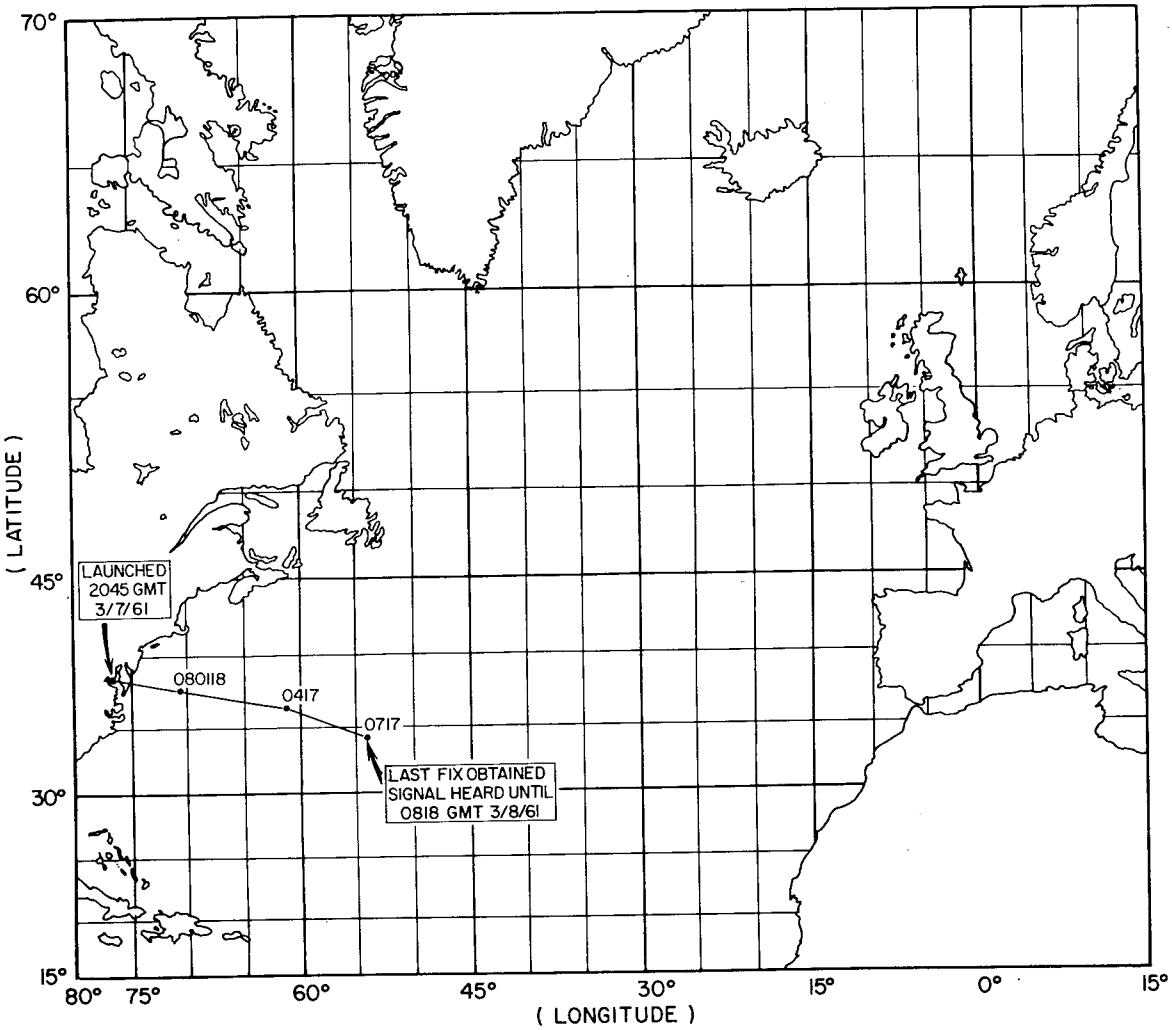

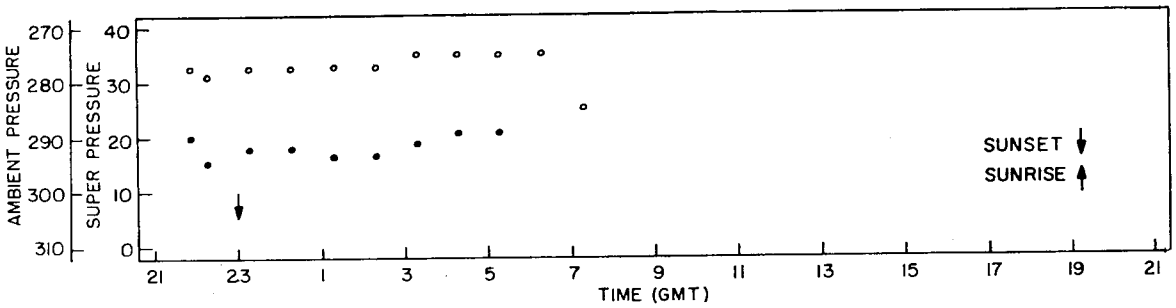

FLIGHT NR 40

Launched	2035, 3/20/61
Balloon Type	Sphere
Free Lift	8 + 5.5 percent
Expected Flight Duration	11 hr
Probable or Actual Duration	2 hr
Data Period	2 hr

Comments

This flight was set up as another "step" flight to further investigate balloon superpressure capability. Four ballast drops were scheduled after the balloon reached ceiling. The balloon burst immediately after the first ballast drop. There was some possibility of excessive strain on the balloon due to faulty rigging of load harness. Because of windy launch conditions, the superpressure tube became pinched off during launch; thus no superpressure data were received.

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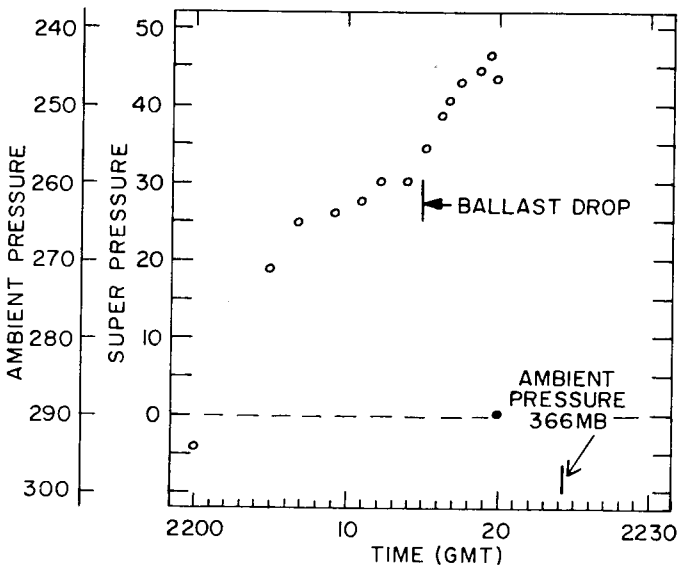

FLIGHT NR 41

Launched	2127, 3/27/61
Balloon Type	Sphere
Free Lift	8 percent
Expected Flight Duration	80 hr
Probable or Actual Duration	12 hr
Data Period	12 hr

Comments

A severe balloon leak caused loss of superpressure after 3 hr. Ballast drop maintained flight for another 9 hr. During inflation it was noted that the Mylar reinforcement ring around the inflation tube was not sealed. It was assumed that this was normal and that the seal was secured by the nut on the inflation tube. A later check on three other balloons of the same group as this one revealed that these Mylar rings had not been sealed on any of them. When these balloons were later pressure tested, they all leaked quite severely around this inflation-tube seal. Thus it is reasonable to assume that the balloon used on this flight also leaked around the inflation tube seal. Following this flight a program was initiated to ground check all balloons for leaks before use on a flight.

DATE/TIME	FIX		CLASS
272318	38.3°N	76.0°W	C
280118	37.0	73.8	D/100
0316	35.3	71.5	C
0516	33.0	69.0	C

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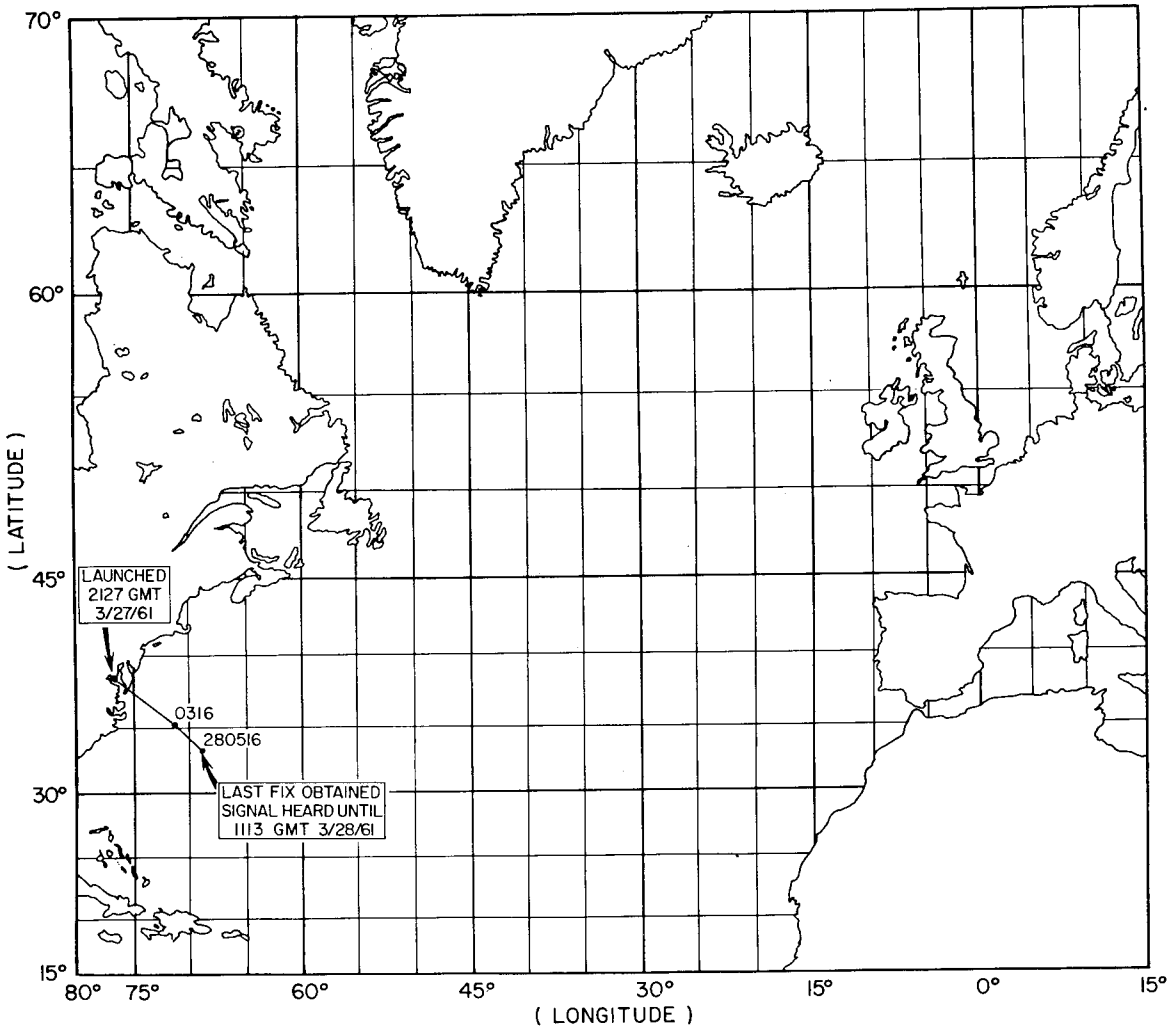

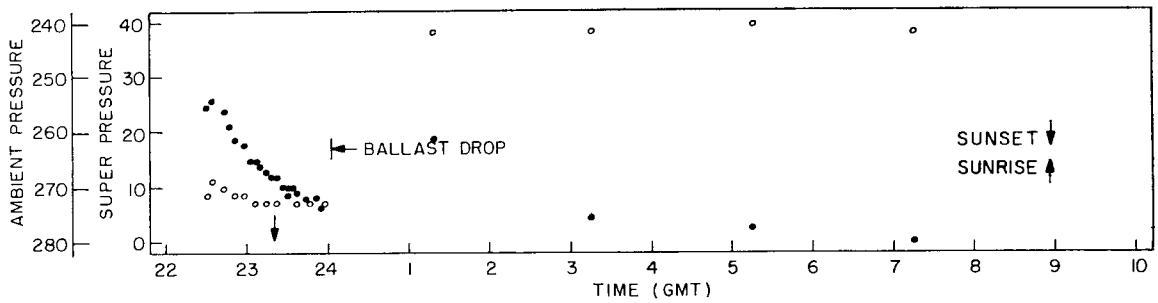

FLIGHT NR 42

Launched	1958, 5/4/61
Balloon Type	Sphere
Free Lift	7 percent
Expected Flight Duration	50 hr
Probable or Actual Duration	50 hr
Data Period	50 hr

Comments

Excellent flight. Time termination. Equipment operated on new high frequency (15026 kc). Consensus of opinion (FCC, NRL) was that signal strength was better. Signal-strength readings of FCC data log tend to confirm that a more usable signal was being radiated on the high frequency. Signal and fixes were obtained out to 3000-mile range. The balloon used on this flight was an "older" model balloon which had undergone thorough testing. During test, two small holes were discovered and patched with Mylar tape, but balloon still had a slow leak (approx 2 mb/24 hr). It was decided that it was not worth while to try to discover the source of such minimal leaks, since they would not detrimentally effect flight performance for short-duration flights when equipment included a ballast drop. Balloon performance during flight confirmed the slow leakage, although data interpretation was hampered somewhat by a ballast drop during the first night, approx. 12 hr after launching. No obvious reason for this drop was determined other than environmental changes experienced by balloon.

DATE/TIME	FIX		CLASS
042118	38.0°N	75.3°W	B
2218	36.9	75.1	B
2318	35.8	71.3	C
050018	37.3	69.6	B
0118	35.0	67.7	B
0218	35.3	66.1	B
0318	35.5	64.5	C
0416	35.8	63.8	B
0616	35.8	61.8	C
0916	41.3	56.7	B
1016	42.1	54.0	C
1618	48.0	41.1	B
1818	49.1	35.5	C
2018	49.5	30.0	C
2118	50.0	27.0	C
2218	50.0	22.0	C

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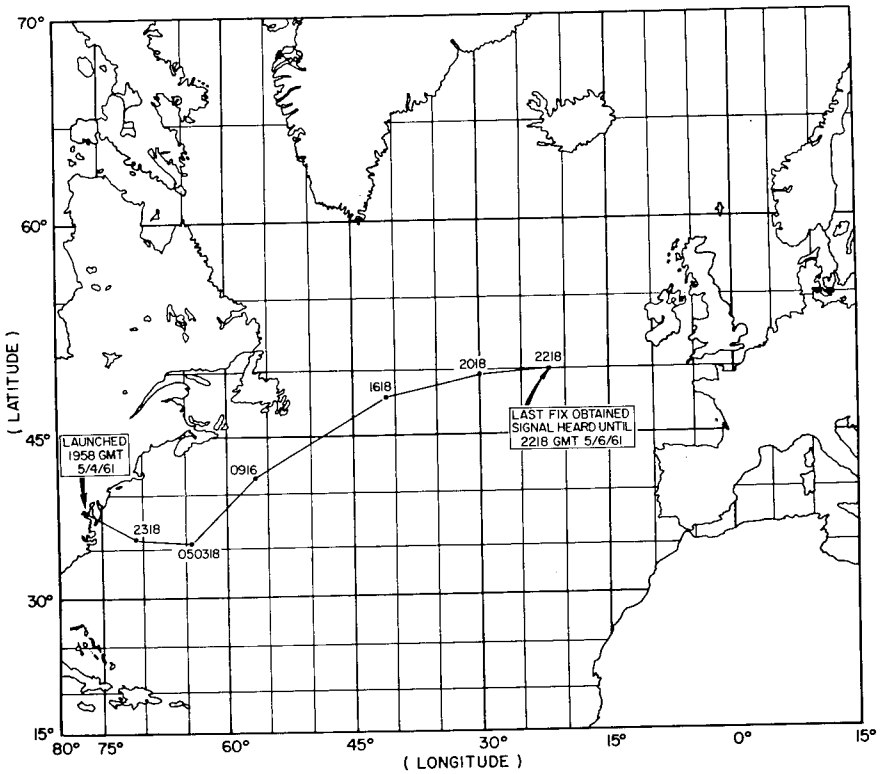

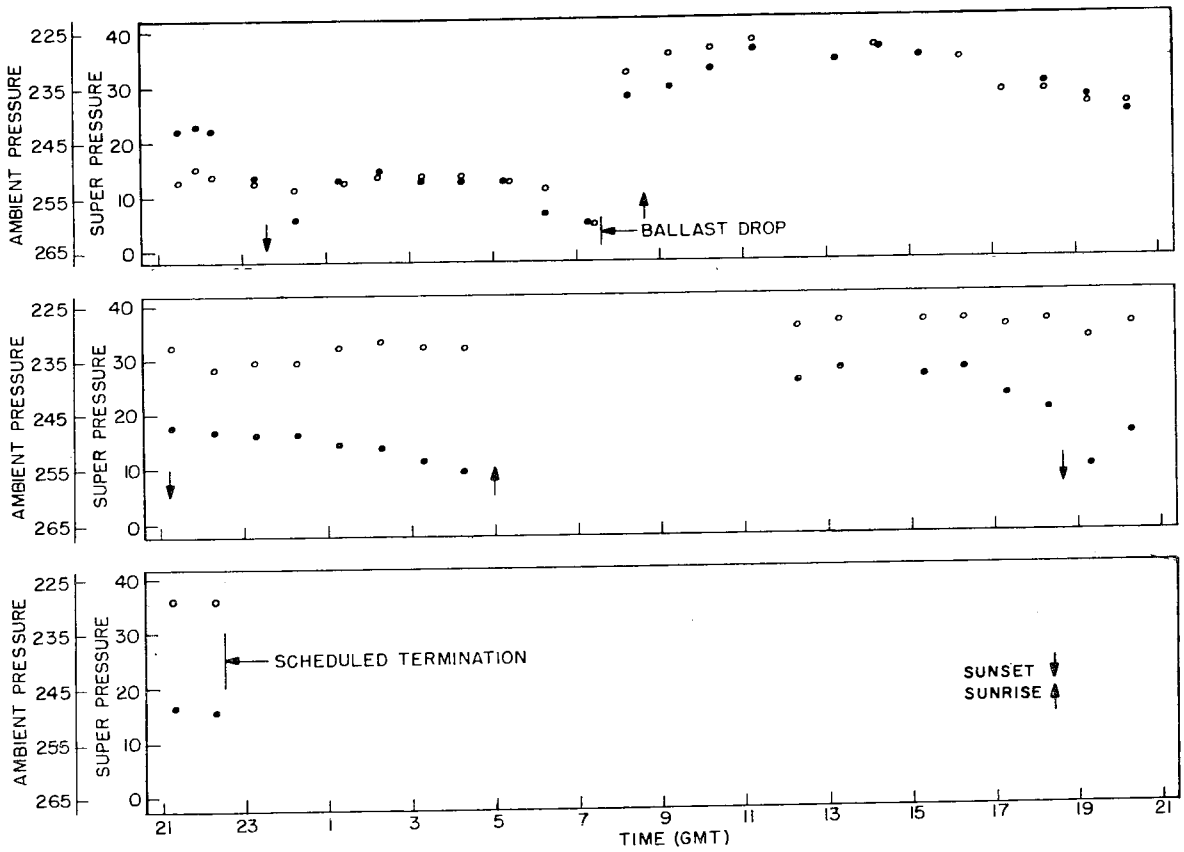

FLIGHT NR 43

Launched	2126, 5/25/61
Balloon Type	Sphere
Free Lift	8 percent
Expected Flight Duration	100 hr
Probable or Actual Duration	Probably 100 hr
Data Period	16 hr

Comments

A bad crystal (high frequency) in the transmitter caused intermittent transmission and final equipment failure after 16 hr. Balloon performance was excellent. Balloon had been thoroughly tested by NRL. Its performance was satisfactory during the early part of the flight, although lack of data prevented a complete evaluation.

Approximately one month after launching, notice was received of equipment recovery in Iraq on 5/30/61. Thus, balloon performance and equipment malfunction were confirmed. The FCC network did not collect any data on this flight.

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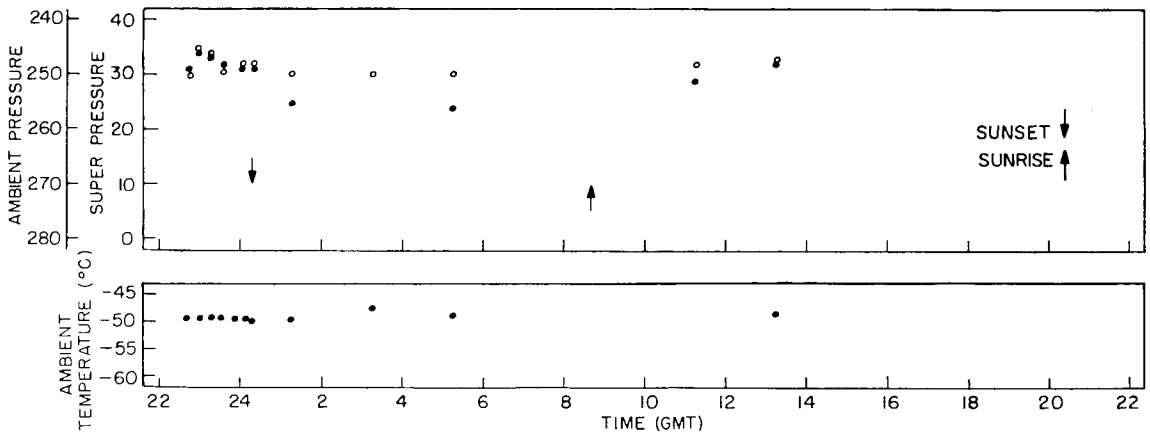

FLIGHT NR 44

Launched	2100, 6/30/61
Balloon Type	Sphere
Free Lift	8 percent
Expected Flight Duration	100 hr
Probable or Actual Duration	123 hr
Data Period	123 hr

Comments

Equipment performance on this flight was very good for the initial flight duration period (100 hours); then the time-termination control failed to function, thus allowing the flight to continue past the scheduled flight period. Post mortem after recovery of equipment showed that an intermittent contact in the termination timer caused this failure. Approximately eight hours after scheduled termination (during the fifth night), the balloon lost superpressure and began to descend. When it reached the 300-mb pressure level, the pressure-termination control was activated, thereby cutting the load line and superpressure tube. But due to entanglement of the parachute with the antenna and load-line section attached to the balloon, the equipment remained effectively tied to the balloon. Since the superpressure tube had been cut, the balloon thereafter functioned as an "open-appendix" or vented balloon. It continued to descend gradually until sunrise. Four hours later the balloon had returned to its ceiling and remained there until sunset. Shortly after sunset it began to descend and continued until it reached ground level (in central Florida). It was subsequently recovered and returned to NRL.

An improved temperature encoder was included on this flight. Its performance was satisfactory, although the data indicated the possibility that the bridge circuit was still being affected by rf interference. Also, the reference drift was excessive during periods when temperature within the thermal package was below approximately -20°C.

Balloon performance on this flight was satisfactory, although some leakage (approx. 5 mb/24 hr) was indicated. Because of this leakage the balloon lost superpressure shortly after sunset on the fourth night, requiring a ballast drop to recharge balloon superpressure and maintain flight. This information verified the test run on this balloon at NRL prior to the flight. The balloon test indicated a very low leakage rate. It was thought that the leakage rate was such that it would not materially affect a four-day flight if equipment included a ballast drop.

Due to the unusual trajectory of this flight, which kept it in an area that could be adequately covered by the FCC df network, the tracking data were the best ever obtained for a superpressure balloon flight; 59 fixes were obtained out of 62 attempts. Of the fixes, 93 percent were class C or better (60 mile radius), with 42 percent of them class B (40 miles) and 13 percent class A (20 miles).

The data for this and the succeeding flight are presented in a slightly different format. The time scale has been compressed in order to give a more comprehensive view of the flight data. Also as a reference check against validity of temperature readings a plot of atmospheric density is included.

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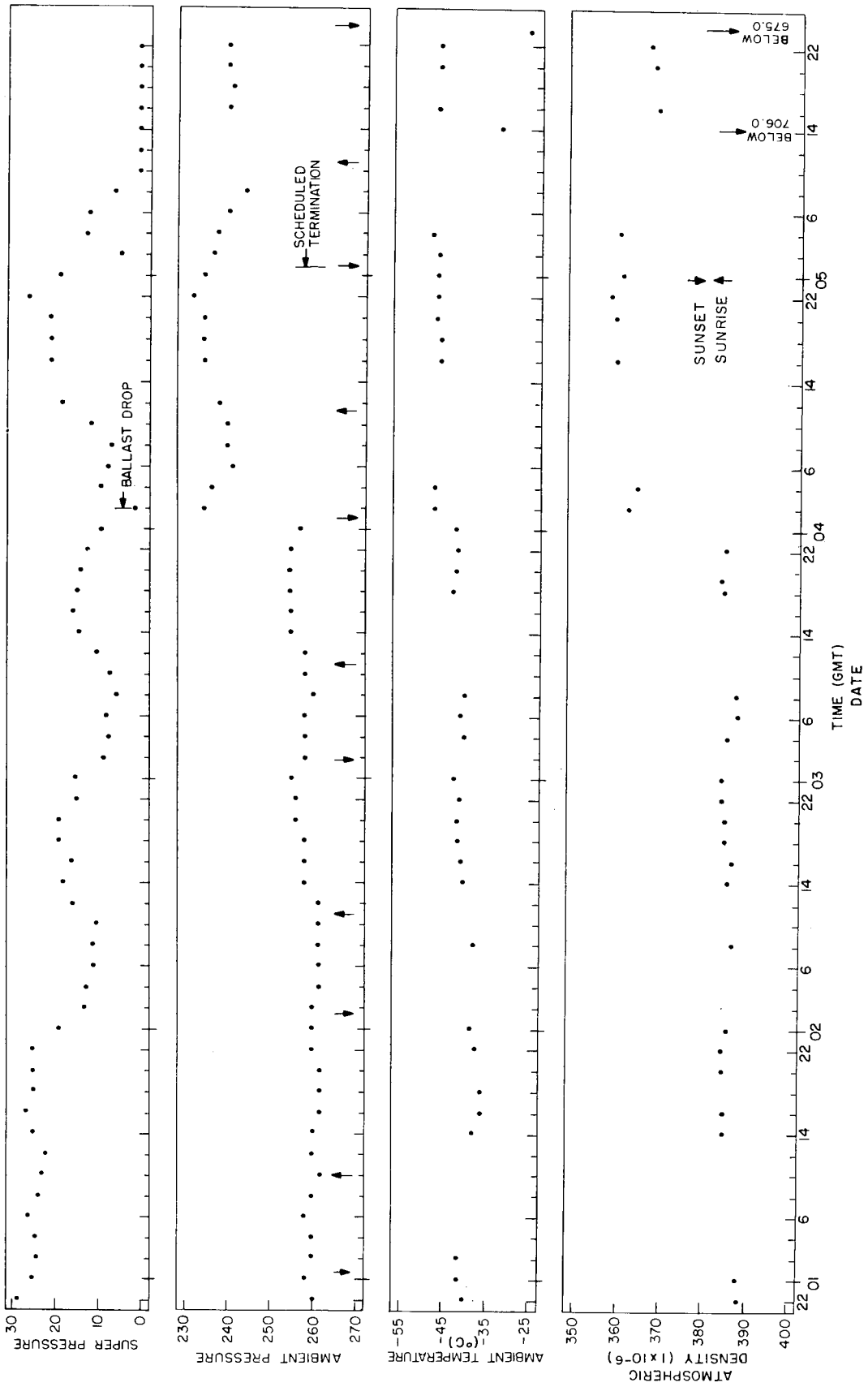
DATE/TIME	FIX		CLASS	DATE/TIME	FIX		CLASS
302218	37.8°N	76.2°W	C	1413	29.3°N	89.4°W	B
010018	37.1	76.2	B	1614	29.4	89.7	C
0218	36.2	76.6	B	1812	28.8	90.1	B
0418	36.0	77.3	C	2012	28.5	90.5	A
0815	36.8	78.4	B	2212	27.5	90.9	B
1016	36.3	80.0	C	040011	27.2	91.9	B
1217	36.5	80.5	C	0212	26.5	92.3	A
1415	36.3	82.3	C	0412	25.0	92.7	B
1616	35.9	83.4	B	0612	25.0	93.1	B
1817	36.1	84.6	B	0809	25.0	93.8	C
2017	36.0	82.2	B	1009	24.1	95.0	C
020016	30.0	89.5	C	1211	22.3	95.0	B
0216	35.1	90.4	D/100	1410	21.5	95.4	B
0416	35.5	90.8	B	1610	20.3	94.0	B
0616	34.6	92.5	C	1810	21.0	92.6	C
0815	34.3	93.0	C	2010	20.3	91.6	B
1016	33.3	93.8	C	2210	21.5	90.0	A
1215	31.8	95.0	C	050012	21.4	89.0	A
1415	31.5	95.8	C	0210	21.0	87.8	B
1616	30.0	96.5	B	0609	22.5	85.8	D/100
1815	28.6	97.1	B	0807	25.6	84.8	C
2015	28.4	96.6	B	1015	25.3	85.6	C
2214	27.6	96.4	B	1206	25.7	84.2	C
030014	27.2	95.3	A	1408	25.9	84.1	C
0214	26.8	94.7	A	1608	26.2	83.5	C
0414	27.0	93.0	B	1808	26.5	83.3	C
0616	27.2	92.0	C	2008	26.8	83.3	A
0814	28.2	90.7	B	2208	26.8	82.5	A
1014	28.6	90.5	B	060007	26.8	82.2	B
1213	29.0	89.7	C				


SUPER PRESSURE
30
20
10
0
BALLAST DROP
AMBIENT PRESSURE
230
240
250
260
270
SCHEDULED TERMINATION
AMBIENT TEMPERATURE (°C)
-55
-45
-35
-25
ATMOSPHERIC DENSITY (1×10-6)
350
360
370
380
390
400
BELOW 706.0
BELOW 675.0
SUNSET
SUNRISE
22
01
6
14
22
02
6
14
22
03
6
14
22
04
6
14
22
05
6
14
22
TIME (GMT)
DATE

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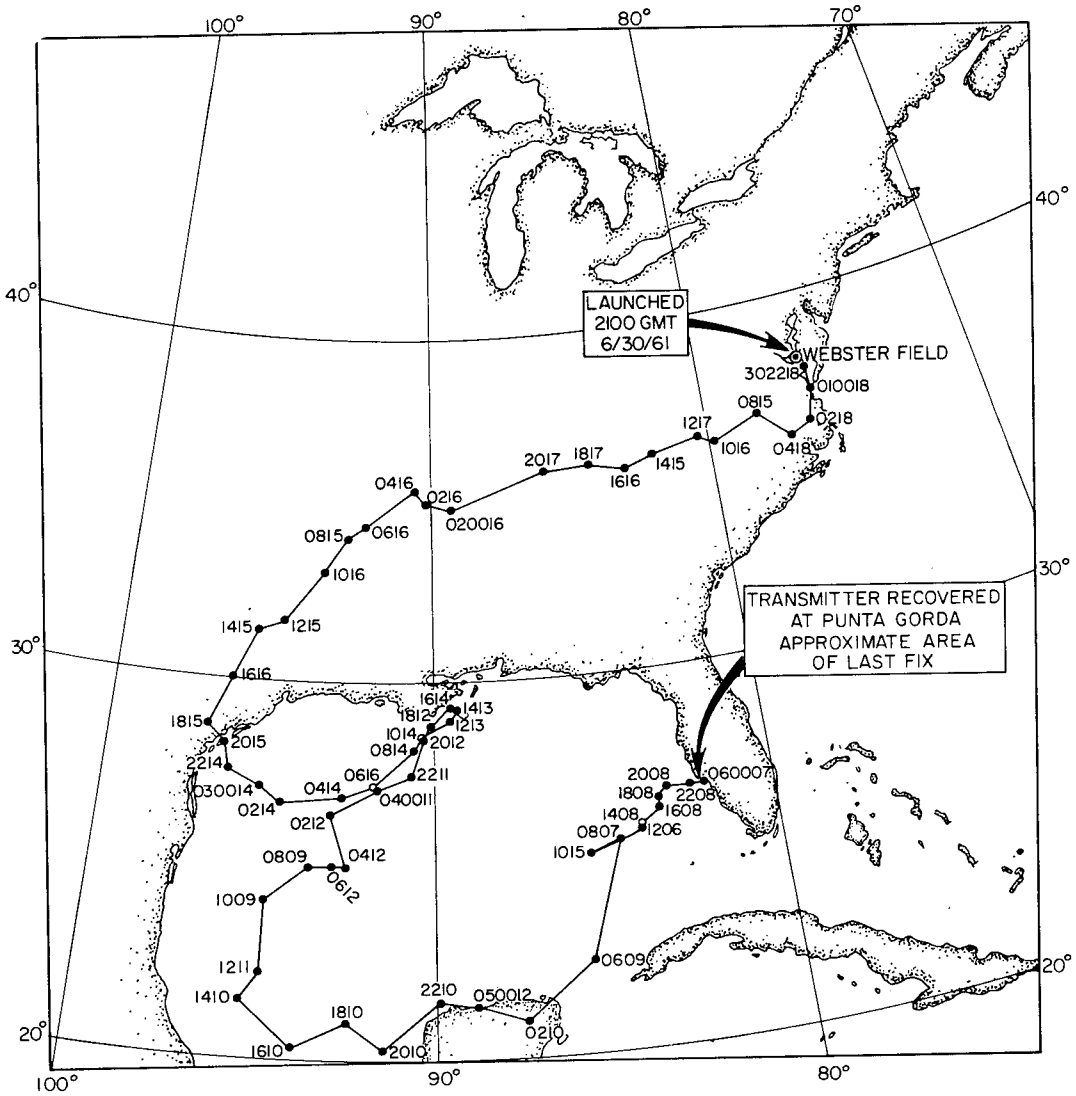


FLIGHT NR 45

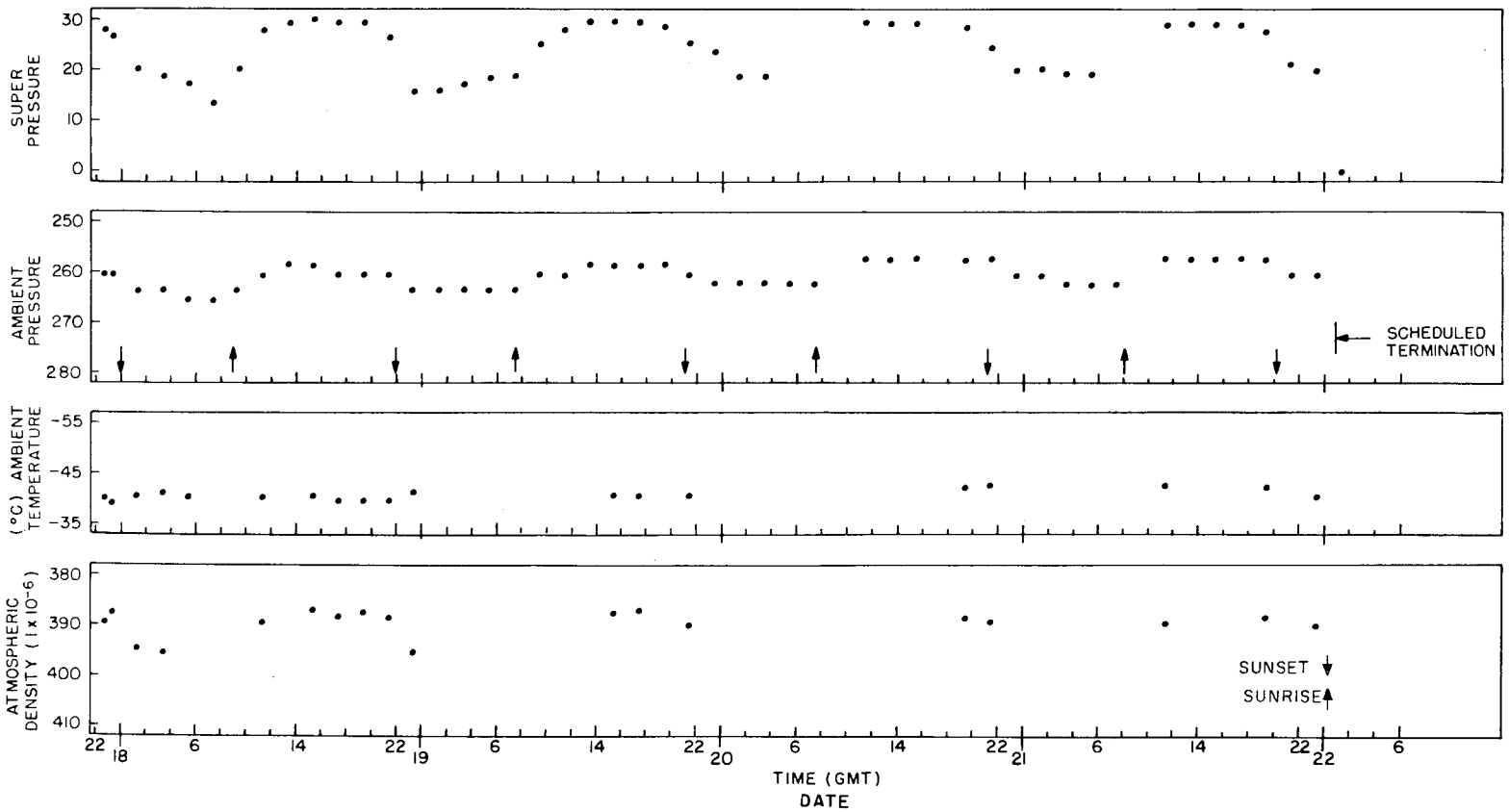
Launched	2123, 7/17/61
Balloon Type	Sphere
Free Lift	8 percent
Expected Flight Duration	100 hr
Probable or Actual Duration	100 hr
Data Period	100 hr

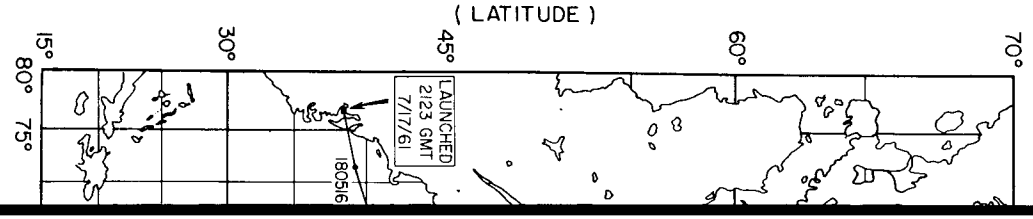
Comments

Balloon and equipment performance on this flight were excellent except for the temperature encoder. This was expected, since same temperature encoder was used on this flight as on the previous flight (NR 44). The temperature data confirmed the problem of periodic rf interference with the bridge balancing circuit. Also, this unit continued to exhibit excessive reference drift at low operating temperatures, thereby degrading the data. These problems will be corrected before this unit is used on future flights.

This balloon had been thoroughly tested prior to flight. No leakage was detected during test. Flight data confirmed the fact that this was an extremely tight balloon. No loss in superpressure was evident during flight. The data have been arranged (in the same form as for the preceding flight, NR 44) so that a more comprehensive picture is presented. The most striking thing about this flight is the fact that the pressures followed an almost identical cycle from day to day. The sunset effect on the superpressure was approximately 12 millibars, which was accompanied by a correlated change in ambient pressure of approximately 5 millibars. Thus this flight definitely shows the resulting volume change (balloon stretch) of this type balloon due to cycling of superpressure.

DATE/TIME	FIX		CLASS
180516	39.3°N	71.8°W	C
0716	40.0	71.0	D/150
0916	40.5	66.0	C
181117	40.8	64.1	C
1316	42.3	61.0	B
1517	42.5	60.3	C
1717	42.5	57.8	B
1916	42.3	54.5	C
2317	39.5	43.2	B
190717	38.5	47.0	D/100
0917	37.8	41.4	D/100
1317	36.7	42.6	D/150
1717	38.0	45.0	D/150
1916	39.0	49.4	D/150
2117	39.8	53.8	D/100
2317	40.2	56.0	D/100
200316	40.5	53.0	D/100
1317	37.0	40.0	D/200
1516	36.5	36.8	C
2115	35.8	32.6	D/100
2315	36.2	35.0	D/100
210315	36.6	32.5	C
0515	34.8	28.1	D/150





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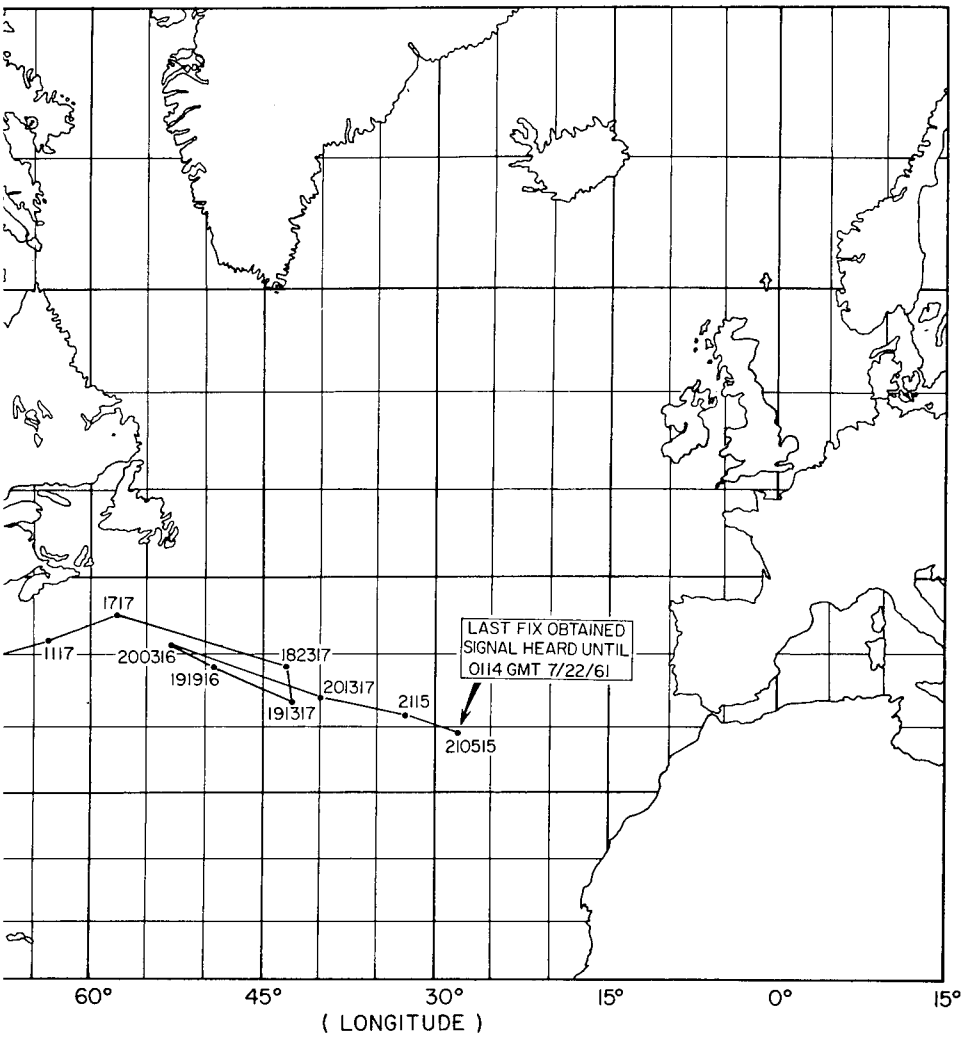
1717
1117
200316
191916
182317
191317
201317
2115
210515
LAST FIX OBTAINED
SIGNAL HEARD UNTIL
0114 GMT 7/22/61
60°
45°
30°
15°
0°
15°
(LONGITUDE)

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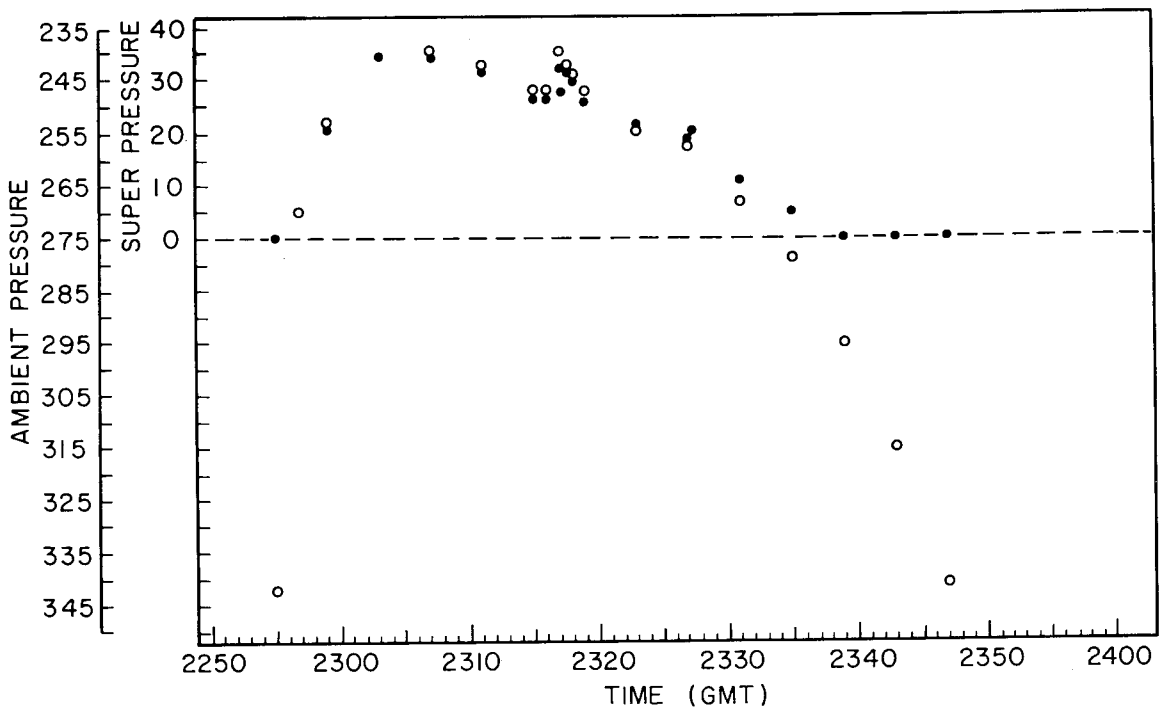

FLIGHT NR 47

Launched	2027, 9/11/61
Balloon Type	Sphere
Free Lift	8 percent
Expected Flight Duration	100 hr
Probable or Actual Duration	Unknown
Data Period	8 hr

Comments

This flight completely disappeared after eight hours duration. There was no definite reason or clue as to the cause. The best surmise is that a major equipment failure occurred, causing transmission termination. A modified temperature encoder (unit recovered from previous flight, NR 46) was included on this flight. It exhibited very stable operation and gave consistently good readings for the duration of transmissions. There was no indication of rf interference with the bridge circuit. The early termination of transmissions prevented performance evaluation of this unit at low operating temperatures. The balloon used on this flight had been thoroughly checked for leaks. Flight performance appeared excellent.

DATE/TIME	FIX		CLASS
112216	38.2°N	76.5°W	B
120017	38.1	76.1	A
0216	38.4	75.8	B
0417	38.5	75.5	B

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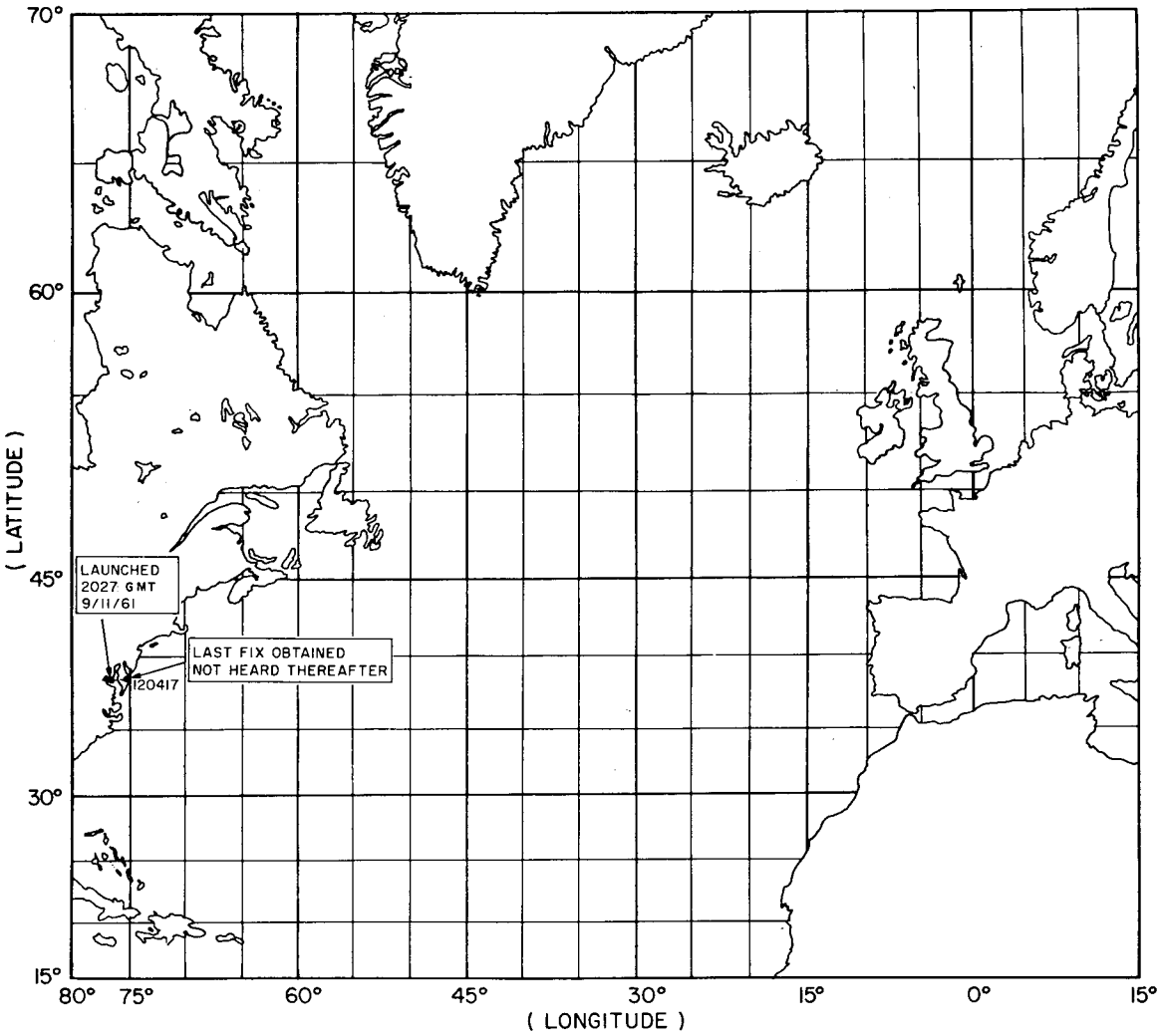

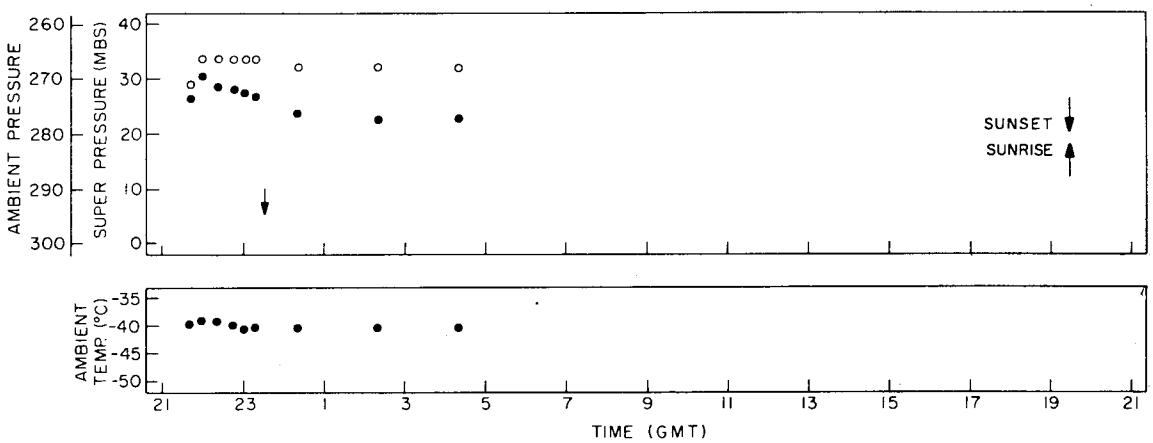

FLIGHT NR 48

Launched	2020, 10/5/61
Balloon Type	Sphere
Free Lift	8 percent
Expected Flight Duration	50 hr
Probable or Actual Duration	50 hr (Time termination)
Data Period	50 hr

Comments

On this flight, both equipment and balloon performance were excellent. The balloon had been thoroughly tested prior to the flight. A new technique was employed in testing this balloon. An odoriferous gas in minute concentration was introduced into the balloon. By using the sense of smell the general area of a leak was readily located. One small pinhole was thus located in this balloon and patched with Mylar tape. Using this technique, leaks well within tolerable limits may be readily found.

The temperature encoder included on this flight performed exceptionally well. It gave consistently good readings for the duration of the flight. There was no indication of excessive reference drift or rf interference with the bridge.

Also included on this flight was an experimental command receiver. The receiver could be activated by a dual (sequential) audio tone signal applied as a modulating signal to the transmitted frequency. When the receiver was energized it turned on the balloon transmitter. During the first hour of flight it was energized several times using only the second audio tone control. During the following two hours, numerous spurious triggerings of the receiver were noted. Thereafter the receiver could not be energized, nor were any false triggerings noted. A laboratory check of a similar receiver indicated that the high operating temperature experienced by the receiver during the ascent period and immediately thereafter could have caused a component (diode) in the relay control circuit to change value and thereby allow the false triggerings to occur.

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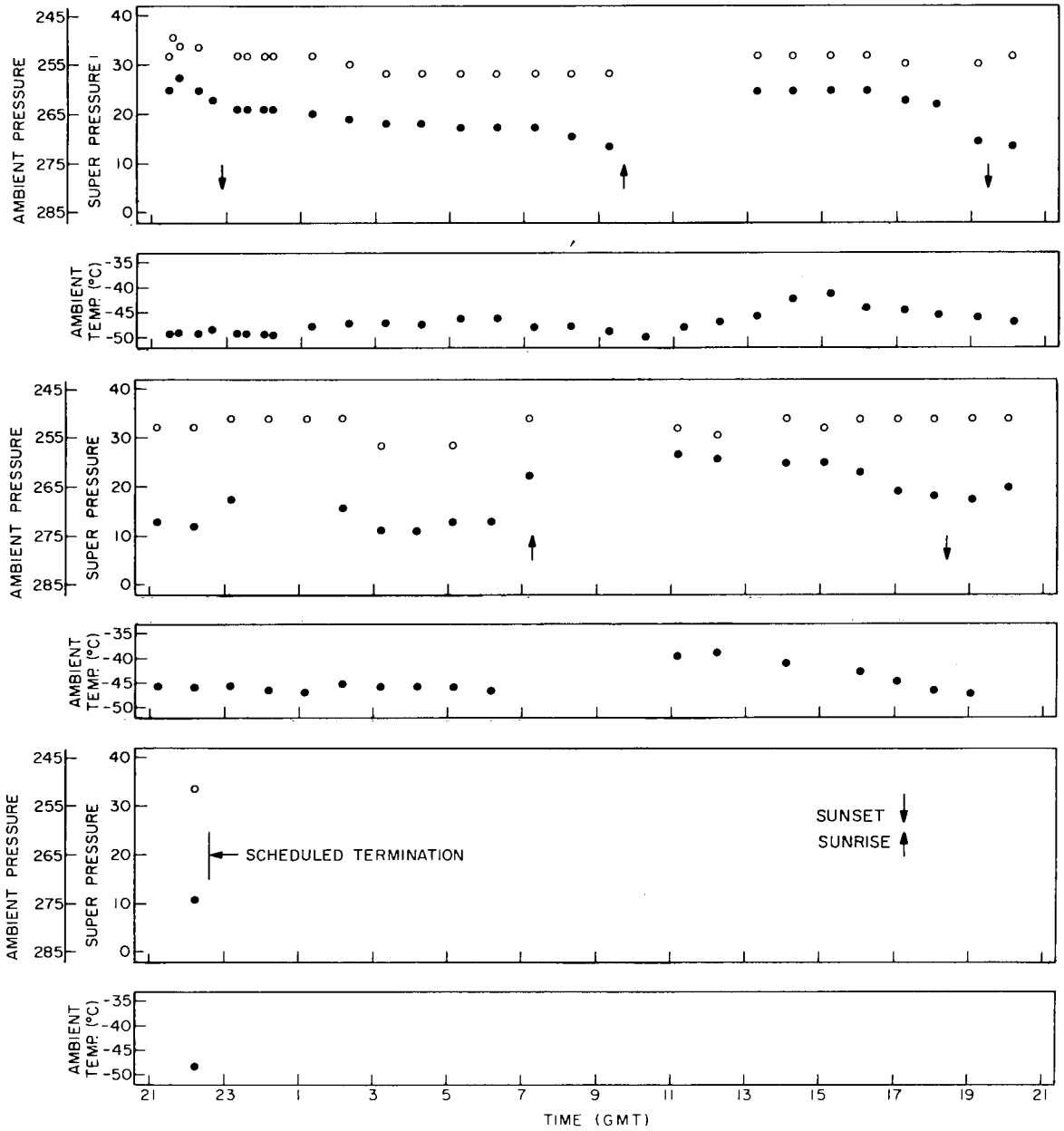
DATE/TIME	FIX		CLASS
052215	38.2°N	75.0°W	B
2317	38.9	75.2	B
060015	39.0	74.4	C
0118	39.3	73.5	C
0217	40.0	72.0	C
0317	40.5	69.5	C
0417	40.8	67.3	B
0516	41.5	67.0	B
0616	42.8	64.8	C
0716	44.4	63.0	C
0916	45.8	59.4	C
1015	46.8	58.8	B
1115	48.2	58.0	D/100
1213	48.9	54.3	D/100
1313	50.3	49.0	B
1412	50.8	47.0	D/100
1512	51.6	44.0	B
1612	52.1	41.3	D/100
1812	52.5	35.0	D/100
2110	54.3	37.7	C
070609	49.0	24.3	D/50
1305	43.8	02.3	D/200
1404	43.0	02.0	D/200
1902	41.0	09.0°E	D/200


AMBIENT PRESSURE
SUPER PRESSURE
AMBIENT TEMP. (°C)
SCHEDULED TERMINATION
SUNSET
SUNRISE
TIME (GMT)

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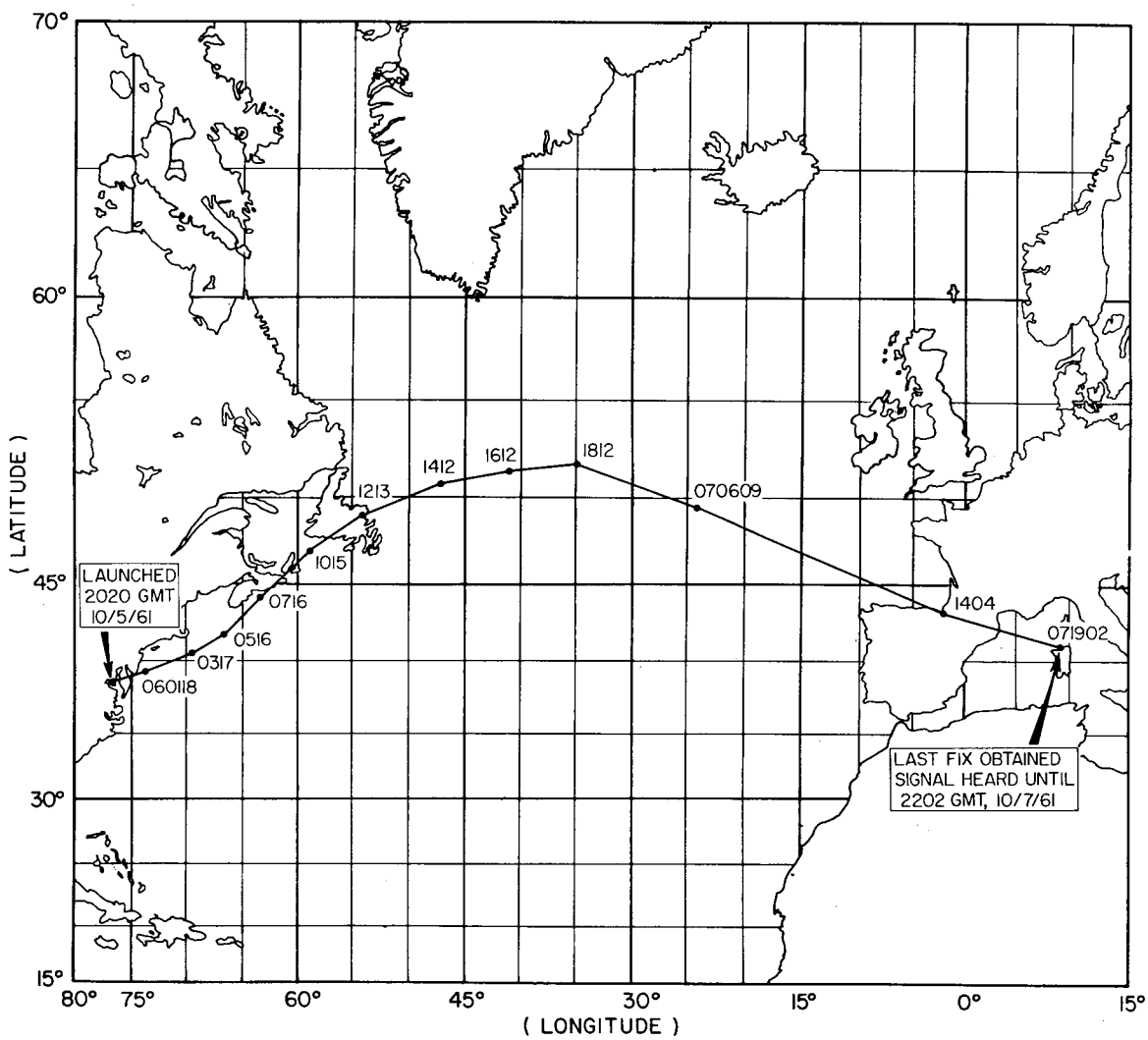

FLIGHT NR 49

Launched	2010, 10/27/61
Balloon Type	Sphere
Free Lift	8 percent
Expected Flight Duration	264 hr
Probable or Actual Duration	Unknown
Data Period	18 hr

Comments

This flight was intended to determine balloon performance for long-duration flights. To provide the additional programming necessary, a special program clock was added to the equipment. When equipment was energized just prior to launching, this clock failed to start, thereby placing a continuous drain on the battery pack; this caused premature exhaustion of the batteries after 18 hr. The programming was arranged to provide a transmission every 3 hr, but because of failure of the auxiliary clock, transmissions were received every 6 hr. The performance of the balloon was excellent. It had been thoroughly tested prior to the flight.

DATE/TIME	FIX		CLASS
280216	37.8°N	75.3°W	D/100
0815	40.0	62.9	D/200
1415	41.3	55.1	D/200

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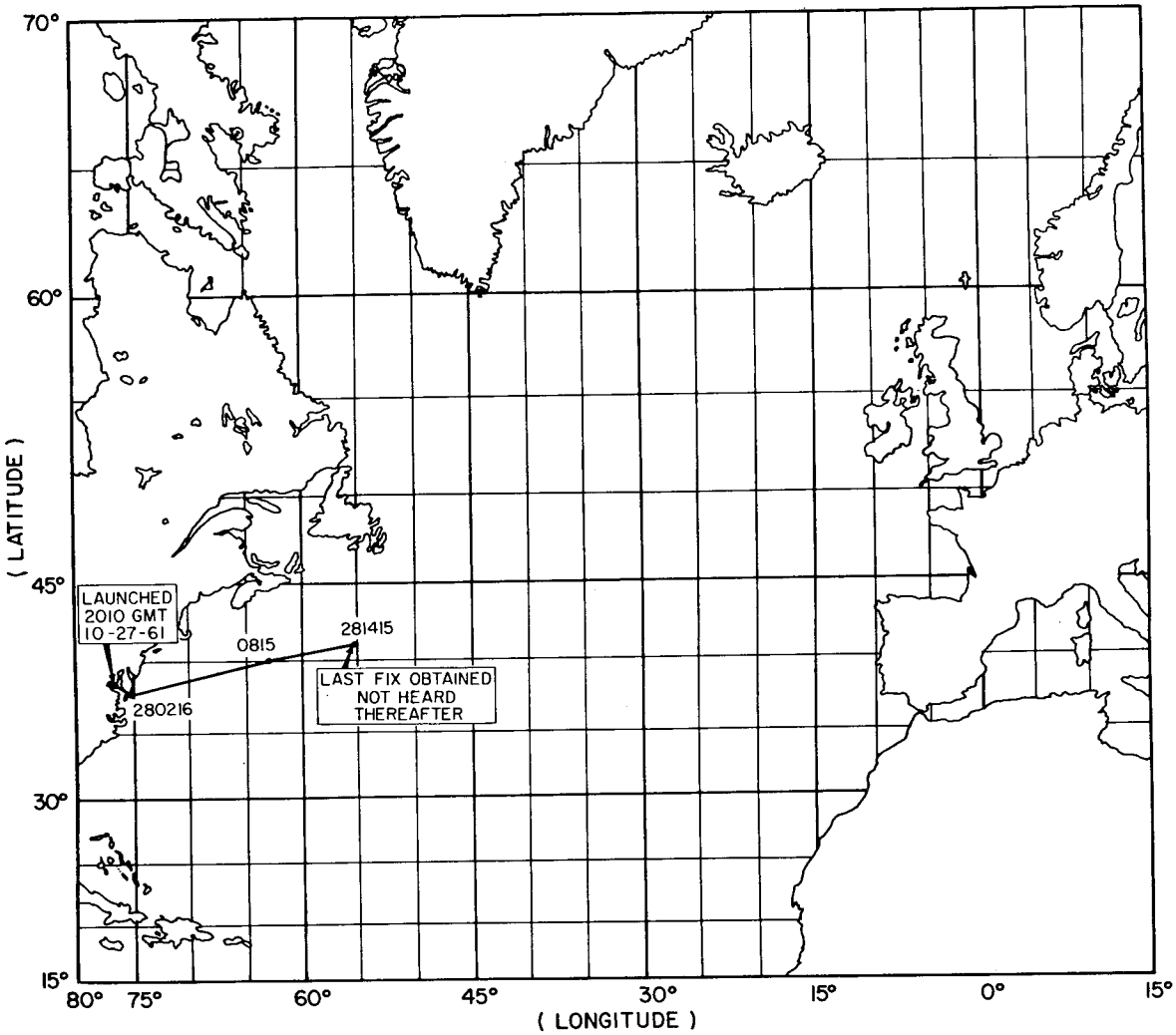
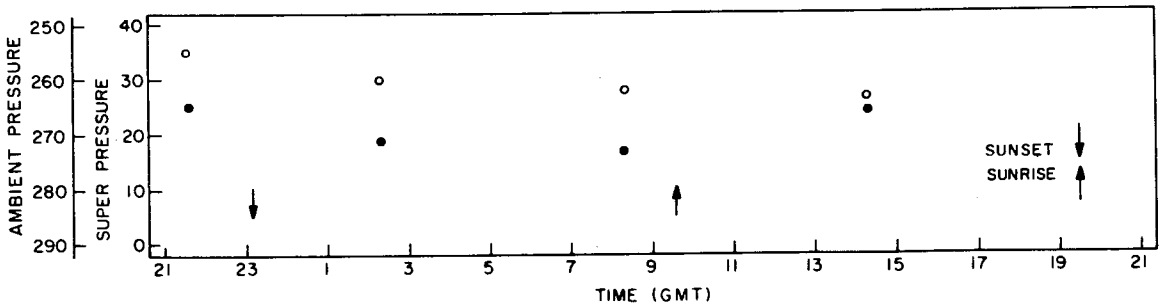


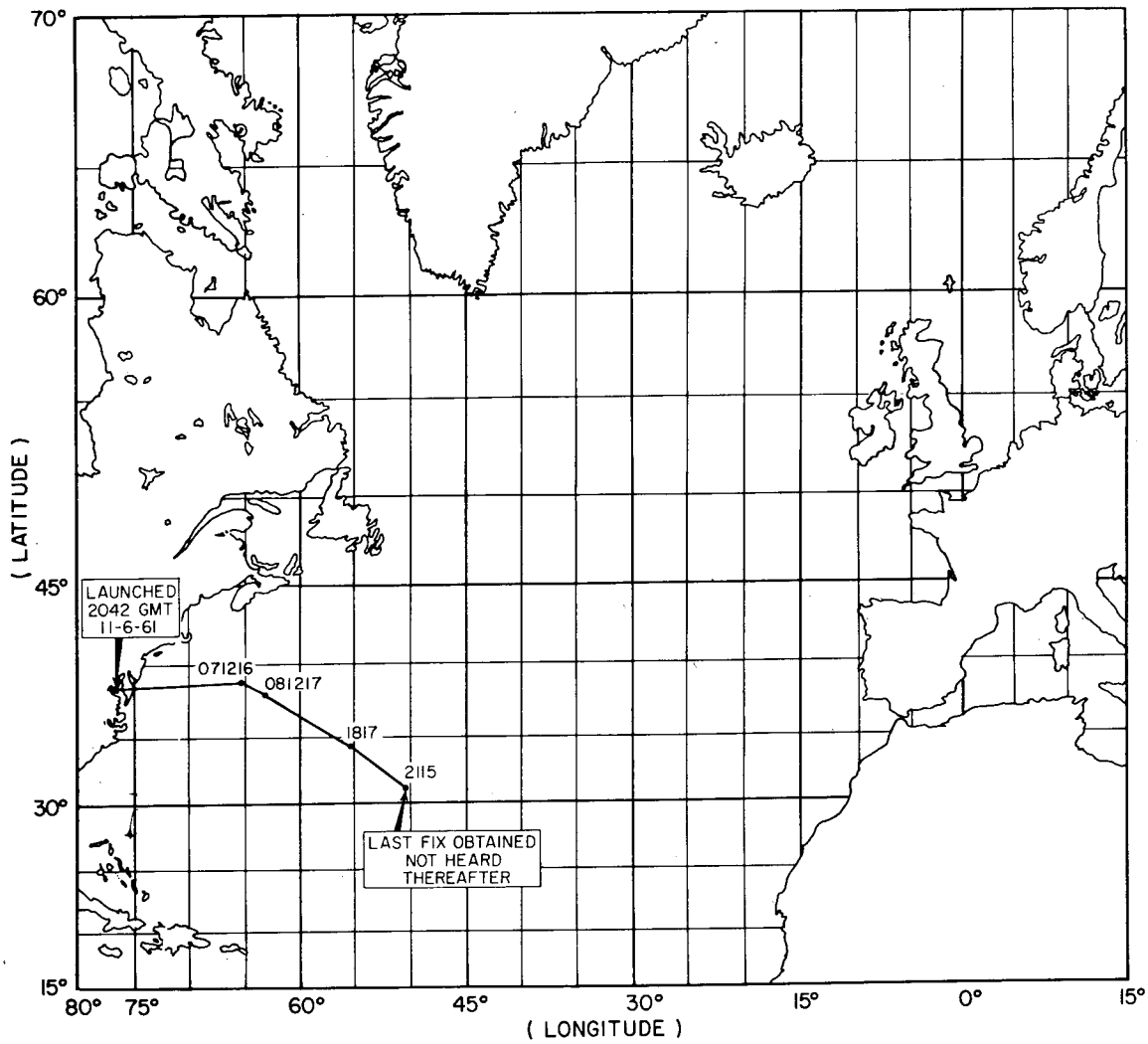
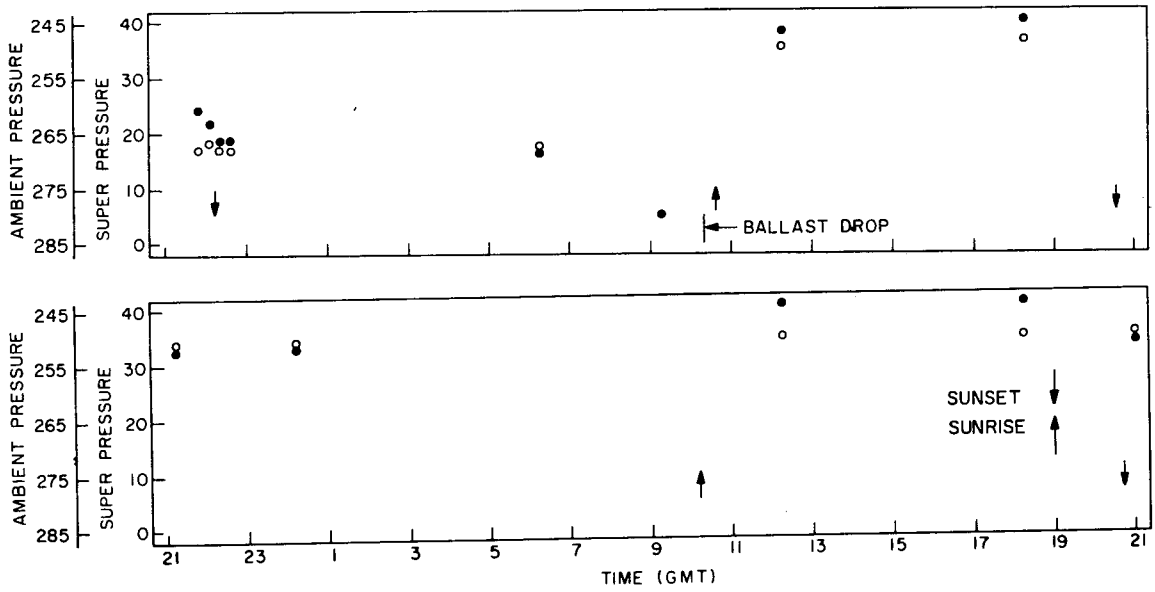


FLIGHT NR 50

Launched	2042, 11/6/61
Balloon Type	Sphere
Free Lift	8 percent
Expected Flight Duration	48 hr
Probable or Actual Duration	48 hr
Data Period	48 hr

Comments

Excellent flight. Equipment included special program unit to provide transmission every 3 hr. Balloon had been thoroughly tested prior to the flight. Balloon performance during flight was satisfactory, although a ballast drop was required during the first night to maintain superpressure. Loss of initial superpressure was apparently due to environmental factors experienced by balloon rather than balloon leakage.

DATE/TIME	FIX		CLASS
071215	38.5°N	65.8°W	C
1817	38.2	62.0	C
081215	37.3	63.5	C
1817	34.0	55.1	C
2115	31.5	50.4	B

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