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FLIGHT TERMINATION SYSTEM

FOR

CENTAUR VEHICLE AC-6

GD|C-BTD65-087

17 May 1965

Contract NAS3-3232

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GENERAL DYNAMICS | CONVAIR

FOREWORD

This report was prepared for the Lewis Research Center of the National Aeronautics and Space Administration in compliance with contract NAS3-3232. The primary objective of the report is to describe the Flight Termination System for the Atlas/Centaur/Surveyor Dynamic Model vehicle, AC-6. The report provides information on system concept and design. It also shows system conformance with the requirements of AFETR publications 80-2, 80-7, and 80-9.

TABLE OF CONTENTS

TABLE OF CONTENTS, Contd

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS, Contd

LIST OF ILLUSTRATIONS, Contd

TABLES

SECTION 1

INTRODUCTION

The flight termination system designed for the Atlas/Centaur AC-6 vehicle and its Surveyor spacecraft dynamic model provides the range safety officer (RSO) at the Air Force Eastern Test Range (AFETR) with a reliable means of terminating the mission in the event of Atlas/Centaur malfunction. The system also provides for automatic termination of the mission in the event of inadvertent separation of Centaur/Surveyor.

Vehicle tracking information is presented to the RSO by visual displays. When deviations from the vehicle's prescribed flight path are indicated, the RSO decides whether or not the vehicle must be destroyed, or the flight limited by engine thrust cutoff only. If the decision is made to destroy the vehicle, the RSO initiates tranmission of a destruct command. This is accomplished by sending a main engine cutoff (MECO) command followed by a destruct command. The MECO command cuts off the fuel supply to both Atlas and Centaur main engines. The destruct command fires pyrotechnics which cause: 1) tank rupture and fuel dispersion, and 2) penetration of the Surveyor rocket engine in such a manner as to either destroy the engine or cause the spacecraft to tumble if residual thrust exists. In the event of inadvertent separation of Centaur/Surveyor, the flight termination system automatically issues a destruct command to the Centaur and Surveyor destruct pyrotechnics.

1.1 <u>BASIC DESCRIPTION</u>. The flight termination system for the AC-6 Atlas/Centaur/Surveyor vehicle is composed of three basic subsystems:

a. The range safety command (RSC) subsystem for the Atlas LV-3C 151D booster,

b. The range safety command subsystem for the 2D Centaur high-energy upper stage, and

c. The Surveyor destruct subsystem for the Surveyor SD-2 dynamic model. (This subsystem is mounted on Centaur and is inert on AC-6.)

The RSC subsystem for the 2D Centaur differs from the previous Centaur subsystem in two basic modes. The 2D Centaur subsystem incorporates the lightweight design required by Contract NAS3-3232, Exhibit B and by NASA Technical Directive No. 9. Incorporated also in the 2D Centaur design is the capability of destroying the Surveyor as required by NASA Technical Directive No. 120.

The RSC subsystem design is redundant except for a common antenna system, a single high-explosive charge for Centaur destruction, and a single conical-shaped charge for Surveyor destruction.

1.2 REQUIREMENTS. The requirements for the RSC subsystems are determined by the range (AFETR), the customer (USAF & NASA) and the Contractor (GD/C). Range requirements are contained in AFMTC regulations 80-7 and 80-2. Other requirements are determined by the customer and the contractor in consideration of mission peculiar requirements, hardware availability, and interfaces between other subsystems and ground equipment.

1.2.1 Specific Range Requirements: The requirements imposed by AFMTC Regulation 80-7 are briefly:

a. Missiles must have two separate and independent methods of emergency flight termination throughout powered flight.

b. Systems must be compatible with the standard AFMTC flight termination system and may have no common items except the antenna and the destructor, and must be installed on the last powered stage. Provisions must be such that, in case of premature separation or break-up, no stage will be capable of powered flight unless a system is on that stage.

c. The subsystem must provide adequate coverage over 95 percent of the radiation sphere and must be capable of operating with an electromagnetic field intensity which is 12 db below the intensity provided by the range.

d. The system must provide for conditions of zero thrust and for fuel dispersion. These conditions must be initiated by separate commands; the first command arms the system and initiates fuel cutoff, the second command initiates destruct.

e. Safe/Arm devices, electrically armed, must be armed before vehicle first motion and must have both remote and manual methods of disarming. Devices must have both remote and visual indicators.

f. Primer circuitry must be properly shielded and/or otherwise isolated. Electrical shorts must be maintained across primers until arming the destructor. A method must be provided to open primer circuits at any time during prelaunch phase.

g. A method of turning receivers on and off independently of other systems must be provided.

h. A Safe/Arm device simulator must be provided for monitoring primer circuits until installation of the live unit. The simulator must have an impedance equal to that of the primer and must have an alarm to indicate current which exceeds no-fire primer current.

The requirements imposed by AFMTC Regulation 80-2 in addition to 80-7 are briefly:

a. Destruct systems must have an electro/mechanical safe/arm unit with separate plugs for arming and squib firing circuits. A reinsertable safety pin must be provided.

b. Ordnance locations must be accessible during countdown.

c.* Electro-explosive devices (EED's) must have no-fire current and power of not less than 1 amp and 1 watt for five minutes without use of external shunts.

d.* Firing circuit shielding for 1 amp, 1 watt EED's must provide 40 db minimum attenuation from 150 kc to 10,000 mc.

e.* Firing circuit conductors must be twisted, must be isolated from other electrical circuits and each other by means of shields, and must be balanced to and isolated from the EED case and other conducting parts of the vehicle. If circuits are grounded, there will be only one interconnection with other circuits. Static discharge resistors of 100K or more may be connected to the firing circuits.

f.* The range user must validate survival of each EED before, during, and after installation in the following electromagnetic fields:

150 kc to 50 mc: 2 watts/meter^2; above 50 mc: 100 watts/meter^2.

*Requirements of 80-2 Appendix A. Item f. above is an alternate to Item c. and d. above.

1.2.2 Input Signal Characteristics. The RSC subsystem input signal characteristics are to be compatible with the characteristics of the RSC ground station. The RSC subsystem characteristics are as follows:

a. Carrier frequency tolerance allotted to the transmitter is ± 0.005 percent; an additional 0.003 percent tolerance is allotted for doppler shift.

b. Carrier signal strength provided by the UHF ground transmitters is to be within a range from 950 microvolts to 65 volts/meter.

c. A modulation deviation of ± 60 kc for any number of tones.

d. Equality of modulation tone deviations within ± 10 percent.

e. Tone frequency tolerances with ± 1.0 percent.

SECTION 2

RANGE SAFETY COMMAND SUBSYSTEM, FIRST STAGE (ATLAS)

2.1 SUBSYSTEM DESCRIPTION. The vehicleborne subsystem receives and executes the following commands: 1) manual fuel cutoff (MFCO), all engine cutoff; and 2) destruct, vehicle destruct. To transmit these commands the command destruct transmitter carrier signal is received by the combination of tones: 1 (7.5 kc), 2 (8.46 kc), and 5 (12.14 kc). The modulated carrier signal is received by the antennas (Figures 2-1 and 2-2) and sent to the ring coupler, where the r-f energy is divided and presented to both RSC receivers. The RSC receivers convert modulated r-f signals to 28-vdc command outputs.

If the command is MFCO (tones 1 and 5), 28 vdc is sent through the power and signal control unit to the NAA engine control relay box and operates relays which in turn operate solenoids to stop the flow of propellants to all engines.

If the destruct command is given (tones 1 and 5 followed by tones 1 and 2), MFCO is initiated (to cut off all engines), then 28 vdc is sent through the electrical arming device to the destructor primers. Destruct cannot be initiated without a previous MFCO command, due to logic built into the receivers.

An overall subsystem schematic is shown in Figure 2-3. The RSC subsystem consists of:

a. Two commands receivers. (GFAE) Avco AD319600 MK II or MK III (69-36000-80304-805)

b. One power and signal control unit (27-36236-801).

c. One electrical arming device (27-36244-1).

d. One ring coupler (7-36044-1).

e. Two antennas (27-12507-1, -3).

f. Two RSC batteries (69-06308-1).

g. One destructor (27-04306-803).

2.1.1 Antenna System. Each antenna cavity contains two range safety command probes and one telemetry probe. The combined telemetry and command antenna was designed to require minimum space in the vehicle, yet provide the necessary antenna pattern coverage. At the telemetry frequencies, sufficient isolation exists between the telemetry antenna probe and the command antenna output to prevent possible interference with the RSC subsystem.

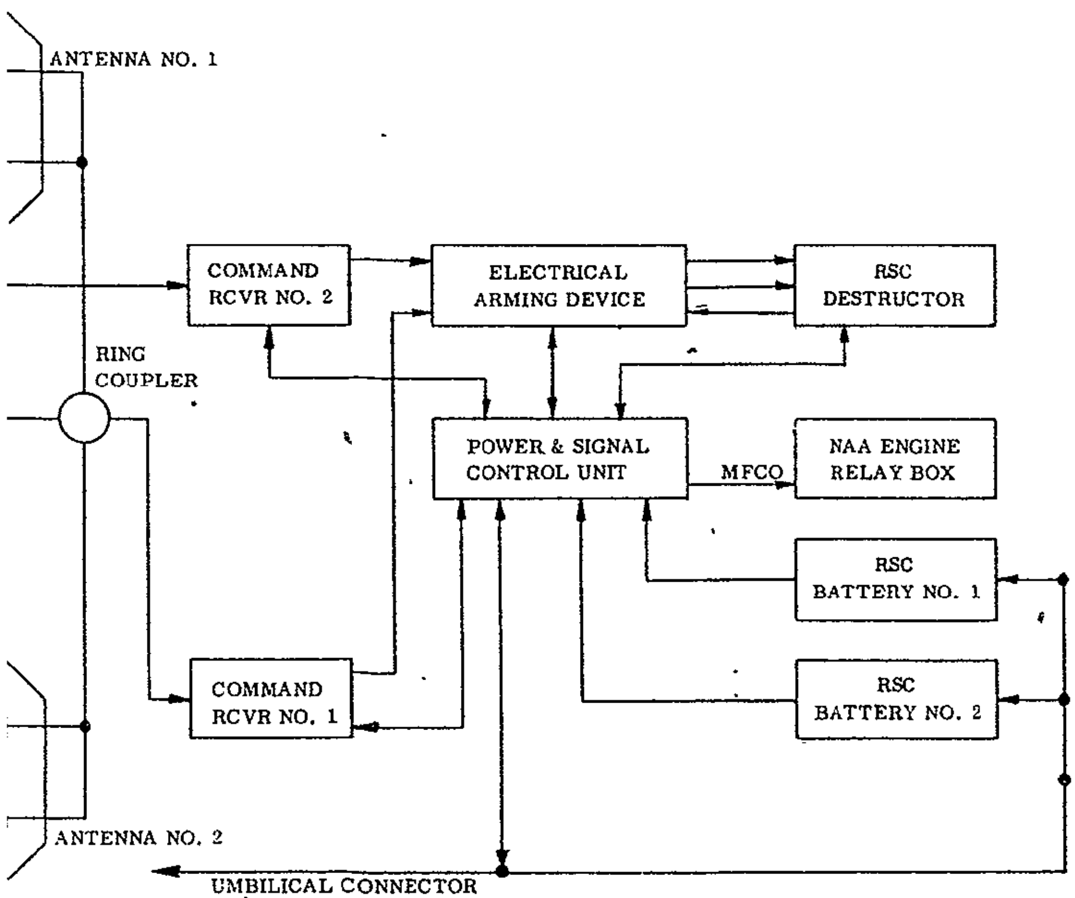


Figure 2-1. Vehicleborne RSC System Block Diagram

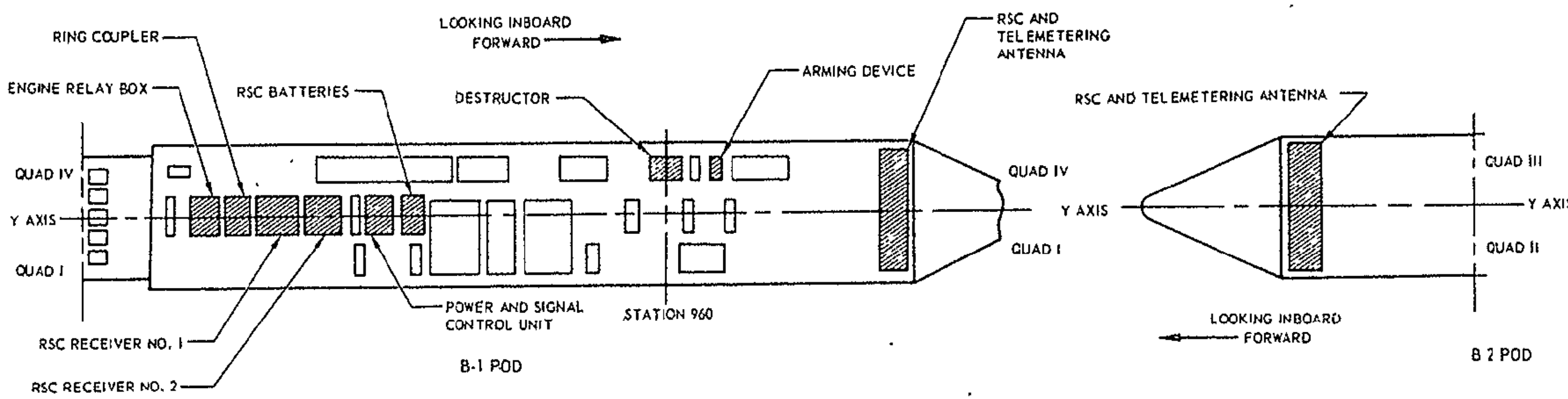


Figure 2-2. Pod Configuration

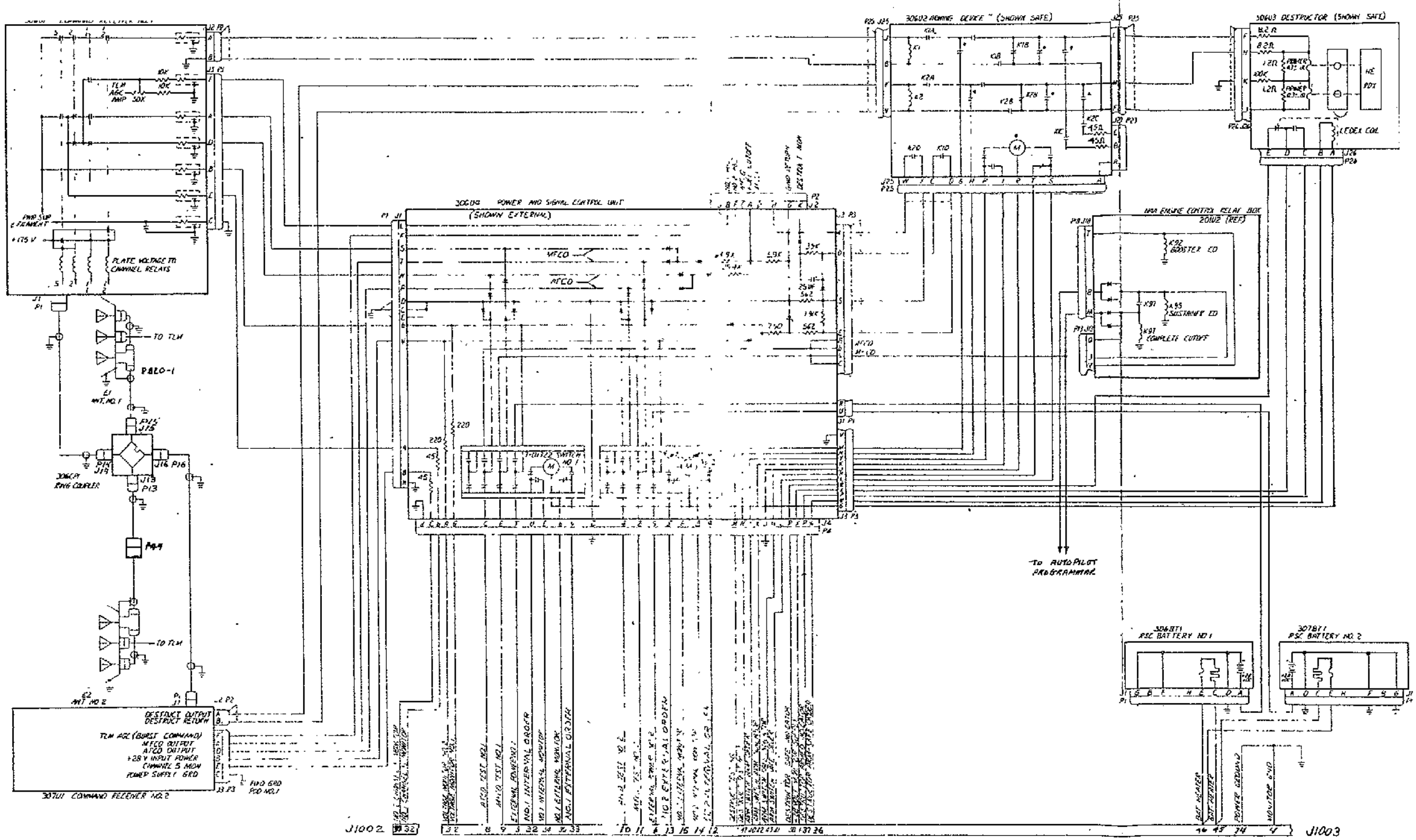


Figure 2-3. Vehicleborne RSC System Schematic

Information for circular polarization patterns was obtained with the use of a 1/10th-scale model of the Atlas vehicle (Figure 2-4), using a left-hand sense (as opposed to the IRE standard) of illumination. Figures 2-5 and 2-6 show the circular polarization patterns, prior to and after staging, respectively, when the adjacent antennas are fed in phase. The three-db loss associated with the transition from linear to circular polarization has been accounted for in the plot, so that the indicated signal intensities may be taken as actual values.

Since the two antennas on the vehicle are separated by approximately four wavelengths, there is an interference region in the radiation patterns along the sides of the vehicle where the individual radiation patterns of the antennas overlap.

The interconnection of antennas and receivers is accomplished by parallel terminals to a re-entrant transmission line 3/2 wavelengths in circumference, known as a ring coupler (Figure 2-7).

The four terminals are separated by one 3/4-wavelength and three 1/4-wavelength branch lines. A signal arriving at the antennas along the pitch axis of the vehicle will produce a signal at the in-phase output terminal (to RSC Set No. 1) of the ring coupler equal to the sum of the two antenna signals. The signal at the out-of-phase output terminal (to RSC Set No. 2) of the ring coupler will be equal to the difference of the two antenna signals. In this case the difference will be zero. If the signal source is moved about the vehicle roll axis until the distance from the signal source to one antenna is one-half wavelength different from the distance between the source and the other antenna, the signals at the in-phase output terminal of the ring coupler are now out-of-phase, and as a result they produce a voltage equal to their difference. At the out-of-phase output terminal of the ring coupler, the signals will be in-phase and, therefore, the voltage will be the sum of both signals. In other words the signal applied to one receiver is the vector sum, and the signal applied to the other receiver is the vector difference of the signals applied to the input terminals of the ring coupler.

This arrangement makes the radiation pattern seen by one receiver in the interference region complementary to the radiation pattern seen by the other. When one receiver receives a strong signal, the other receives a weak signal, and vice versa. For all angles outside the interference region, both receivers receive signals of the same amplitude. As long as both receivers are operative, omnidirectional coverage is provided. If one receiver fails prior to staging, 86.3 percent of all angular directions from the vehicle will have an antenna directivity in excess of 10 db below that of an isotropic radiator; after staging, the amount of angular directions changes to 85.5 percent.

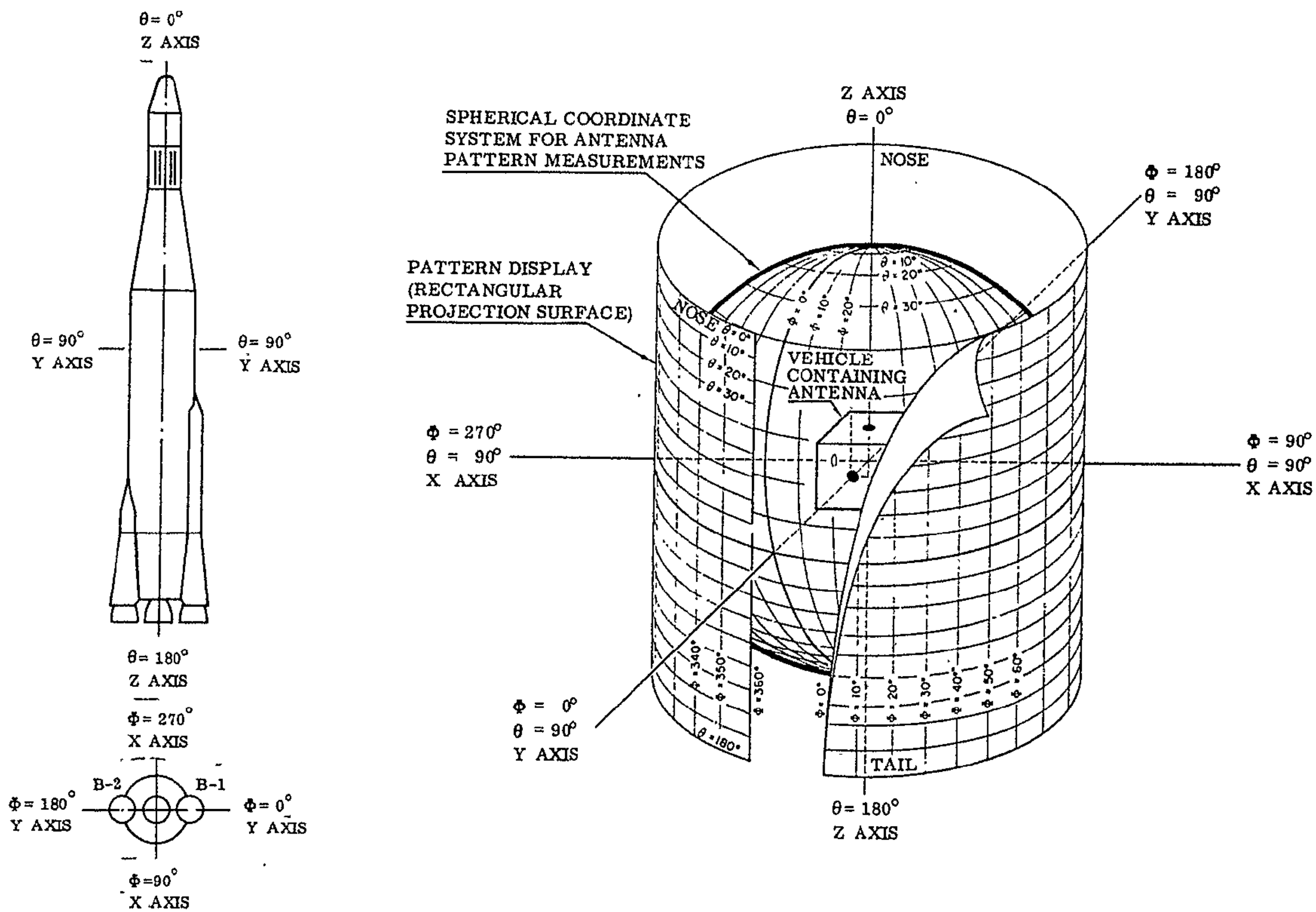


Figure 2-4. Consolidated Vehicle and Antenna Coordinate System

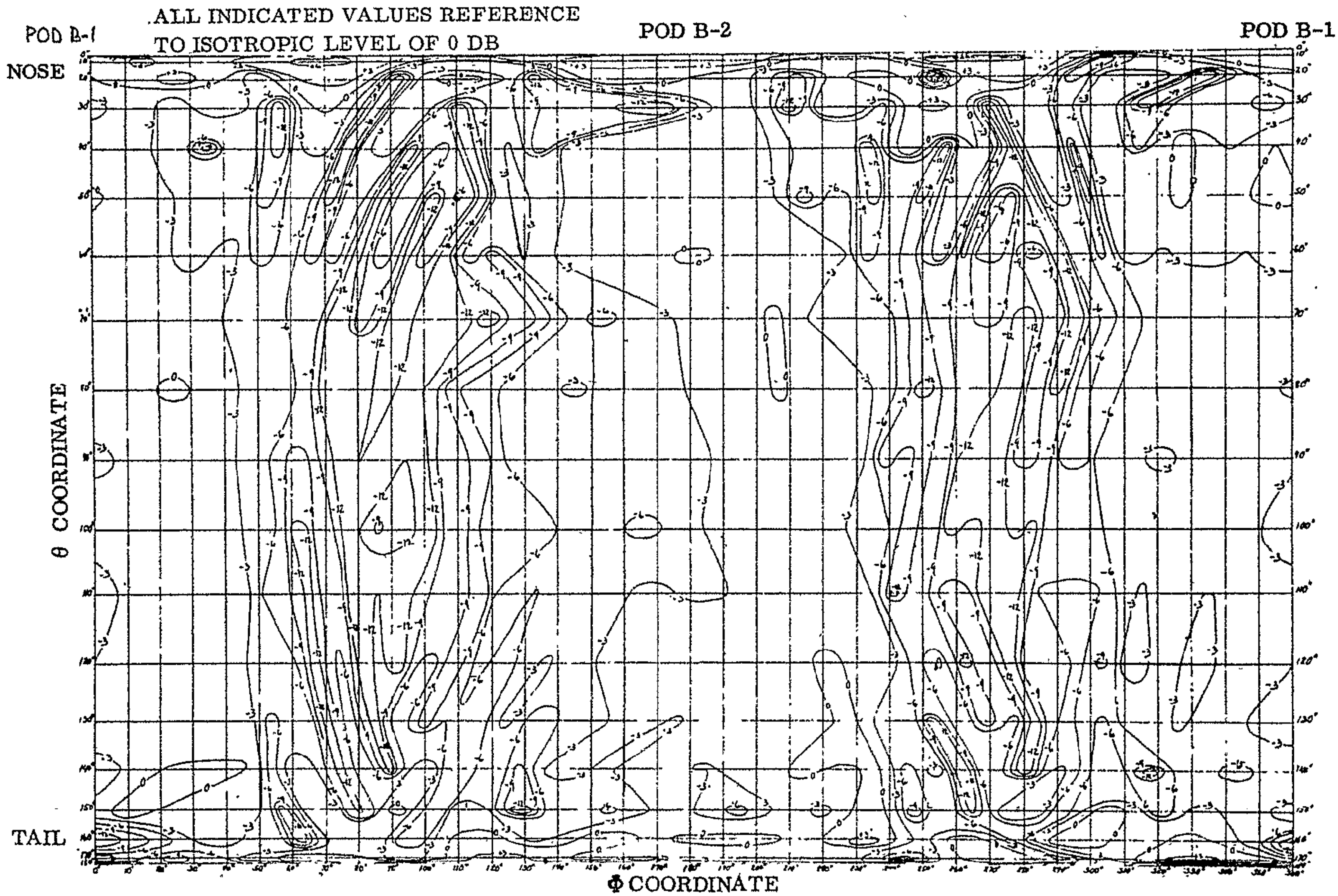


Figure 2-5. RSC Antenna Circular Polarization Patterns (Before Staging)

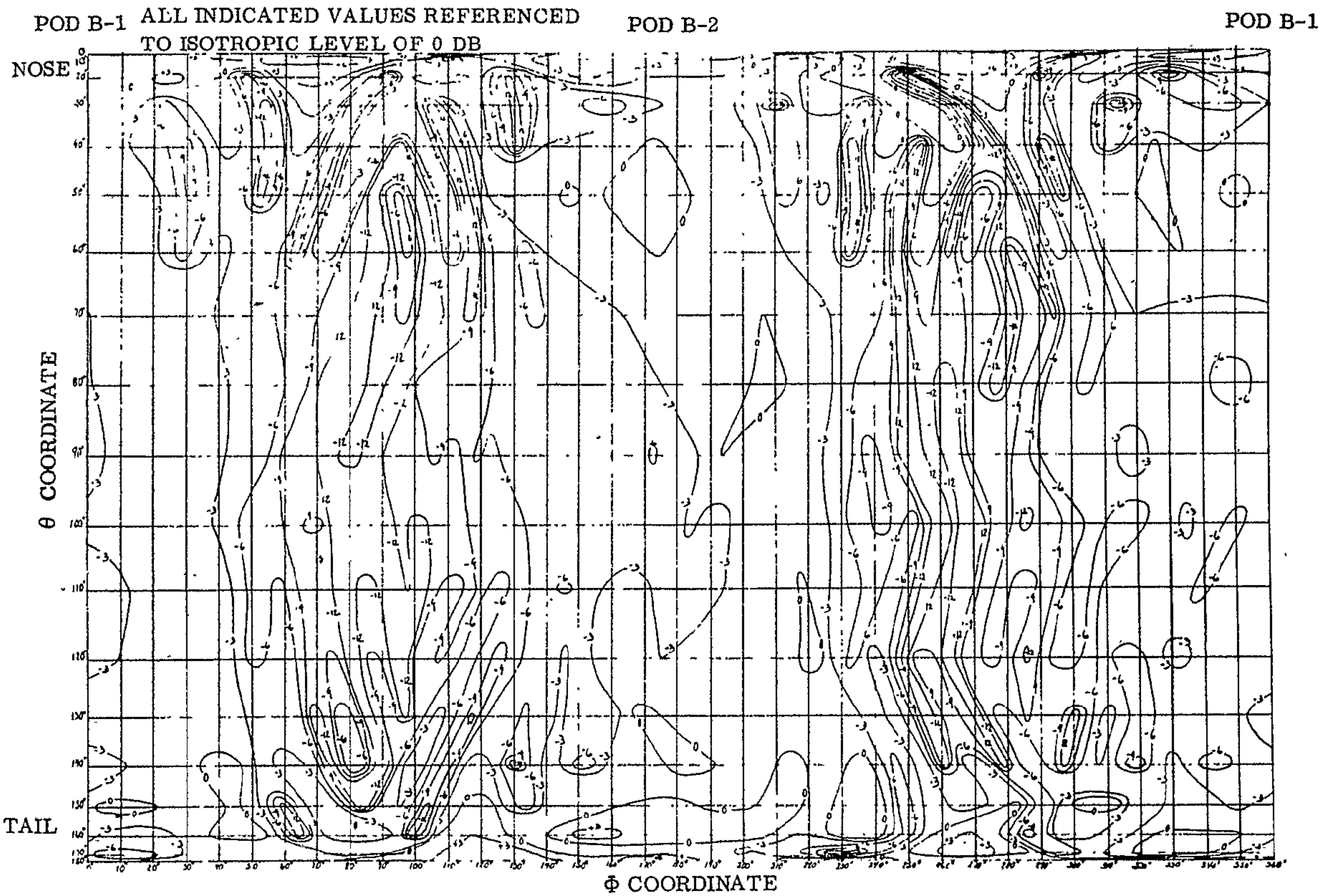


Figure 2-6. RSC Antenna Circular Polarization Patterns (After Staging)

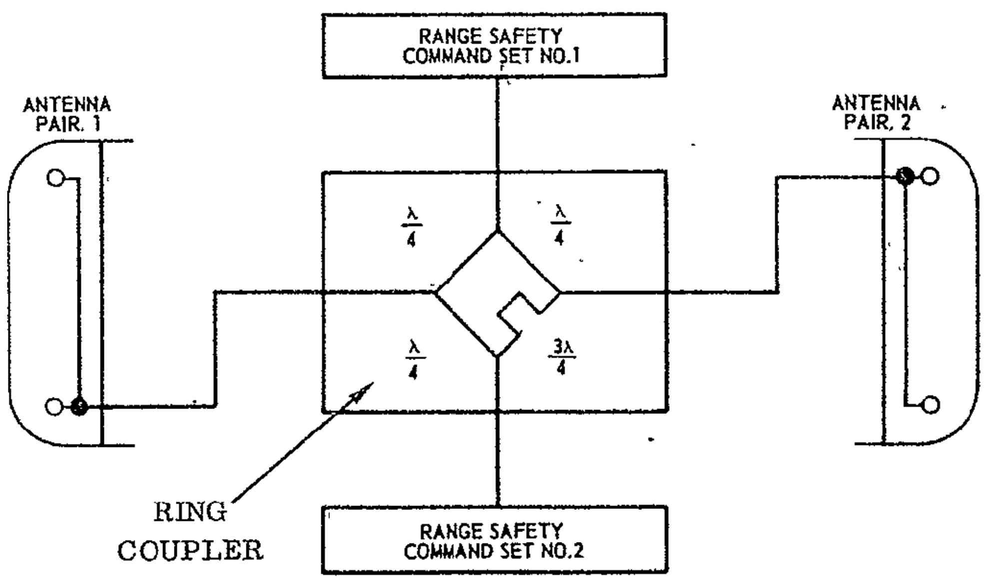


Figure 2-7. Vehicleborne RSC Antenna System

2.1.2 Receiver Operation. The command receivers employ double superheterodyne conversion and may be tuned to any carrier frequency in the range from 406 to 420 mc. Receiver bandpass frequency stability is better than 0.005 percent. An input of approximately three microvolts is required to produce an output signal-to-noise ratio of 6 db. This input corresponds to a signal of less than 260 microvolts per meter at the antenna; however, the system is intended to operate at a signal level greater than 950 microvolts per meter at the antenna. Assuming a 6-db loss from each antenna junction to each receiver and an antenna gain of 10 db above that of an isotropic radiator, a field strength of 950 microvolts per meter at the antenna produces a ten-microvolt signal at the receiver. The sensitivity and stability of the receiver are obtained by utilizing two crystal oscillators. The second i-f amplifier is fixed-tuned at 10.7 mc. The F-M detector and audio decoder stages of the receiver operate with an F-M deviation of ±60 kc. The receiver employs three audio channels. Combinations of the audio channel outputs trigger relays which pass 28 vdc for either destruct, manual fuel cutoff, or automatic fuel cutoff commands. In addition, channel 5 is used as a monitor channel since its output is available at the power connector.

Radio command signals are received as a combination of audio tones. The decoder separates the tones at the output of the receiver by tuned electrical filters. Further amplification is obtained in each filter by passive step-up. Each filter output is rectified, smoothed, and applied as a d-c voltage to the grids of the corresponding channel relay amplifiers. An audio amplifier following each filter section actuates the relay associated with that tone.

The channel relay amplifier unit contains pentodes operating as d-c channel relay amplifiers. The plate load of these pentodes is a channel relay coil. The amplifiers are held in a cutoff state in the absence of grid voltage. Reception of a filter output drives an amplifier into saturation, which energizes the channel relays. The relays complete the logic circuit to provide a command output.

The sequence circuit in the receivers requires that the combination of tones 1 and 5 (MFCO) be received immediately before tones 1 and 2 (destruct) if the combination of tones 1 and 2 is to generate a command output. It is preferable that tone 1 remain on continuously during the transition from the 1-5 combination to the 1-2 combination. If both tones 1 and 5 are turned off during the transition, then the combination of tones 1 and 2 must be received within 105 milliseconds after deletion of tones 1 and 5. The destruct command (tones 1 and 2) output will occur between 110 and 350 milliseconds after removal of tone 5, provided the proper sequence of tones was received.

No sequence is necessary for generation of commands 1-5 (MFCO) and 2-5 (AFCO); however, only one command output signal will be generated for each combination of command tones. The AFCO command (tones 2 and 5) output will occur 6 ± 3 milliseconds after receipt of the tone combination. (AFCO is not used on the Atlas booster).

To obtain any command output signal from the receivers, the two required tones must be received and the third tone must not be received. Simultaneous receipt of all three tones inhibits the generation of any command output signal, although a "burst" command signal will appear on the normal telemetry agc output pin.

2.1.3 Component Functions. The functions of the vehicleborne components of the RSC subsystem are described below.

The power and signal control unit performs the following functions:

a. Individual control of 28-vdc power from external to internal for each of the two command receivers.

b. Arm/safe for each of the AFCO and MFCO output commands from each of the two command receivers. The arm/safe function is coordinated with the power changeover control switch for each command receiver; e.g., the fuel cutoff functions are "safed" (and returned individually to the umbilical for transmission to the launch control equipment) when the power switch is in the external position; the fuel cutoff functions are armed and routed to the appropriate terminal in the NAA engine relay box when the power switches are in the internal position.

c. Instrumentation to the vehicleborne telemetry is provided for the fuel cutoff commands and the destruct command. The destruct command signal voltage is NOT routed through the power and signal control unit; a contact closure in the arming device is used for this instrumentation. The fuel cutoff outputs are isolated from instrumentation feedback by diodes.

d. Straight feed-through connections are provided for specific control and monitoring signals from the umbilical connector to the arming device and the destructor unit.

The electrical arming device performs the following functions:

a. Arm/safe for the destruct output commands from each of the two command receivers. In the safe position, electrical short circuits are maintained across the input to the destructor primer circuits, and the command signals are returned individually to the umbilical for transmission to the launch control equipment. In the arm position, the command signals are routed to the destructor unit.

b. Provides relays in the destruct circuits to provide isolation of both sides of the destructor primers from ground and the energizing voltage, and maintains electrical short circuits across the destructor primers until the destruct command is initiated.

The destructor unit performs the following functions:

a. Arm/safe for the explosive train in the destructor unit. The unit is mechanically armed (or safed) by the rotation of a steel shaft located between the primers and the booster charges. The shaft has two 1/8-inch-diameter holes, filled with primer charge, which are aligned (or misaligned) with the primers and the booster charges. Detonation of the booster charges and the main charge cannot occur unless the destructor unit is in the arm position.

b. Provides explosive output for destruction of the vehicle.

c. Provides visual and electrical monitors of arm/safe condition.

Control of the arming/safing and the internal/external changeover of the components is provided by the launch control equipment. Motor-driven switches provide these functions in the power and signal control unit and the electrical arming device. A Ledex solenoid is used in the destructor unit.

2.1.4 Fuel Cutoff Command Operation. A logic schematic for the MFCO circuits with the subsystem operating on internal power and the MFCO command actuated is shown in Figure 2-8. The RSC battery voltage is applied to each command receiver independently through the changeover switches in the power and signal control unit. Relay contact closures in the command receivers route the receiver input voltage to the MFCO output. The MFCO signals from each receiver are combined by the changeover switches in the power and signal control unit, and the MFCO command is routed to the NAA engine relay box. This command signal actuates the complete cutoff relay, which in turn actuates the sustainer cutoff relay. Operation of these relays drops out lock-in relays. The dropout of the lock-in relays operates solenoids to cut off propellant flow to the vernier, sustainer, and booster engines.

2.1.5 Destruct Command Operation. A logic schematic for the destruct circuits with the subsystem operating on internal power and armed with the destruct command actuated is shown in Figure 2-9. Relay contact closures in the command receivers route the receiver input voltage to the destruct output. The destruct signals from each receiver operate relays in the electrical arming device, which remove the short circuits across the destruct primers and complete the destruct firing circuits to the destructor. The signals are combined through two 8.2-ohm resistors in the destructor and supply the firing current to the primers. The primers are connected in series and shunted by resistors in such a way that an open or short circuit of one primer will not affect the operation of the other primer. A destruct signal from either receiver will fire either or both destruct primers. Initiation of the primers causes subsequent initiation of the booster charges and the main explosive charge, resulting in destruction of the vehicle.

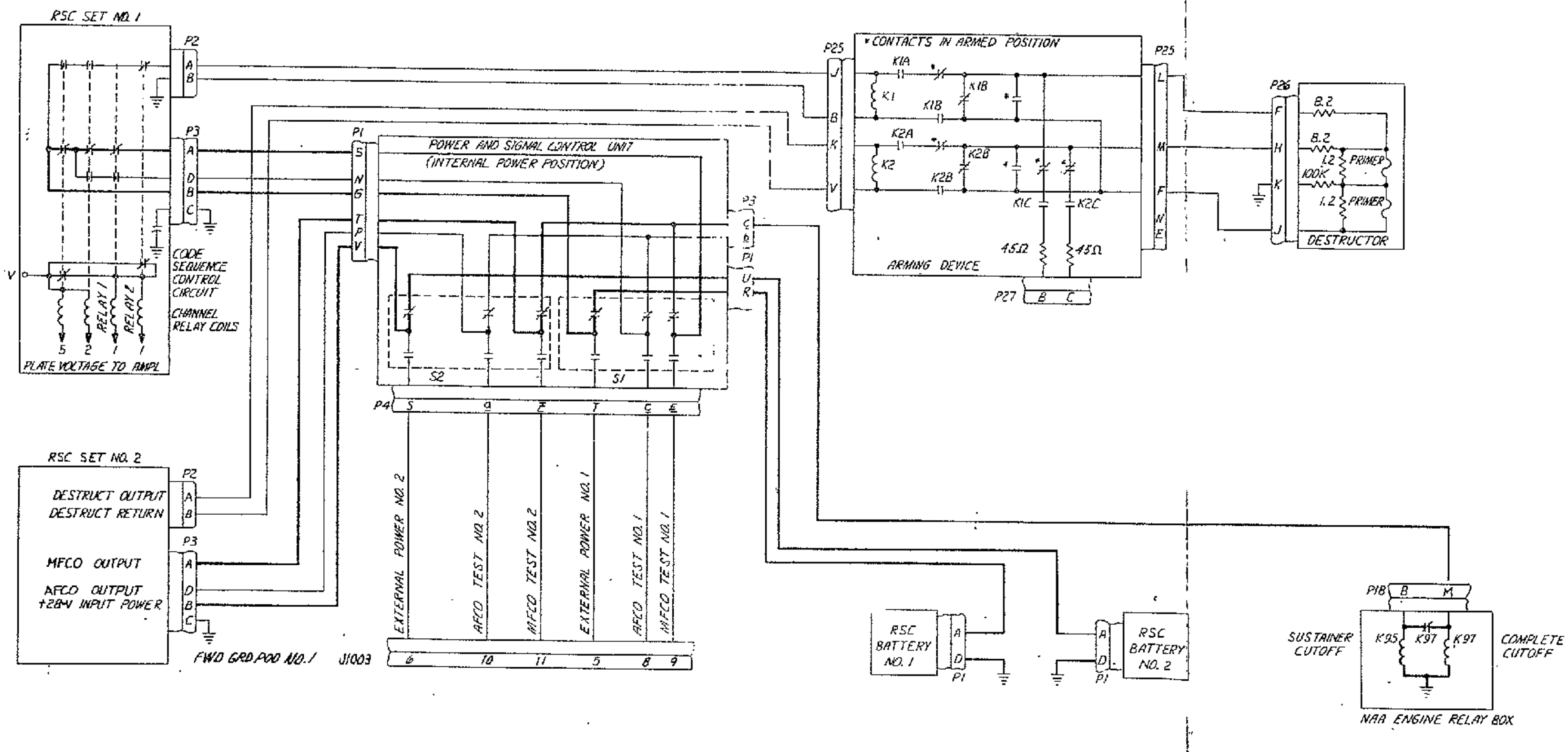


Figure 2-8. RSC Logic Schematic - MFCO Command Actuated

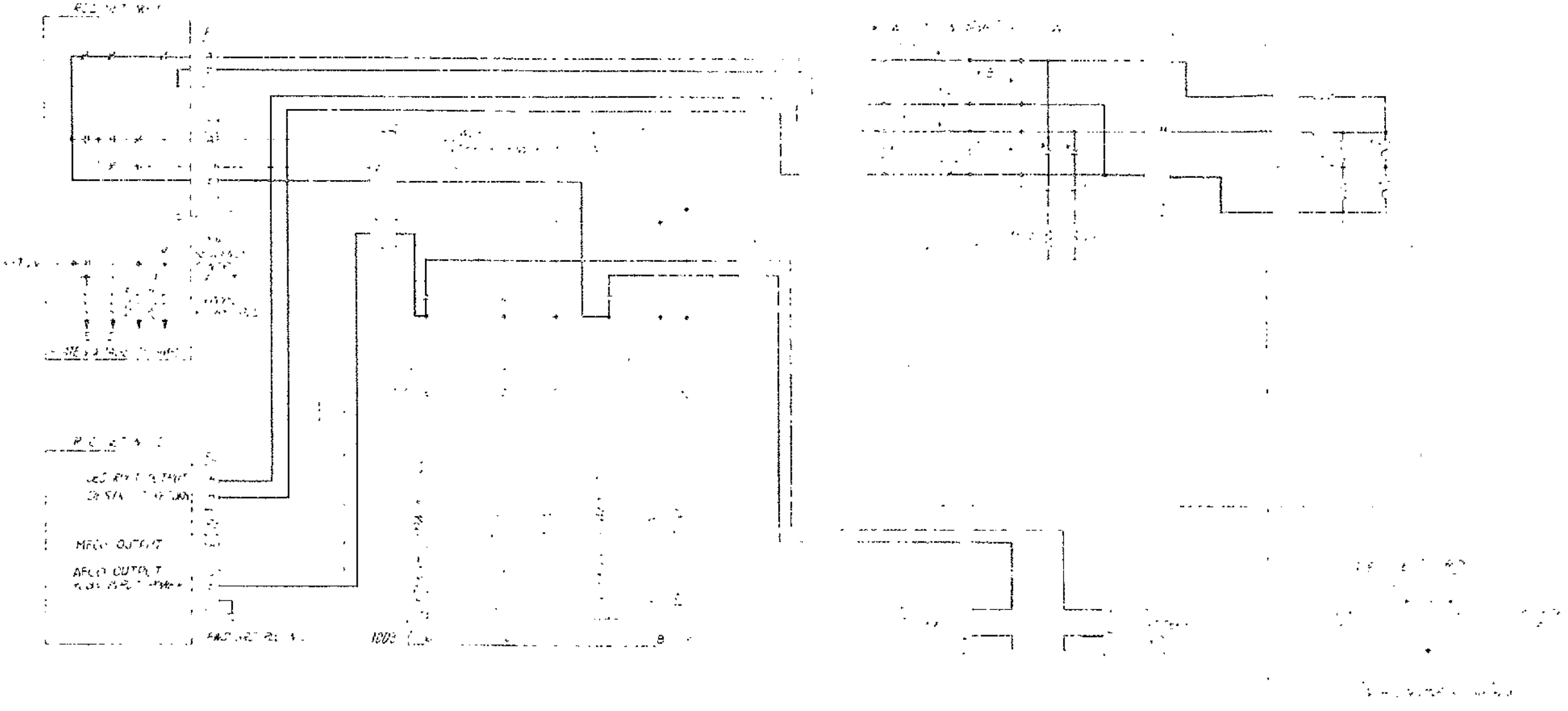


Figure 2-9. RSC Logic Schematic - Destruct Command Actuated

2.1.6 Electrical Harnessing. All wire used in the electrical harness for the RSC subsystem has the following properties:

Insulation Voltage	-	600 Volts
Maximum Temperature	-	200° C
Primary Insulation	-	Teflon
Conductors	-	Silver Plated Copper

Twenty-gauge wire is used throughout except for battery connections, which are 16 gauge, and some umbilical connections. The wires between the RSC receivers and the electrical arming device and between the electrical arming device and the destructor are individually shielded. The connectors on the electrical arming device and the destructor are MS type. Pygmy-type connectors are on all other components. Crimp-type connectors are used for the batteries and solder-type connectors are used for the other components. The MS-type connectors have a grommet wire seal and the other solder-type connectors are potted. All connectors are safety-wired before flight.

Calculated harness voltage drops have shown that under the worst-case conditions (that is, minimum battery voltage of 26.5 volts, only one receiver operating, and destruct command actuated) the voltage at the input to the receiver will be not less than 25.5 volts, and the current through the destructor primers will be not less than 1.9 amp. The recommended minimum firing current for the destructor primers is 1.0 amp.

2.2 INSTRUMENTATION. RSC data telemetered during flight are as follows:

Measurement No.	Description	Channel No.	Type of Measurement
D7V	RSC No. 1 Signal Strength (agc)	1.A.3	Commutated - 10 rps
D1V	RSC Cutoff	1.13.7	Commutated - 5 rps
D3X	Destruct	1.E.S	Superimposed on Channel E.

Signal strength, fuel cutoff, and destruct outputs on each command set are monitored. To minimize the number of telemetered measurements, the fuel cutoff outputs of the two command sets are recorded on one track. The signal strength from only one command set is telemetered to give a relative indication of the signal level present during flight.

Fuel Cutoff Instrumentation. A voltage divider network in the logic circuit of the power and signal control unit is used for instrumentation MFCO and AFCO commands. The two cutoff outputs are differentiated by voltage level. MFCO provides 2.2 volts to telemetering equipment. All cutoff signals occurring external to the command sets are isolated, and only cutoff signals initiated through the RSC are monitored on command instrumentation.

Signal Strength. The signal strength voltage is obtained from a voltage divider network in the d-c amplifier stage, which is driven by the limiter stage. This voltage is adjusted during production to give a 4.8-volt ±10 percent output. A 28-volt output signal is also available at burst command to indicate when channels 1, 2 and 5 relays are closed. A plot of instrumentation voltage versus signal strength is made for each command set. A typical signal strength calibration curve for the Avco AD-319600 MK III set is shown in Figure 2-10.

Destruct Instrumentation. Instrumentation for destruct is performed through a network of voltage dividers in the power and signal control unit and relay contacts in the electrical arming device. This network provides output voltage levels and isolates the instrumentation from the destruct command signal wires. When set No. 1 is activated, the instrumentation output is initially 6 volts and rapidly decays to 3 volts. When set No. 2 is activated, the instrumentation output is 2.25 volts. Both sets activated simultaneously produce an instrumentation output of 6 volts. These are calculated values assuming a telemetry load impedance of 39 K ohms.

The RSC launch control sequence data displayed and recorded in the blockhouse are as follows:

Atlas Measurement No.	Item
AN 1496X	CMD RCVR NO 1 INTERN
AN 1497X	CMD RCVR NO 2 INTERN
AN 1498X	CMD RCVR NO 1 EXTERN
AN 1499X	CMD RCVR NO 2 EXTERN
AN 1472X	ATLAS RSC SAFE
AN 1473X	ATLAS RSC ARMED
AN 1474X	ATLAS DESTRUCT NO 1
AN 1475X	ATLAS DESTRUCT NO 2
AN 1824X	ATLAS DESTRUCT MONITOR
AN 1825X	MFCO MONITOR
AN 1476X	RSC MFCO NO 1
AN 1477X	RSC MFCO NO 2
AN 1826X	AFCO MONITOR

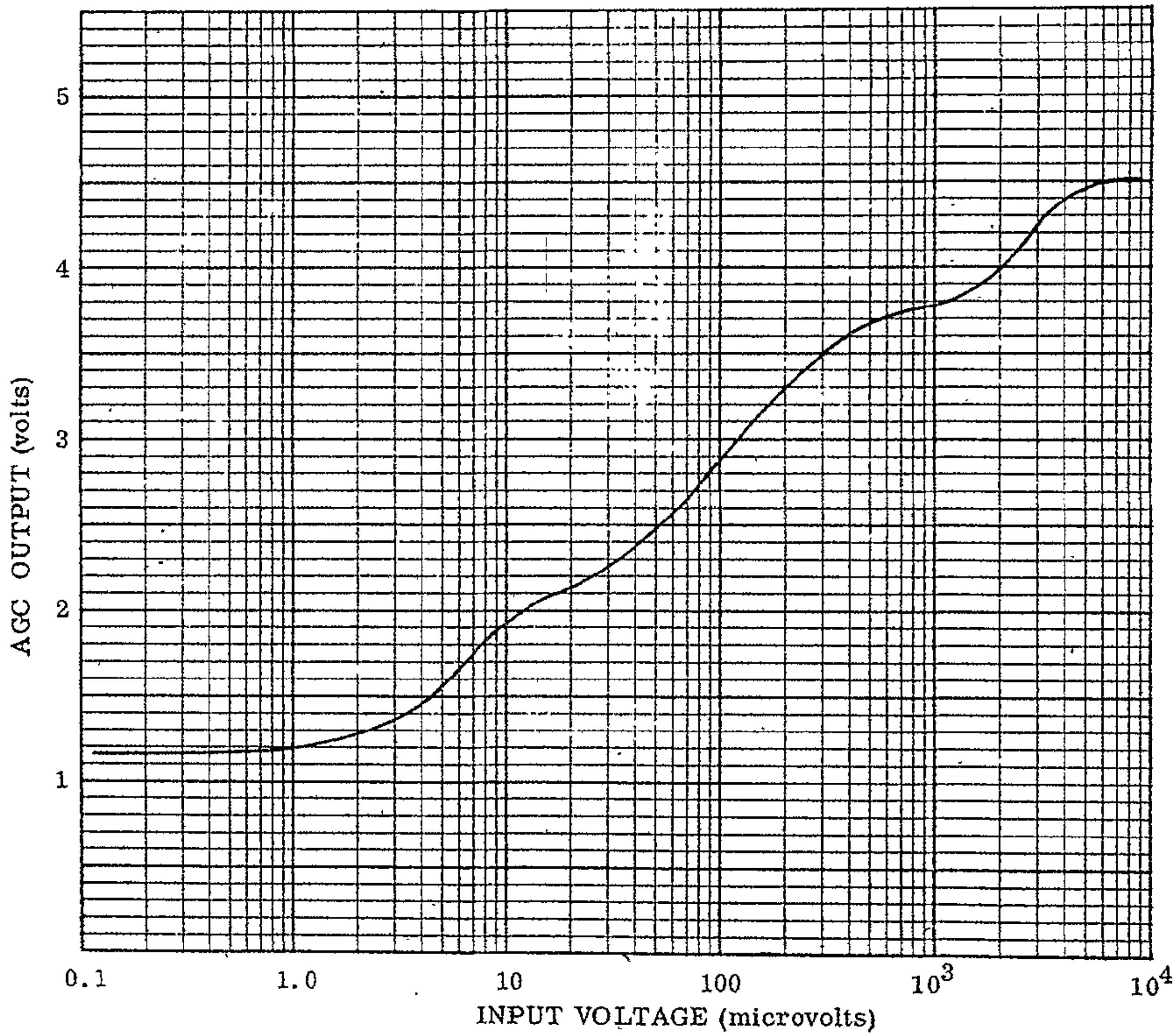


Figure 2-10, Typical Signal Strength (AGC) Curve

Atlas Measurement No.	Item
AN 1484X	RSC CHAN 5 NO 1
AN 1485X	RSC CHAN 5 NO 2
AE 1609X	CMD BATT 1 OVERTIME
AE 1610X	CMD BATT 2 OVERTIME

2.3 CHANGES TO RSC SUBSYSTEM. The RSC subsystem presently used on the Atlas booster is basically the same as that used on previous "D" series space boosters used at ETR, with the following changes.

The AFCO command (sustainer cutoff) was deleted on F-1 (first Centaur vehicle) because there is no vernier solo phase of booster-powered flight. Destruction of the upper-stage vehicle was accomplished by command from the booster RSC subsystem or by the premature separation destruct system (PSDS).

A separate subsystem was designed for the upper stage on the AC-2 vehicle. The booster RSC subsystem was the same as used on F-1, except for the deletion of the destruct command interface with the upper stage.

No changes were made to the Atlas booster RSC subsystem for AC-3 and AC-4.

For the AC-5 vehicle, the Atlas booster subsystem was basically the same except that newer, manually activated batteries were used, and there was a design change to the destructor. (See 2.6.6.2.)

The AC-6 vehicle (Atlas booster) subsystem is identical to that of AC-5, except for a reidentification of the RSC receivers. The RSC receivers for AC-6 and on will be reidentified as GD/C part number 69-36000 and appropriate dash number. This was done to maintain configuration control.

2.4 PROBLEM AREAS. The following are recognized problem areas which affect the Atlas RSC subsystem.

Battery Open-Circuit Voltage. Presently there is no way to monitor the open-circuit voltage of the manually activated batteries prior to changeover to internal power. The receiver applied voltage is monitored on the launch control panel.

Receiver Signal Strength (AGC). The only way to monitor the operation of the RSC receivers at present is the channel 5 monitor or the telemetered agc voltage of RSC receiver No. 1. It would be both convenient and advantageous to monitor the agc voltage of both receivers on the launch control panel.

MKI, MKII, and MKIII Receivers. Direction has been received to eliminate the installation of MKI receivers on Atlas boosters 151D, 194D, and 291D. Verbal information from range personnel indicates that MKIII receivers are preferred over MKI and MKII receivers because of the increased sensitivity and the higher vibration characteristics. (See 2.6.3.2.)

1 AMP — 1 WATT and Other E.E.D. Requirements. The Atlas RSC subsystem does not meet the requirements of AFMTC Regulation 80-2 and 80-2 Appendix A. (Reference Section 1.2.1.) These requirements necessitate submission of waivers for the Atlas RSC subsystem. (See 2.5.) A TWX has been received from Space Systems Division requesting submission of a proposal for the required compliance changes.

2.5 DESTRUCT CIRCUIT SENSITIVITY ANALYSIS. The Franklin Institute has completed a worst-case analysis of the range safety command destruct system. The analysis was conducted on a model based on actual circuitry. The philosophy is that if an electro-explosive device can be shown to be safe in a worst-case analysis, then in actuality it is very safe since it is unlikely that all the worst-case conditions will occur simultaneously.

This analysis shows the minimum power densities to fire destructor primer part No. BW10081D installed in the range safety command firing circuit at the 0.1-percent firing levels of the primer. The minimum power density to fire falls below 100 watts/meter^2 as required by AFMTC regulation 80-2A only between 2700 mc and 3100 mc, where it falls to 79 watts/meter^2.

Also calculated were the maximum theoretical environmental power densities at Complex 36. The frequency at which the maximum theoretical environmental power density most closely approaches the firing level curve is at 5690 mc where the maximum theoretical environmental power density due to the TPQ-18 radar is 1.01 watts/meter^2 and the firing level power density is approximately 270 watts/meter^2. The maximum theoretical environmental power density is therefore 24 db below the firing level power density.

The three range ship transmitters operate at greater power than the TPQ-18, but the normal operating area for the ship is 150 miles downrange. From this distance the effect on the environmental power density at Complex 36 is negligible.

2.6 AIRBORNE COMPONENTS DESCRIPTION

2.6.1 Range Safety Command and Telemetering Antennas

Manufacturer	Drawing No.	Specification No.
General Dynamics/Convair	27-12507-1, -3	27-01202

Purpose. To receive range safety command r-f signals in the 406-mc to 420-mc range and to transmit telemetering information in the 220-mc range.

Characteristics. The combined telemetering and range safety command antenna (Figure 2-11) was designed to require the least amount of space in the vehicle, yet provide the antenna pattern coverage. At the telemetry frequencies, sufficient isolation exists between the telemetering antenna probe and the RSC antenna output to prevent possible interference with the RSC subsystem.

The TLM/RSC antenna housing consists of a cavity whose outside face forms a portion of the pod surface. Radiation is achieved through the cavity opening which is about 5 inches wide and about 40 inches long. The TLM antenna consists of a single radiating probe located in the center of cavity. The TLM probe and the two RSC probes are not electrically connected. In the base of each RSC receiving probe is a coaxial filter which rejects the TLM frequency. The output of one RSC receiving probe is connected directly to a coaxial T-connector, and the output of the other RSC probe is connected to the same coaxial T-connector through a line that is 1/2-wavelength long at the TLM frequency. The output of the coaxial T-connector is fed to the RSC ring coupler. Since the coaxial filters in each RSC receiving probe attenuate the TLM frequency by about 20 db, and the phase difference at the coaxial T-connector attenuates the TLM frequency by about 20 db (because of the TLM 1/2-wavelength coupling-line difference), the TLM frequency is attenuated approximately 40 db at the RSC antenna output terminal.

2.6.2 Ring Coupler

Manufacturer	Drawing No.	Specification No.
General Dynamics/Convair	7-36044-5	7-03272

Purpose. The ring coupler (Figure 2-12) ensures that failure of one receiver will not affect the other receiver in the dual system. In addition, the ring coupler connects the signals from the B-1 and B-2 pod antennas to one RSC receiver in-phase and to the other receiver out-of-phase. This arrangement effectively produces isotropic radiation coverage about the vehicle.

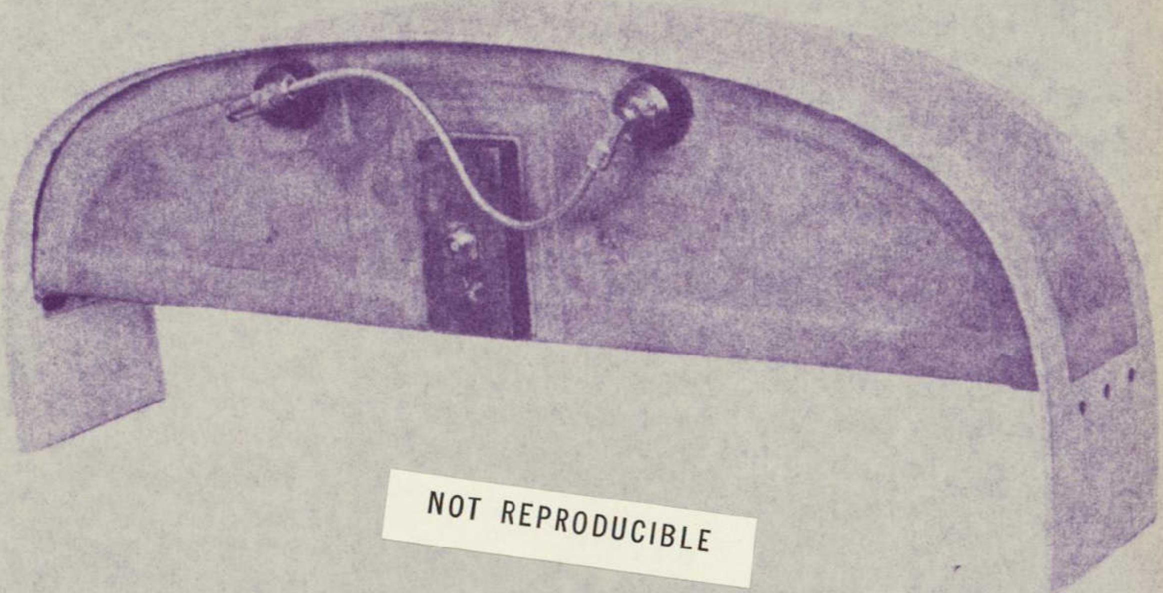


Figure 2-11. Range Safety Command and Telemetering Antenna

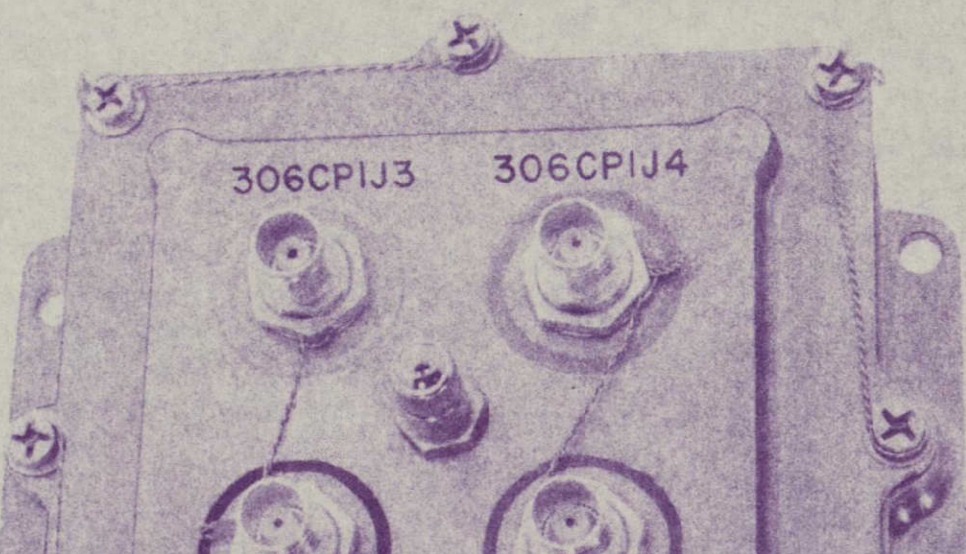


Figure 2-12. Range Safety Command Ring Coupler

Characteristics. The ring coupler is, essentially, a phase-shifting device using strip-line manufacturing methods to obtain a coaxial re-entry line 1-1/2 wavelengths long with four input/output connections. Thus the ring coupler may be considered as a coaxial cable 1-1/2 wavelengths long, at the band center frequency, that forms a continuous loop with four coaxial T-connectors used as terminals. Three of the coaxial lines, between the terminals, are 1/4-wavelength long and the fourth coaxial line, which completes the loop, is 3/4-wavelength long. This type of phase-shift line, continuous but with re-entry points, gives a four-terminal unit with the following characteristics.

From any terminal, the opposite terminal will have an attenuation, considered to be a rejection, of more than 20 db, and the adjacent terminals will have an attenuation of only 3 ± 1 db. The 3 db attenuation to the adjacent terminals is considered to be a division of power (not a loss), and the ± 1 db is added only for a possible uneven division or a possible loss in power. The attenuation between opposite terminals should theoretically be infinite but, because of fixed-line length and variable frequency and power loss, the attenuation over the frequency band of 406 to 420 mc is specified to be only greater than 20 db.

2.6.3 Receivers

Manufacturer	Drawing No.	Specification No.
Avco Corporation Electronics Division	GD/A Part No. 69-36000-803 or -805 Avco AD-319600 MKII or MKIII	GM 36.2-677-3

Purpose. To receive the range safety command r-f signals and convert these signals into 28-vdc commands for automatic fuel cutoff (AFCO), manual fuel cutoff (MFCO) or destruct.

Characteristics. The vehicleborne RSC subsystem employs redundant command receivers to increase system reliability. The Avco AD-319600 Mk III or Mk II remote control receiver (Figure 2-13) is utilized as GFAE (Government-Furnished Airborne Equipment). The command receiver subassemblies include the power supply, F-M receiver, decoder, and logic circuits to translate the r-f signals into commands for MFCO, AFCO, and destruct.

The electronic equipment is packaged in a cast aluminum case, with deep fins on the exterior surfaces to aid in dissipating internal heat. To facilitate maintenance and troubleshooting, top and bottom covers have turnbuckle-type latches. Pressure release is accomplished by loosening the screw in the top cover or by depressing the pressure valve on the front panel.

The command receiver units are of the plug-in type and connect through sockets mounted on the base plate. The following circuits have been made into individual

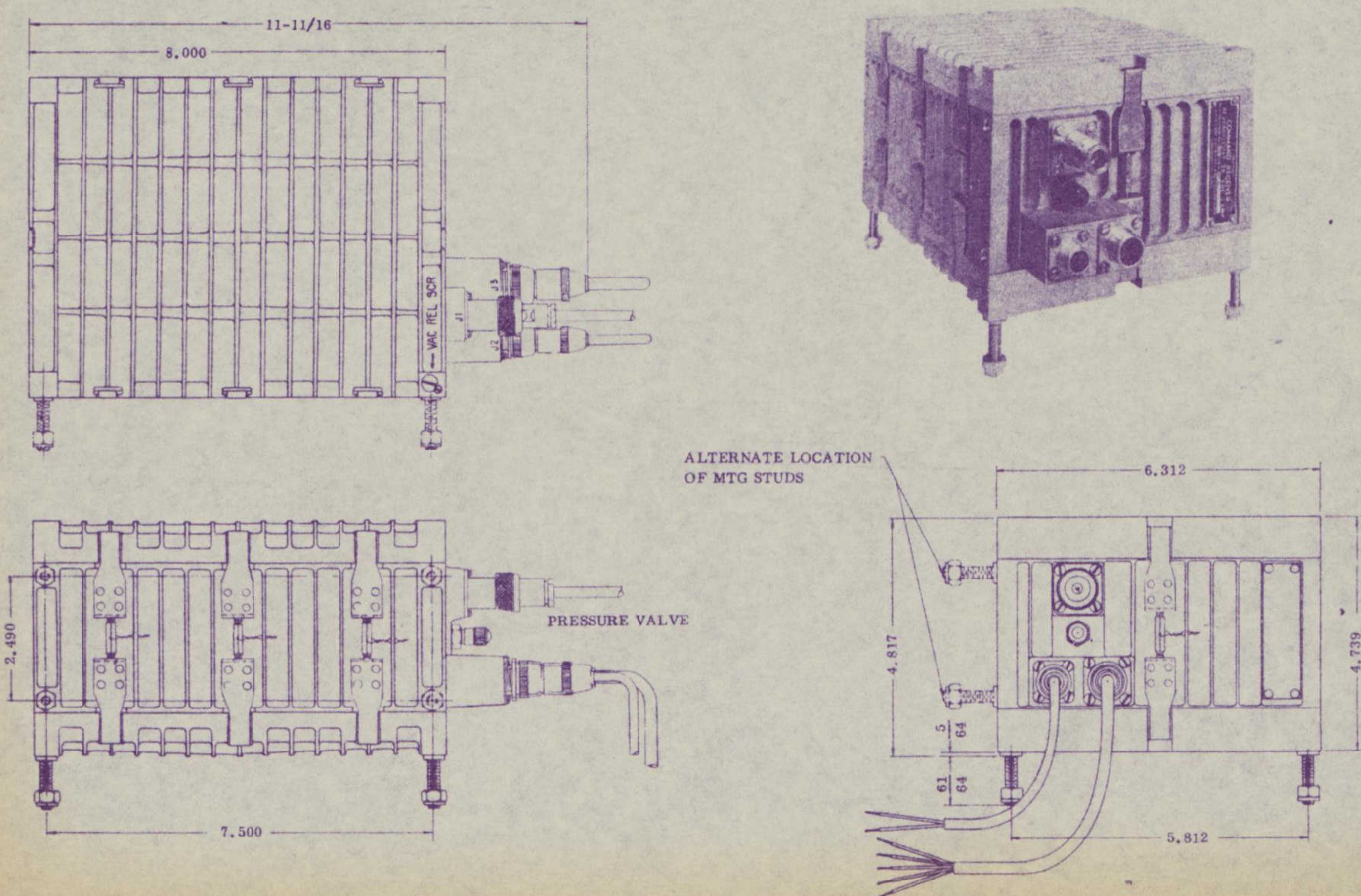


Figure 2-13. Atlas RSC System Receiver

plug-in units: 1) broadband converter, 2) the variable i-f amplifier, 3) fixed i-f amplifier and discriminator, 4) audio amplifier, 5) each audio tone filter and detector, 6) channel relay amplifiers, and 7) a transistorized power supply. The channel relays are mounted directly on the chassis. Individual compartments in the main case are designed to prevent insertion of the wrong unit, with the exception of the audio filters. The audio filter compartments have the channel numbers marked on the base plate next to their sockets.

Covers of the command receiver are sealed with O-rings. The O-rings are covered with a light coating of silicone grease to ensure a good seal and to prevent damage to them. After the covers are fastened, the case is purged and then pressurized to 1.5 atmospheres with dry nitrogen to protect the equipment from moisture damage during storage and shipment. Prior to flight, the canister is bled to 1.0 atmosphere.

2.6.3.1 Functional Description

Receiver Section. The received signal enters the command receiver at antenna connector J1, where it is passed through a band pass filter (Figure 2-14). The signal is then applied to the crystal mixer of the broadband converter unit, where it is mixed with a 355-mc signal from the broadband converter oscillator to give a difference frequency in the 50- to 65-mc range. The resulting signal is fed to the VIP (variable intermediate frequency) amplifier unit, and then to the VIP mixer. Here it is mixed with the signal from the VIF crystal oscillator to give a difference frequency of 10.7 mc. The 10.7-mc signal is amplified by three stages in the fixed i-f amplifier unit. The signal is then fed to the limiter, whose output drives the discriminator. The audio signal is amplified and applied to the decoder.

The limiter also supplies a d-c voltage to the squelch tube, which biases the audio amplifier to cutoff in the absence of a received signal. In addition, the d-c voltage from the limiter in parallel with d-c voltages from the two preceding amplifier grids is applied to a telemeter amplifier, which provides a voltage of positive polarity for telemetering the receiver signal level. Signal levels from about 2 through 10,000 microvolts can be determined from the telemeter output.

Decoder Section. Radio command signals are received as a combination of audio tones. The decoder separates the tones at the output of the receiver through tuned electrical filters. A filter output is rectified, smoothed, and applied as a d-c voltage to the grids of the corresponding channel relay amplifier, the plate load of which is a channel relay coil. The amplifiers are held in a cutoff state in the absence of grid voltage. Reception of a filter output drives an amplifier into saturation and results in plate current energizing the channel relays. The relays complete the logic circuit to provide a command output.

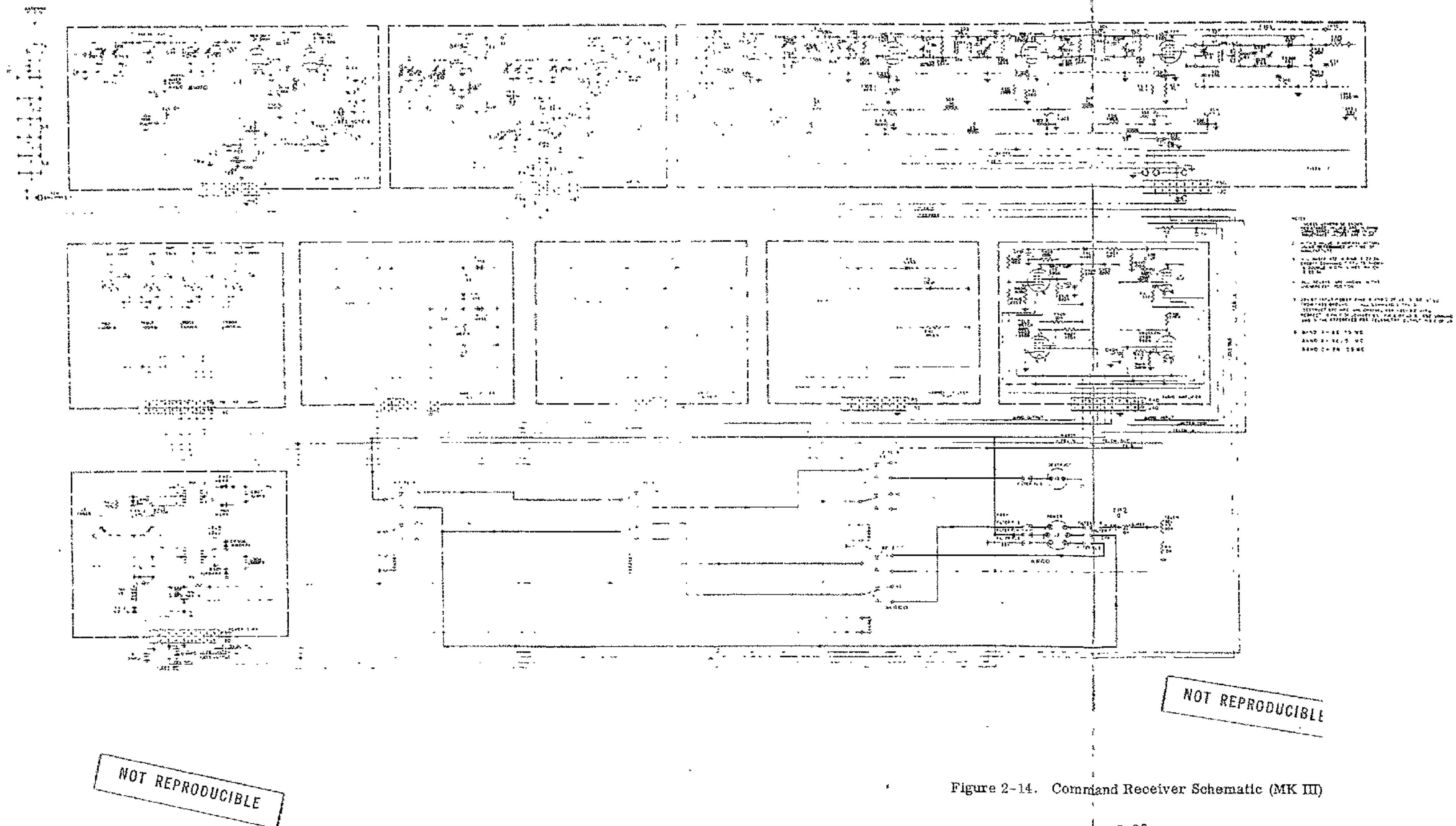


Figure 2-14. Command Receiver Schematic (MK III)

Logic Section. The logic circuit in the Avco receivers requires that the combination of tones 1 and 5 (MFCO) be received immediately before tones 1 and 2 (destruct), if the combination of tones 1 and 2 is to generate a command output. It is preferable that tone 1 remain on continuously during the transition from the 1 and 5 combination to the 1 and 2 combination. If both tones 1 and 5 are turned off during the transition, then the combination of tones 1 and 2 must be received within 105 milliseconds after deletion of tones 1 and 5. The destruct command output will occur between 110 and 350 milliseconds after removal of tone 5, provided the proper sequence of tones was received.

No sequence is necessary for generation of commands 1 and 5 (MFCO) and 2 and 5 (AFCO). Only one command output signal will be generated for each combination of command tones. The AFCO command output will occur 6 ± 3 milliseconds after receipt of the tone combination.

The filter-rectifier circuit immediately preceding the channel 5 relay amplifier is designed to allow the channel 5 relay to have a dropout time of 110 to 350 milliseconds. This long dropout time is incorporated to override the very short dropout time of the channel 1 relay if tone 1 is briefly deleted in the transition from tones 1 and 5 to tones 1 and 2.

To obtain any command output signal from the receivers, the two required tones must be received and the third tone not received. Simultaneous receipt of all three tones inhibits the generation of any command output signal, although a telemeter output called a "bust" command is generated. A signal will appear at the receiver monitor pin whenever tone 5 is received, whether tone 5 is received by itself or in combination with other tones.

Power Supply Section. Plate voltage for the RSC set is furnished by a transistorized power supply. It contains two 2N1538 transistors and a transformer, and operates as a d-c converter. An input of 27.5 vdc produces an output of 175 vdc for plate voltage in the audio and channel relay amplifiers.

In addition, the 27.5-vdc input provides a voltage that is regulated to 25 vdc by a 1N2821B voltage-reference diode. This diode supplies plate and screen voltages for the receiver sections and for the audio squelch tube, so that voltage-compensation networks are not required for the critical components.

2.6.3.2 Receiver History. The Mk II receiver, which is used on AC-6, has the following major differences from the Mk I "yellow dot" receiver:

a. The input power return is isolated from case ground. All command outputs deliver 28 vdc with respect to input power return. Case ground is the reference for the telemetry output only.

b. The four-channel relay amplifier assemblies were replaced by one relay amplifier assembly and four micro-miniature relays.

c. The power supply was changed to provide a regulated 28-vdc supply with respect to case ground, which is isolated from the input power, for the filaments in the r-f section of the receiver. The 28-vdc supply is taken from the regulated 28-vdc supply rather than the regulated 175-vdc supply.

d. The connectors were replaced with potted connector assemblies which are completely shielded and permanently attached to the rear of the connectors. These assemblies contain special feed-through filters on the power/output and destruct output connectors, and the bandpass filter on the r-f input connector. This resulted in an increase of 1-3/8 inch in the over-all length of the case.

e. The snap latches were replaced with screw-type latches to make a better seal.

Various other minor changes were made because of the isolation of the input power return and minor improvements in the design. Most of the above changes were made to meet the isolation and r-f interference requirements of MIL-I-26600.

The Mk III receiver is basically the same as the Mk II except that the operating sensitivity was increased from 5 to 3 microvolts. The telemetry voltage is adjusted at the factory for 5 volts at 5000 microvolts input across the load specified in the contract instead of a maximum of 4.8 volts across a 100-K ohm load. The screw-type latches are not reusable on the Mk III and are tightened with a torque wrench. This prevents GD/C personnel from opening the receivers to adjust the telemetry voltage as was done previously. There is a possibility that these latches may be replaced in the future with larger re-usable latches.

There are numerous minor differences in the receivers, but these have minimal effect on the performance of the receivers.

2.6.4 Power and Signal Control Unit

Manufacturer	Drawing No.	Specification No.
General Dynamics/Convair	27-36236-801	27-03013

Purpose. To provide changeover between ground and vehicleborne power sources for the RSC receivers, provide arming and safing of the fuel cutoff commands, provide signal conditioning for telemetry instrumentation, and to provide a junction and isolation unit for the RSC subsystem.

Characteristics. The power and signal control unit (Figure 2-15) is housed in an aluminum canister and contains two power changeover switches (General Dynamics/Convair part No. 7-01722), two circuit boards, and electronic components. The power

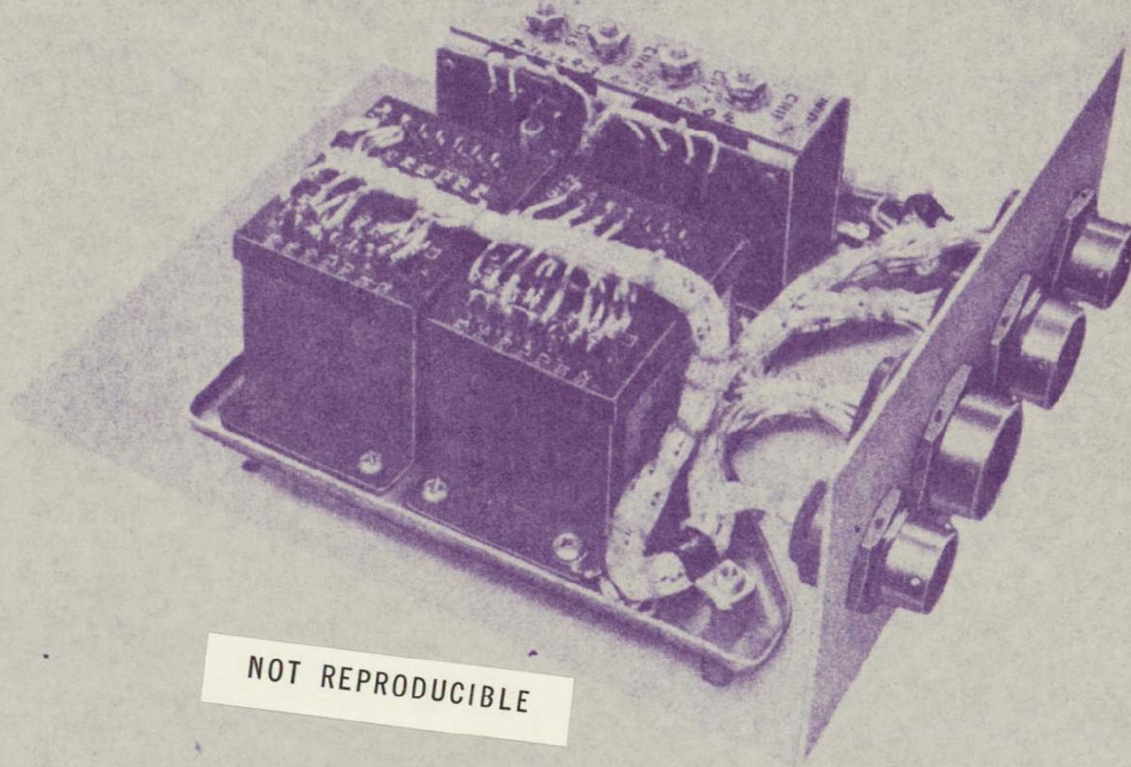


Figure 2-15. Power and Signal Control Unit

changeover switches provide sufficient contacts for all functions and spares. Two sets of contacts in one switch are for power changeover to each command receiver, and four sets of contacts in the other switch are for arming the engine cutoff command circuits for AFCO and MFCO in each receiver. The fuel cutoff will be in the safe position when the RSC subsystem is operated from ground power. When the signal is received to change from external to vehicleborne power, the fuel cutoff outputs will be automatically changed from the ground test position to the engine relay box position. The two switches are operated independently, so that the position monitor indicates "launch control". The AFCO command circuit is open-circuited at the output pin of the power and signal control unit. The command can still be monitored on the ground control equipment in the external power position.

All other circuits required to make the RSC subsystem compatible with other vehicleborne subsystems and with the launch control equipment are housed in the control unit.

Instrumentation signals for receiver agc, fuel cutoff commands, and the destruct command are derived in, or routed through, the power and signal control unit and are then supplied to the vehicleborne telemetry system.

In addition, the subsystem harnessing is simplified by placing all connections, from the RSC subsystem to the umbilical connector and to related equipment, in the power and signal control unit.

2.6.5 Electrical Arming Device

Manufacturer	Drawing No.	Specification No.
General Dynamics/Convair	27-36244-1	27-03008

Purpose. To place the destruct firing circuits in either the arm or safe position.

Characteristics. The electrical arming device (Figure 2-16) is housed in an aluminum canister and contains two relays, one power changeover switch (General Dynamics/Convair part No. 7-01722), and two resistors. The power changeover switch provides the arm safe functions of the unit. The relays (one for each destruct signal path) maintain open circuits in both sides of the destruct lines and short circuits the primer leads in the destructor until an actual destruct signal is received.

When the device is placed in the arm position, the portion of the destruct circuit between the command receivers and the destructor circuit is partially completed. The

Figure 2-16. Electrical Arming Device

receipt of the destruct signals at the arming device effects relay contact closures within the arming device and completes the destruct circuit, causing detonation of the destructor unit.

When the arming device is placed in the safe position, the destructor unit is isolated from the command receivers by switch contacts that short-circuit the primer leads and open-circuit the destruct lines in the arming device. These precautions reduce the hazard of accidental ignition of the primers because of stray currents.

The arming device is provided with instrumentation that displays arm or safe information on the RSC console in the blockhouse. In the safe position all destruct commands are routed to the blockhouse for monitoring and to prevent arming of the system while commands are being sent.

2.6.6 Destructor Unit

Manufacturer	Drawing No.	Specification No.
Beckman/Whitely	27-04306-803	27-04230

Purpose. To terminate vehicle flight by detonation.

Characteristics. Reliability of the destructor has been demonstrated through qualification tests and flights; therefore, only one is used. The destructor, shown in Figure 2-17, is enclosed in a red anodized-aluminum box that measures 5.0 × 5.5 × 5.5 inches. Glass-wool insulation protects the switch and explosive charge from abnormal temperature and moisture. The destructor is capable of operating at temperatures up to 160° F for four hours and at temperatures as low as -65° F for eight hours. The destructor complies generally with specification MIL-E-5272A for environmental testing.

Primer Circuit. The primer circuit ensures the firing of either one or both primers within the destructor. The circuit has both primers in series, each primer being shunted by a resistance that requires only one quarter of the current (Figure 2-18) passing through the shunted primer. Two separate circuits are provided to the destruct primers, one from each command receiver. Malfunction of either circuit will not affect operation of the destruct system. The primers are connected in series to prevent malfunction of one primer if an electrical short or open circuit occurs in the other primer. A high-resistance leakage path to ground is provided for safe drainage of static charges from the destructor circuit. The destructor case is connected to structural ground by a 5-inch bonding strap.

Destruct Primer. The primer used by Atlas vehicles (BW-10081) incorporates a pyrotechnic delay consisting of a slow-burning powder train. The pyrotechnic delay time is 105 $\pm$ 45 milliseconds, and the minimum firing time is 60 milliseconds plus the ignition time. The BW-10081 primer will fire the high explosive within 60 to 150

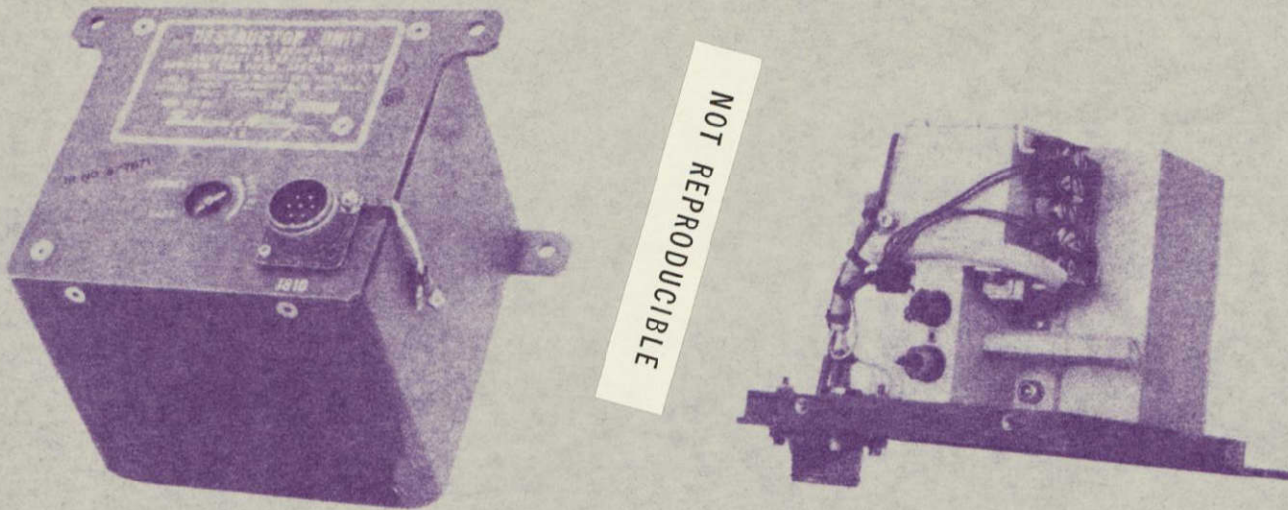


Figure 2-17. RSC Destructor Unit

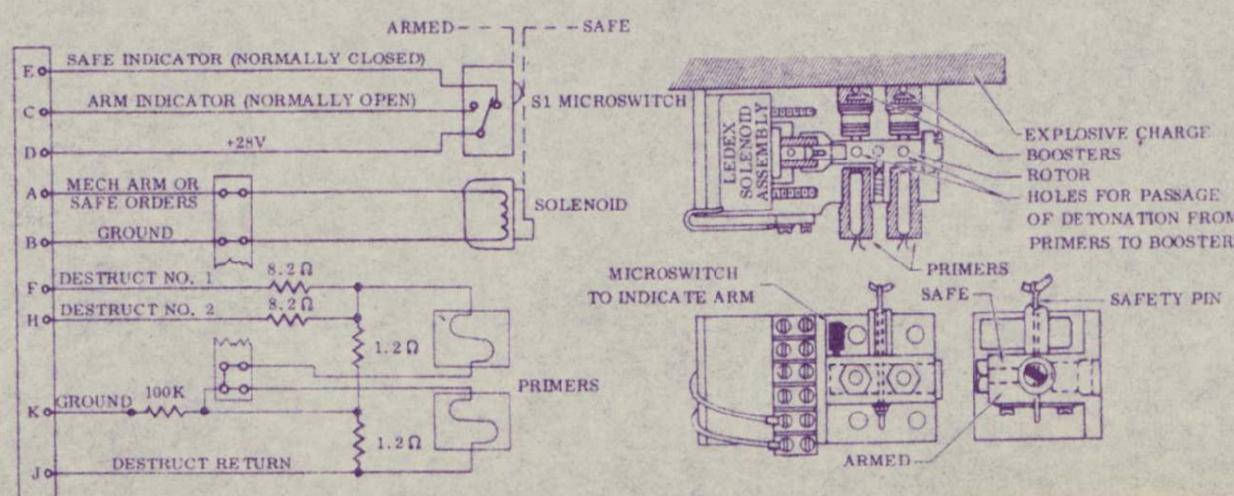


Figure 2-18. Destructor Mechanical Arming Switch

milliseconds following ignition, even though the electrical signal is removed simultaneously with ignition. The BW-10081 primer has the following electrical characteristics:

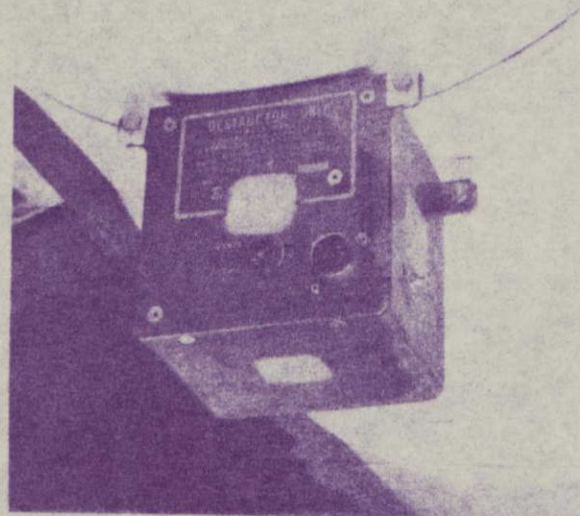
a.	Bridgewire resistance	0.3 ± 0.1 ohms at 70° F 0.5 ± 0.15 ohms at 350° F
b.	Maximum no-firing current for a 5 minute period	0.150 amp
c.	Recommended minimum firing current	1.0 amp
d.	Ignition time, (1 amp)	58 ± 15 msec
e.	No-firing current (test)	10.0 ma
f.	Auto-ignition temperature	370° F

Mechanical Arming Mechanism. The destructor is mechanically armed (or disarmed), by the rotation of a steel shaft located between the primer and the booster charges. The shaft has two 1/8-inch holes which are aligned (or misaligned) as it rotates between the primer and booster charges. An arm or safe command from the range safety console produces a 28-vdc impulse that actuates a Ledex solenoid. The downward motion of the solenoid is converted to rotary motion by three inclined ball races that force the shaft to rotate by cam action. A clutch permits the races to return without turning the shaft. Successive actuations of the solenoid cause successive 90-degree rotations of the shaft in the same direction, alternately aligning (armed) and misaligning (safe) the explosive train. A dual system, utilizing two primers, shaft holes, and boosters, ensures reliable destructor operation. A safety wire inserted through the housing assembly, via a third hole in the shaft, prevents accidental arming when the unit is not in use. Visual monitoring of the destructor arm/safe condition is also provided by means of the shaft. The end of the shaft is visible and accessible through a hole in the case. A cross-pin extending through the shaft shows shaft position and the armed or safe condition of the destructor. If the destructor is armed, manual safing of the destructor is accomplished by rotating the pinned shaft 90 degrees.

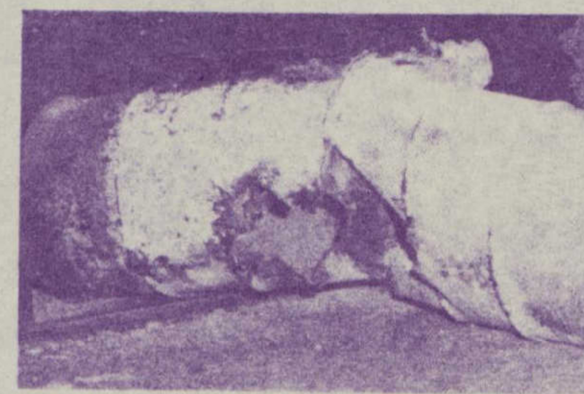
The destructor is monitored by a three wire, two-position microswitch that controls the 28-vdc indicator lights on the command console. A cam on the arming shaft actuates the microswitch, energizing the appropriate light to indicate whether the unit is armed or safe. The mechanical arming mechanism is shown in Figure 2-18.

Explosive. Instantaneous detonation is initiated by the primer, which in turn explodes a booster charge next to the main destructor charge. Detonation cannot occur unless the system is armed. The main destructor charge in the booster vehicle consists of approximately one pound of RDX with 3 to 5 percent wax, and 1 to 1.5 percent graphite.

2.6.6.1 Destructor Test. A test was performed at Point Loma to demonstrate the ability to destroy the Atlas vehicle.



Test photo showing location of destructor installation. Destructor is mounted on two 50-gallon steel drums welded together to simulate the vehicle fuel-oxygen bulkhead.



Test photo showing the drums after detonation of the destructor.

Figure 2-19. Destructor Test Setup and Results

Two 50-gallon steel drums were welded together (Figure 2-19) so that the two adjacent bulkheads would roughly simulate the vehicle fuel/oxygen bulkhead. This configuration represents greater rigidity than the actual vehicle structure. A destructor was then mounted on the simulated vehicle in accordance with the vehicle mounting geometry. Detonation of the destructor caused thorough destruction of the drums.

2.6.6.2 Destructor Design Change. The 27-04306-5 destructor intermittently failed to indicate "armed" when power to "arm" was applied. Tests performed by General Dynamics/Convair personnel showed that the rotor would travel from the "safe" position. A design modification was made in which teeth were machined on a floating clutch. The teeth directly engage a stop screw mounted through the rotor block. (Refer to Figure 2-20.) In conjunction with the destructor change, others included the following: a hole was added to the middle of the detent dimple on the rotor; the detent spring was red-drawn and changed from right-hand to left-hand coiling; and the detent screw cup point was changed to a dog point (to fit the inside diameter of the detent spring).

The solenoid cavity tolerances were changed to provide better engagement of the floating clutch to the stop screw. A new solenoid assembly provided a closer tolerance between the clutch and the solenoid mounting surface. A new rotor cap and locking washer were provided, and the detent spring force was changed to 46 ± 4 ounces. During a 1000-cycle lift test and a 100-cycle overload test the test unit performed satisfactorily.

2.6.7 RSC Batteries

Manufacturer	Part No.	Drawing No.	Specification No.
Yardney	61083	69-06308-1	69-06307
Power Sources	200994		

Purpose. To provide the primary vehicleborne power for the RSC subsystem.

Characteristics. The RSC batteries (Figure 2-21) are composed of primary, manually activated, silver-oxide zinc cells that are enclosed in a welded stainless steel case with a removable cover. The electrolyte is 40-percent KOH. The batteries contain temperature-regulating heaters and have pressure valves.

The battery specifications are as follows:

Output Voltage:	26.5 to 30.0 volts within 200 milliseconds after application of rated load current, and during pulse application.
Load Current:	1.2 to 5.0 amps steady state, with four superimposed 0.5-second pulse loads with a peak current of 12.0 amps.

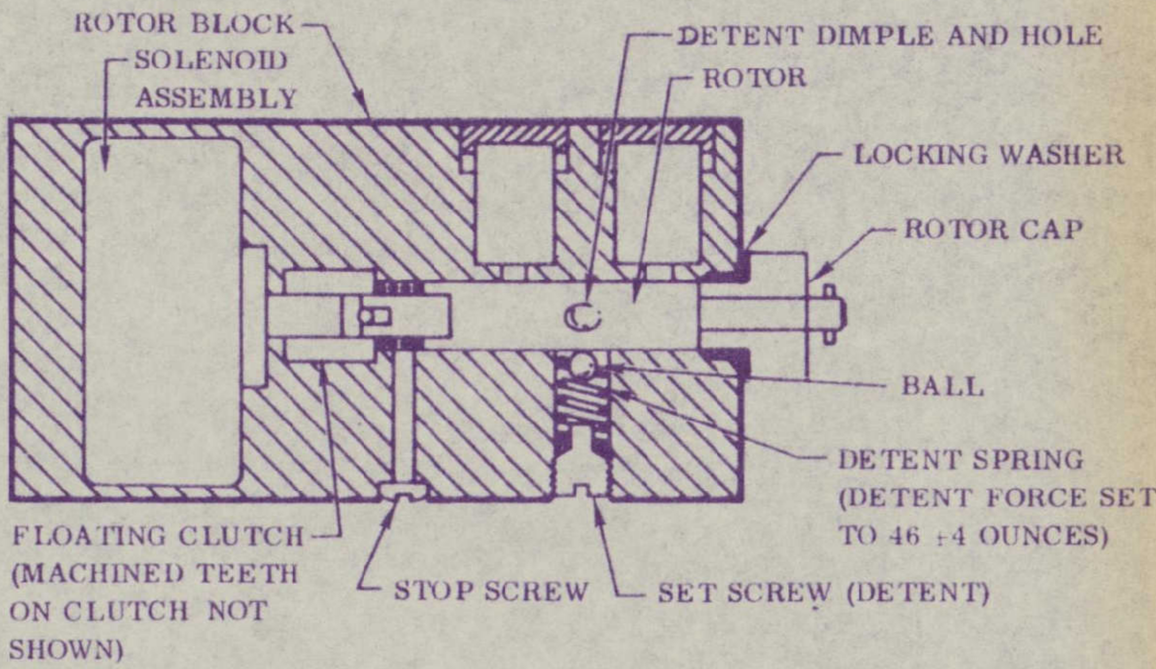
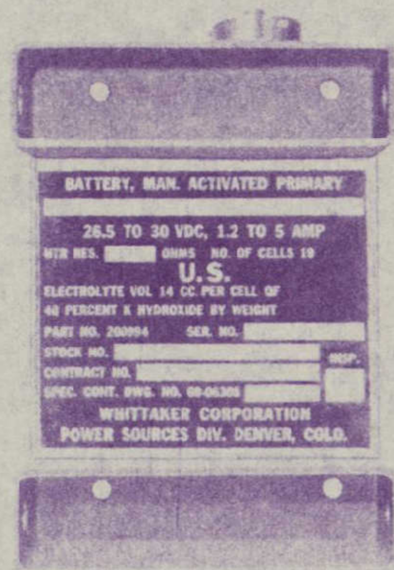


Figure 2-20. Destructor Rotor Design Change

Capacity:	Battery shall perform within specifications for a period of 30 minutes or for a total capacity of 2.5 amp-hours.
Activation Time:	Battery shall perform to specifications after a 3-hour soak period, with battery heat applied for the last 2 hours.
Activated Stand Time:	Battery shall provide one flight duty cycle within 15 days and 2 test duty cycles within 30 days after initial activation.
Shelf Life:	Unactivated - 3 years.

There are no significant differences between the Yardney and Power Sources batteries; they were designed to the same General Dynamics/Convair specification. Detailed battery handling procedures for AFETR, including activation and installation, are given in General Dynamics/Convair Report No. 69-92705-2.



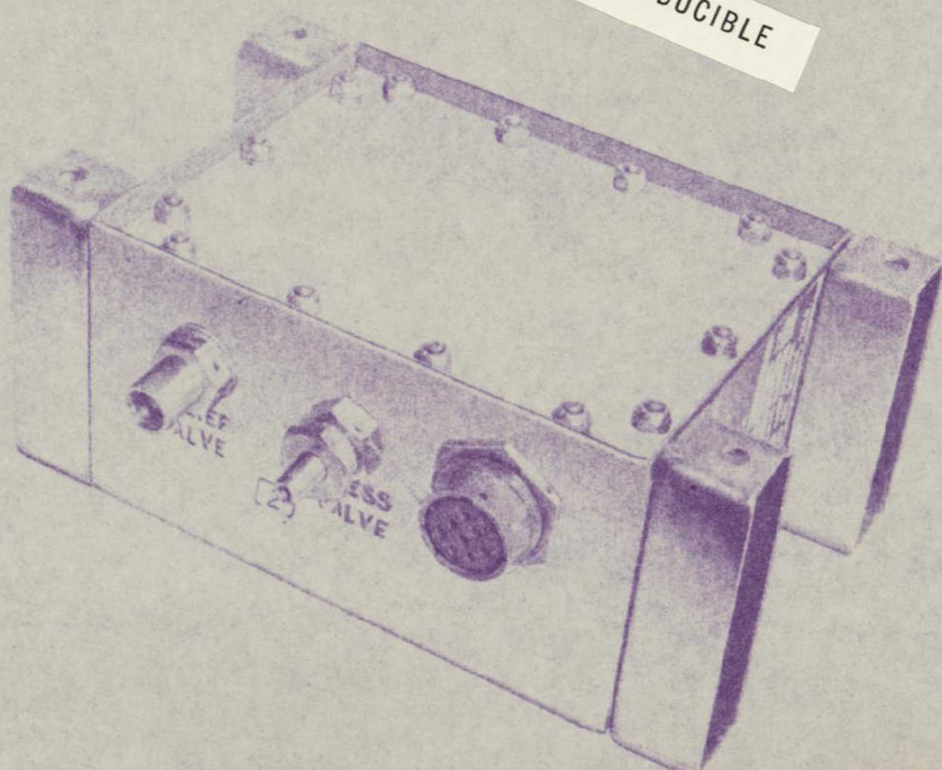


Figure 2-21. RSC Battery, Typical (Power Sources)

SECTION 3

RANGE SAFETY COMMAND SUBSYSTEM, SECOND STAGE (CENTAUR) AND SPACECRAFT (SURVEYOR)

3.1 INTRODUCTION. The functions of the second stage and spacecraft range safety command subsystems on AC-6 are to:

a. Cut off the Centaur main engines in response to an r-f command, thus imposing a condition of zero thrust.

b. Destroy the LH_2 and LO_2 tank structure, in response to an r-f command, to disperse the propellants.

c. Test the equipments, system, and procedures that will be used with the operational Surveyors, such as SC-1 on AC-7. The functions of this system are to

   1. Destroy the Surveyor engine, in response to an r-f command, by causing a conical-shaped explosive charge to detonate. (The charge is designed to bore a 2-inch hole through the engine housing, penetrate the propellant, and emerge through the opposite side. This action will either destroy the engine or impart a tumbling moment if residual engine thrust exists.)

   2. Cause the actions in b. and c. upon detection of premature separation of the Surveyor from Centaur, thus eliminating the possibility of powered flight without an operable command destruct system.

3.1.1 System Compatibility. The vehicleborne equipment has been designed for compatibility with the ETR range safety ground subsystem equipment and operational procedures, and to be completely compatible also with the existing first stage Atlas subsystem with respect to carrier frequency and command tones.

The location of the components is shown in Figure 3-1. A subsystem block diagram is shown in Figure 3-2.

3.1.2 System Events. The logic events that interrelate the elements of the flight termination system (ground equipment, vehicleborne equipment, and their r-f link) are termed "orders" and "commands". Those events associated with ground support equipment are called GSE orders; all other events are commands. Thus, the events that are initiated by the vehicleborne programmer are programmer commands, and those that result from signals propagated by the r-f link are r-f commands. Table 3-1 lists the system events.

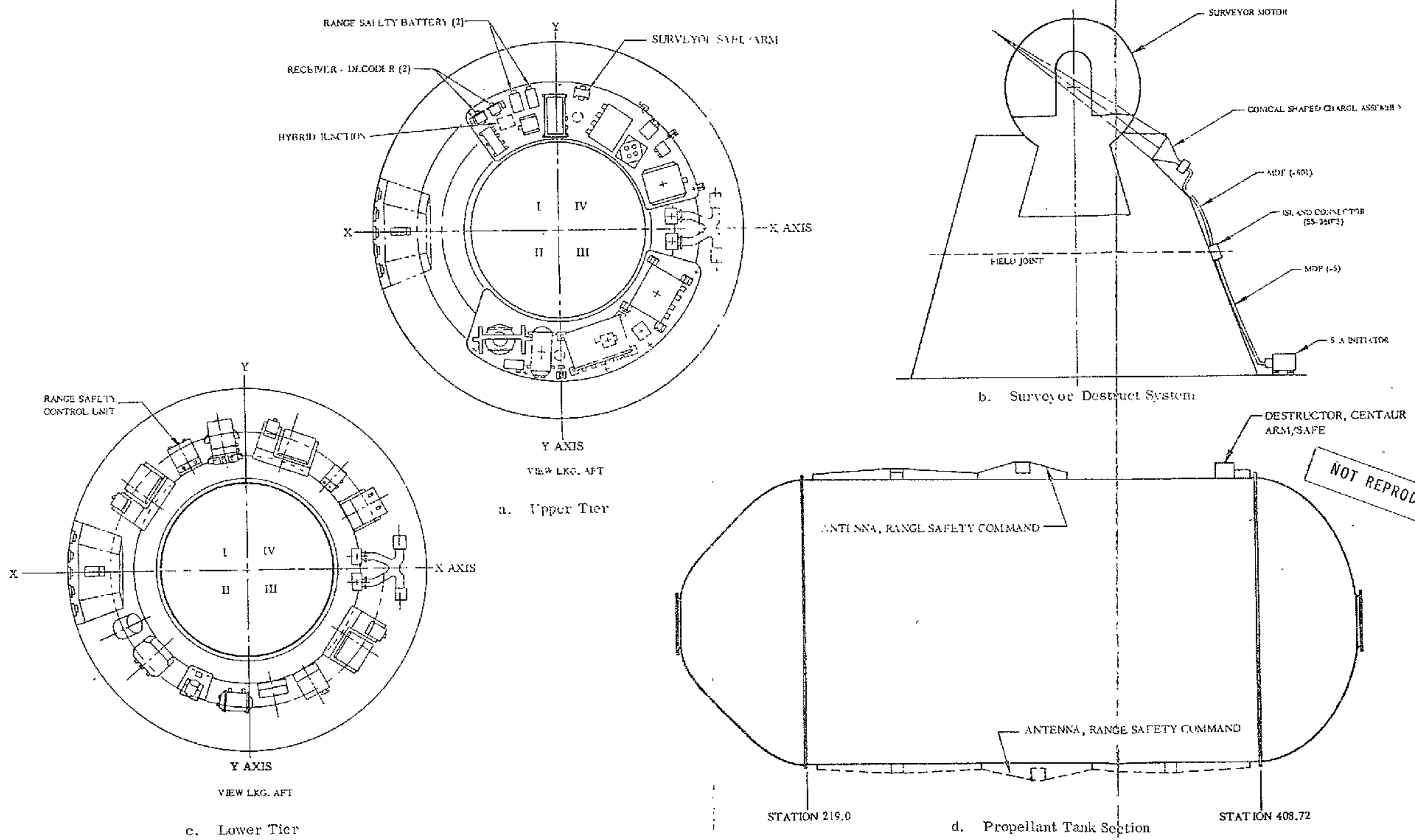


Figure 3-1. Centaur AC-6 Range Safety Command Subsystem Installation

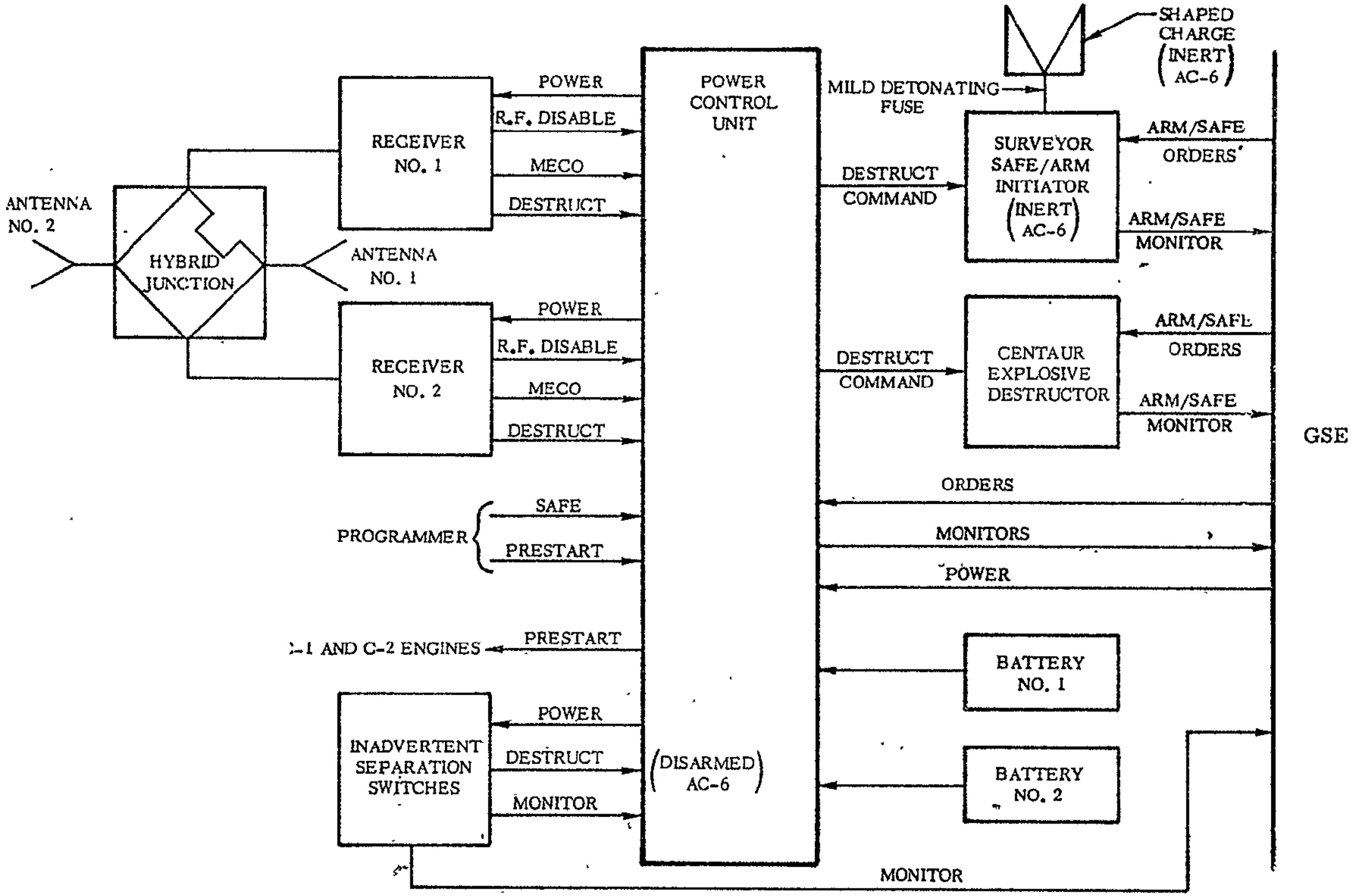


Figure 3-2. Block Diagram of Second Stage RSC Subsystems

Table 3-1. Second Stage RSC Subsystem Events

GSE ORDERS
Internal Power No. 1
External Power No. 1
Internal Power No. 2
External Power No. 2
Safe - Inadvertent Separation Destruct
Arm - Inadvertent Separation Destruct
Safe - Centaur Destructor
Arm - Centaur Destructor
Safe - Surveyor Safe/Arm Initiator
Arm - Surveyor Safe/Arm Initiator
MECO Reset
Battery Heaters - On
Battery Heaters - Off
R-F Disable Reset

PROGRAMMER COMMANDS
Inadvertent Separation Safe

R-F COMMANDS
R-F Disable
MECO
Destruct

INADVERTENT SEPARATION SWITCHES COMMAND
Inadvertent Separation Destruct

3.2 R-F COMMANDS. Frequency modulated signals are converted into three commands - r-f disable, main engine cutoff (MECO), and destruct. The receiver output commands are routed through the circuits by a power control unit to perform the operations.

The r-f disable command disables the RSC subsystem by causing the batteries to be disconnected from all components. This command from either receiver operates a pair of magnetic latching type relays connected in parallel within the power control unit. Upon actuation of both relays an "external" command is delivered to both power changeover switches, the power source being their respective batteries. The switches then move to their "external" position and remove power from the entire system. Figure 3-3 shows in schematic form the RSC response to an r-f disable command.

The MECO command operates relays (located in the power control unit) that will cut off the Centaur main engines if the engines are operating, or prevent starting if the engines are not operating. The relays are also magnetic latching types and will interrupt the engine LH_2 prestart circuits. The LH_2 prestart commands are issued to each engine from the Centaur programmer. The interruption of the engine prestart command will remove all pneumatic pressure from the engine valves controlling the LH_2 and LO_2. The valves will then return to their deenergized state causing engine shutdown. These relays can be reset only through the umbilical cable. (Refer to Appendix A for propulsion description.) Figure 3-4 is a schematic diagram of system response to the MECO command.

The destruct command consists of the MECO command and a subsequent signal to activate the Centaur destructor and the Surveyor conical-shaped charge. The Centaur destructor is located on a fairing alongside the intermediate bulkhead. Upon receipt of the appropriate sequence of signals the firing current is connected to initiators within the destructor. After 90 ±30 millisecond pyrotechnic time delay, the initiator fires, setting off a booster charge which, in turn, detonates the main charge. The main charge ruptures the bulkhead, separating the LH_2 and LO_2 tanks, thus dispersing the propellants. Figure 3-5 shows schematically, the system response to the destruct command.

On missions that carry an operational spacecraft, such as on AC-7, an operational conical-shaped charge will be mounted on the payload adapter. The shaped charge will be actuated by a mild detonating fuse. This fuse assembly is connected to the safe/arm initiator (Figure 3-5) in the same manner that the main charge of the Centaur destructor is connected to its booster charge. Upon receipt of the proper sequence of signals this pyrotechnic chain is activated, terminating in an explosive jet that pierces the Surveyor engine and passes through the opposite side. On AC-6 the Surveyor safe/arm unit and the conical-shaped charge will be inert. See Figure 3-5.

3.3 VEHICLE SYSTEM COMMANDS. The commands are generated by vehicleborne equipment in flight. These are: 1) The surveyor inadvertent separation destruct

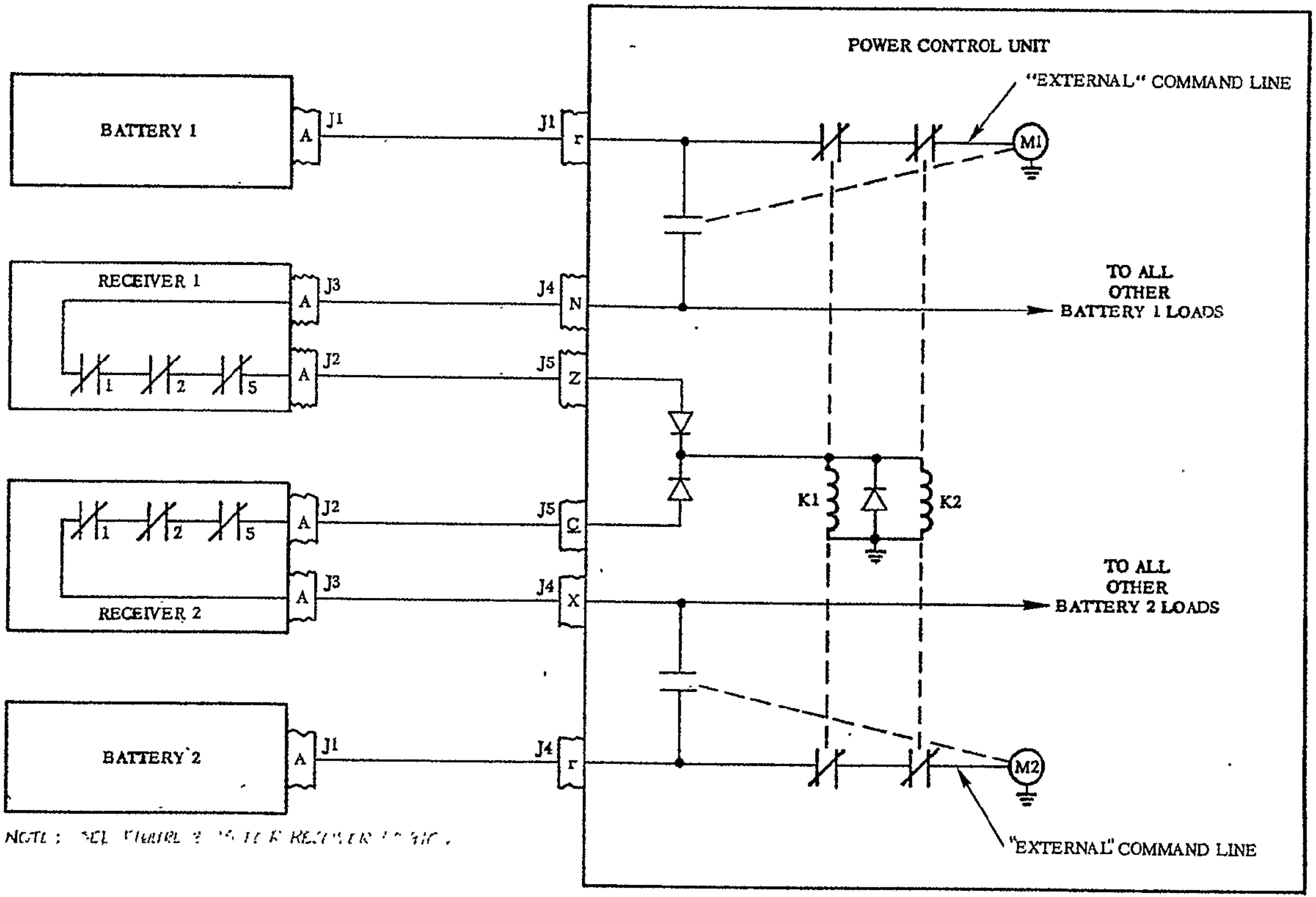
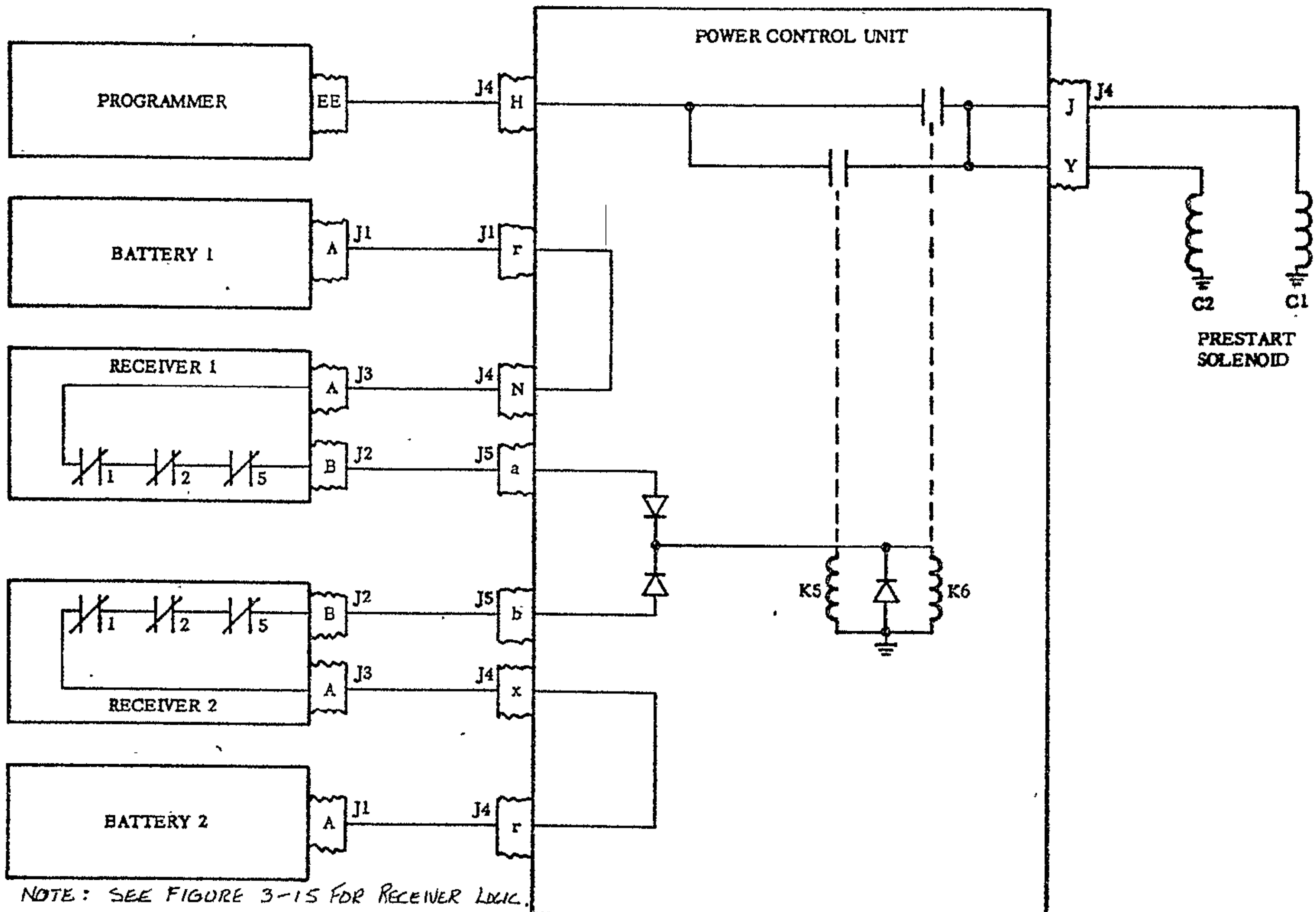


Figure 3-3. R-F Disable System (Energized)



NOTE: SEE FIGURE 3-15 FOR RECEIVER LOGIC.

Figure 3-4. Main Engine Cutoff (MECO) System (Energized)

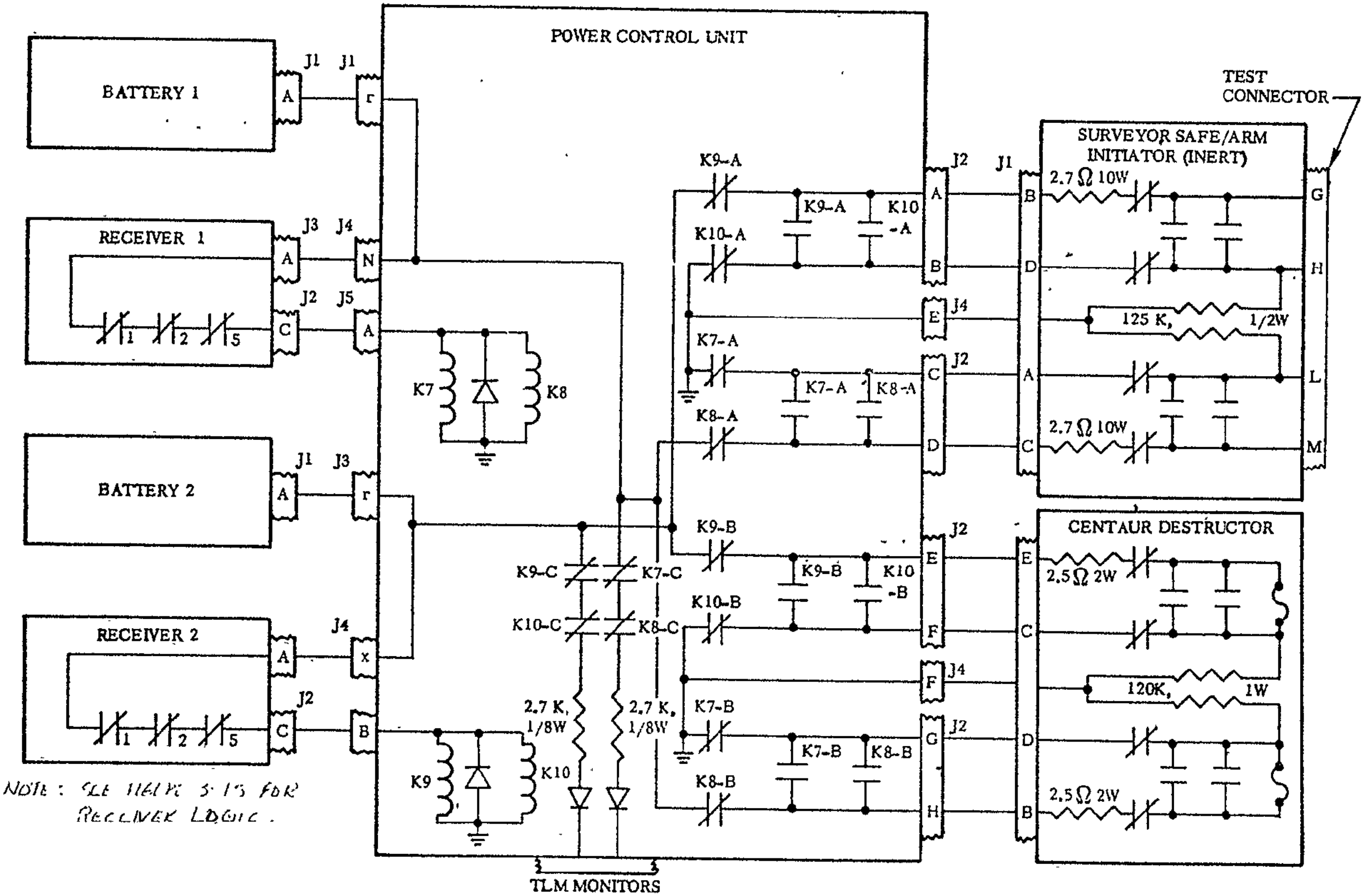


Figure 3-5. Destruct System (Energized and Armed)

command, and 2) The surveyor inadvertent separation safe command. The surveyor inadvertent separation destruct command is caused by any two of the three inadvertent separation switches mounted on the payload adapter/Surveyor interface. Upon detecting one-half inch of travel, these switches actuate the destruct relays in the power control unit in the same manner as those that respond to an r-f command through the receivers. (On AC-6, the wires connecting the separation switches to the destruct relays will be removed to eliminate the possibility of destroying Centaur upon inadvertent separation.) Figures 3-5 and 3-7 show schematically, the system capacity of responding to this destruct command.

The Surveyor inadvertent separation safe command is issued by the Centaur programmer at MECO backup + 0.5 second (60 seconds prior to normal Surveyor separation). This command insures that no inadvertent separation destruct command can actuate the destruct relays when normal separation occurs. This command energizes two magnetic latching type relays in the power control unit, either of which will interrupt the signal path between the separation switches and the destruct relays. Figure 3-7 shows schematically, the system capability of responding to this Safe command.

3.4 INPUT SIGNAL CHARACTERISTICS. The second stage subsystem operates concurrently on the same frequency and command tones as the first stage. The input characteristics are the same as those described for the first stage in Section 2 of this report.

3.5 ANTENNA SYSTEM. The AC-6 vehicle employs two single-cavity antennas (Figure 3-6) mounted opposite each other at station 328.0, on the Y-Y axis, at the junction of quadrants I and IV, and II and III. The antenna radiation patterns are shown in Figure 3-8. These cover 95 percent of the radiation sphere at 15 db below an isotropic radiator. (The 3-db loss, circular-to-linear polarization, has been accounted for in the plot.) Figures 3-9 and 3-10 show the antenna with foam removed and mounted on the vehicle.

The antennas are connected to the receivers through a hybrid junction General Dynamics/Convair Part No., 80-65903-002). The unit performs the same functions as the ring coupler used on previous Centaur missions, but is lighter, more stable, and more rugged. Figure 3-11 illustrates the hybrid junction installed on the vehicle.

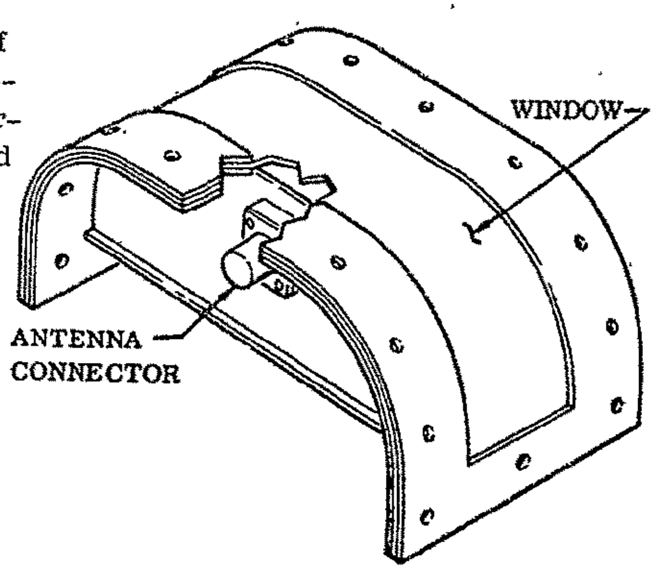


Figure 3-6. Range Safety Command Antenna

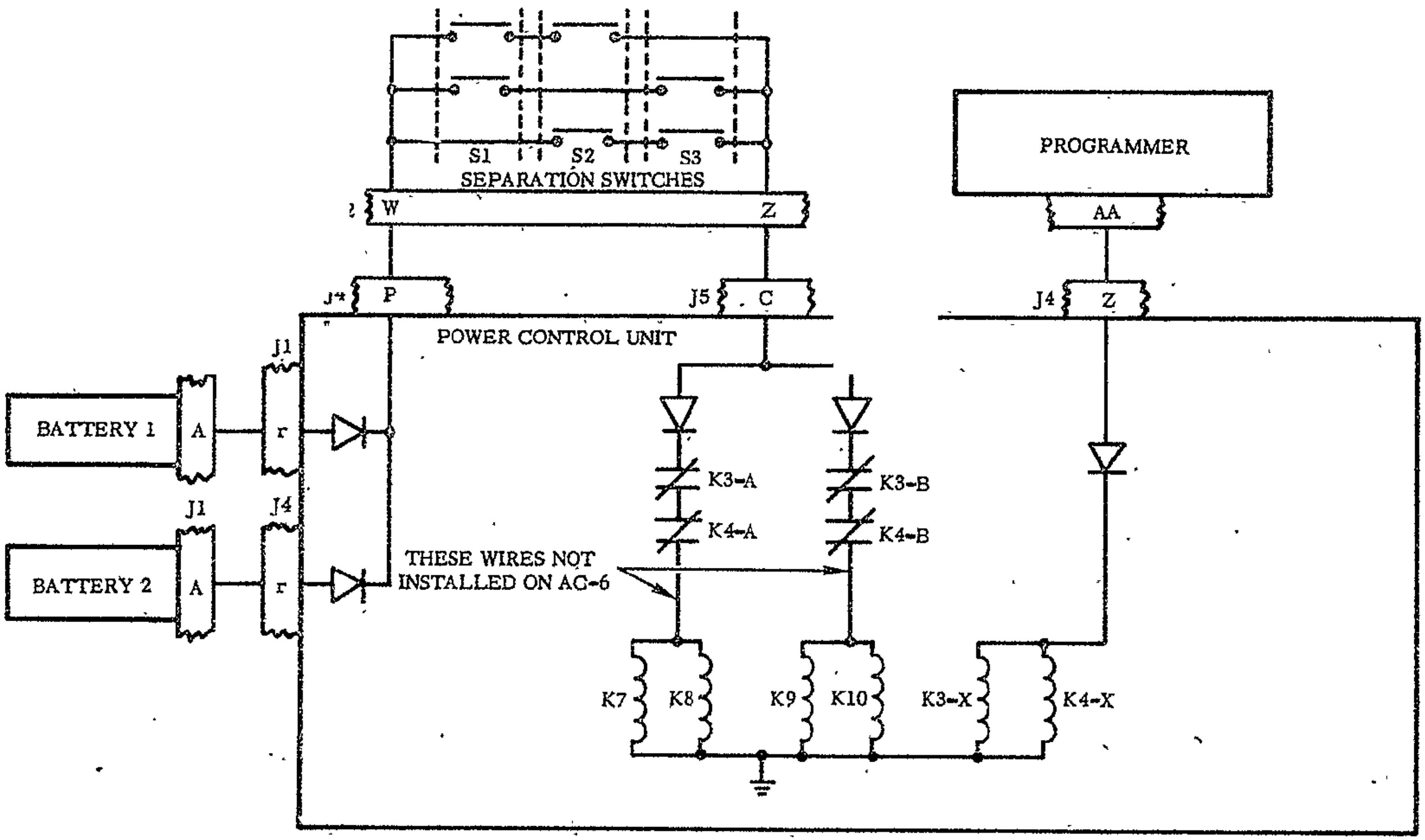


Figure 3-7. Separation Destruct System (Unenergized and Armed)

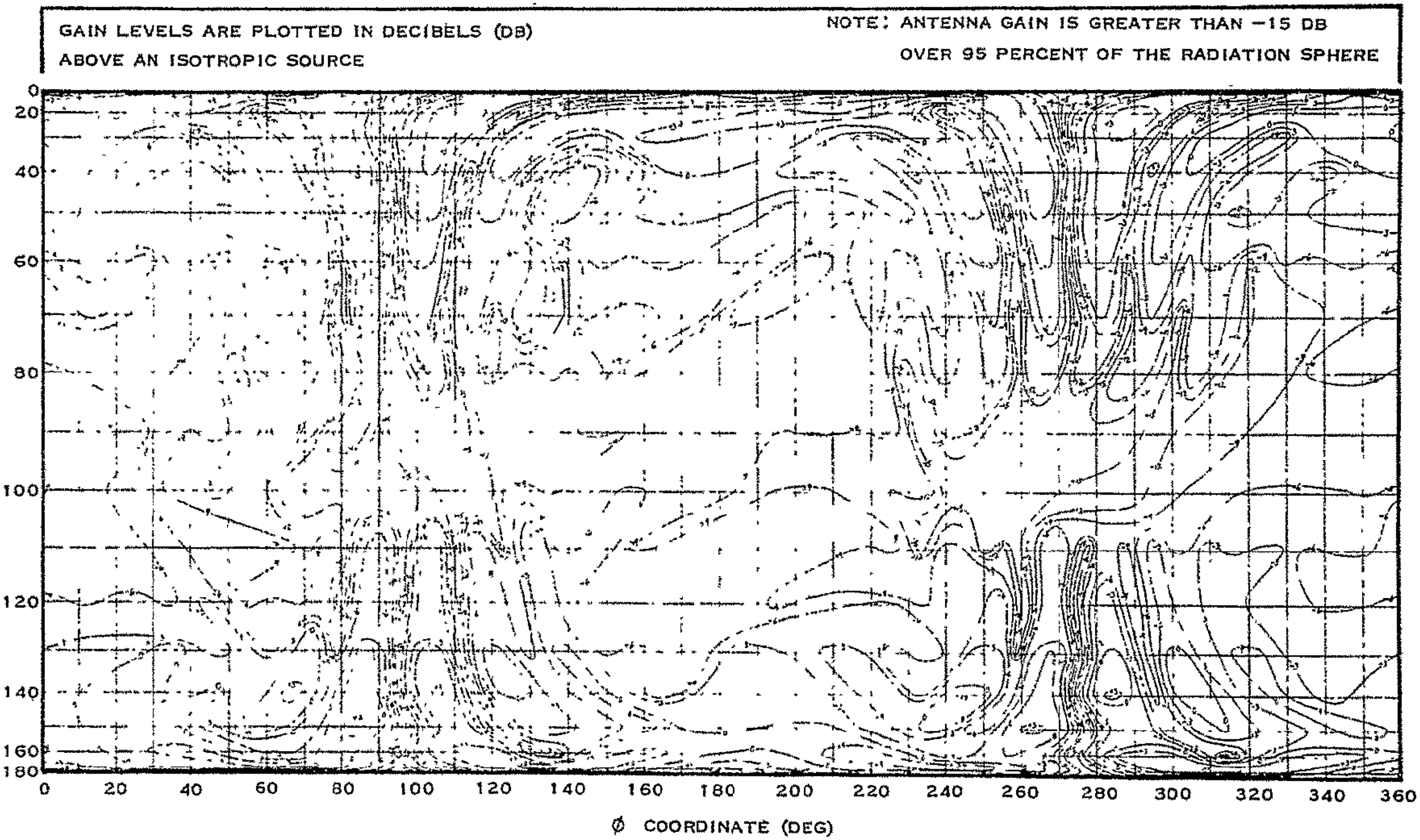


Figure 3-8. Centaur Range Safety Command Antenna Pattern (Left-Hand Circular, IRE)

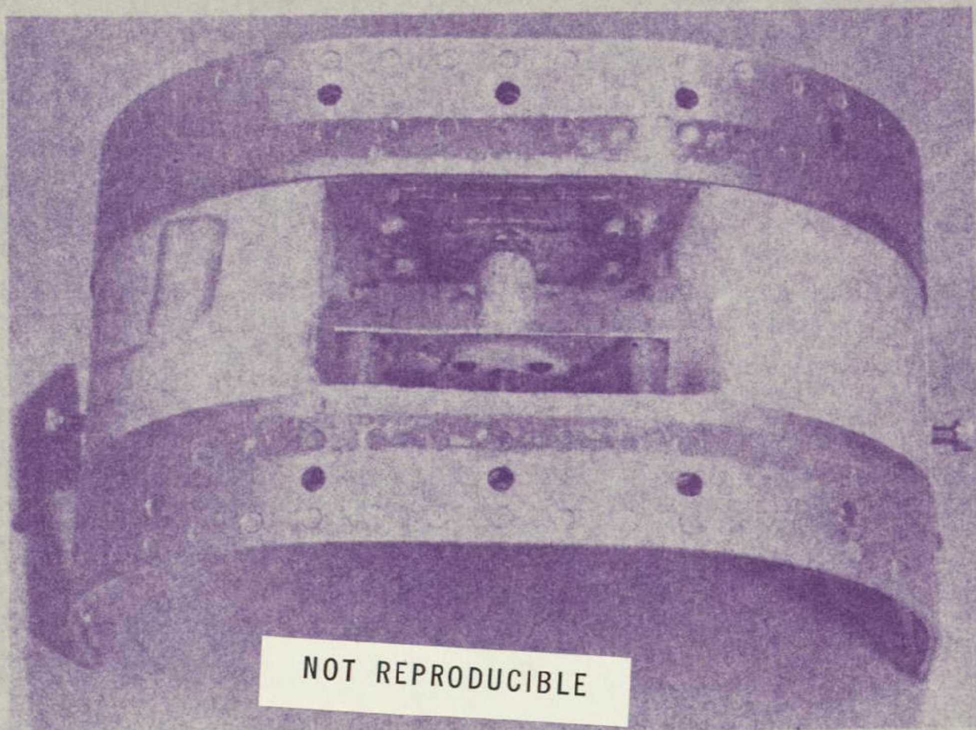


Figure 3-9. Detail of Centaur Range Safety Command Antenna

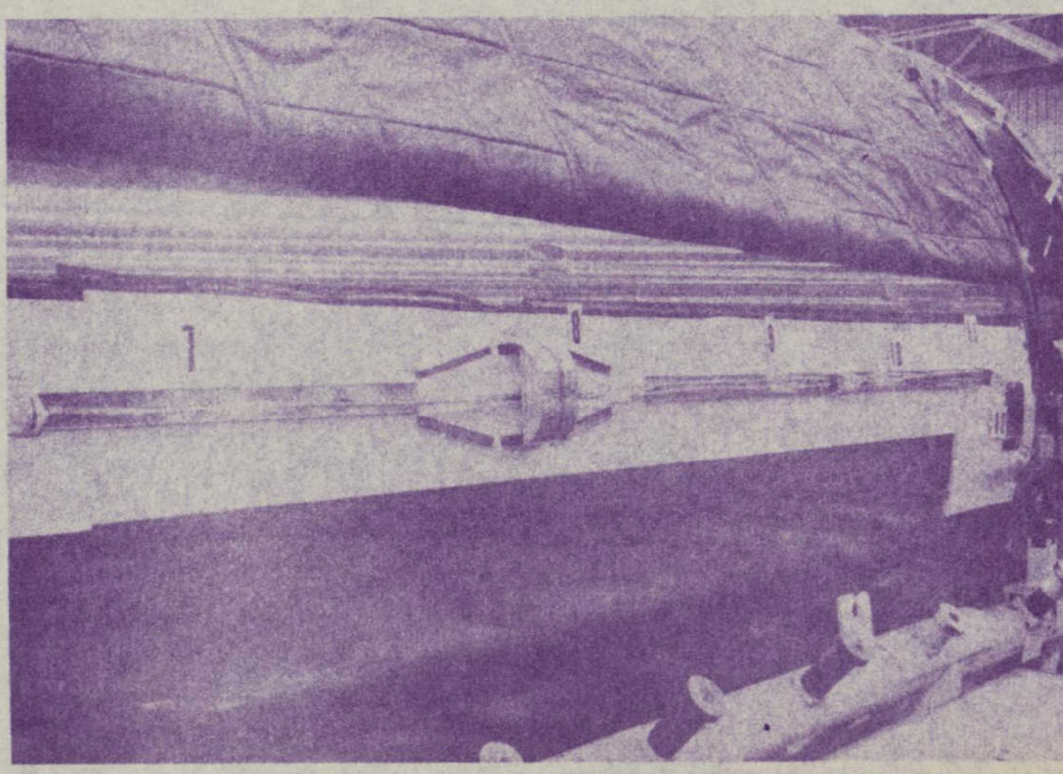


Figure 3-10. Centaur Range Safety Antenna Installation

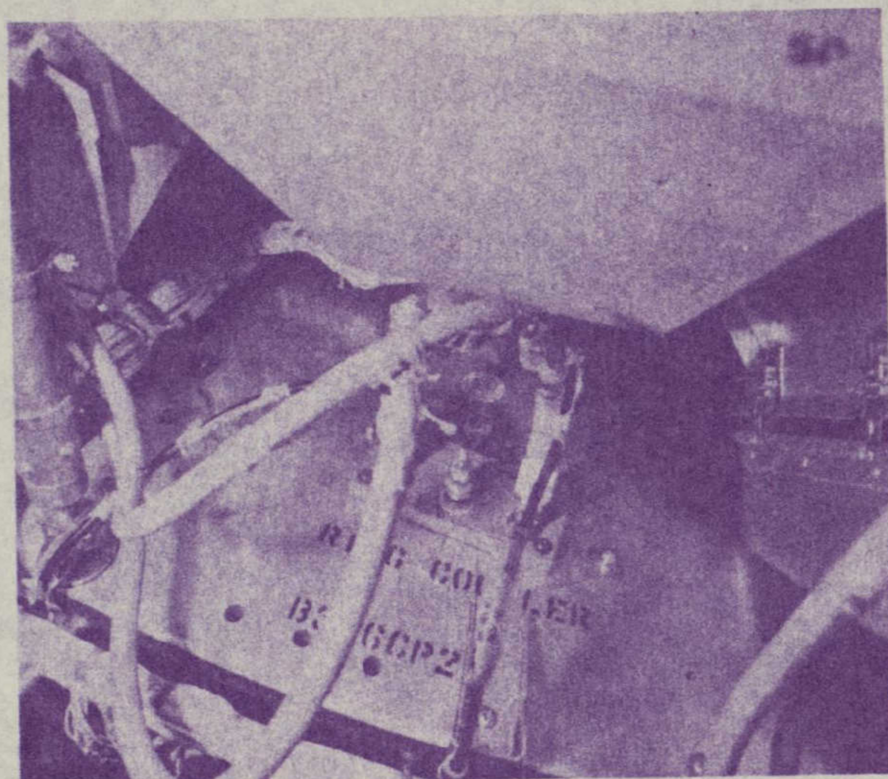


Figure 3-11. Hybrid Junction on AC-6

3.6 COMMAND RECEIVER - DECODERS. The vehicleborne second stage RSC subsystem contains two identical command receivers to assure reliability through independent operation. The units are manufactured by Avco Corporation as part number 185010 for General Dynamics/Convair under Specification 55-01233. The unit is comprised of four subassemblies – the r-f deck, i-f deck, decoder deck and relay deck. (See Figure 3-37 for the schematic diagram.)

The electronic equipment is housed in a cylindrical aluminum package, Figure 3-12. The total volume is 45 cubic inches and nominal weight is 2.5 pounds. (Outline dimensions are given in Figure 3-13.) The outer surface of the unit is coated with a low emissivity and low absorptivity aluminized epoxy enamel that retains a portion of the generated heat and reflects a majority of solar radiation.

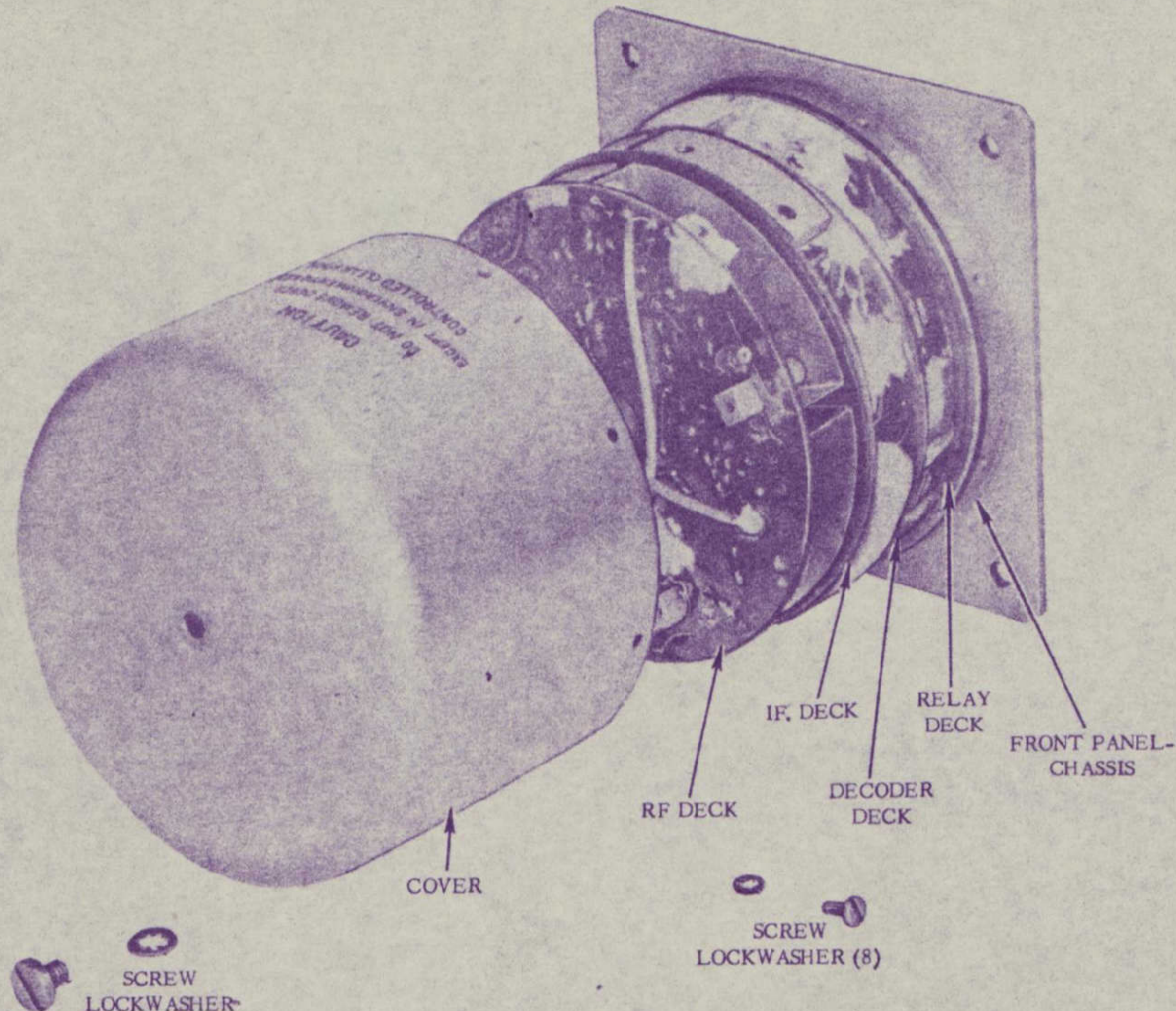


Figure 3-12. Command Receiver - Decoder

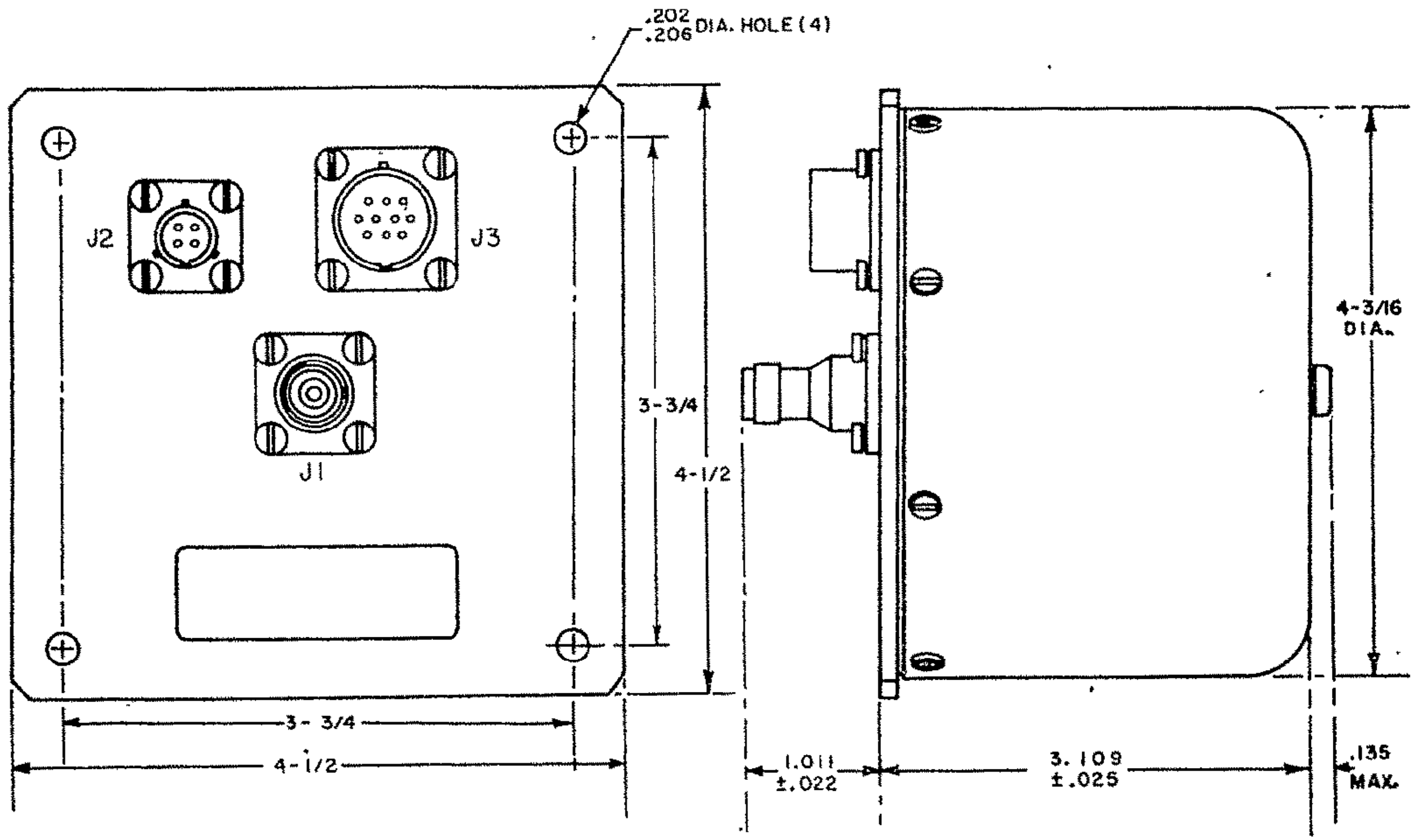


Figure 3-13. Outline Drawing of Command Receiver - Decoder

The cover is fastened to the chassis by eight 1/4-inch, 4-40 screws around the circumference of the cover, and by one 1/4-inch, 10-32 screw inserted through the center of the rear surface of the cover. Preformed O-ring packings are used between cover and chassis and at the rear screw to preserve cleanness. All tuning controls are exposed when the cover is removed. The four modules that form the command receiver — decoder are of the printed-circuit deck type and include the r-f deck, i-f deck, decoder deck, and relay deck. The decks are attached to the front panel — chassis assembly with mounting screws and spacers through each deck. Additional mechanical stability is provided by spacers around a 1/2-inch-diameter preselector tube that runs through the centers of the decks. The decks are arranged so that those containing heavier components are mounted near the front panel — chassis. Electrical interconnections between the decks, and from the decks to chassis-mounted components, are made by short jumper wires.

3.6.1 Receivers. This unit is a double-conversion superheterodyne F-M receiver — decoder operating in the 400- to 550-mc band. A simplified block diagram is shown in Figure 3-14. The r-f carrier appearing at input connector is applied to a five-

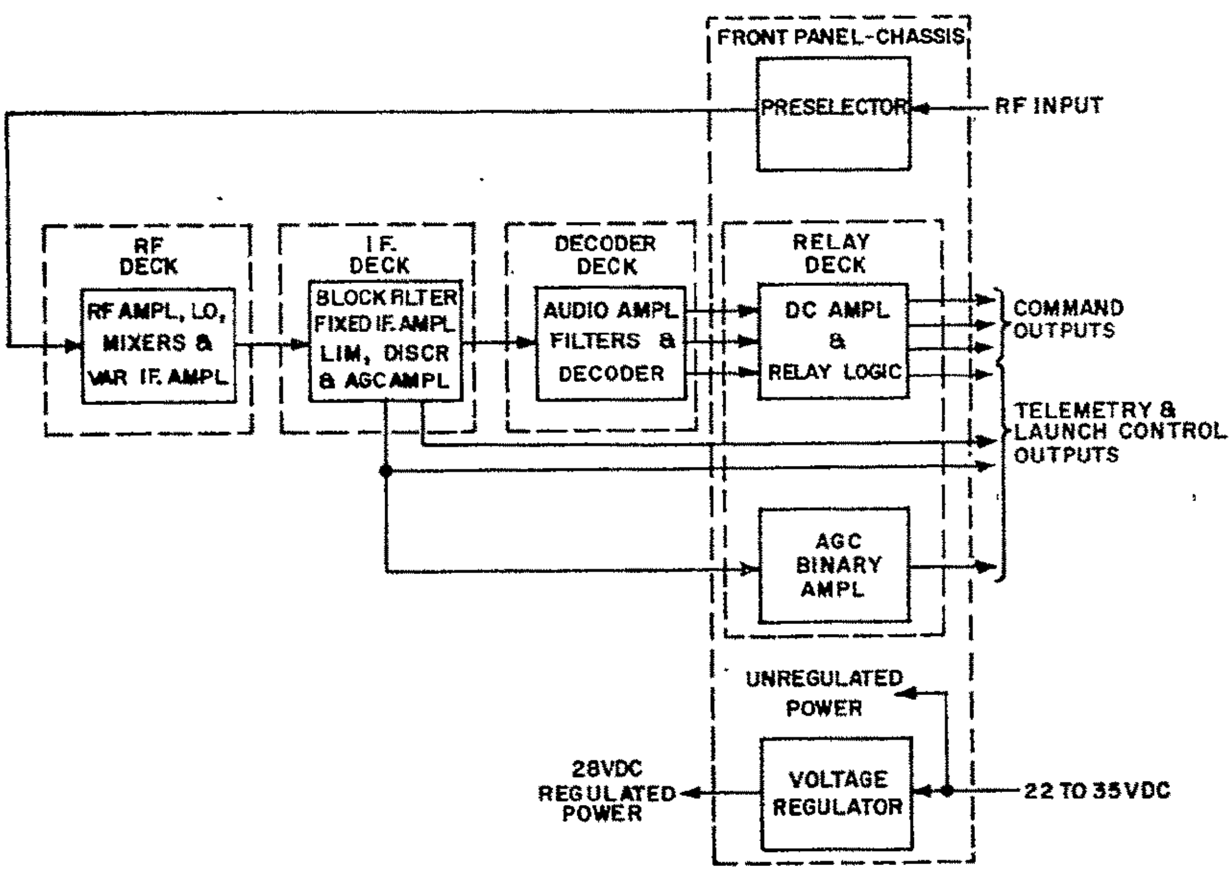


Figure 3-14. Simplified Block Diagram of Command Receiver - Decoder

section preselector that rejects all except a 5-mc segment of the 400- to 550-mc band. The selected segment is applied to a low-noise r-f amplifier tuned to the specified carrier frequency. One output of a crystal-controlled local oscillator is multiplied six times and applied to a first mixer. Here a first i-f is produced that is variable between 66.31432 and 87.74290 mc. The converted signal is amplified in a variable i-f amplifier stage and applied as one input to a second mixer. Here it is mixed with the fundamental frequency of the crystal-controlled local oscillator to produce a second or fixed i-f of 10.7 mc.

The fixed 10.7 mc i-f signal is applied through a 10.7-mc block filter with a minimum 3-db bandwidth of 220 kc. This signal is then applied to a three-stage, 10.7-mc i-f amplifier that provides 60 db gain. The amplified signal is limited and applied to a F-M discriminator. The demodulated audio signals are amplified in an audio pre-amplifier that drives two audio amplifiers. One is a single-ended stage which couples audio voltage to a connector for external monitoring.

3.6.2 Decoder. The second audio amplifier is located in the decoder deck. Here the audio is applied through a low-pass filter to the amplifier which consists of a driver stage followed by a push-pull stage. The low-pass filter rejects all tones above the highest frequency associated with the tone filters. The push-pull stage drives three series-connected noise-immune filters. Each filter and its associated detectors form the initial element of a command channel.

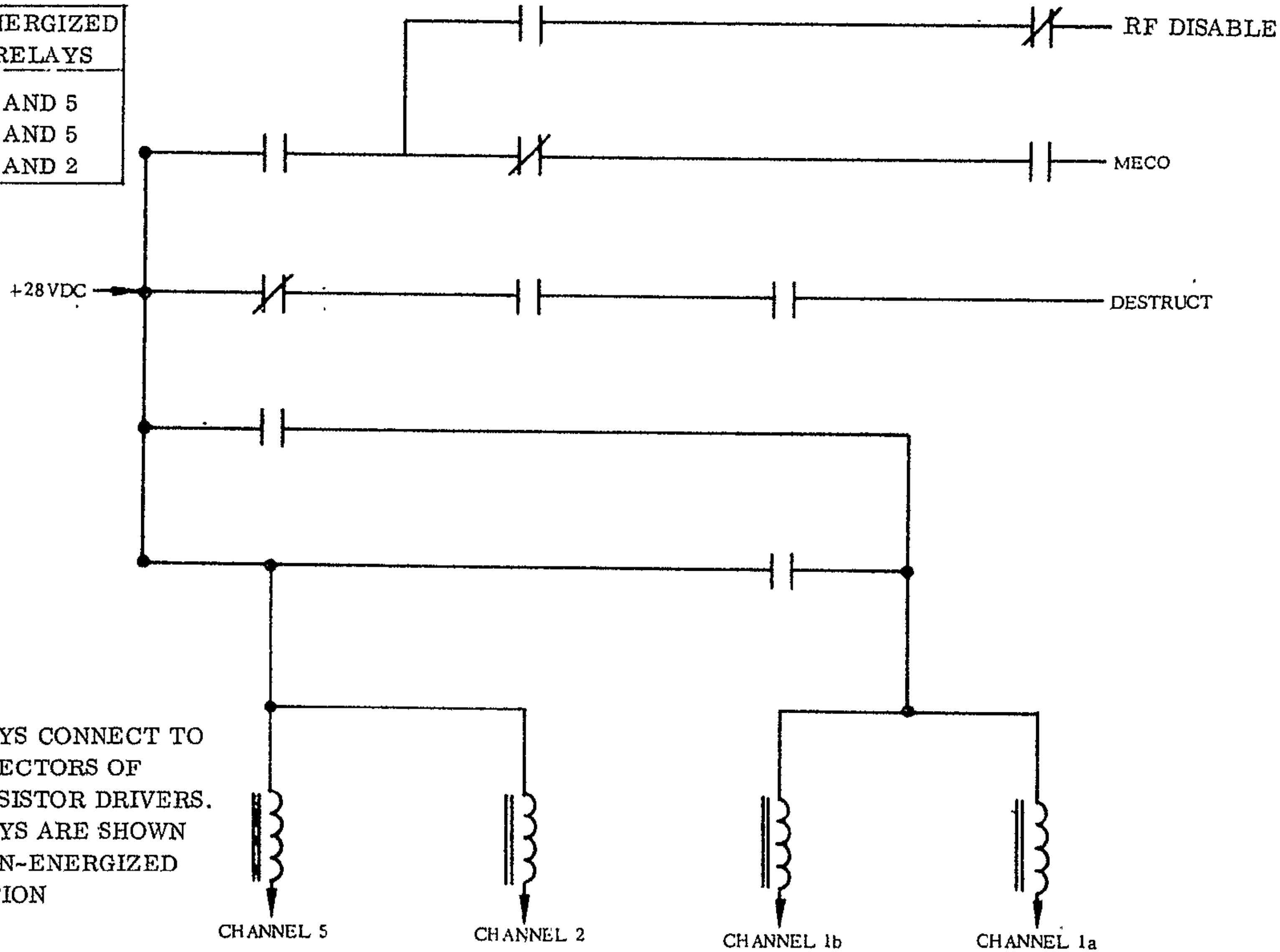
The complete command channel consists of the tone filter, a two-stage d-c amplifier, and one or more command relays. The relays in a particular channel operate when the incoming r-f signal is frequency modulated with that tone to which the associated noise-immune filter is tuned. The command relay contacts are interconnected to produce the r-f disable, MECO, and destruct output commands. A direct connection from the channel 5 relay provides a monitor output when the channel 5 tone is applied.

A sample of the signal level present in all three 10.7-mc i-f amplifiers is combined and amplified in a single-stage agc analog amplifier in the i-f deck. The amplified output is applied as an agc output directly to an output connector pin and is also used as a driving voltage to a series pair of d-c amplifiers in the relay deck. The output of the d-c amplifiers drives an agc binary relay that operates when the r-f signal exceeds a predetermined level. The agc voltage is used as an indicator of r-f signal level and does not control the gain of the receiver amplifiers.

The voltage regulator is a single-stage device. Its transistor is mounted on the front panel — chassis to provide a good heat sink. The B+ power of the command receiver — decoder is maintained at a nominal 24 volts dc.

The sequence circuit in the decoder requires that the combination of tones 1 and 5 (MECO) be received immediately before tones 1 and 2 (Destruct) if the combination of tones 1 and 2 is to generate a command output. Tone 1 must remain on during the

FUNCTION	ENERGIZED RELAYS
RF DISABLE	2 AND 5
MECO	1 AND 5
DESTRUCT	1 AND 2



NOTES: 1. RELAYS CONNECT TO COLLECTORS OF TRANSISTOR DRIVERS.
2. RELAYS ARE SHOWN IN NON-ENERGIZED POSITION

Figure 3-15. Receiver Relay Logic

transition from MECO to destruct. (See Figure 3-15 for the logic interlock circuit.) Unlike the Atlas command set, the Centaur receiver – decoder does not have the 110- to 350-millisecond time delay in the channel 5 filter-rectifier.

3.7 POWER CONTROL UNIT. The Centaur RSC subsystem power control unit, General Dynamics/Convair part No. 55-36080, (Figure 3-16) performs the following functions:

a. Carries out the r-f and programmer commands detailed in Sections 3.2 and 3.3.

b. Interconnects all RSC subsystem units.

c. Provides a common source of telemetry and landline instrumentation. (Except for the Surveyor arm/safe unit and Centaur destructor arm/safe monitors). (See Figure 3-2 block diagram.)

d. Controls power changeover.

3.7.1 Command Functions. The r-f disable command from either receiver operates four magnetic latching type relays (Figure 3-3) in the power control unit as explained in Section 3.2. This command ensures that power will be removed from the entire system by causing the batteries to be connected to the external command lines of their respective power changeover switches. Actuation of either relay (Surveyor inadvertent separation relays K3 and K4) of the other pair will disconnect the inadvertent separation switches from the destruct relays K7, K8, and K9, K10.

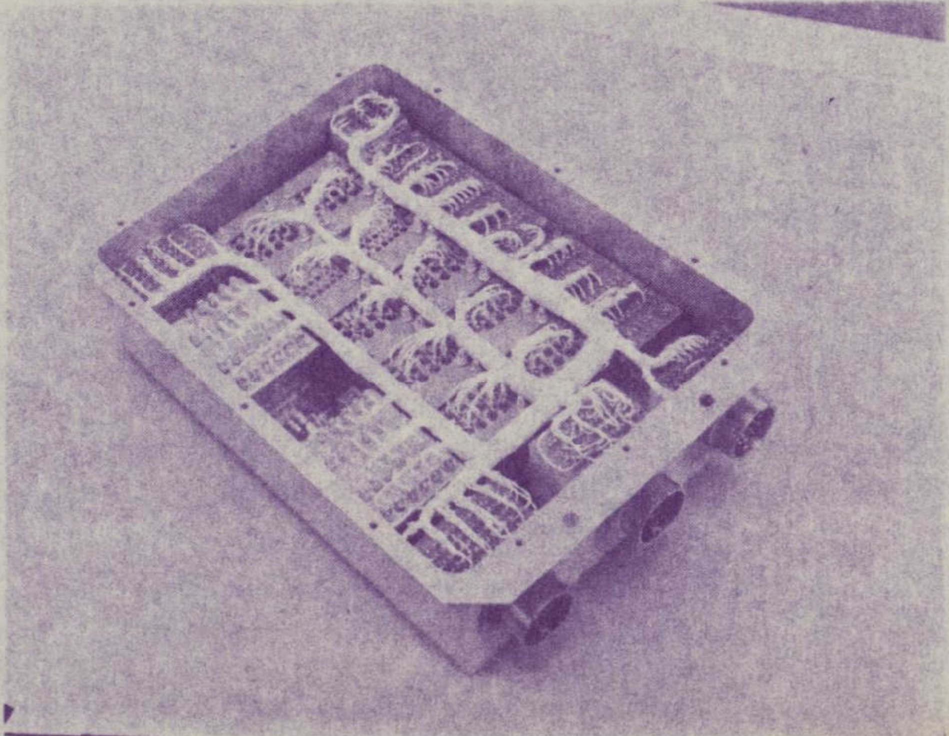


Figure 3-16. Power Control Unit

Thrust termination or MECO is accomplished by magnetic latching relays K5 and K6 in the power control unit. Both relays are operated by either receiver, but both relays must operate to accomplish the command. The operation of the relays interrupts the LH_2 prestart signal, which removes all pneumatic pressure from engine valves controlling the LH_2 and LO_2.

The destruct command from each receiver is connected to its own pair of destruct relays, K7, K8 and K9, K10. Both relays of either pair must operate to connect firing current to Surveyor and Centaur initiators, (Figure 3-5). These relays require continuous application of voltage to hold the contacts in the destruct position.

Surveyor inadvertent separation destruct command is issued by any two of the three inadvertent separation switches detecting a displacement of 0.5 inch of the Surveyor with respect to the Centaur. This command results in the application of 28 vdc to destruct relays K7, K8, and K9, K10, (Figure 3-7). (On the AC-6 mission there will be no connection between the separation switches and destruct relays.)

Surveyor inadvertent separation safe command is issued by the Centaur programmer at MECO backup + 0.5 second to insure a safe condition at normal Surveyor separation. This command operates a pair of relays (Surveyor destruct relays K3 and K4) to their safe position. These relays are magnetic latching-type and require no electric energy to hold the armature in either position. Operation of either relay to its safe position will disconnect the separation switches from the destruct relays.

3.7.2 Interconnection. To perform the command functions all signal and power lines between range safety command subsystem components are routed through the power control unit. The exceptions are those for the arm and safe command of the Surveyor destruct safe/arm initiator and the Centaur explosive destructor. All monitor circuits are routed through the power control unit except the arm and safe monitors of the Surveyor destruct safe/arm initiator and the Centaur explosive destructor, plus the continuity monitor of the inadvertent separation switches.

Two power changeover switches (General Dynamics/Convair part No. 90-05575-001) are contained in the power control unit. These transfer the system power source from external to internal and vice versa.

3.8 CENTAUR EXPLOSIVE DESTRUCTOR. The destructor (General Dynamics/Convair part No. 55-04348-1) is housed in red anodized aluminum. A picture of the unit is shown in Figure 3-17; an assembly sketch in Figure 3-18. The unit complies with environmental testing in accordance with General Dynamics/Convair Specification 55-00200E.

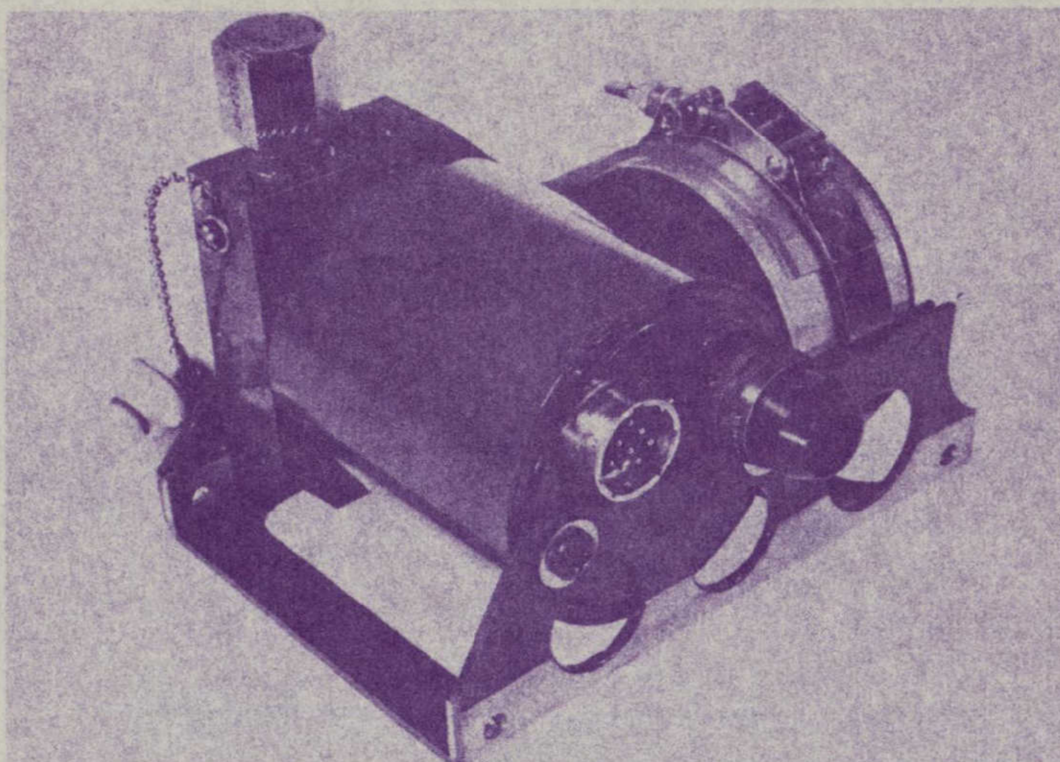


Figure 3-17. Centaur Destructor

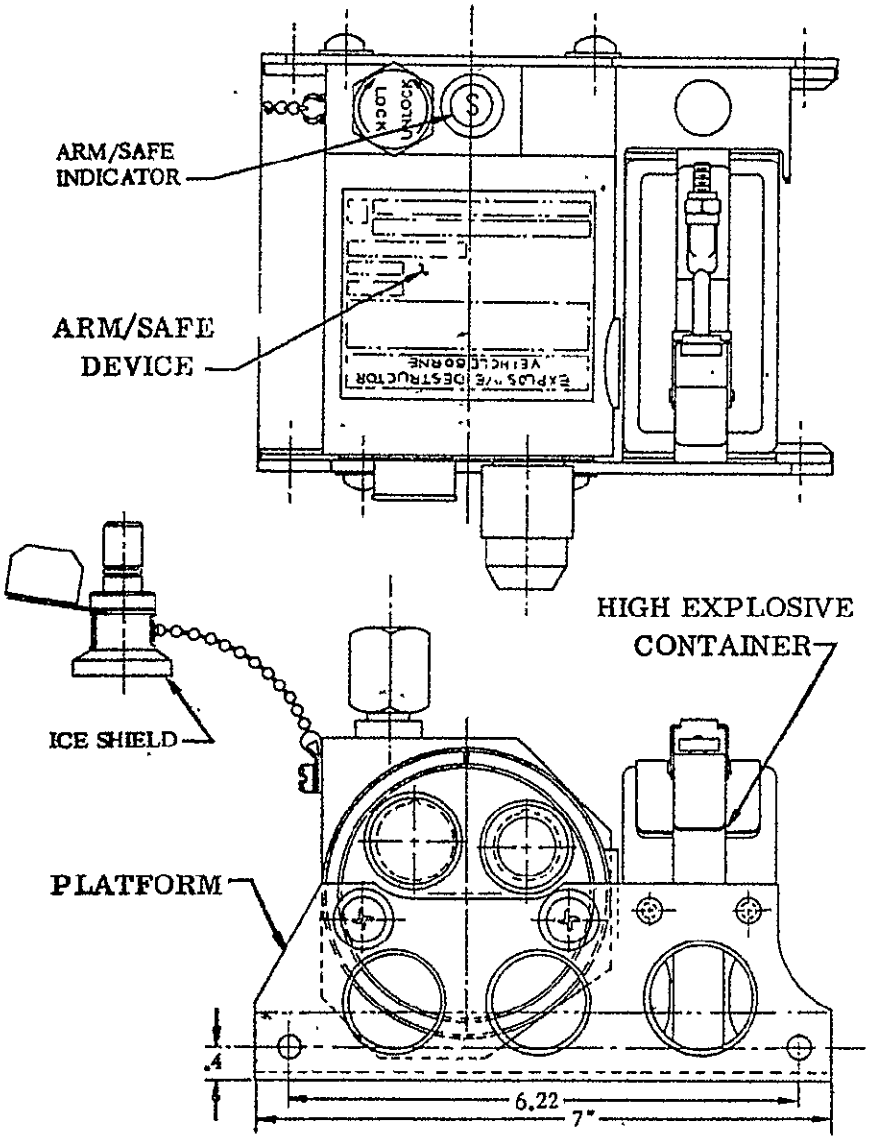
The destructor consists of three separable major assemblies: platform, high-explosive container, and arm/safe device. Except for repair or overhaul, the arm/safe device is not removed from the platform. The high-explosive container may be removed as a safety measure during handling and shipping.

The platform provides the mounting interface between the vehicle and the unit as well as the support structure for the high-explosive container and the arm/safe device. The high-explosive container houses a one-pound block of RDX high explosive, the main charge.

The arm/safe device is the unit's operating assembly. It contains an electric motor to allow remote arming and safing. Driven electrical switches electrically arm and safe the electro-explosive initiator circuits and allow remote monitor and control. Also included are a mechanical safing barrier, manual safing mechanism, visual indicator, and a high-explosive booster cup. Figure 3-19 shows the schematic.

The safe lock provides a positive mechanical lock, constraining the mechanism to a safe position. The electrical circuits and control motor cannot override the lock nor can the lock accidentally fall out. Manual safing can always be performed by inserting the safe lock into the unit.

The arm/safe indicator provides a means for visually determining arm/safe status.



LENGTH	7.00 INCHES
WIDTH	5.00 INCHES
HEIGHT	5.50 INCHES
WEIGHT	5 POUNDS
MOUNTING	4 - 0.257 HOLES
CONNECTORS	J-1 FIRING CIRCUITS
PRESSURIZATION	16 PSIA - 98% N_2 2% He
LEAK RATE	10^{-5} STD CC/SEC.
STORAGE LIFE	2 YEARS

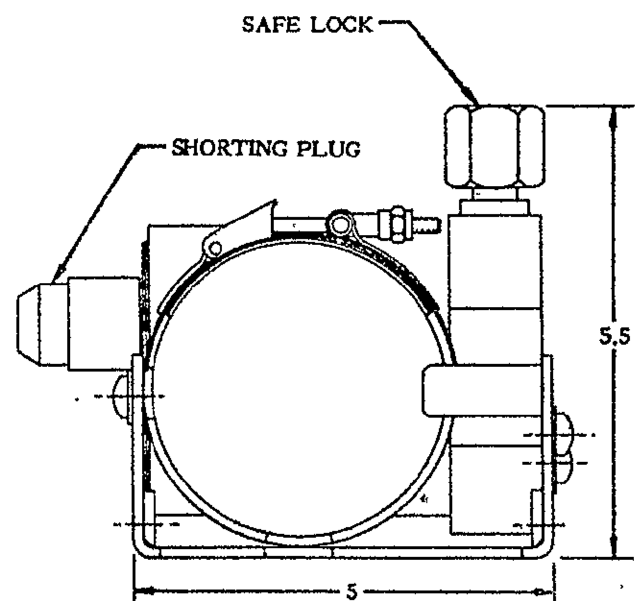


Figure 3-18. Assembly Drawing of Destructor

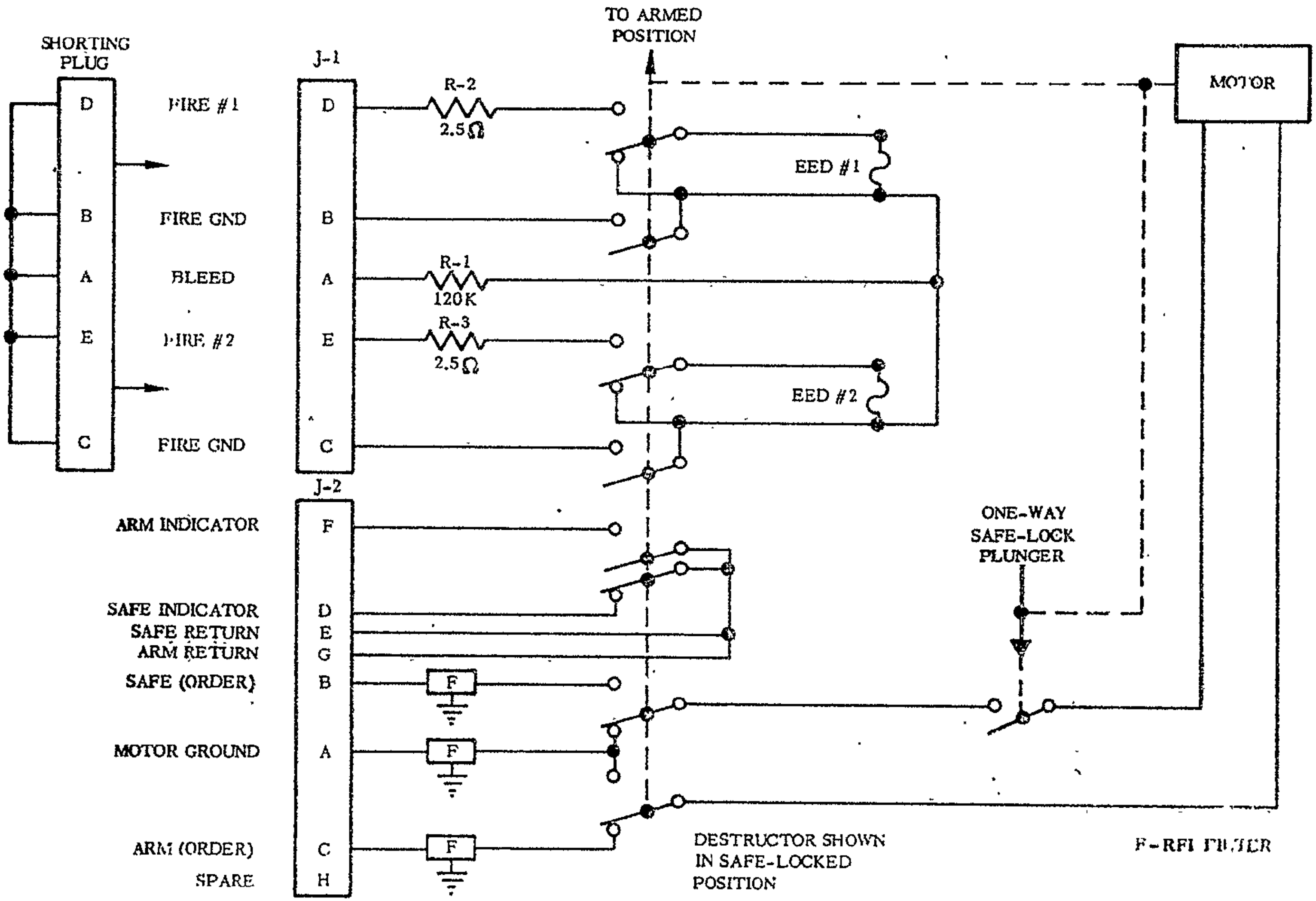


Figure 3-19. Destructor Schematic

An ice shield closes the mechanical safing port and protects the window over the arm/safe indicator from ice. When desired, all pins of the firing connector can be short circuited by inserting the plug furnished.

3.8.1 Primer Circuit. The destructor contains two independent primers of the one-amp, one-watt, no-fire type. The hazard of accidental operation of the primers due to stray currents is considerably reduced by arranging the arming switch circuit to provide isolation of both sides of the destructor primers from ground, and from the energizing voltage when in the safe position. A short circuit is also provided across the destructor inputs until the destruct command is initiated. A high-resistance leakage path to ground is provided for safe drainage of static charges from the destructor circuit.

Electrical characteristics are:

a. Bridgewire resistance: 1 ± 0.2 ohm.

b. Recommended minimum firing current: 4 amps.

c. Ignition time: 15 millisecond maximum.

d. No-Fire current: 1 amp (5 minutes).

e. Continuity test current, nominal: 0.05 amp.

f. Spontaneous detonation temperature: 375° F.

Figure 3-20 shows the firing characteristics.

The primer delay time is 90 ± 30 milliseconds over the temperature range of -65° F to 200° F. The minimum firing time is equal to 60 milliseconds plus the primer ignition time. This time delay insures ignition of both first- and second-stage destructor units by compensating for the differences in the individual subsystem time response.

The 2.5 ohm resistors (Figure 3-19) are primarily used to decrease the possibility of pre-ignition, but also prevent a battery short circuit if the circuit at the initiator were to become shorted. This is important because the same battery is used to initiate the Surveyor destruct system.

3.8.2 Explosive. Detonation is initiated by the primer, which in turn explodes a booster charge adjacent to the main destructor charge. Detonation cannot occur unless the system is armed. The main destructor charge, approximately one pound of RDX, consists mostly of cyclonite with 3 to 5 percent wax, and 1 to 1.5 percent graphite.

RDX has a melting temperature of approximately 400° F, fumes at 550° F, but does not detonate at a temperature less than 680° F. It is not hygroscopic and has good storage

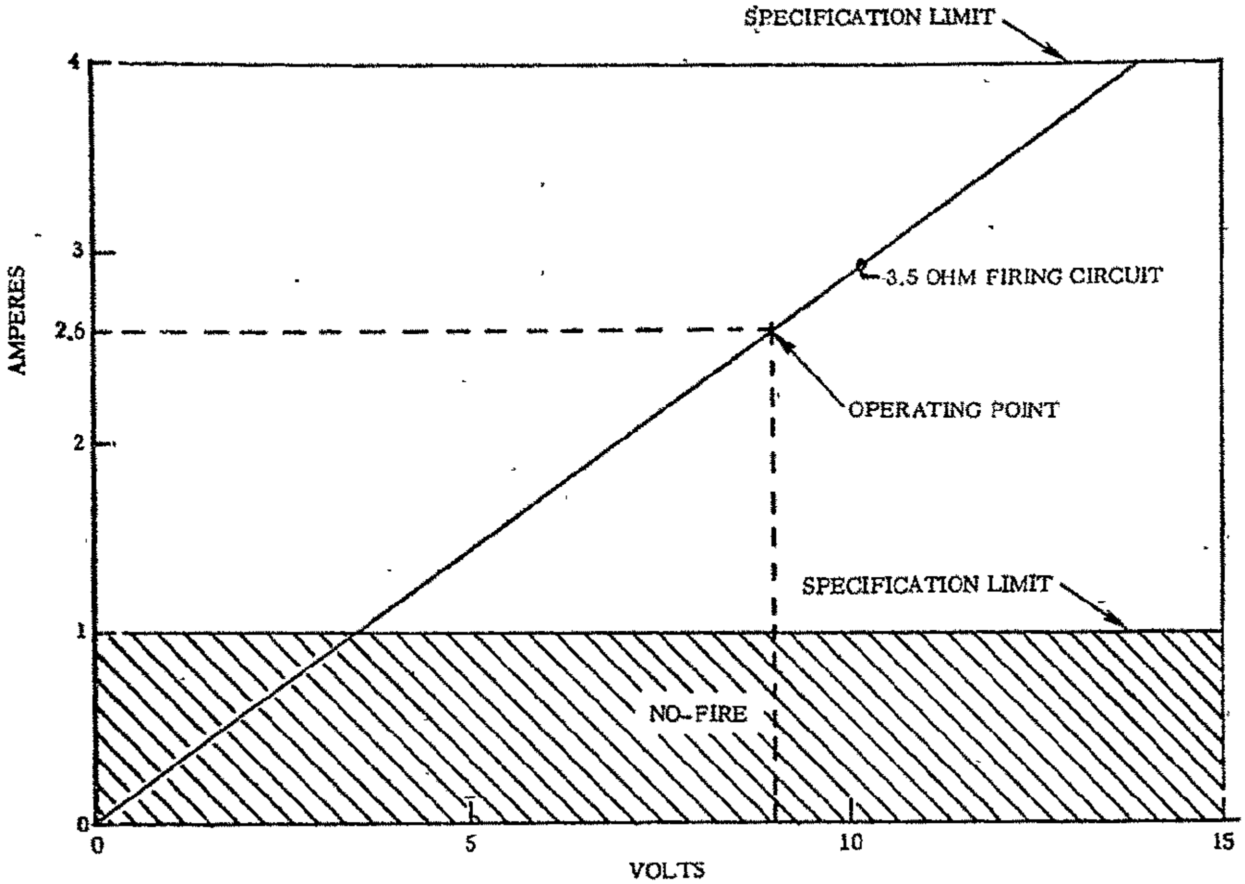


Figure 3-20. Primer Firing Characteristics

stability. Destructive qualities are not affected by the environmental temperatures encountered during flight. For normal storage conditions of −80° F to 160° F, at zero to 95 percent relative humidity, the RDX should be good for five years or longer.

The high explosive is housed in a cylindrical metal container (Figure 3-21) which may be removed from the assembly by removing a band clamp as shown in Figure 3-22.

3.8.3 Mechanical Arming Mechanism. The destructor is armed or safed by a d-c motor that turns a rotor shaft assembly, Figure 3-23. Located at one end of this shaft is a metal barrier that separates the primers from the booster charge when in the safe position. This shaft is rotated by application of 28 vdc from the range safety console to one side or the other of the d-c motor. When the shaft is rotated to the arm position, the barrier is removed from between the primer and booster charge. Located on the same shaft assembly are contacts that monitor the position of the shaft, connect firing current to the initiator, and connect alternate sides of the d-c motor to the range safety console. Once transferred, the shaft is held in the armed or safed position by a roller and toggle mechanism shown in Figure 3-24. Visual determination of shaft position is accomplished by a gear linking the shaft to a rack pinion which displays, through a window in the unit, an "A" or "S".

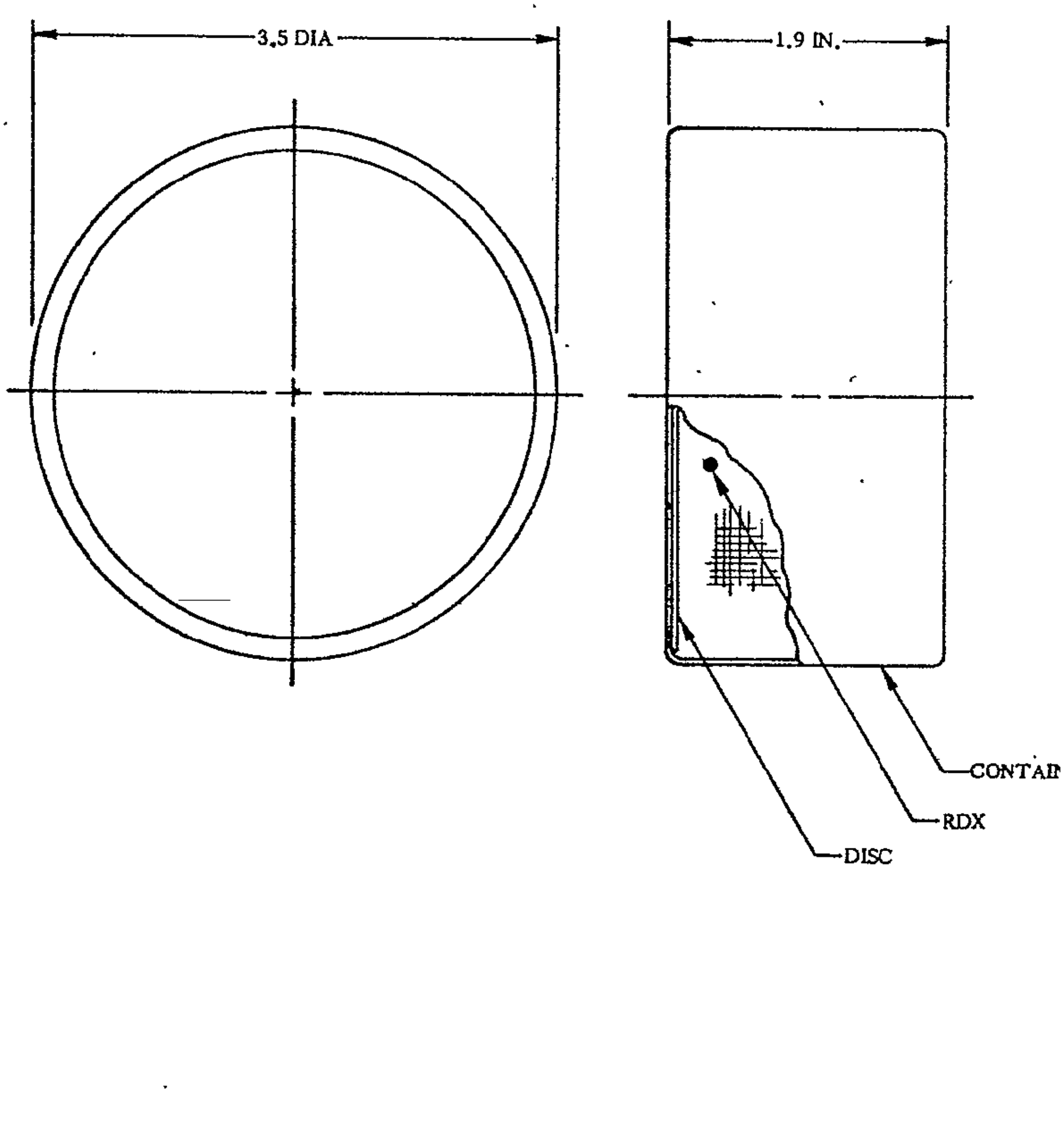


Figure 3-21. High Explosive Container

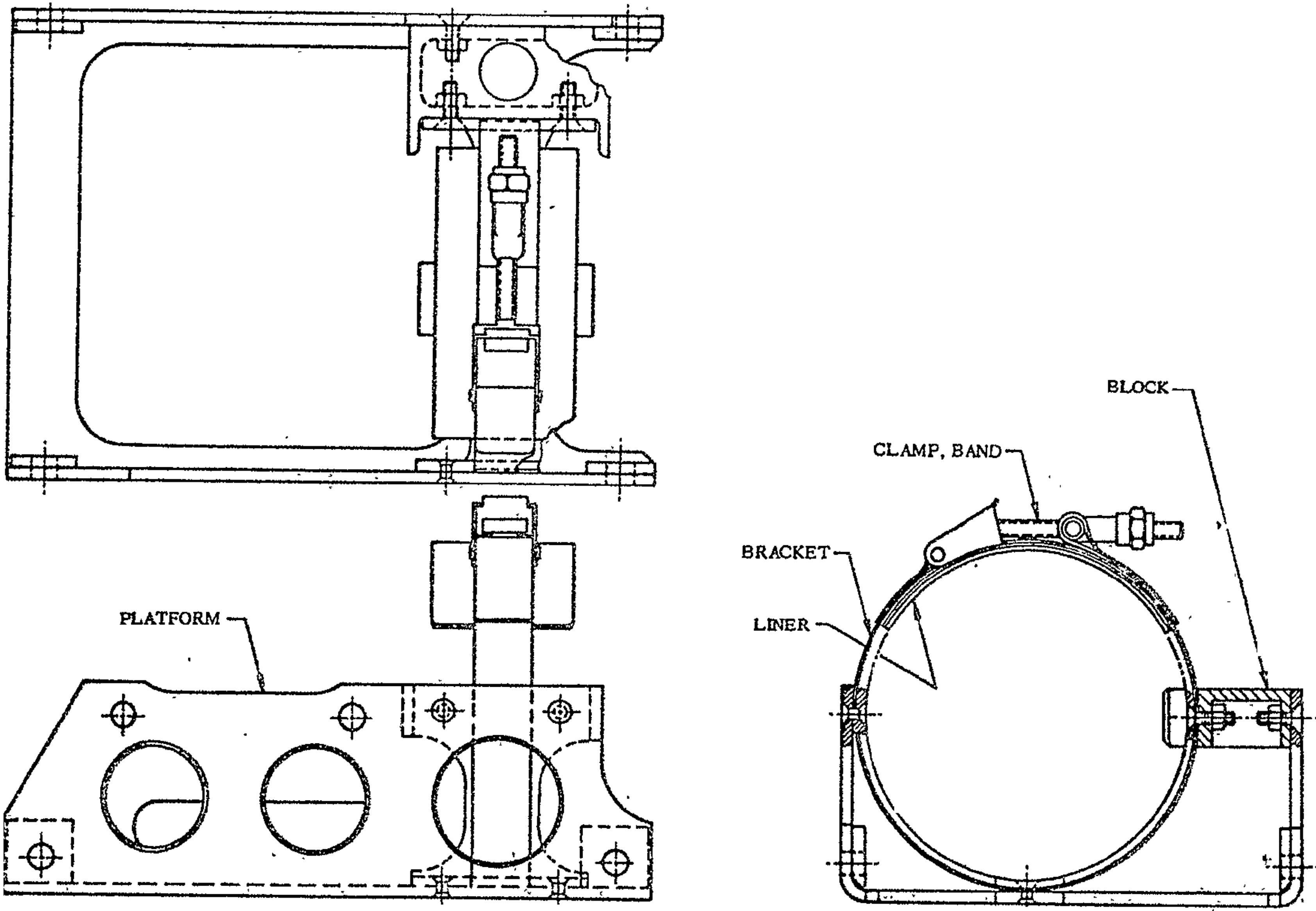


Figure 3-22. Centaur Destructor Platform Assembly

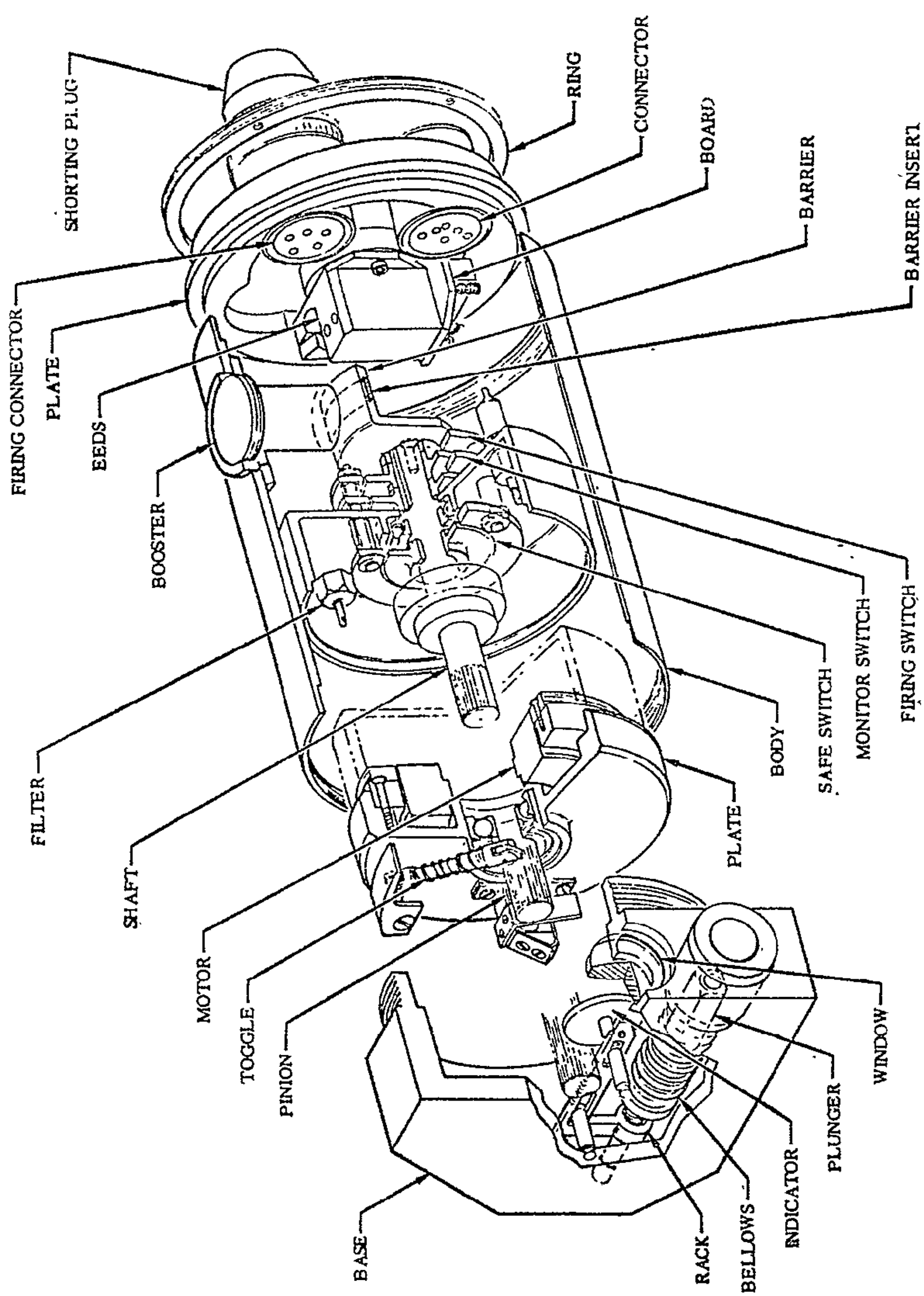


Figure 3-23. Exploded View of Centaur Destructor

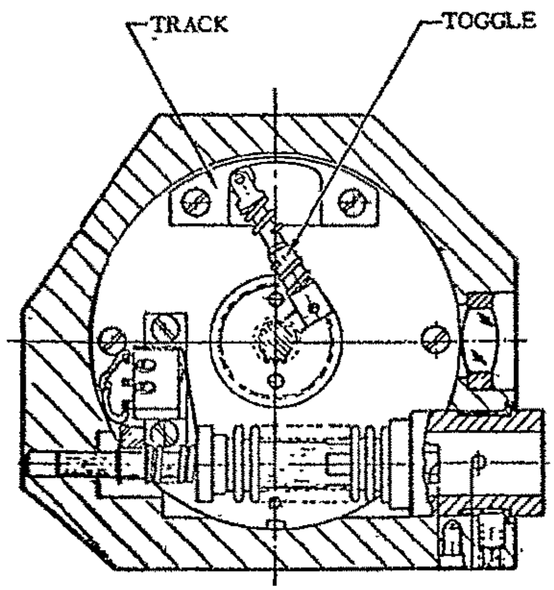


Figure 3-24. Centaur Destructor Toggle Detail

3.9 SURVEYOR DESTRUCT SAFE/ARM INITIATOR. This unit (General Dynamics/ Convair part No. 55-01276-1 or -3) is housed in anodized aluminum. The -1 is painted red and the -3 green. The following discussion is concerned primarily with the -1 unit which contains the live primer and booster charges, although the inert -3 unit will be flown on AC-6. The -1 units will be used on operational Surveyor missions to initiate a pyrotechnic chain that will activate the conical-shaped charge. A picture of the unit is shown in Figure 3-25. The -1 unit complies with General Dynamics/ Convair environmental testing Specification 55-00200E. An outline drawing is shown in Figure 3-26.

3.9.1 Primer Circuit. The primer circuit in the -1 unit is of the same type and has the same hazard-reducing features as in the Centaur destructor. (See Section 3.8.) A schematic is provided in Figure 3-27. Electrical characteristics are:

a. Bridgewire resistance: 1 ± 0.2 ohm.

b. Recommended minimum firing current: 4.5 amps.

c. Ignition time: 15 milliseconds maximum.

d. No-fire current: 1 amp (5 minutes).

e. Continuity test current, nominal: 0.1 amp.

f. Spontaneous detonation temperature: 365° F.

Firing characteristics of this unit are shown in Figure 3-28.

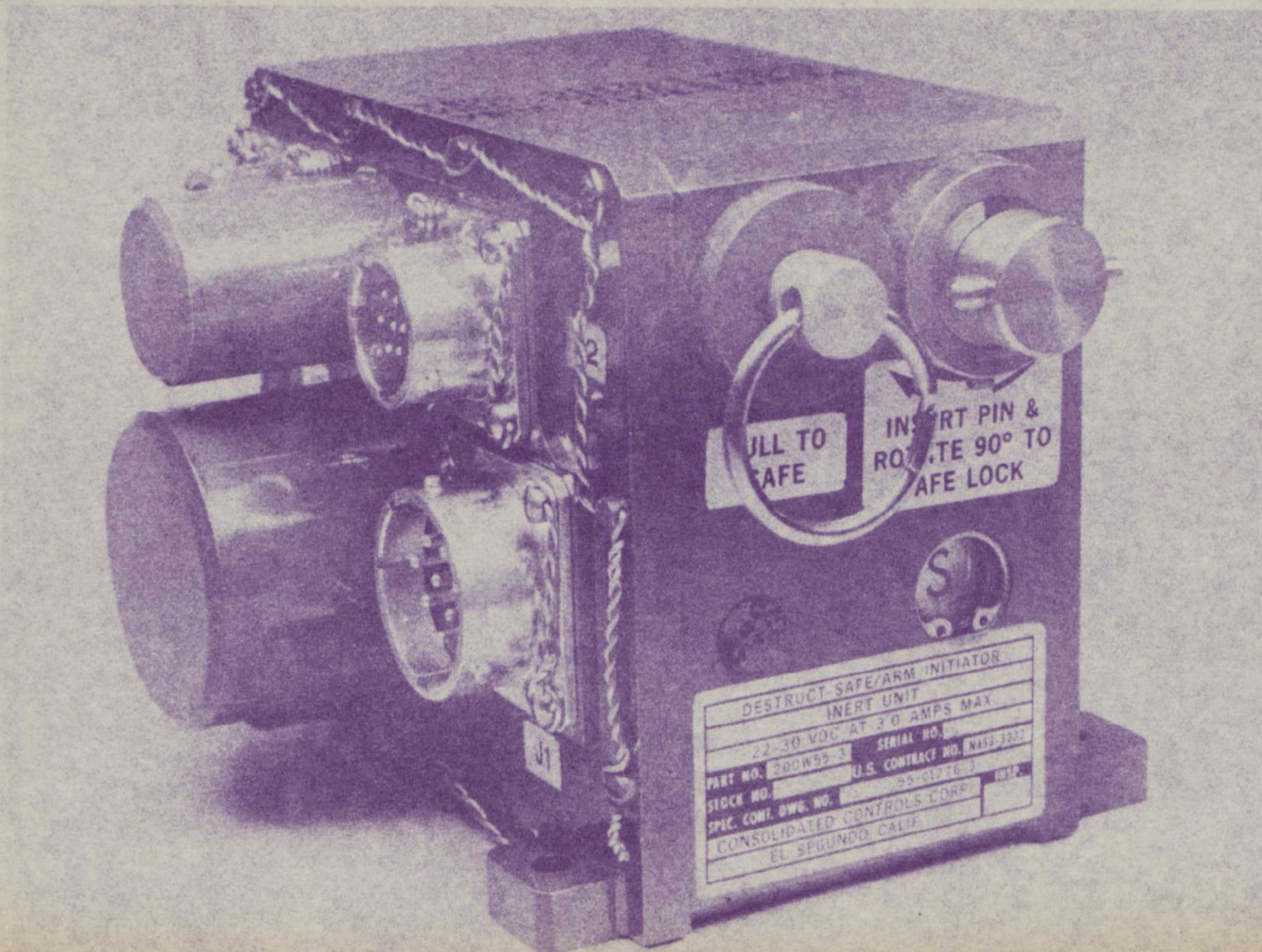


Figure 3-25. Photograph of Surveyor Safe/Arm Initiator

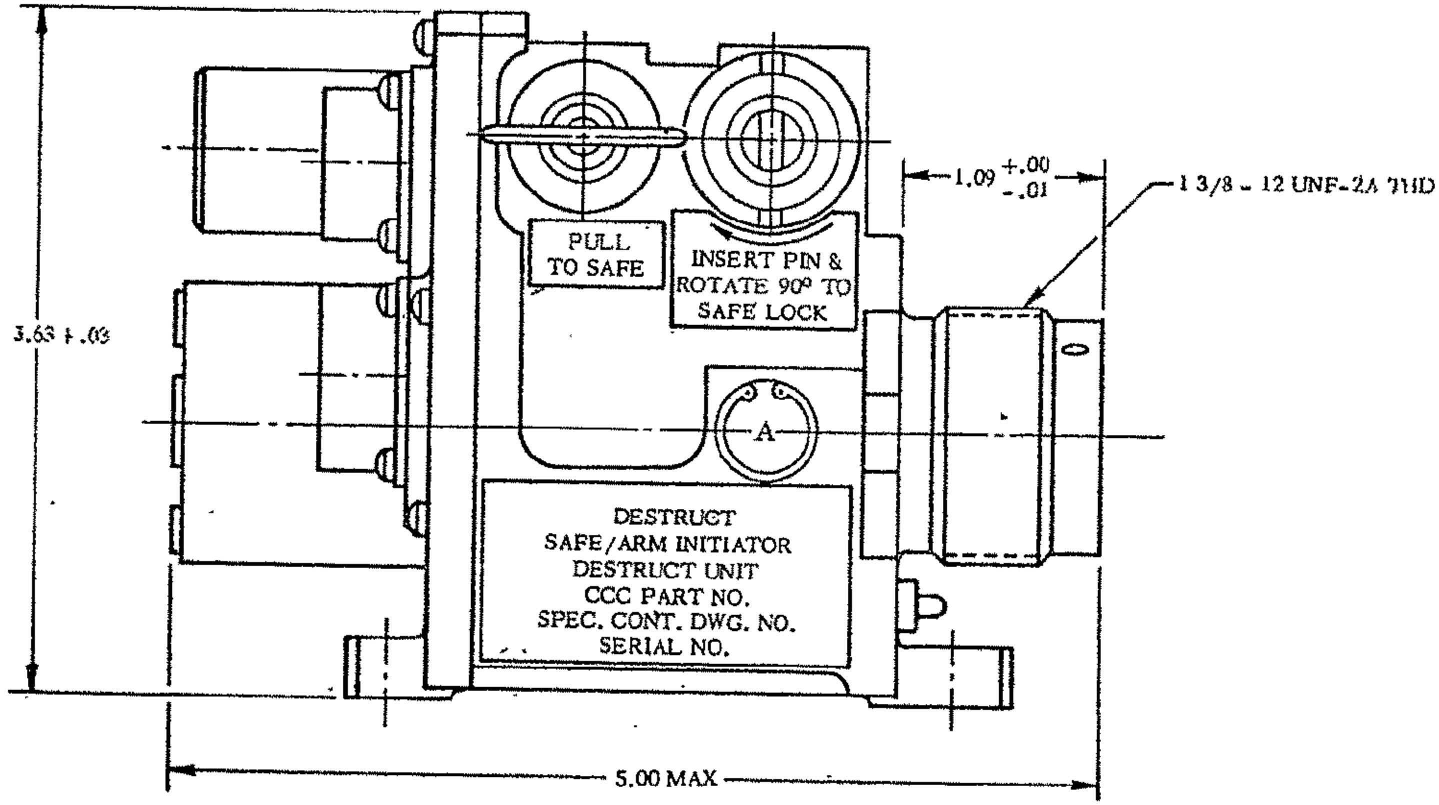


Figure 3-26. Outline Drawing of Surveyor Destruct Safe/Arm Initiator

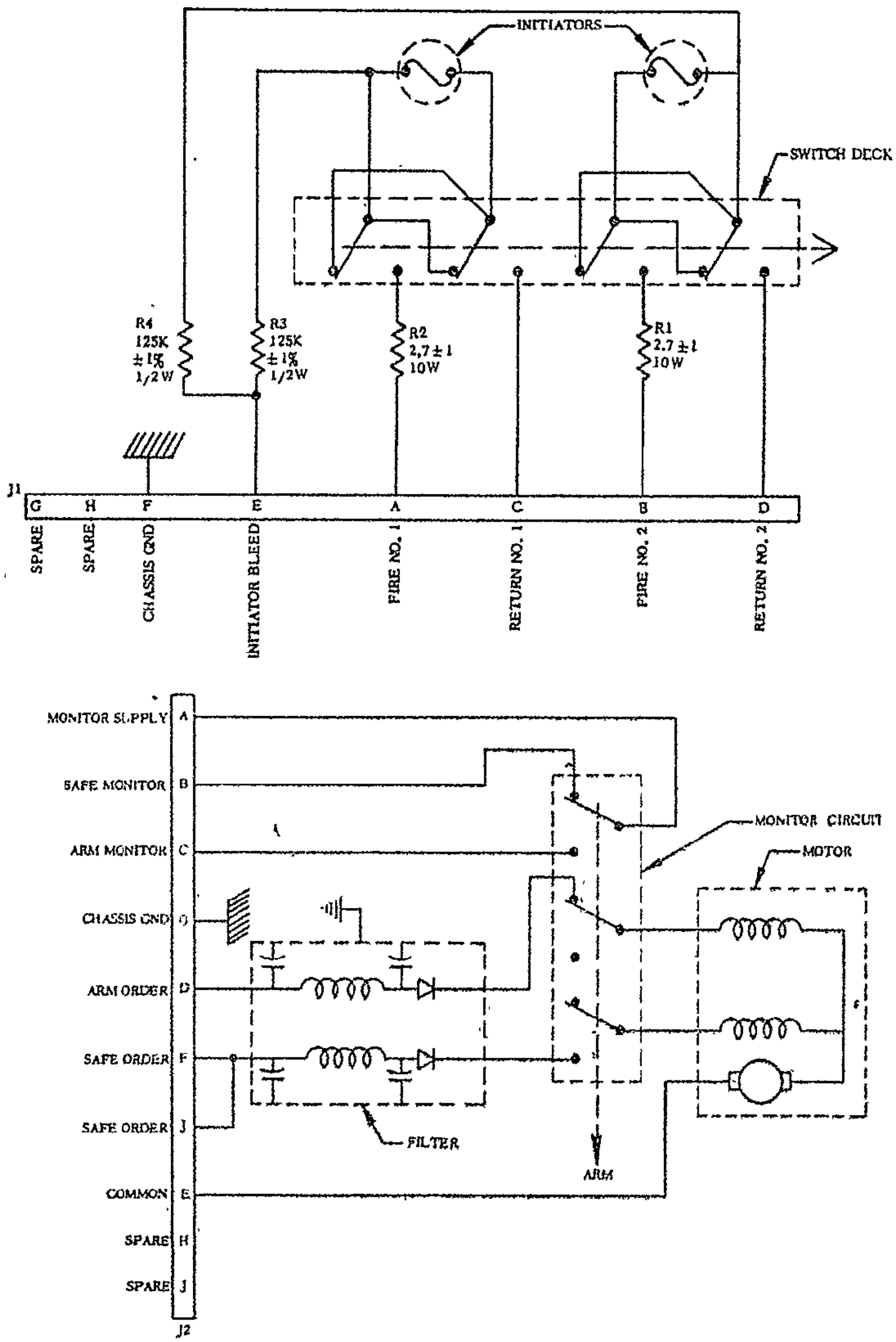


Figure 3-27. Surveyor Destruct Safe/Arm Initiator Schematic (-1 Unit)

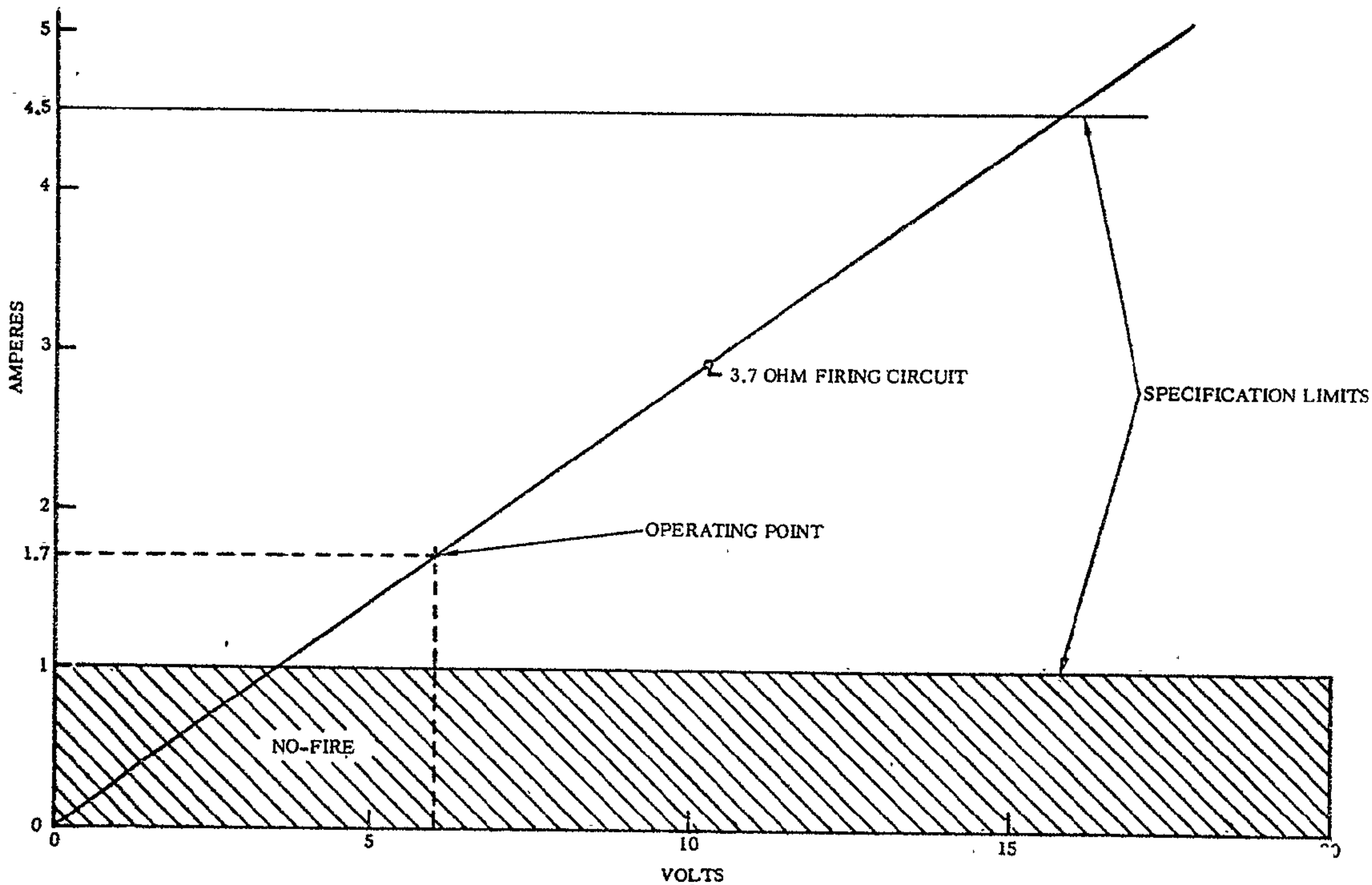


Figure 3-28. Firing Characteristics of the Surveyor Safe/Arm Initiator

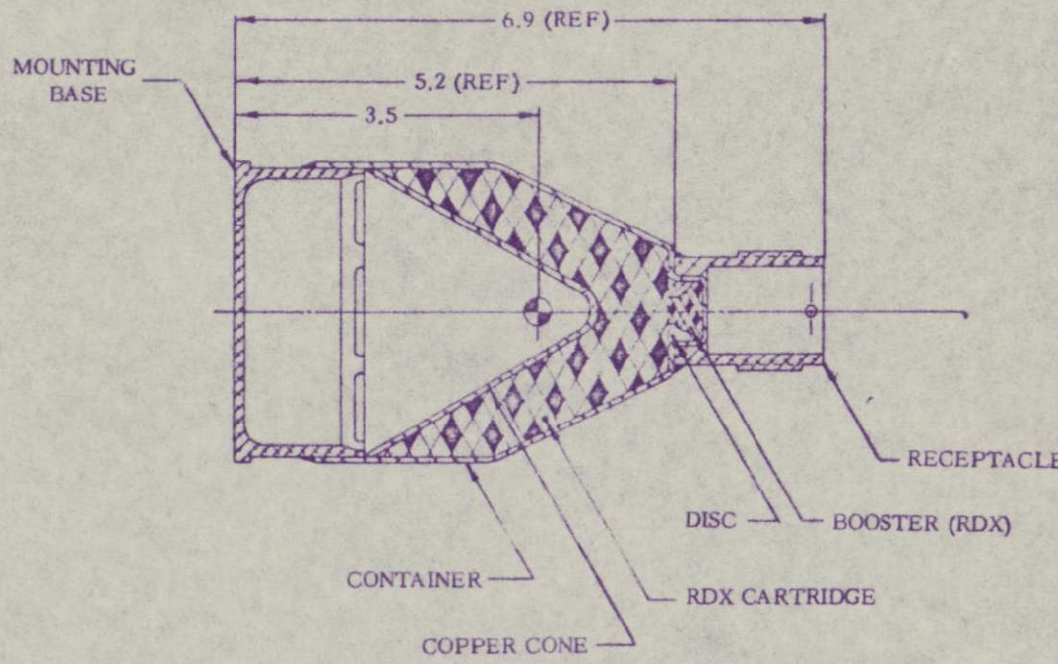
Unlike the Atlas and Centaur destructor primers, no time delay is incorporated in the Surveyor system. This insures the fastest possible response of all Surveyor destruct system components in case of inadvertent separation. See Section 3-12 for a detailed discussion.

3.9.2 Explosive Train Detonation. In place of the RDX high explosives used with Centaur and Atlas destructors, the Surveyor safe/arm initiator has an explosive train that initiates a mild detonating fuse assembly (General Dynamics/Convair part No. 55-36074-5).

3.9.3 Mechanical Arming Mechanism. The unit is armed or safed by a d-c motor that turns a wedge-shaped rotor assembly. Mounted on the flat wedge of the rotor is a booster charge that is rotated 22.5 degrees by a gear train assembly driven by the d-c motor. When in the armed position the booster is aligned with the primer. A clutch into which teeth are machined prevents the possibility of the rotor traveling from the safe position through the armed position and on to the opposite safe position. The teeth engage a stop screw mounted through the rotor block. Located on the same rotor assembly are contacts which monitor shaft position, connect firing current to the initiator, and connect alternate sides of the d-c motor to the range safety console. Visual determination of rotor position is accomplished by a stand-off mounted 180 degrees from the booster charge which displays, through a window in the unit, an "A" or "S".

3.10 MILD DETONATING FUSE. A mild detonating fuse assembly (General Dynamics/Convair part No. 55-36074-5) of PETN and RDX is connected to the Surveyor arm/safe initiator to continue the pyrotechnic chain after the primer has actuated. The fuse assembly is routed along the adapter structure, through the thermal bulkhead, to the conical-shaped charge. Sufficient slack is provided so that if the adapter structure were to fail at a point between the shaped charge and the Surveyor arm/safe unit, the fuse will not pull tight and snap before the destruct system reacts and destroys the Surveyor engine.

3.11 CONICAL-SHAPED CHARGE. A conical-shaped charge (General Dynamics/Convair part No. 55-01275-1) will be used to destroy the Surveyor solid-propellant engine. The unit is shown in Figure 3-29, and its mounting position on the adapter with respect to the Surveyor is shown in Figure 3-30. The method of destruction is to provide, after receipt of a detonation input from the mild detonating fuse, an explosive jet that bores a 2-inch-diameter entrance hole in the Surveyor engine, penetrates the propellant, and emerges out the other side. The explosive mixture is RDX. The unit has a minimum auto ignition temperature of 365° F. On the AC-6 flight an inert unit, General Dynamics/Convair part No. 55-01275-3, will be used to simulate the shaped charge.



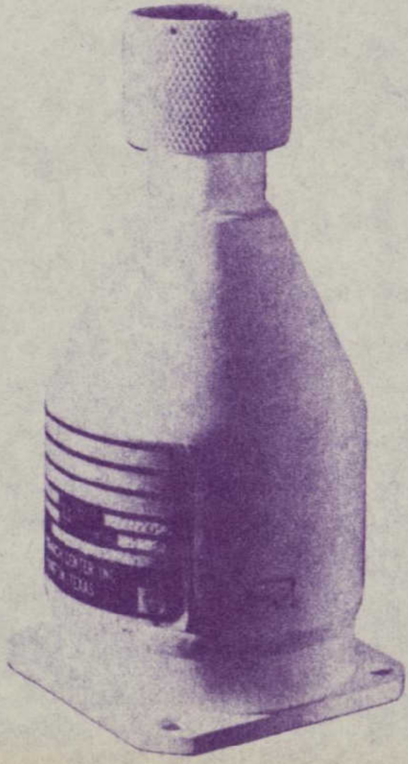


Figure 3-29. Surveyor Conical-Shaped Charge

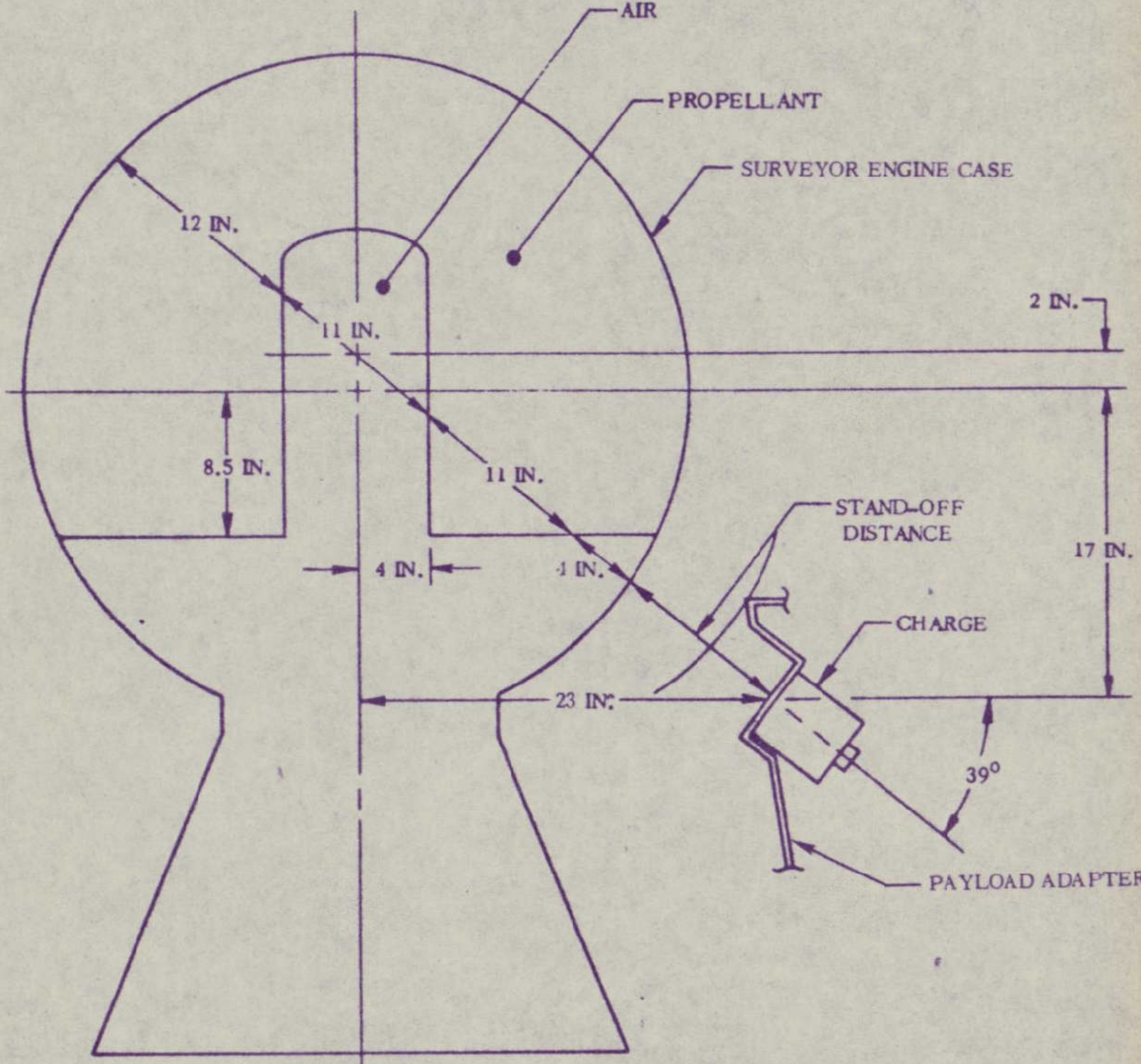


Figure 3-30. Target and Mounting Drawing of Shaped Charge

3.12 INADVERTENT SEPARATION SWITCHES. The inadvertent separation switches (General Dynamics/Convair part No. 55-01292-1) are mounted below the plunger mechanism of the Surveyor separation springs as shown in Figure 3-31. Figures 3-32 through 3-34 show a picture of the switch, its dimensions, and schematic. The switch is fitted with a cap, spring, and adapter pieces, and mounted so that it applies 13 lb of force to the shaft of the switch when the Surveyor is mated. This is sufficient force to insure that the switches track the large plunger under all conditions of Surveyor separation, including premature engine ignition. After one half-inch of vertical travel, two pairs of contacts in the switch close. The three switches are wired so that detection of one-half inch travel by any two of the three will actuate both pairs of destruct relays in the power control unit, initiating the destruct system (see Figure 3-7). Switch characteristics are:

a. Conduct 1.5 amp upon making contact.

b. Break current, 0.5 amp.

c. All contacts isolated from the case.

d. Contact bounce limited to 100 μ sec.

e. Force required to start shaft, 21 ounces.

f. Shaft can be aligned in any direction within ± 0.03 in.

g. Maximum contact resistance, 10 ohms.

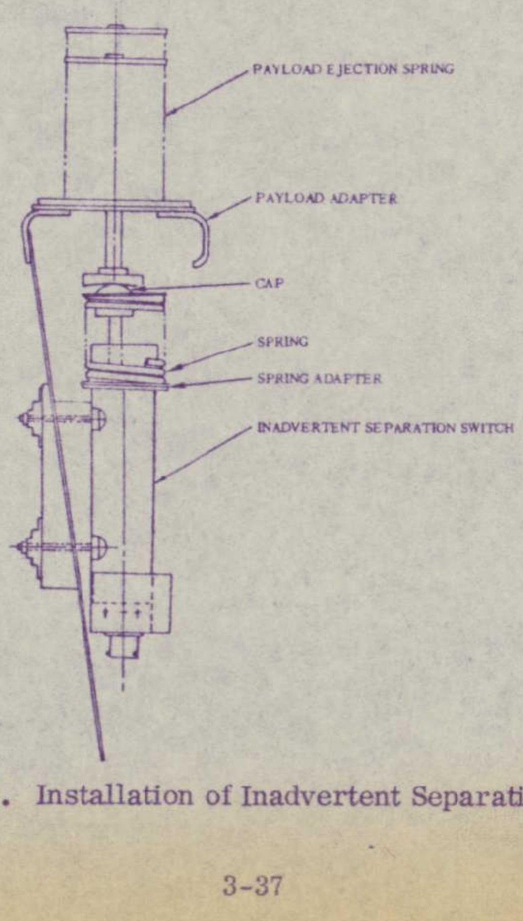


Figure 3-31. Installation of Inadvertent Separation Switch

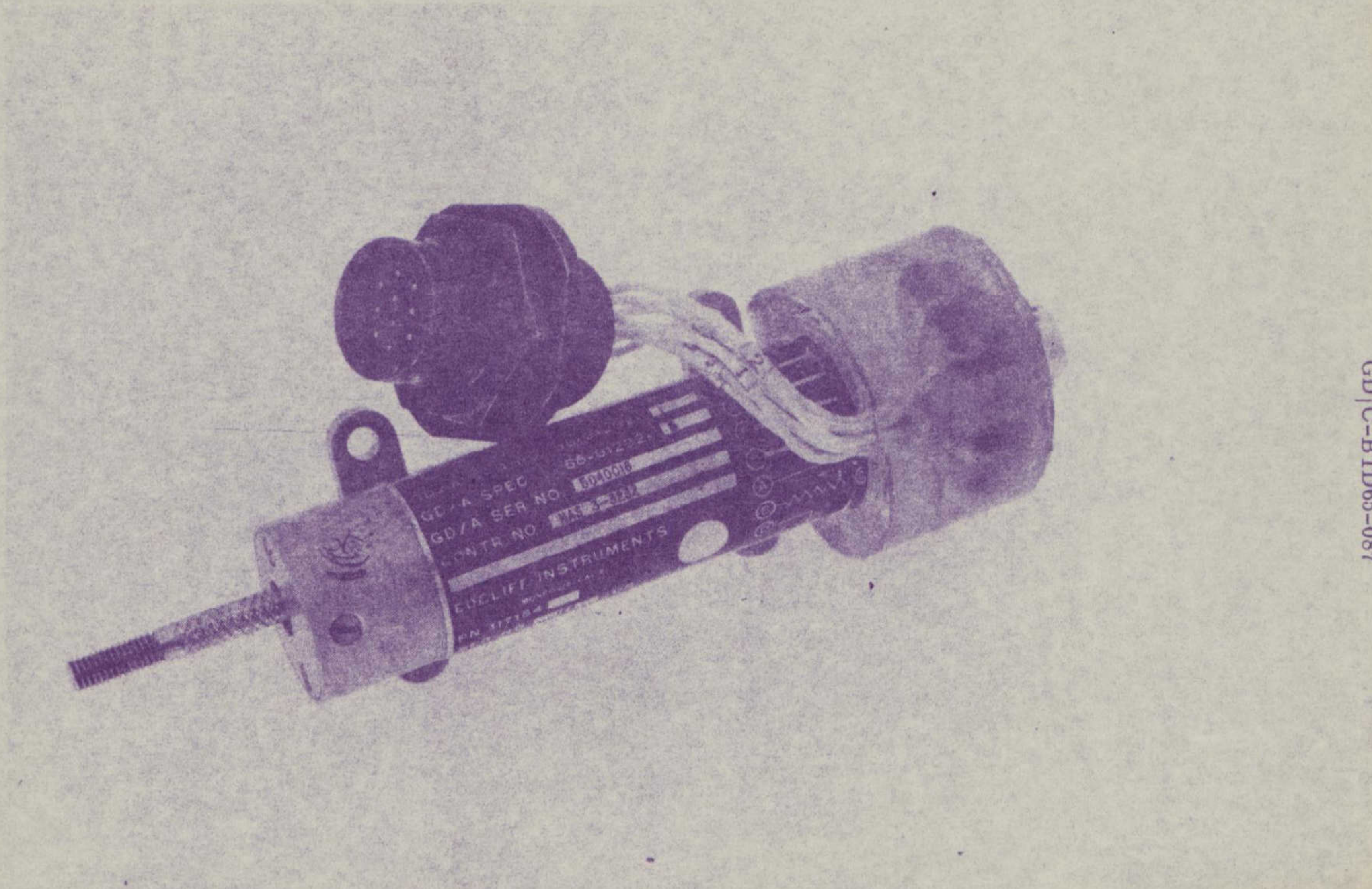


Figure 3-32. Photo of Inadvertent Separation Switch

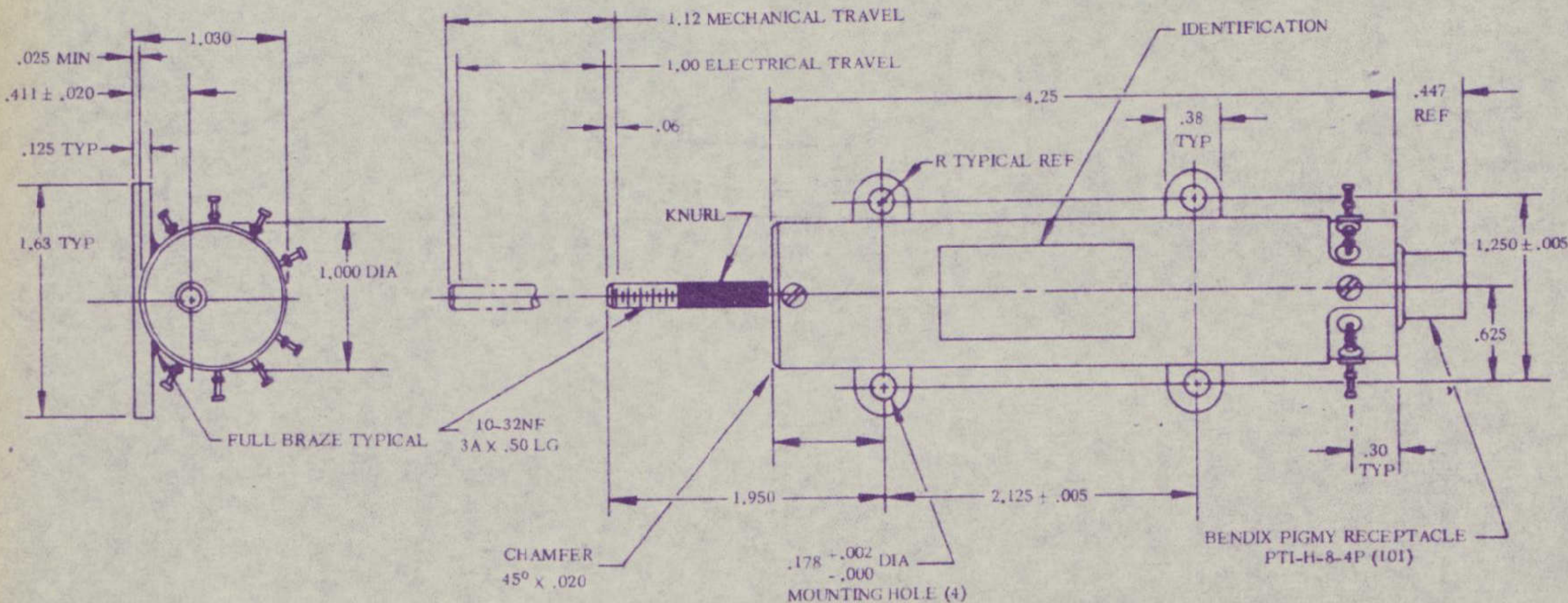


Figure 3-33. Sketch of Inadvertent Separation Switch, Showing Dimensions

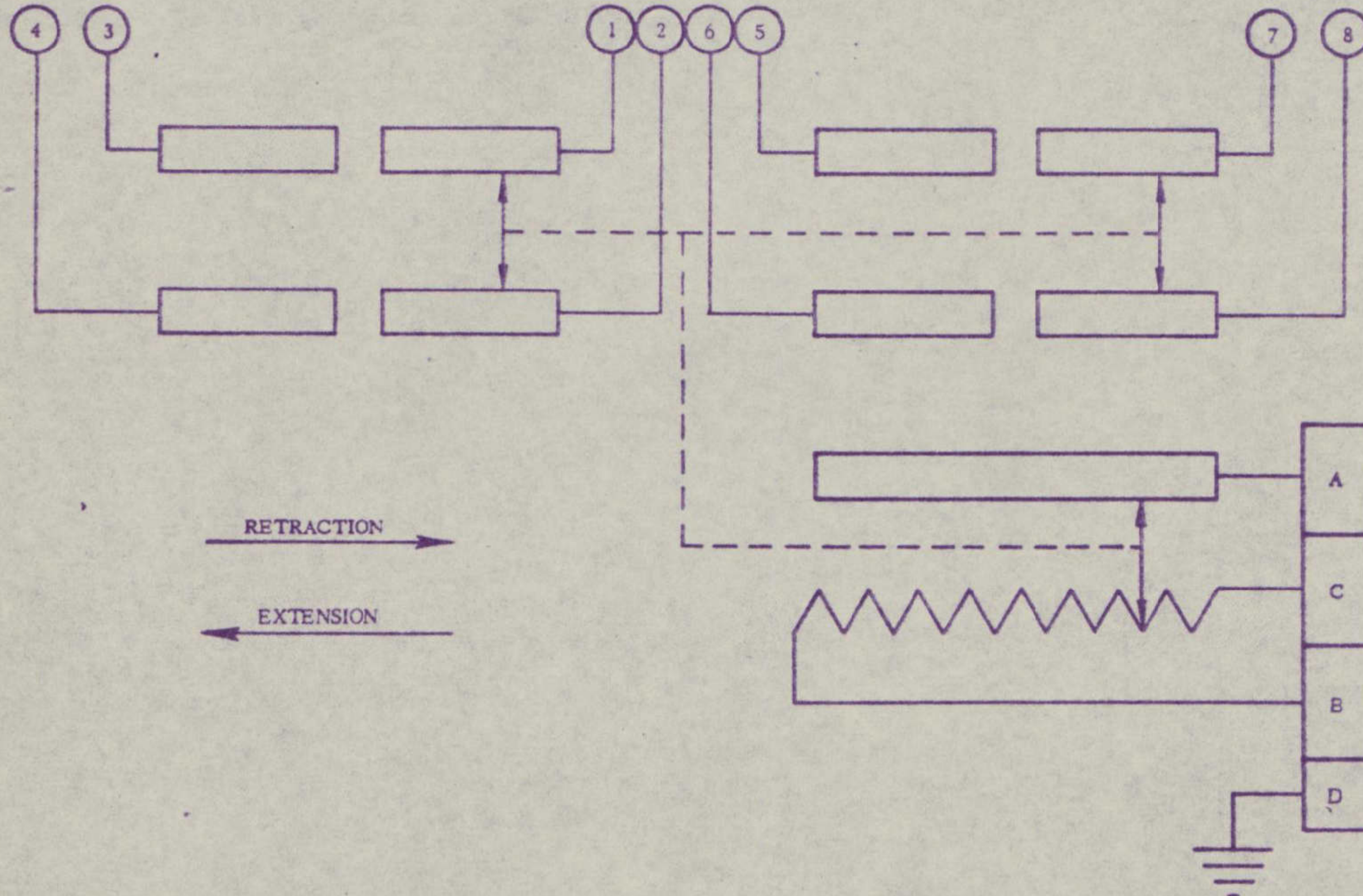


Figure 3-34. Electrical Diagram of Inadvertent Separation Switch

A 7500-ohm extensometer is included within the switch housing. This device is electrically isolated from all switch contacts, and is wired to an external harness through its own connector. The extensometer is excited by 5 vdc, which is 2 vdc below the dropout voltage of the destruct relays in the power control unit. The extensometer monitors, by telemetry, the condition of the switch shaft during flight.

Since two of three switches are required to initiate destruction, certain circumstances must be considered when determining the location of the Surveyor engine at time of shaped-charge discharge. The worst case arises if (a) the three Surveyor hold-down latches were to break, (b) the Surveyor were to slide in a direction perpendicular to a line drawn through a separation spring plunger and a latch until the spherical section of the engine hits the adapter, and (c) rotates out of the axis on this line. Since there are three possible axes associated with the above conditions, there are three positions at which the Surveyor may be when the shaped charge ignites, Figure 3-35. The shaped charge is designed to accomplish the functions detailed in Section 3-11 at all three positions.

3.13 BATTERIES. Power for the Centaur range safety command subsystem and the Surveyor destruct subsystem is provided by two silver-zinc batteries, one battery for each subsystem. The batteries utilize monoblock cell construction and titanium case material to reduce weight. A photograph of the battery, General Dynamics/ Convair part No. 55-06286-1, is presented in Figure 3-36. Each battery contains a heating element to maintain its temperature, thus permitting good voltage regulation and more efficient operation. The thermostat and GSE controls are the same as for the Atlas battery.

3.14 INSTRUMENTATION. Data monitored during the AC-6 flight consist of telemetered data, landline data, and command set signal level. This section presents the sequences of recording these data.

3.14.1 Telemetered Data. These data consist of the following:

Centaur Measurement No.	Item
CD2V	RSC RCVR NO. 1 AGC VOLTAGE
CD7V	RSC RCVR NO. 2 AGC VOLTAGE
CD3X	RSC MECO
CD5X	DESTRUCT NO. 1
CD6X	DESTRUCT NO. 2
CD25X	SURVEYOR SEP SWS OPEN
CY2D	SEPARATION LEG 1
CY4D	SEPARATION LEG 3
CY5D	SEPARATION LEG 2
CD24X	AUTO DESTRUCT SAFE

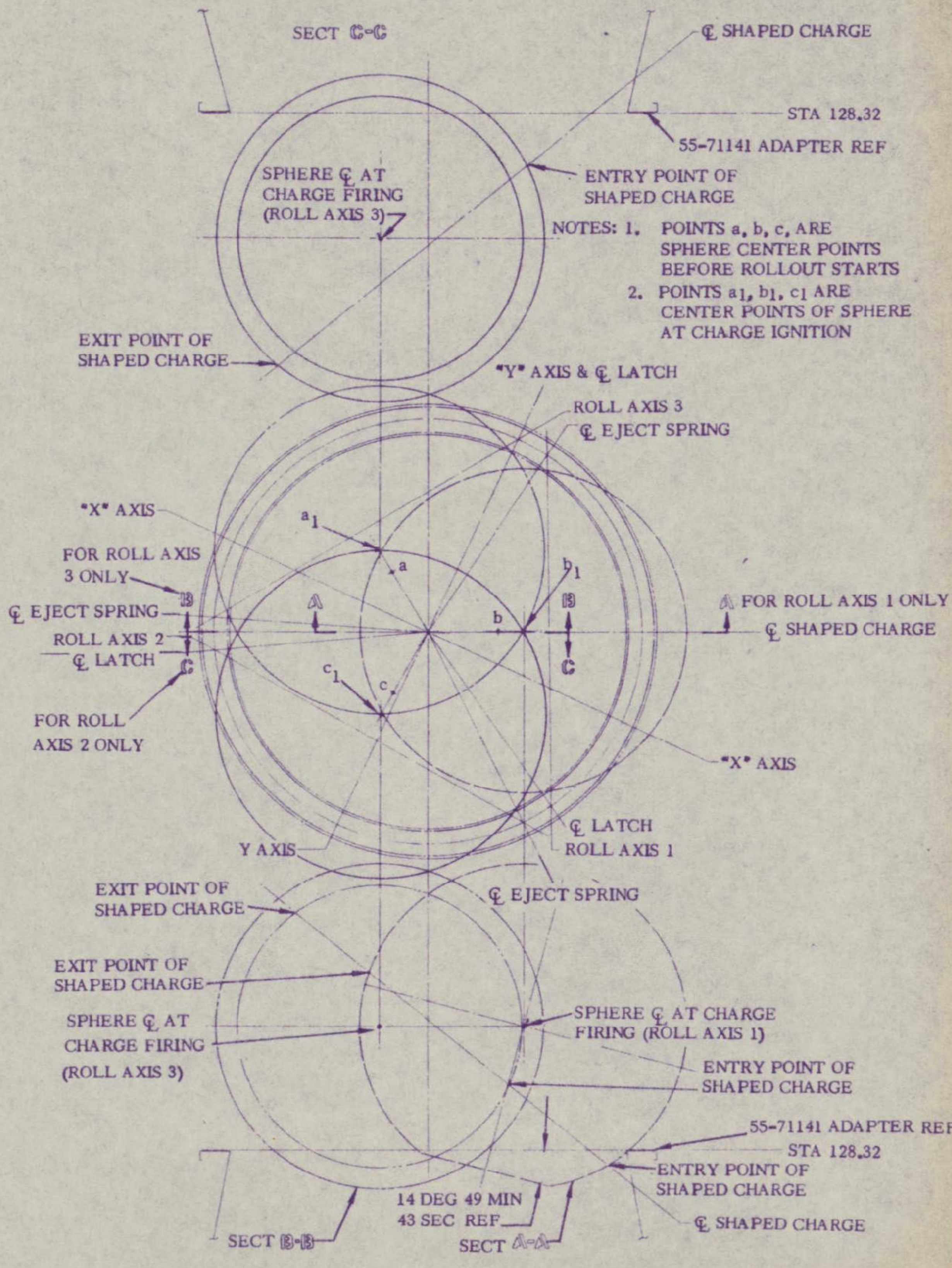


Figure 3-35. Possible Positions of Surveyor at Shaped-Charge Ignition

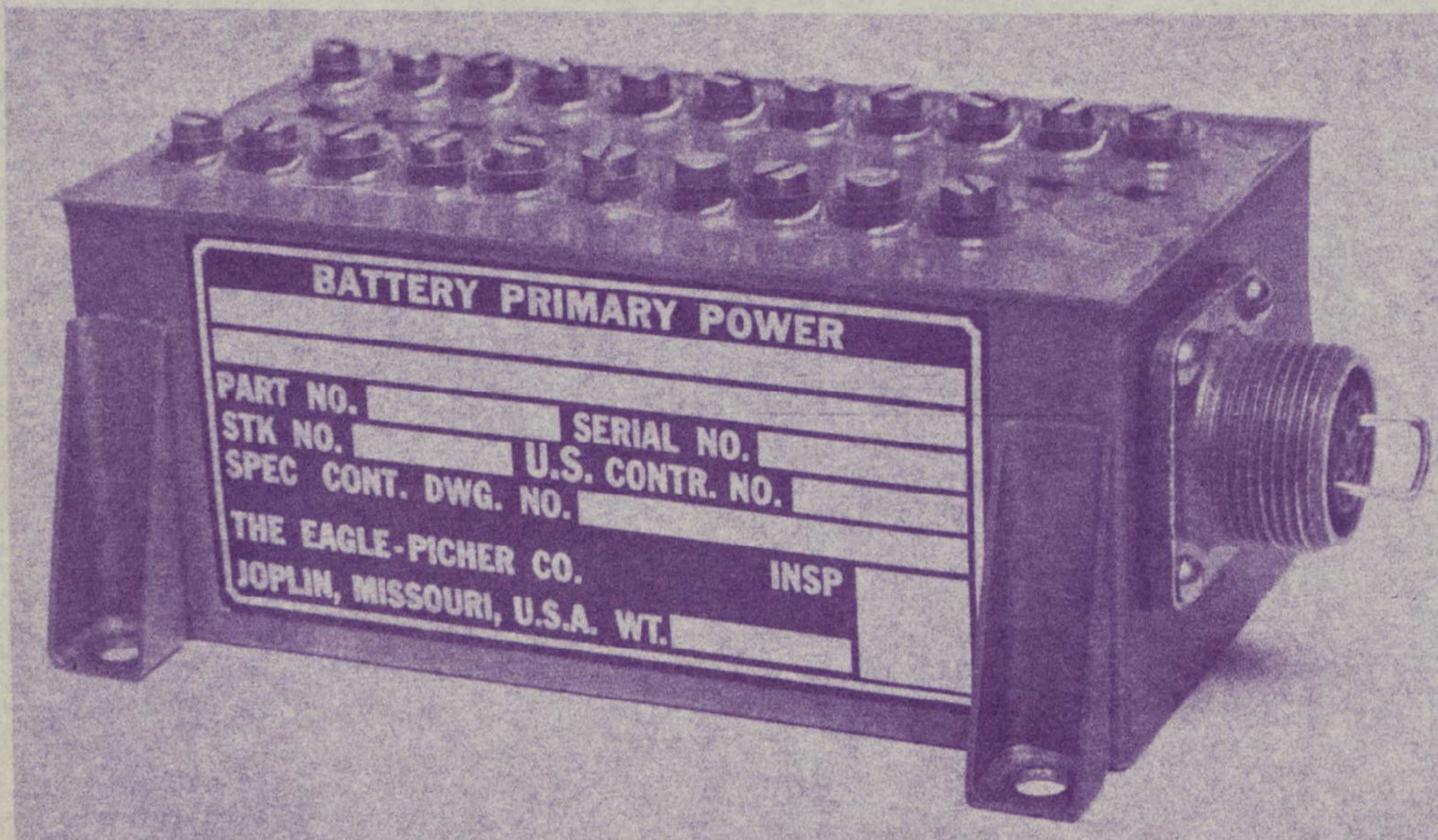


Figure 3-36. Second Stage (Centaur) Battery

3.14.2 Landline Data. The range safety launch control sequence data displayed and recorded in the blockhouse are listed below.

Centaur Measurement No.	Item
CD5002V	RSC NO. 1 RCVR AGC
CD5007V	RSC NO. 2 RCVR AGC
CD1029X	SURV DESTRUCT ARMED
CD1030X	SURV DESTRUCT SAFED
CD1031X	SEPARATION SW ARM
CD1032X	SEPARATION SW SAFE
CD1033X	SEPARATION SW CLOSED
CD1034X	R-F SAFING MON
CD1035X	AFCO NO. 1
CD1036X	AFCO NO. 2
CN1226X	CENTAUR DESTRUCT NO. 1
CN1227X	CENTAUR DESTRUCT NO. 2
CN1256X	RSC RCVR NO. 1 INT
CN1257X	RSC RCVR NO. 1 EXT
CN1258X	RSC MECO
CN1259X	RSC MECO RESET
CN1313X	RSC RCVR NO. 2 INT
CN1314X	RSC RCVR NO. 2 EXT
CN1317X	RSC CENTAUR DESTRUCTOR ARMED
CN1318X	RSC CENTAUR DESTRUCTOR SAFED
CN1319X	RSC SECOND STAGE READY
CN1490X	RSCN RCVR NO. 1 PWR ON EXT
CN1491X	RSC RCVR NO. 2 PWR ON EXT

3.14.3 AGC Level (Signal Strength). The agc (signal strength) voltage is obtained from a separate winding in the i-f transformers. These voltages are rectified and added in an amplifier whose output is applied across a 5-volt zener diode.

SECTION 4

GROUND SUPPORT EQUIPMENT OPERATIONS
ATLAS/CENTAUR

4.1 INTRODUCTION. Ground support equipment is required to control, check out, test, and monitor the vehicleborne RSC subsystems. This section of the report considers the functions of the test support vehicle equipment, launch control equipment, and the launch control operations.

All launch pad checkout tests of the vehicleborne RSC subsystems will be accomplished by the launch control equipment in conjunction with the RSC signal generator and modulator in the blockhouse.

4.2 TEST SUPPORT EQUIPMENT. Test support equipment is used at the launch site to check out the RSC subsystems. The checkout, conducted by range safety personnel, follows a strict step-by-step test procedure using the following equipment:

a. Uhf signal generator.

b. Subcarrier modulation generator.

c. Control panel.

d. Launch control equipment (see Paragraph 4.3).

e. Antenna couplers.

f. Destructor substitution test unit.

g. External test cabling (shown in Figure 4-1).

The signal generator, modulation generator, and the control panel are located in a cabinet in the blockhouse. The r-f signal is routed to the vehicle via cable link from the blockhouse to the gantry tower. Antenna couplers are used on the first stage and on gantry-mounted test antennas for the second stage. The launch control equipment is used for all control and monitoring functions during the checkout tests.

4.2.1 UHF Signal Generator. The signal generator has been designed to test F-M receivers in the 406- to 420-megacycle range, with provision for deviations up to ± 150 kilocycles. It is a rack-mounted instrument providing F-M crystal-controlled r-f carrier signals. The output level is continuously variable from 1 to 100,000 microvolts. The signal generator panel is shown in Figure 4-2.

4.2.2 Subcarrier Modulation Generator. The modulation generator is a self-contained unit of 20 audio channels. The 20 channels may be operated separately or simultaneously without damage to the unit. Channels 1, 2, and 5 have been permanently assigned

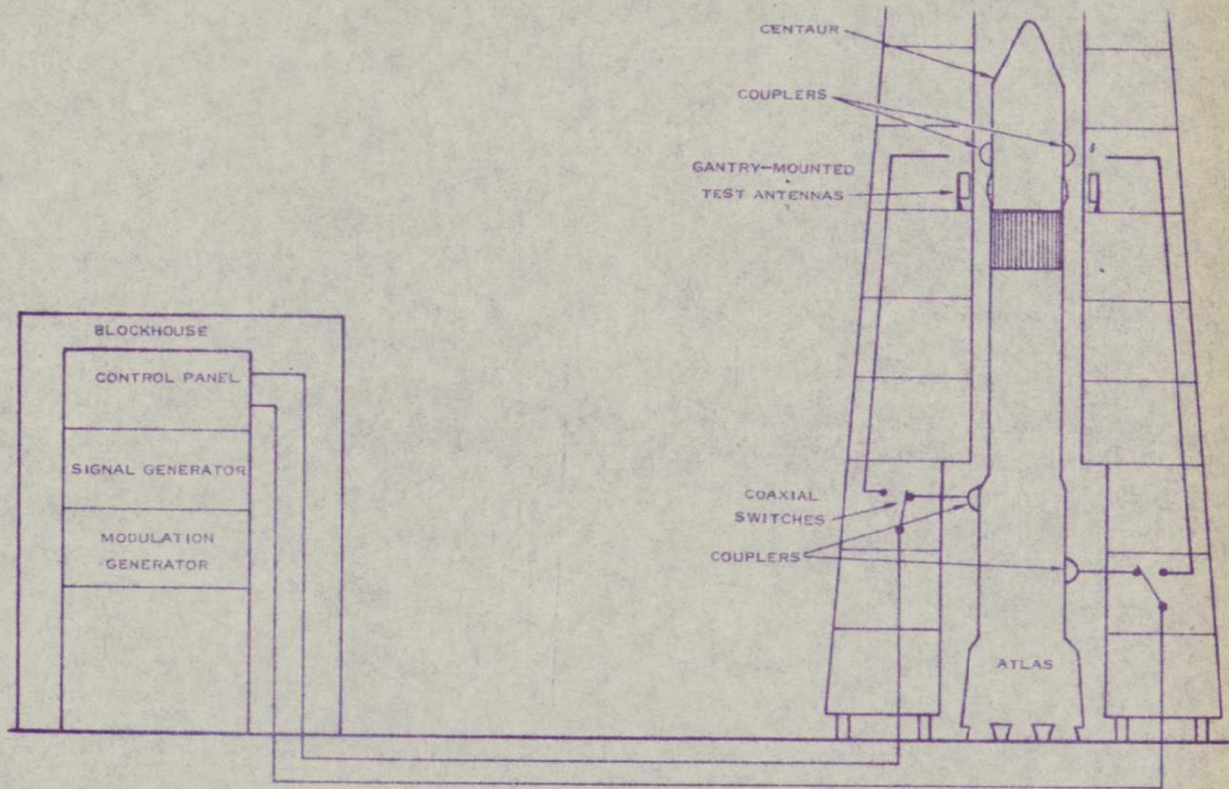


Figure 4-1. Diagram of Checkout Test Equipment and Vehicle

Figure 4-2. Signal Generator Panel

to the RSC. Each channel is operated by a toggle switch on the front panel. The modulation generator panel is shown in Figure 4-3.

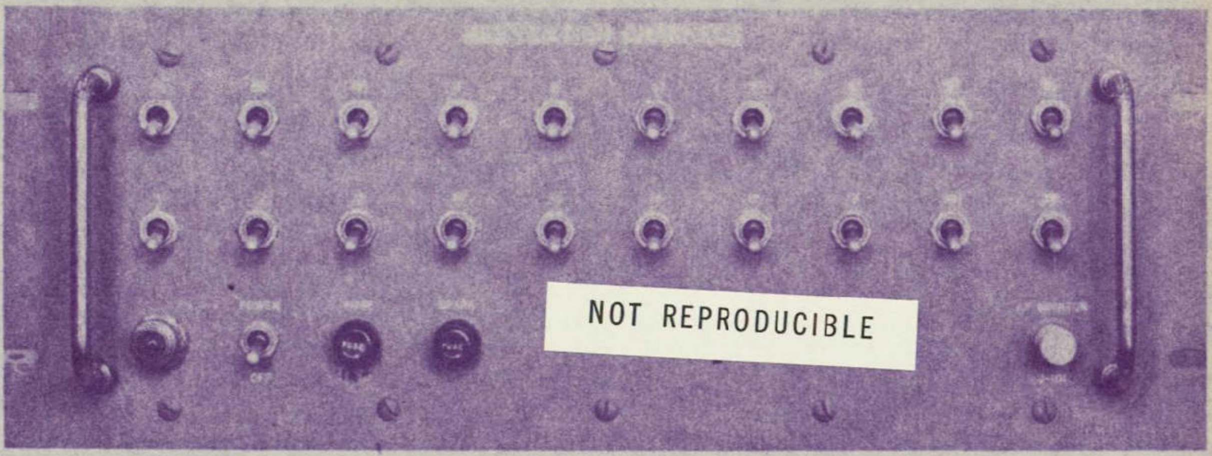


Figure 4-3. Modulation Generator Panel

4.2.3 Control Panel. The control panel for the generators is located in the check-out cabinet. The generator outputs are monitored on the launch control panel. The following switches are located on the panel:

a. Panel power.

b. Antenna selector (B-1 or B-2).

The panel power switch controls the power to the signal generator and the modulator. This switch is normally locked in the OFF position and can be turned on only by use of a key. For range security of the command carrier frequency, this key must be in the hands of the pad safety officer through all launch periods during which the range safety officer has mandatory prime control of the RSC subsystems by means of the destruct ground transmitter.

4.2.4 Destructor Substitution Test Unit. A destructor substitution box is used to simulate the actual destruct box used on the Atlas subsystem as closely as possible during system tests. Fuse tests verify the destruct capability of the RSC subsystem and detect the presence of stray currents in the primer circuit.

The capability for destruct is determined by requiring each command set to blow a separate 1.5-ampere fuse. This fuse requires more current than the actual primers. A 62-milliampere fuse detects the presence of stray currents. This fuse blows with less than 10 percent of the minimum current required to ignite the primers. Stray currents of sufficient magnitude to blow the 62-milliampere fuse would have to be isolated and eliminated before the launch countdown could proceed.

The arm-safe circuit is checked by simulating the arm-safe switch with a Ledex stepping switch. This switch produces indications of proper external wiring conditions, and illuminates an arm or safe lamp to indicate this condition. All components of the test box can withstand the environmental effects of a static firing test. A schematic diagram of the destructor substitution test unit is shown in Figure 4-4.

The test capability of the destructor substitution test unit is summarized as follows:

a. Checks the capability of the battery to blow a 1.5-ampere fuse in response to a destruct command

b. Checks for stray currents in the primer circuit of sufficient magnitude to blow a 62-milliampere fuse.

c. Checks the operation of the arm-safe circuit and provides a lamp indication of the arm or safe status.

4.2.5 Gantry-Mounted Antennas. Centaur employs gantry-mounted antennas to check out the range safety subsystems. Two corner reflector antennas mounted on permanent brackets approximately 13 inches from the airborne antennas are used. These corner reflectors are connected by coaxial cable to the r-f switches mounted on the gantry at the level of the Atlas RSC antennas. The switches allow the blockhouse signal generator to be switched from the Atlas test couplers to the Centaur test antennas (Figure 4-1).

4.2.6 Initiator Simulators. The second-stage subsystem employs substitution units in place of the Centaur explosive destructor and the Surveyor safe/arm initiator for test purposes. Both substitution units provide test connectors to which test boxes containing fuses are attached. This arrangement provides for testing in the same manner as described in Section 4.2.4. See Figure 4-5.

4.3 LAUNCH CONTROL EQUIPMENT. The launch control equipment controls and switches power to the vehicleborne RSC subsystems, arms the destructor packages, monitors receiver commands, and sends ready signals to the test conductor's consoles indicating the vehicleborne subsystems are ready for launch. A block diagram of the launch control equipment and the vehicle is shown in Figure 4-6. The Atlas test conductor cannot receive an r-f systems ready signal unless the vehicle is on internal power, battery life is sufficient for flight, and the destructor is armed. The Centaur test conductor cannot receive a ready light until the RSC receivers are set to INT, MECO is reset, the Centaur destructor is armed, Surveyor arm/safe initiator is armed, separation switches are armed, and there is separation switch continuity. The launch control equipment, in conjunction with the uhf transmitter, tests the operation of the command subsystem during the launch countdown. The launch control equipment is comprised of the following units: Atlas r-f systems control console, the Centaur RSC control panel, Surveyor RSC control console, r-f systems relay boxes, power supplies, r-f systems timer auxiliary panel, and the test conductor's console.

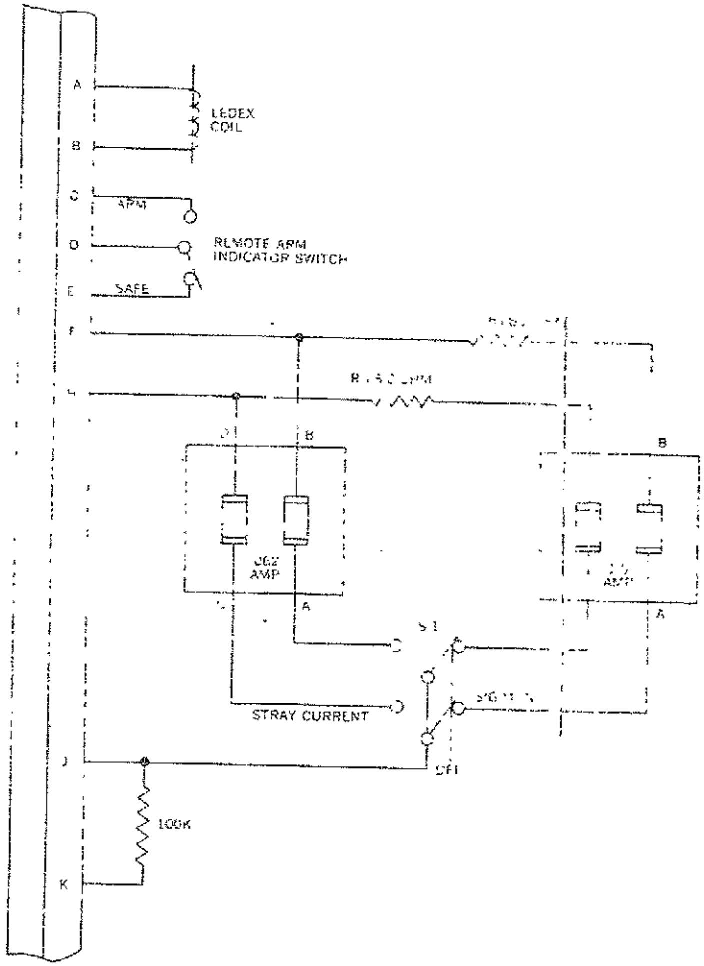


Figure 4-4. Atlas Vehicle Green Destructor Substitution Test Unit

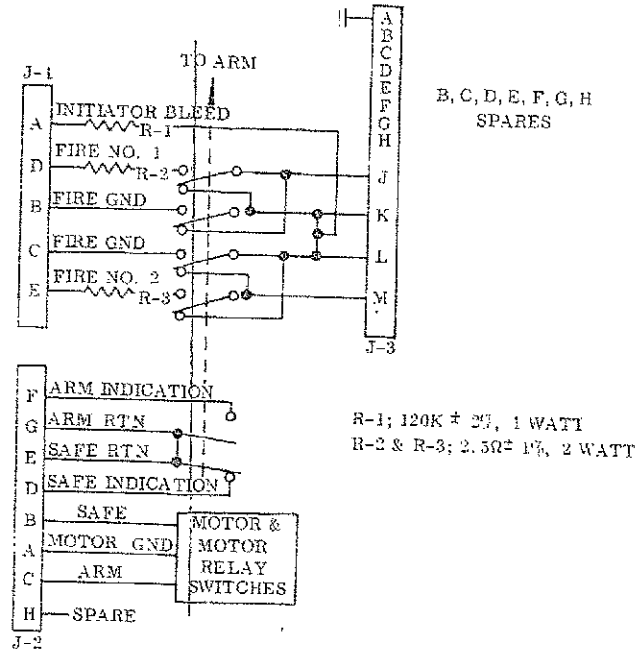


Figure 4-5. Centaur Vehicle Green Destructor Subsystem Test Unit

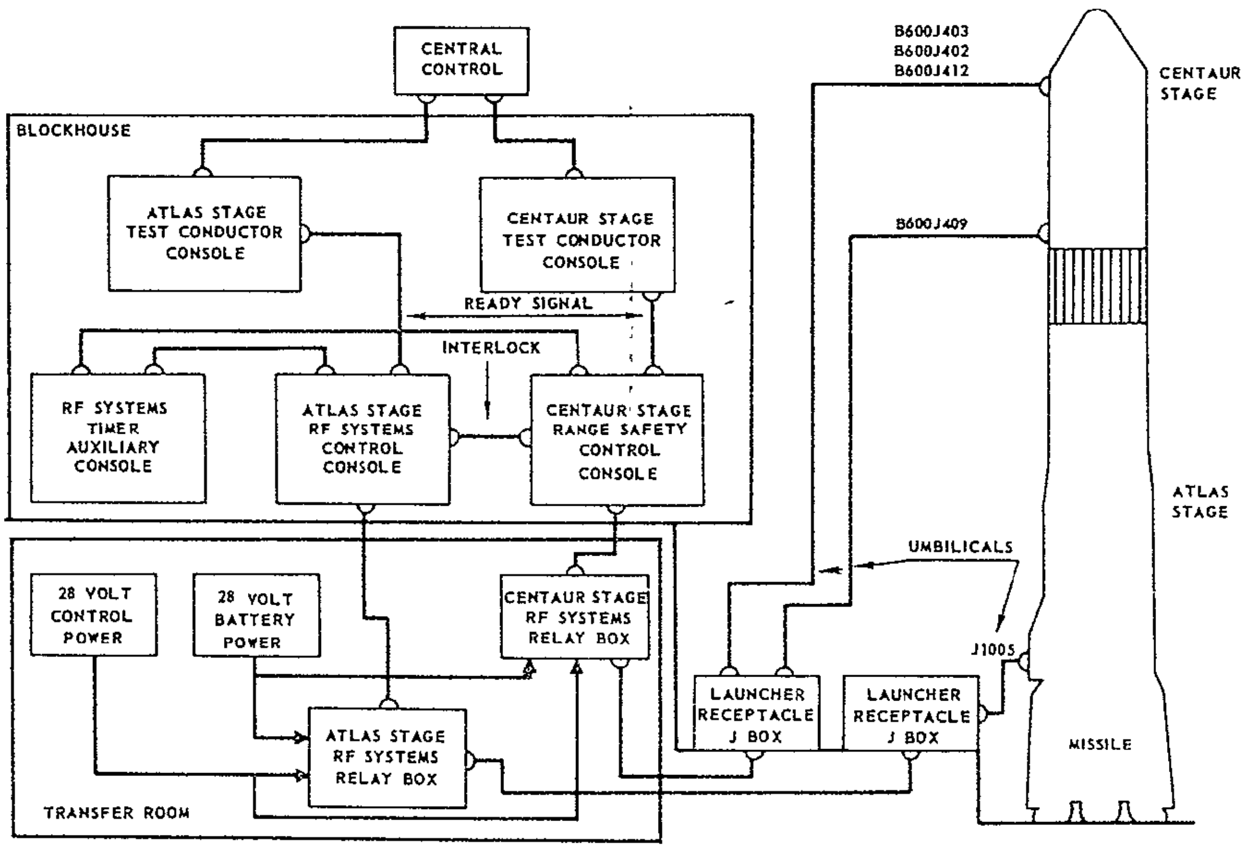


Figure 4-6. Block Diagram of Launch Control Equipment and Missile

4.3.1 Atlas RF Systems Control Console, Centaur RSC Control Panel, Surveyor RSC Control Panel. These consoles, which are located in the blockhouse, control and monitor the operation of their respective systems. The relay panels contain the relays to interlock the various control panel circuits. The interlocks prevent removal of panel power during control operations or when the destructor is armed. Figure 4-7 outlines the location of the control switches and the monitoring lights for the Atlas r-f systems control console. Figures 4-8 and 4-9 show the location of control switches and lights for the Centaur and Surveyor RSC control panels respectively.

4.3.2 RF System Relay Boxes. The r-f systems relay boxes, located in the ground power transfer room, contain pilot and slave power relays. These relays control and switch power from ground to vehicleborne sources.

4.3.3 Power Supplies. The command subsystem is energized by two power supplies, both located in the transfer room. One, backed up by a battery, supplies power for the control functions. In case of pad facility power loss, battery power would be used to place the destructor in a safe condition. The second power supply provides power for the command receivers.

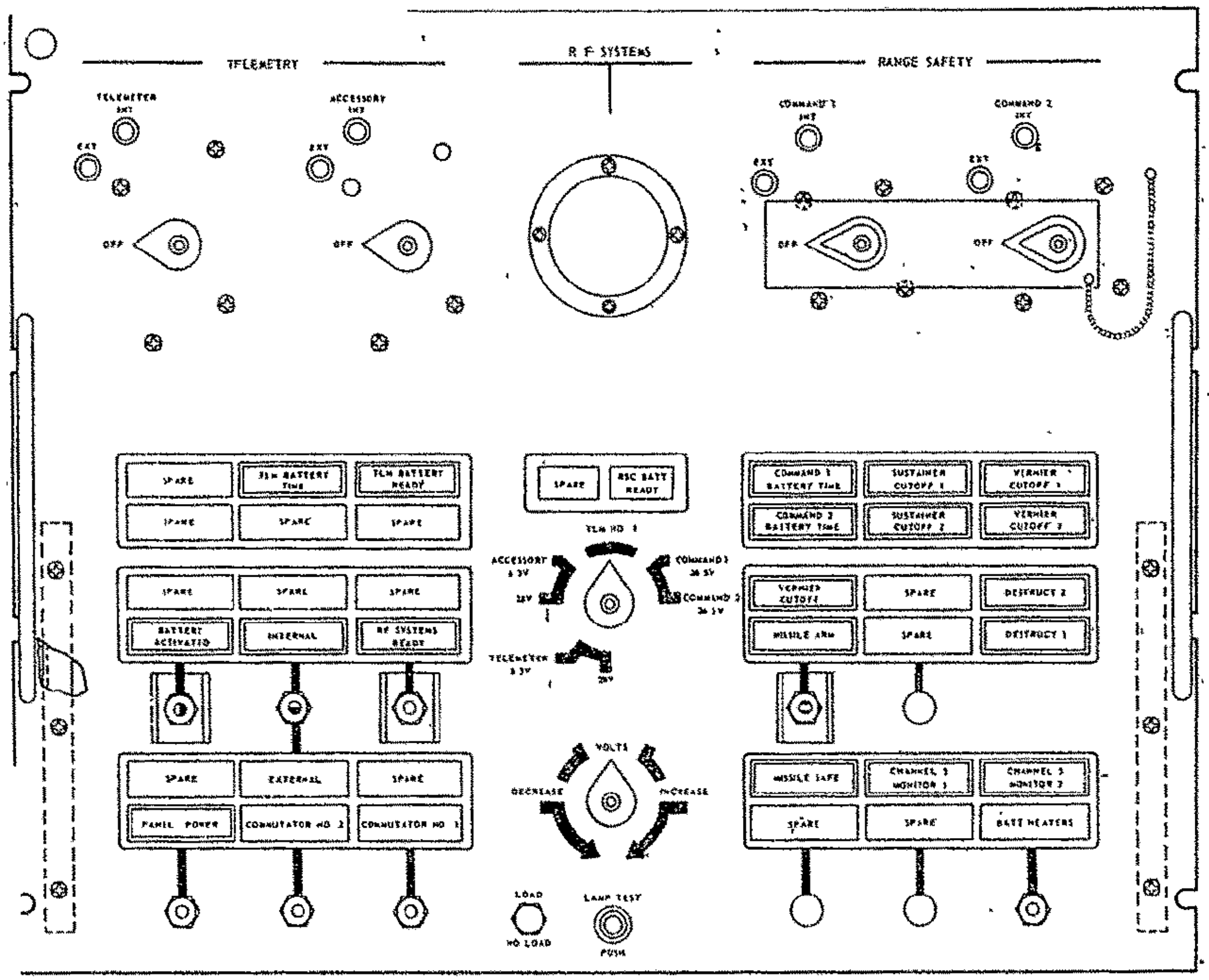


Figure 4-7. Atlas RF System Control Console

4.3.4 RF Systems Timer Auxiliary Panel. The timer panel is equipped with meters to monitor the operating time of each first-stage command receiver and battery. The battery units are designed to provide 20 minutes of command set operation. Some of this time is expended during launch countdown when the command sets are being checked out. The timers indicate the amount of time remaining during and after check-out procedures. If sufficient life remains for command set operation during flight, the operator presses the r-f systems ready switch.

4.3.5 Test Conductor's Console. The test conductor's console interlocks the command system with all other vehicle systems. A ready light, actuated by the r-f systems ready switch, provides a visual indication to the test conductor that the command subsystem has been checked out and is operative. There are individual consoles for the first and second stages.

4.4 FIRST-STAGE LAUNCH CONTROL OPERATION. Launch controls of the first-stage command subsystem may not be energized until the key lock pad safety switch

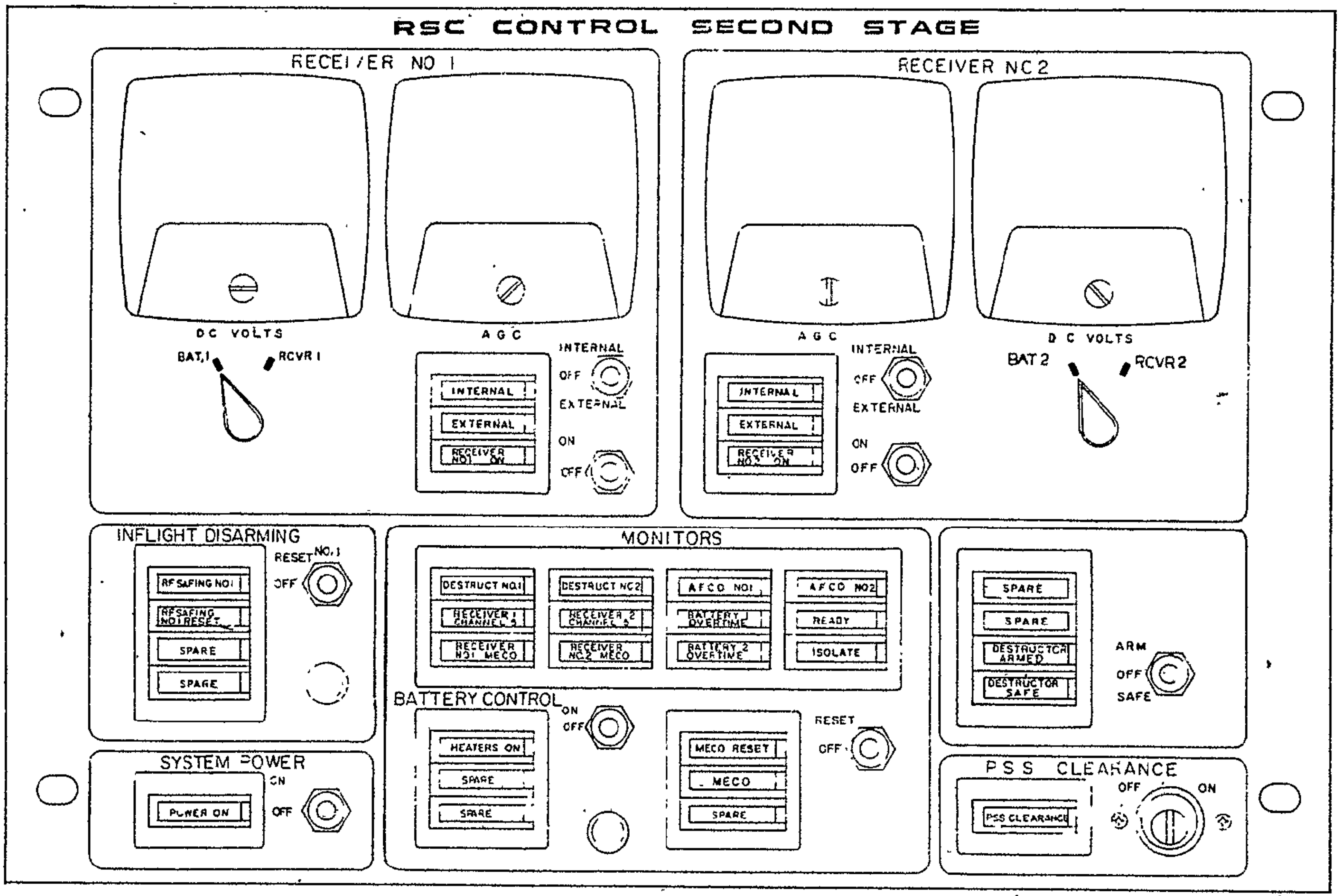


Figure 4-8. Centaur RSC Control Panel

GD|C-BTD65-087

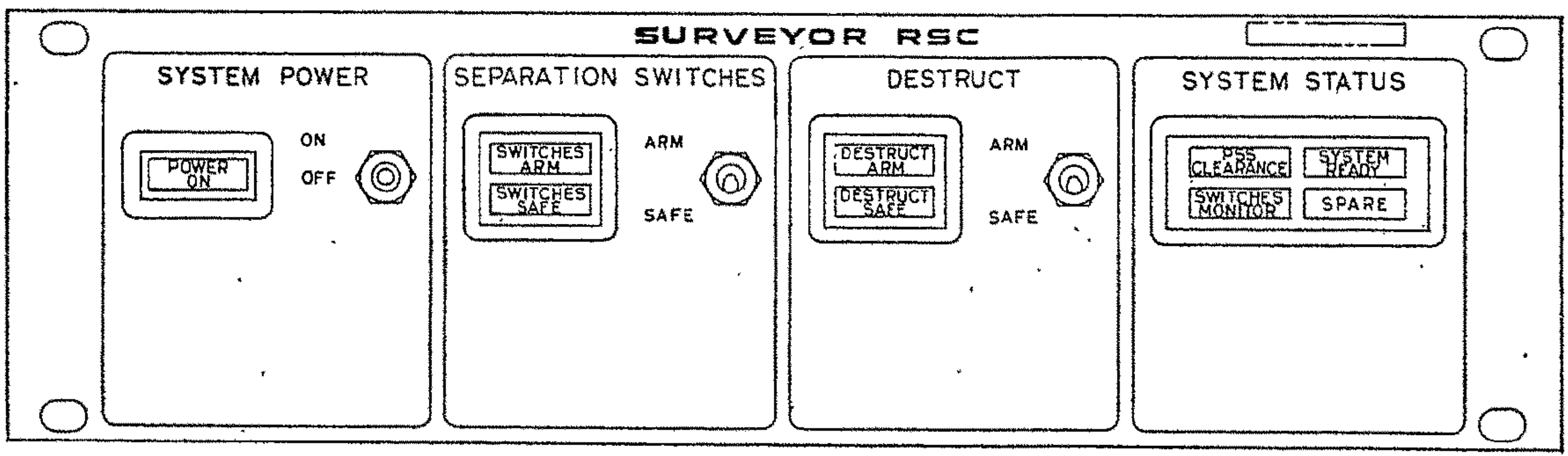


Figure 4-9. Surveyor RSC Control Panel

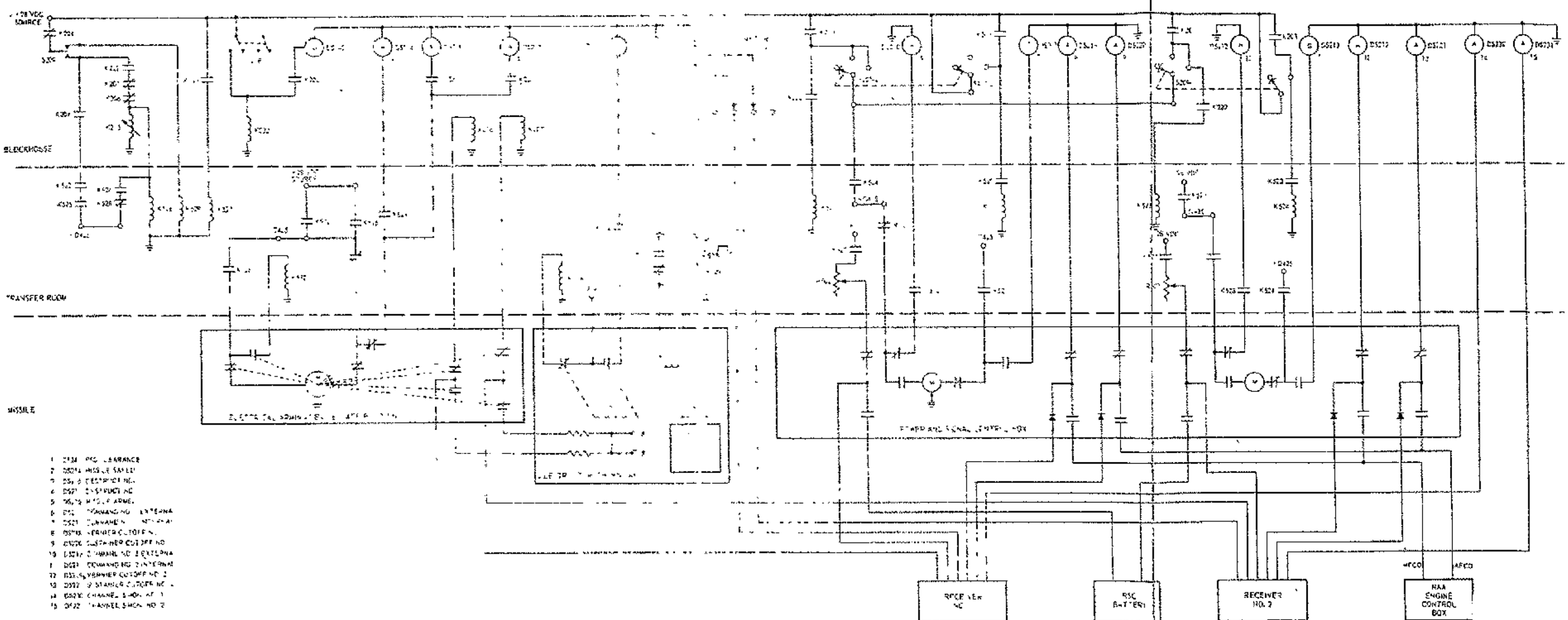
is unlocked, the recorded time correct switch has been turned on, and all power sources to the system are operative. Upon these conditions, the panel power switch is turned to the on position, lighting an amber lamp which provides a visual indication that the above conditions have been met and that the systems control bus is now energized. Energy is then applied to: 1) the heaters of the vehicleborne batteries, stabilizing their temperature for better voltage regulation; 2) the vehicleborne power changeover switches, positioning them for external power; and 3) the electrical arming switch and the destructor package, positioning them to safe. The circuit schematic is shown in Figure 4-10.

4.4.1 External Operation of Command Sets Number 1 and Number 2. Command sets numbers 1 and 2 may be tested and operated concurrently or separately on external power. Warmup and initial test operations of the command sets begin with command 1 "ext" power and command 2 "ext" power switches turned "on" and the internal-external switch turned to "command ext." This circuit then supplies +28 volts external ground power to each of the vehicleborne command receivers through their respective power supply switches. An amber "ext" lamp for each receiver and one for the power changeover switch provide visual indication of this condition. At this time total elapsed time meters begin recording, providing a record of operating time for both command sets.

4.4.2 Internal Operation of Command Sets Number 1 and Number 2. Placing the power changeover switches to the internal position shifts the command sets from external ground power to internal battery power. Upon successful transfer of power the external indicator lights are extinguished, the green internal light is illuminated, and the battery elapsed time meters commence recording.

4.4.3 Armed-Safe Signals. The destruct unit and the electrical arming device may be either armed or rendered safe by momentary contact of the missile armed - missile safe switch on the control panel. Safe and armed positions are visually indicated by appropriate missile safe and missile armed lamps on the control panel. In a missile armed condition, panel power cannot be removed until a safe condition again exists, or until the umbilicals are ejected just prior to launch. When the destructor unit and the electrical arming switch are in the arm position, circuit interlocks prevent another arm order from being initiated and stepping the system to a safe condition. Conversely, in the safe condition, another safe order will not arm the flight vehicle. The flight vehicle cannot be armed if a destruct test is being conducted.

4.4.4 Command Test Indicators. Both command receivers are tested for satisfactory operation of destruct and manual and automatic fuel cutoff commands while on external power, with the vehicleborne electrical arming switch in a safe position. The receivers can be tested simultaneously or individually. The MFCO lamp is illuminated when the command carrier is modulated by tones 1 and 5. The AFCO lamp is illuminated when the command carrier is modulated by tones 2 and 5. The destruct lamps are illuminated when the command carrier is modulated by tones 1 and 2, preceded by tones 1 and 5.



gure 4-10. Atlas Launch Control Schematic

4.4.5 Range Safety Ready. The r-f systems ready switch interlocks all the r-f functions that must be accomplished before launching. This switch will override any switch in the console except the panel power switch. An indicator lamp on the first stage test conductor's console is energized when all the r-f functions have been satisfactorily completed.

4.5 SECOND-STAGE LAUNCH CONTROL OPERATION. The second stage monitors and controls are operable when the RSC panel power switch is placed in the "on" position. This switch supplies power to the panel power buses in the blockhouse and the transfer room, and monitor power to the vehicle. System monitors and commands are enabled, provided that the required interlocks are present.

The chart in Figure 4-11 shows the logic employed by the range safety system to ensure the system is functioning properly prior to rise-off. Each horizontal column represents an order which may be sent to the vehicleborne equipment. Each vertical column in which there is an "X" to the left of the double line represents an order or monitor which must be satisfied before the vehicleborne equipment responds. $\overline{X}$ represents a condition that must not be present. The columns to the right of the double line contain information associated with launch sequence, abort functions, and the ready ladders. A composite schematic of the Centaur GSE and airborne systems is included as a supplement to this report.

4.5.1 PSS (Pad Safety Supervisor) Clearance A key-locked switch labeled "PSS Clearance" is provided to prevent arming of the RSC system or turning power on in the command receivers unless the safety supervisor has given permission. This switch interlocks the receivers "int" and "ext" command and the arm and safe commands of the Centaur explosive destructor, Surveyor destruct safe/arm initiator, and separation switches.

4.5.2 Receiver Power Control. Two switches are provided for the control of each receiver. One switch is detented and marked "on" and "off". This allows ground battery power to be delivered to the range safety system when in the external position. The other is a SPDT momentary switch which drives the power changeover switch from internal to external and vice versa. PSS clearance is required prior to making either switch operable.

4.5.3 Arm-Safe Signals. The Centaur destructor is operated to the armed and safed positions by means of the arm-safe control switch on the panel. The armed-safed status of the destructor and of the arming device are indicated on the panel. The logic is set up so that the destructor may not be armed if the inadvertent separation switches are armed.

4.5.4 MECO Signals. Monitors are provided to indicate the status of the MECO relays. Switches are provided on the RSC panel to reset the MECO relays in the power control unit.

	CSE ORDER	PSS ON	R.F. SAFING, RESET	SURVEYOR AUTO DESTRUCT SAFE	NO DESTRUCT MONITORS	SEPARATION SWITCH CONTINUITY	INT. ORDER	EXT ORDER	TIME ACCOMPLISHED IN COUNT (APPRX)-MIN	USED IN CASE OF ABORT	RSC READY	SPACECRAFT READY	
RCVR 1 INT	X	X	X					$\bar{X}$	T-3		X		
RCVR 1 EXT	X	X					$\bar{X}$			X			
RCVR 1 OFF	X									X			
RCVR 2 INT	X	X	X					$\bar{X}$	T-3		X		
RCVR 2 EXT	X	X					$\bar{X}$			X			
RCVR 2 OFF	X									X			
CENTAUR DESTRUCTOR ARM	X	X		X	X				T-2* (1)		X		
CENTAUR DESTRUCTOR SAFE	X									X			
SURVEYOR ARM/ SAFE - ARM	X	X		X	X				T-2* (2)			X	
SURVEYOR ARM/ SAFE - SAFE	X									X			
SURVEYOR AUTO DESTRUCT ARM	X	X		X		X			T-2* (3)			X	
SURVEYOR AUTO DESTRUCT SAFE	X									X			
RF DISABLE RESET	X												
MECO RESET	X										X		
SEPARATION SWITCH CONTIN. MON.												X	

*NOTE: (1), (2), (3) SHOWS ARMING SEQUENCE

Figure 4-11. Flight Termination System Logic

4.5.5 Ready Lights. Interlocks are provided to ensure that the vehicle cannot rise off unless the RSC subsystem is in the launch configuration. These are combined in a ready ladder and include MECO reset, receiver No. 1 internal, receiver No. 2 internal, and destructor armed.

4.6 SURVEYOR LAUNCH CONTROL OPERATION.

The Surveyor stage monitors and controls are made operable by switching the systems power switch to "on". This action supplies power to the panel power buses in the blockhouse and transfer room, and monitor power to the vehicle.

4.6.1 Arm/Safe Signals. Switches are provided which drive the Surveyor safe/arm initiator from its safe to arm position, and which connect the inadvertent separation switches to the destruct relays within the power control unit. The logic is so arranged that the arm/safe unit cannot be armed if the separation switches are armed. Also, the separation switches cannot be armed if there is an auto destruct signal present.

4.6.2 Relay Lights. Interlocks are provided to ensure that the vehicle cannot rise off unless the RSC subsystem is in the launch configuration. These circuits are combined in a ready ladder, and include Surveyor arm/safe initiator armed, separation switches armed, and no auto destruct signal indications.

4.7 SUBSYSTEM CHECKOUT

4.7.1 General Discussion. The RSC subsystem checkout will be accomplished on both the Atlas and Centaur subsystems simultaneously as far as is practical. The detailed test procedure and countdown procedure are prepared at ETR and are not available at this time. The tests will verify the following for both the Atlas and Centaur RSC subsystems:

a. Ability of system to destruct, using destructor simulator.

b. Ability of system to terminate thrust by operation of associated thrust terminating relays.

c. Absence of inadvertent destruct and engine cutoff commands during switching operations.

4.7.2 Detailed Countdown and Subsystem Checks. This information will be supplied at a later date in the AC-6 countdown procedures.

APPENDIX A

PROPULSION SYSTEM DESCRIPTION

In the second stage, the MECO command will cut off the main engines. To have a better understanding of how the engines are cut off, a brief description of an engine start is presented.

Engine start is initiated by the receipt of three commands generated by the programmer: LH_2 prestart, LO_2 prestart, and start commands. The LH_2 prestart command opens the LH_2 prestart valve allowing helium to flow in the pneumatic control lines opening the LH_2 inlet shutoff valves (Figure A-1). LH_2 flows through the LH_2 engine pump and is vented overboard through two cooldown valves.

The LH_2 and LO_2 signals will be given at the same time on vehicle AC-6, although the capability for split chilldown exists.

Approximately 6 to 10 seconds following the prestart commands the start command is issued, opening the start solenoid valve. This allows helium to partially close the LH_2 cooldown valves and open the main fuel (gaseous hydrogen) shutoff valve. As the hydrogen flows through the thrust chamber jacket tubes, it is vaporized and passes through to the turbine. Upon expansion it continues on to the thrust chamber where it is mixed with oxygen and ignited.

The normal programmed cutoff is accomplished by removing the start (and both prestart signals), closing the main fuel shutoff valve, opening the cooldown valves, and closing the propellant inlet shutoff valve. For cutoff by the RSC subsystem, only the LH_2 prestart signal is interrupted.

The LH_2 prestart signal is routed from the programmer through normally closed relay contacts in the power control unit to the C1 and C2 prestart solenoids. When the MECO command is received the relay contacts are opened, closing the prestart solenoid valves. This action stops the flow of helium from the pneumatic control lines, which opens the cooldown valves and closes the main fuel shutoff valve and the propellant inlet shutoff valve of both engines, shutting them down.

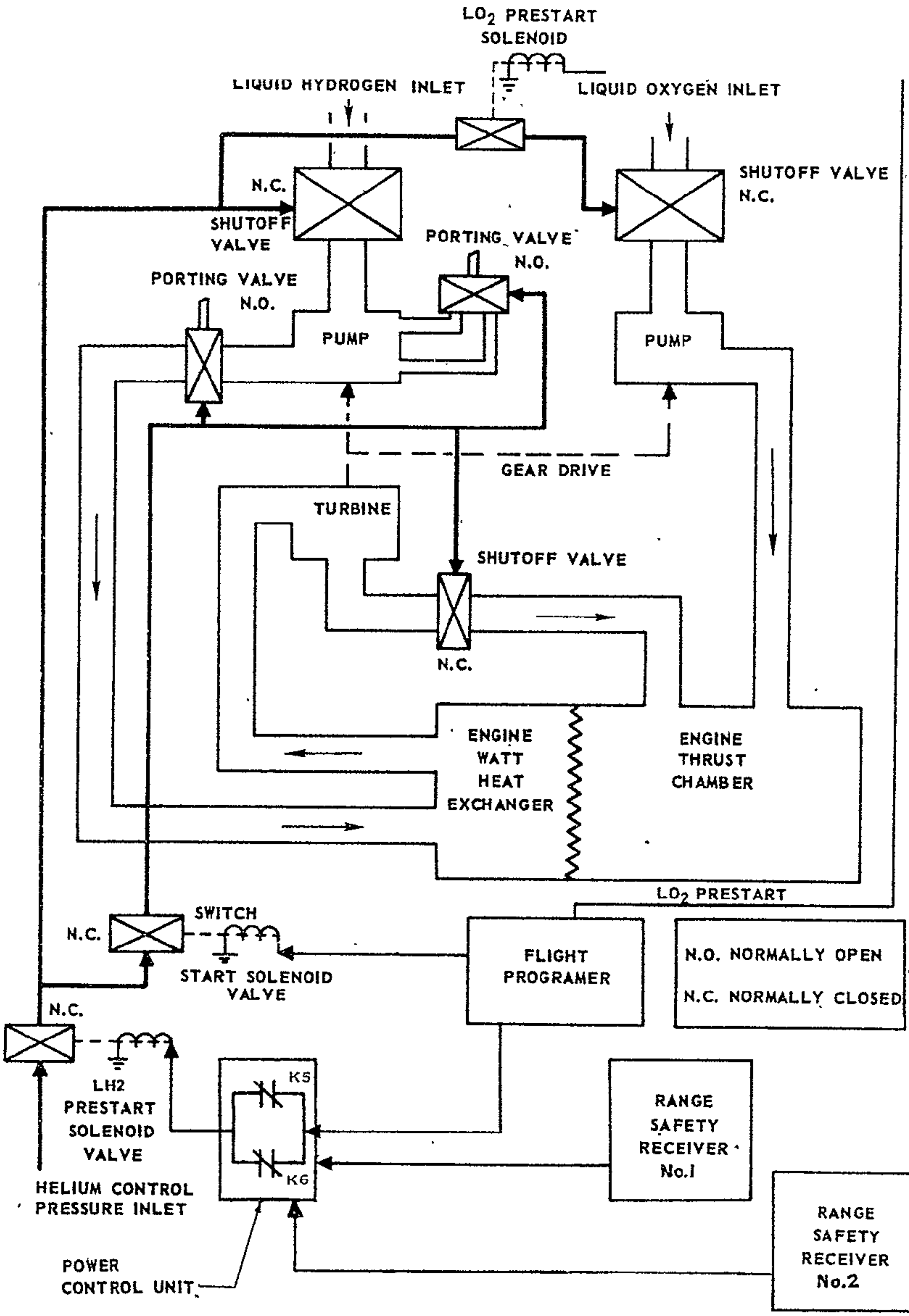


Figure A-1. Propulsion System Diagram

APPENDIX B

TEST PROGRAM OPERATIONS

B.1 INTRODUCTION. The RSC subsystem test program covers component, system-level, composite, flight-readiness firing, and pre-flight testing. The purpose of this test program is to establish the reliability of the command subsystem to perform the function for which it is intended.

The vehicleborne subsystems are checked out at staged intervals at the individual production lines and after installation in the vehicle, until the time of actual launch.

B.2 ATLAS FLIGHT CERTIFICATION. For Atlas R&D flight vehicles, all components of the RSC subsystem that are required for flight, are "proof-tested" to the minimum requirements of General Dynamics/Convair Specification 7-00210. Components which have been pre-production tested to General Dynamics/Convair Specification 7-00209B also meet the minimum requirements of 7-00210. Specification 7-00210 differs from 7-00209B in that certain tests such as salt-spray, sand, fungus, dust, etc., have been deleted.

The following table lists the environmental test status of the RSC subsystem components.

FLIGHT PROOFING STATUS OF ATLAS SUBSYSTEM COMPONENTS

Component		Test Status
AD 319600 MK II or MK III	RSC Set, ARW-62, Modified	GFME, Not tested by General Dynamics/Convair
27-36244	RSC Electrical Arming Device	Applicable portions of 7-00209B
69-06307-1	RSC Battery	Qualified to 69C3125.1
27-04306-803	RSC Destructor	Functionally tested in accordance with Beckman and Whitley Quality Control Form 175-4 and 5.
27-12540	RSC-TLM Antenna	Applicable portions of 7-00209B
27-36236	RSC Power and Signal Control Unit	Applicable portions of 7-00210
7-36044	RSC Ring Coupler	Applicable portions of 7-00209B

B.3 CENTAUR AND SURVEYOR FLIGHT CERTIFICATION. All Centaur and Surveyor range safety components are qualified or design proof tested to General Dynamics/Convair Specification 55-00200E. This specification includes all expected environmental conditions and test for RFI to MIL-I-26600.

DESIGN PROOFING STATUS OF CENTAUR SUBSYSTEM COMPONENTS

Component		Test Status
55-36046	RSC Antenna	Qualified to applicable portions of 55-00200
81-65903-002	Hybrid Junction	Qualified to applicable portions of 55-00200
55-01233	Receiver-Decoder	Qualified to applicable portions of 55-00200
55-36080	Power Control Unit	Qualified to applicable portions of 55-00200
55-01292	Inadvertent Separation Switch	Qualified to applicable portions of 55-00200
55-04348	Centaur Destruct Safe/Arm Initiator	Qualified to applicable portions of 55-00200
55-01276	Surveyor Safe/Arm Initiator	Qualified to applicable portions of 55-00200
55-36074	Mild Detonating Fuse	Qualified to applicable portions of 55-00200
55-36073	Mild Detonating Fuse Connector	Qualified to applicable portions of 55-00200
55-01275	Conical Shaped Charge	Qualified to applicable portions of 55-00200
55-06286	Battery, Range Safety	Qualified to applicable portions of 55-00200

B.4 SYSTEM-LEVEL TESTS. Each component of the RSC subsystem must meet the acceptance and test requirements called out in "Equipment Operation Procedures," prior to installation on the vehicle. Additional tests are required after installation to discover if any malfunction resulted from vehicle movement and to reveal, through combined operation of the subsystems, a malfunction not previously determined by tests of the individual units. Equipment for checkout of the complete system is installed in the blockhouse at the launching pad. Similar equipment is located in the assembly building for checkout prior to erection.

APPENDIX C

GENERAL DESCRIPTION OF THE RANGE SAFETY SYSTEM
(For Information Only)

C.1 RANGE SAFETY SYSTEM. The range safety system consists of vehicleborne and ground-based equipment used to track the vehicle during flight, to provide instantaneous impact prediction and display, to cut off the rocket engines, and, if necessary, to destroy the vehicle in flight. Two major subsystems in the range safety system are, 1) the RSC , and 2) the impact prediction and display systems. The functions of the range safety system are controlled by the RSO, who determines from the apparent impact point when to restrict the vehicle's range or to actually destroy the vehicle.

The RSO is stationed at CKMTA, (Cape Kennedy Missile Test Annex) in the central control building, where all flight information is available to him (Figure C-1). He is assisted by officers stationed in the blockhouse and at supplementary observation posts

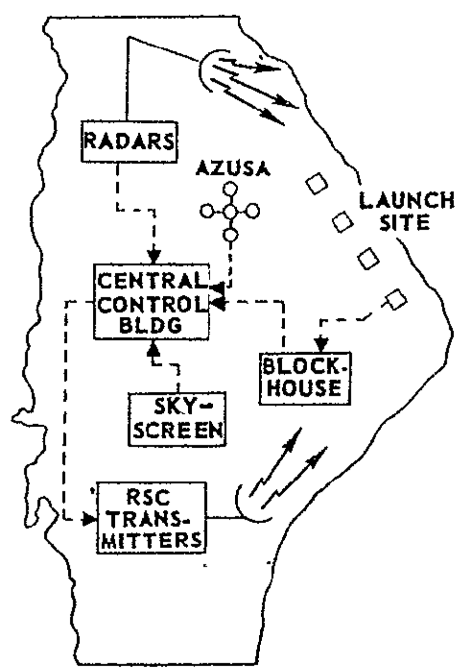


Figure C-1. Diagram of Cape Kennedy Range Safety System

C.2 RANGE SAFETY COMMAND SYSTEM. The RSC system consists of the ground and vehicleborne components of the range safety system which initiate and complete the following sequences:

a. MFCO. The RSO may initiate this command, cutting off all rocket engines.

b. Destruct. The RSO may initiate this command, after cutting off all rocket engines by MECO command, to destroy the vehicle.

c. RF Disable. The RSO may initiate this command to remove all power from the RSC system in flight. It is intended that the command be given as soon as the vehicle becomes orbital. This command does not affect the Atlas booster vehicle.

The RSC ground equipment consists of uhf transmitters capable of transmitting the above commands. The vehicleborne subsystem consists of equipment to receive the commands and perform the associated functions.

C.2.1 Range Safety Command UHF Transmitters. UHF transmitters are used to transmit commands to the vehicleborne unit of the RSC system. Transmitters are located at Cape Kennedy and at various stations downrange; one transmitter transmits at a time. The transmitted signal must be of sufficient strength to operate the vehicleborne receivers during the powered portion of flight. To maintain the signal strength, the RSO switches downrange, from one transmitter to the next. Carrier switching may also be controlled automatically by the command control programer, if the RSO so elects.

Two transmitters (one master and one standby) are located at each station to ensure reliable transmission of command signals. The carrier may be frequency-modulated by subcarrier channels 1, 2, and 5. These channels have been permanently allocated to RSC. The tones are controlled by the RSO at Cape Kennedy. RSC system gain margin (GM) for the stations at Cape Kennedy, Grand Bahama, San Salvador, Grand Turk, and Antigua are computed to verify the adequacy of the system for the AC-6 flight. The vehicle antenna gain becomes a constant parameter because the antenna must provide minimum coverage over a certain percentage of the radiation sphere. This criterion assures a certain probability that the vehicle may be destroyed at any given instant. The radiation sphere required by AFMTC Regulation 80-7 is 95 percent, and the Atlas RSC antennas provide gain levels in excess of -12 db, while the Centaur system provides levels in excess of -15 db over 95 percent of the radiation sphere. The difference in minimum gain levels is due to a difference in the antenna system design between the vehicles. The system parameters are shown in Table C-1 for each of the two separate RSC systems. The difference in ground instrumentation between Cape Kennedy and the four downrange stations requires two GM expressions for each system.

As indicated in the list of parameters, a 12-db margin is required by AFMTC as further assurance that an adequate signal level will be available. The GM expressions

A complete checkout of the system should be performed under each of the following conditions:

a. Upon installation of the complete RSC subsystem on the flight vehicle.

b. Following any component replacement or repair to the RSC subsystem.

c. Following any relocation or disturbance of the vehicle.

All system checkouts are normally recorded on a prepared data sheet to allow com plete insertion of the subsystem responses and operational characteristics.

B.5 VEHICLE SYSTEM-LEVEL TESTS. Vehicle system-level tests are those conducted under operational conditions, either simulated in the factory, at a test site, or in actual flight. Each subsystem installed on a vehicle normally undergoes the following tests:

a. Composite checkout.

b. FACT (Flight Acceptance Tests)

c. Tanking Test.

d. Flight testing.

B.6 COMPOSITE CHECKOUT. The composite checkout procedure determines if interference exists between subsystems which operate concurrently. During testing, data and records are obtained which indicate if the subsystems perform satisfactorily. Unsatisfactory operation of a subsystem due to possible interference by one or more subsystems may be detected by analyzing the time-correlated records of the subsystem parameters.

Table C-1. Range Safety Command System Parameters

PARAMETERS	CENTAUR	ATLAS
GROUND-TO-AIR LINK:		
Ground Transmitter Power Output	70 dbm	70 dbm
Ground Antenna Gain (Except Cape Kennedy)	15 db	15 db
Ground Antenna Gain (Cape Kennedy Only)	10 db	10 db
Ground Transmitter Line Loss	-3 db	-3 db
Vehicle Receiver Sensitivity	97 dbm	97 dbm
Vehicle Line Loss	-2 db	-3 db
80-7 Regulation, Required Margin	-12 db	-12 db
Minimum Vehicle Antenna Gain	-15 db	-12 db
Totals	+150 db	+152 db
Totals (Cape Kennedy Only)	+145 db	+147 db

GM (Atlas - Except Cape Kennedy) = 152 - (Path Loss) (C-1)

GM (Atlas - Cape Kennedy Only) = 147 - (Path Loss) (C-2)

GM (Centaur Except Cape Kennedy) = 150 - (Path Loss) (C-3)

GM (Centaur - Cape Kennedy Only) = 145 - (Path Loss) (C-4)

are shown for the Atlas system (Equations C-1 and C-2) and the Centaur system (Equations C-3 and C-4).

The gain margin versus time is shown in Figure C-2 for the Centaur system and Figure C-3 for the Atlas system. The values shown for each ground station are based on the trajectory having the greatest slant-range path loss and the least time above the 5-degree horizon.

Adequate range safety coverage exists for the Atlas and Centaur powered phases of flight for both systems.

UHF Command at Cape Kennedy, Grand Bahama Island, San Salvador, and Grand Turk will be used for early coverage. When the vehicle leaves the coverage of Grand Turk, command, by remote control from Cape Kennedy, will be transferred to Bermuda or Antigua, depending on the flight azimuth. At the end of first-burn, the vehicle has achieved orbit and there is no longer a requirement for RSC capability.

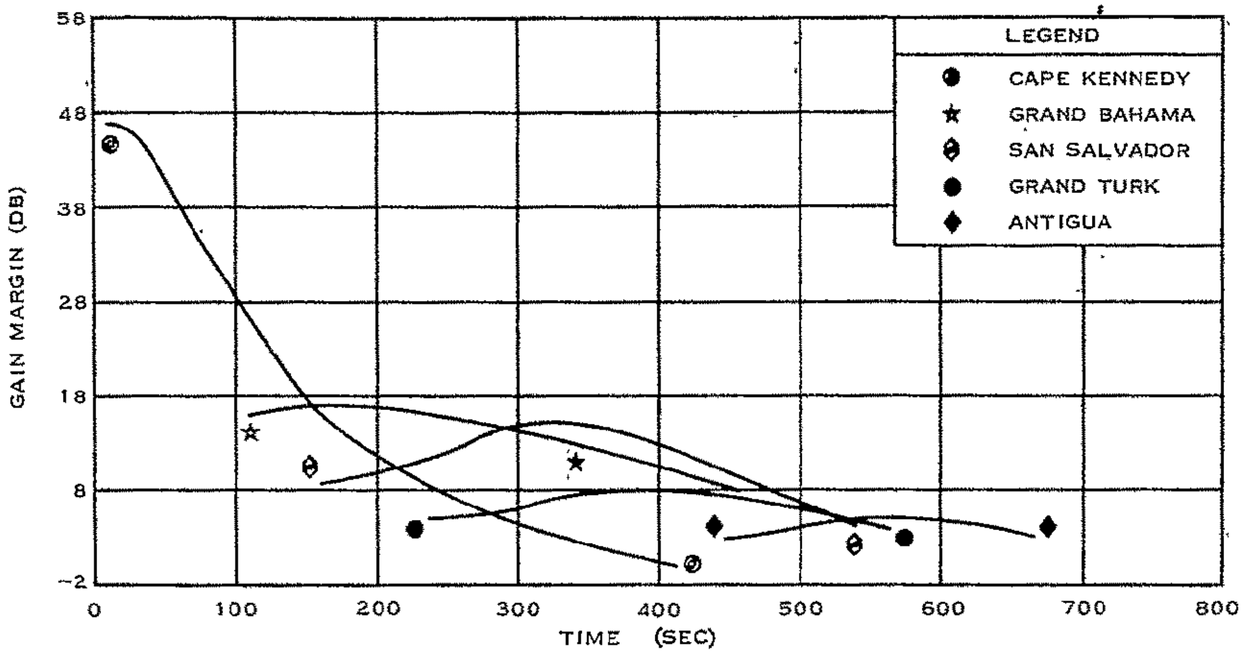


Figure C-2. Centaur RSC System, Gain Margin as a Function of Time

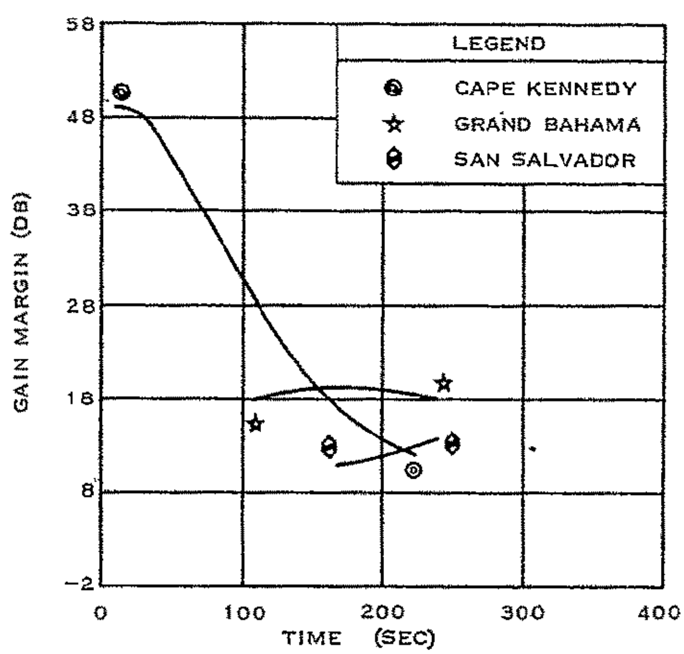


Figure C-3. Atlas RSC System, Gain Margin as a Function of Time

C.2.2 Range Safety Command Subsystem. The vehicleborne portion of the RSC system known as the vehicleborne RSC subsystem, receives F-M signals transmitted from the ground, decodes these signals, and performs the required command. Ideally, the transmitted signals are received by independently operating command receivers, through an antenna system which provides omnidirectional coverage about the vehicle. The signal transmitted by the uhf transmitters will be received regardless of vehicle attitude.

C.3 TRAJECTORY MEASUREMENT. Range safety control is normally exercised by the RSO from just prior to launch to the end of powered flight, which is approximately five minutes. During this time, the vehicle passes through three phases of flight: vertical rise, pitchover, and final powered trajectory. Each phase presents a hazard to different range areas. If thrust were to be terminated during the vertical-rise phase of approximately 12 seconds duration, the launch area and its installations would be endangered. Following the vertical rise, the vehicle makes a gradual turn, or pitchover. During pitchover the danger area expands from the launch site to the surrounding region. Once the vehicle has successfully completed pitchover, the danger area gradually shifts to the outlying islands.

The trajectory measurement equipment provides the RSO with information about the vehicle position. This information is obtained from skyscreens, radar skin tracking, and impact predictors.

The skyscreen is an extremely simple, visual, low altitude monitoring system. Each skyscreen consists of a pair of vertical wires mounted on a rotating frame located in a remote viewing point. The two skyscreens used are identical in configuration, but because of their location with respect to the vehicle pad they have different nomenclatures. The azimuth skyscreen is located on the rear firing azimuth, and the program skyscreen is located on a line perpendicular to the launching azimuth, using the flight vehicle as the point of intersection. The skyscreen operator aligns the two sighting wires with the flight vehicle as it is launched. An electrical indication of the flight-vehicle position is sent to central control from a helipot mounted at the base of the frame. Any deviation from the programmed flight path will be apparent at central control.

An ELSSE (Electronic Skyscreen) uses vehicle telemetry signals for data on the position of the vehicle. Two or more of these screens send data, similar to that described above, to central control.

Radar beacon and skin tracking is used to obtain continuous position information on the vehicle. This information is displayed on plotting boards in central control for use by the RSO.

The predicted instantaneous impact point is that location on the earth's surface where the vehicle would land if the thrust were terminated at that instant. The purpose of the impact predictor is to continually display, to the RSO, the predicted instantaneous impact point of the vehicle. Impact prediction systems consist of three basic components: tracking, computing, and display systems. A tracking system feeds flight-path information, with other known constants, into a computer to determine the impact point. (Figure C-4). The impact predictor used at ETR has a plotting board for visual display of the predicted impact point. By using special maps on the surface of the plotting board, the RSO can observe the continually moving impact point and its position relative to the range boundaries, islands, shipping lanes, and population centers. The range boundaries are predetermined safety limit lines which represent "forbidden" territory for the vehicle.

The impact predictor system at ETR consists of the Azusa tracking system, an IBM 7090 computer, and an Electronic Associates plotting board display system.

The Azusa tracking system is an automatic, high-precision electronic trajectory measuring system consisting of a single ground station and a vehicleborne transponder. Continuous, nonambiguous data is provided in real time in the form of two direction cosines and range. The X, Y, and Z position coordinates of a vehicle can be derived with greater accuracy through Azusa data than through data from any other known tracking system.

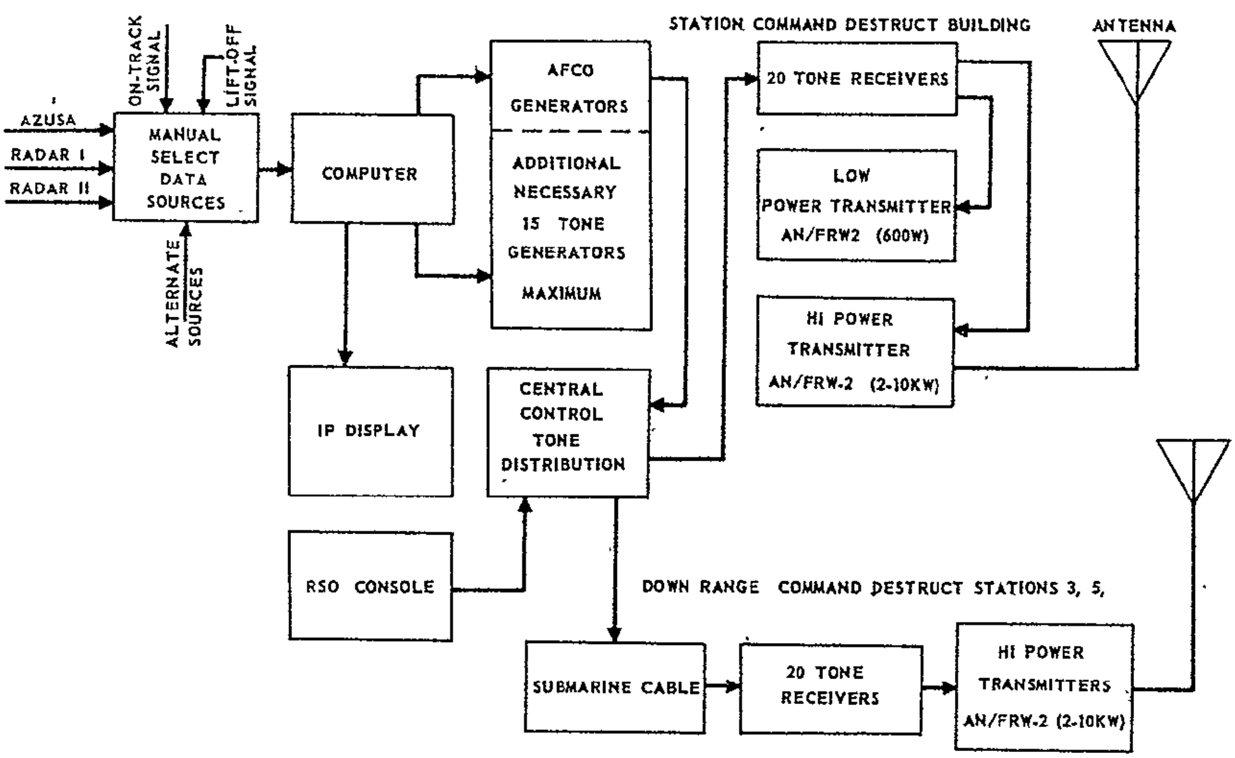


Figure C-4. Command Ground Support Equipment

The IBM 7090 computer is provided by the Air Force for use with Azusa. The computer is used to derive vector velocity and solve each successive impact point corresponding to the most recent position and velocity data automatically fed into it by Azusa. The impact point trace is displayed on plotting boards which are fed from the digital computer via digital-to-analog converters.

As an alternate to Azusa, a radar tracking system may be used. AN/FPS-16 radars operating in the C-band will provide immediate input to the IBM 7090 computer for determination of impact prediction. These radars will maintain automatic beacon and skin tracking to the limit of signal discernibility of range capabilities. Information obtained by direct observation of the radar scopes is sent to the Cape Kennedy Radar Controller, who controls the input to the IBM computer. The radar controller evaluates the quality of the data he receives from the two systems, radar and Azusa, and feeds the data of higher quality to the computer.

The impact point constantly moves during the pitchover and the following powered phase of operation. Increased acceleration occurs toward the end of Centaur first-burn. At this time the impact point goes to infinity as the vehicle is injected into orbit.*

---

* The instantaneous impact point as a function of time, T, is the point on the earth's surface at which a vehicle will impact if thrust is terminated at T.

APPENDIX D

LIST OF DRAWINGS

D-1 ATLAS

Number	Drawing
Avco AD-319600	Receiver, Range Safety Command
7-36044	Ring Coupler
27-04306-5	Destructor
27-36244	Arming Device, Range Safety Command
27-12507-5, -801	Antenna, Range Safety Command
27-61143, 27-61028, 27-61023	Equipment Installation, Electrical and Electronic, Airborne Drawings
55-64111	Schematic, Electrical, Range Safety Command Subsystem
55-64510	Harness, Coaxial, Range Safety Command Antennas
55-64503	Harness, Power Umbilical to Range Safety Command Components
27-04306-1	Test Substitution Destruct Box
27-36236	Power and Signal Control Unit

D-2 CENTAUR

Number	Drawing
55-36080	Power Control Unit
55-36046	Antenna, Range Safety Command
55-61000	Equipment Installation, Airborne
55-56014	Schematic Diagram - Systems, Range Safety Control (Reference Only)

APPENDIX E

LIST OF SPECIFICATIONS

E-1 ATLAS

Number	Specification
55-03015	Subsystem, Range Safety Command
GM 36.2-677	Set, Range Safety Command
7-03272	Ring Coupler, Range Safety Command
27-03008	Arming Device, Range Safety Command
27-04230	Destructor Unit, Explosive
69-06307	Battery, Range Safety Command
27-03013	Power and Signal Control Unit

E-2 CENTAUR-SURVEYOR

Number	Specification
55-01233	Receiver-Decoder
55-01292	Inadvertent Separation Switch
55-04348	Centaur Destructor
55-01276	Surveyor Safe/Arm Initiator
55-36074	Mild Detonating Fuse
55-36073	Mild Detonating Fuse Connector
55-01275	Conical Shaped Charge
55-06286	Battery, RSC
81-65903	Hybrid Junction

CHANGE PAGES

FOR THE

FLIGHT TERMINATION SYSTEM

FOR

CENTAUR VEHICLE AC-6

GD|C-BTD65-087

17 May 1965

CHANGED 30 June 1965

INSTRUCTIONS

Remove and destroy the title page and pages 3-41 and 3-42, A-1 and A-3, B-1 and B-2, from your copy of GD|C-BTD65-087, and replace with the attached pages.

GENERAL DYNAMICS | CONVAIR

F-1

FLIGHT TERMINATION SYSTEM

FOR

CENTAUR VEHICLE AC-6

GD|C-BTD65-087

17 May 1965

Contract NAS3-3232

Updated by Change Pages on 30 June 1965

Prepared by:

for A. H. Tuckman

Checked by: H. E. Seibert

H. E. Seibert

Approved by: K. C. Lejman

K. C. Lejman

GENERAL DYNAMICS | CONVAIR

F-2

Changed 30 June 1965

A 7500-ohm extensometer is included within the switch housing. This device is electrically isolated from all switch contacts, and is wired to an external harness through its own connector. The extensometer is excited by 5 vdc, which is 2 vdc below the dropout voltage of the destruct relays in the power control unit. The extensometer monitors, by telemetry, the condition of the switch shaft during flight.

Since two of three switches are required to initiate destruction, certain circumstances must be considered when determining the location of the Surveyor engine at time of shaped-charge discharge. The worst case arises if (a) the three Surveyor hold-down latches were to break, (b) the Surveyor were to slide in a direction perpendicular to a line drawn through a separation spring plunger and a latch until the spherical section of the engine hits the adapter, and (c) rotates out of the axis on this line. Since there are three possible axes associated with the above conditions, there are three positions at which the Surveyor may be when the shaped charge ignites, Figure 3-35. The shaped charge is designed to accomplish the functions detailed in Section 3-11 at all three positions.

3.13 BATTERIES. Power for the Centaur range safety command subsystem and the Surveyor destruct subsystem is provided by two silver-zinc batteries, one battery for each subsystem. The batteries utilize monoblock cell construction and titanium case material to reduce weight. A photograph of the battery, General Dynamics/ Convair part No. 55-06286-1, is presented in Figure 3-36. Each battery contains a heating element to maintain its temperature, thus permitting good voltage regulation and more efficient operation. The thermostat and GSE controls are the same as for the Atlas battery.

The 55-06286-1 battery has the following output:

Rated Load:	0.12 ± 0.06 amperes
Voltage:	
At rated load	28 to 34 VDC
At rated load (plus 20 amperes for one-half second)	22 VDC minimum
Capacity:	0.5 ampere/hours

3.14 INSTRUMENTATION. Data monitored during the AC-6 flight consist of telemetered data, landline data, and command set signal level. This section presents the sequences of recording these data.

F-3

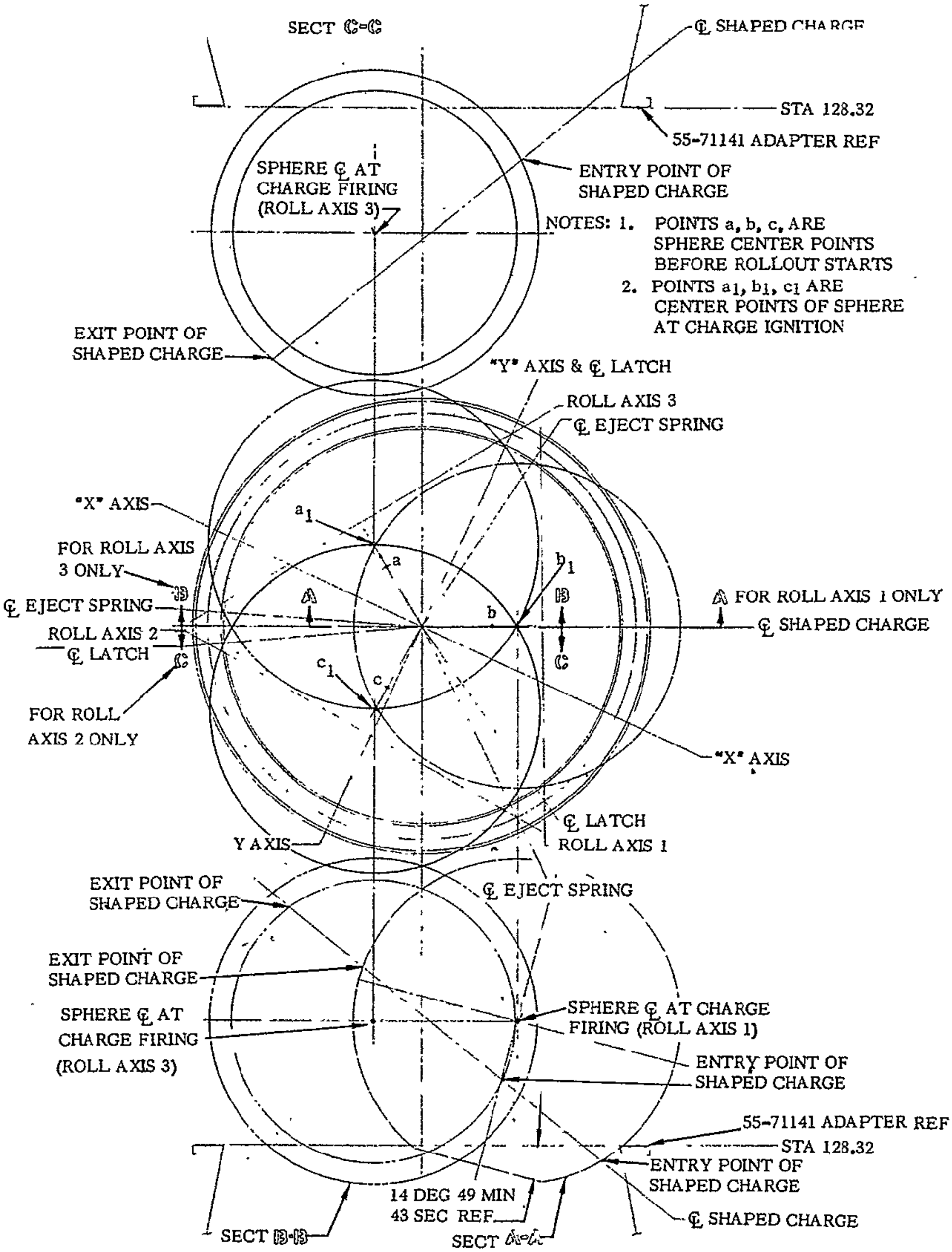


Figure 3-35. Possible Positions of Surveyor at Shaped-Charge Ignition

F-4

Changed 30 June 1965

3.14 INSTRUMENTATION. Data monitored during the AC-6 flight consist of telemetered data, landline data, and command set signal level. This section presents the sequences of recording these data.

3.14.1 Telemetered Data. These data consist of the following:

Centaur Measurement No.	Item
CD2V	RSC RCVR NO. 1 AGC VOLTAGE
CD7V	RSC RCVR NO. 2 AGC VOLTAGE
CD3X	RSC MECO
CD5X	DESTRUCT NO. 1
CD6X	DESTRUCT NO. 2
CD25X	SURVEYOR SEP SWS OPEN
CY2D	SEPARATION LEG 1
CY4D	SEPARATION LEG 3
CY5D	SEPARATION LEG 2
CD24X	AUTO DESTRUCT SAFE

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F-6

Changed 30 June 1965

APPENDIX A

PROPULSION SYSTEM DESCRIPTION

In the second stage, the MECO command will cut off the main engines. To have a better understanding of how the engines are cut off, a brief description of an engine start is presented.

Engine start is initiated by the receipt of three commands generated by the programmer: prestart, start and igniters-on commands. The prestart command opens the prestart solenoid allowing helium to flow in the pneumatic control lines opening the LH_2 and LO_2 inlet shutoff valves (Figure A-1). LH_2 flows through the LH_2 engine pump and is vented overboard through two cooldown valves. LO_2 flows through the engine oxidizer pump and thrust chamber.

Approximately 5 seconds following the prestart command the start command (MES) and igniters-on is issued, opening the start solenoid valve. This allows helium to partiall close the LH_2 cooldown valves and open the main fuel (gaseous hydrogen) shutoff valve. As the hydrogen flows through the thrust chamber jacket tubes, it is vaporized and passes through to the turbine which drives the LH_2 and LO_2 turbopumps. Upon expansion it continues on to the thrust chamber where it is mixed with oxygen and ignited. The igniters are turned off 4 seconds after MES.

The normal programmed cutoff is accomplished by removing the start and prestart signals, closing the main fuel shutoff valve, opening the cooldown valves, and closing the propellant inlet shutoff valve. For cutoff by the RSC subsystem, only the prestart signal is interrupted.

The prestart signal is routed from the programmer through normally closed relay contacts in the power control unit to the C1 and C2 prestart solenoids. When the MECO command is received the relay contacts are opened, closing the prestart solenoid valves. This action stops the flow of helium from the pneumatic control lines, and vents the engine pneumatic system which opens the cooldown valves and closes the main fuel shutoff valve and the propellant inlet shutoff valves of both engines, shutting them down.

F-7

Changed 30 June 1965

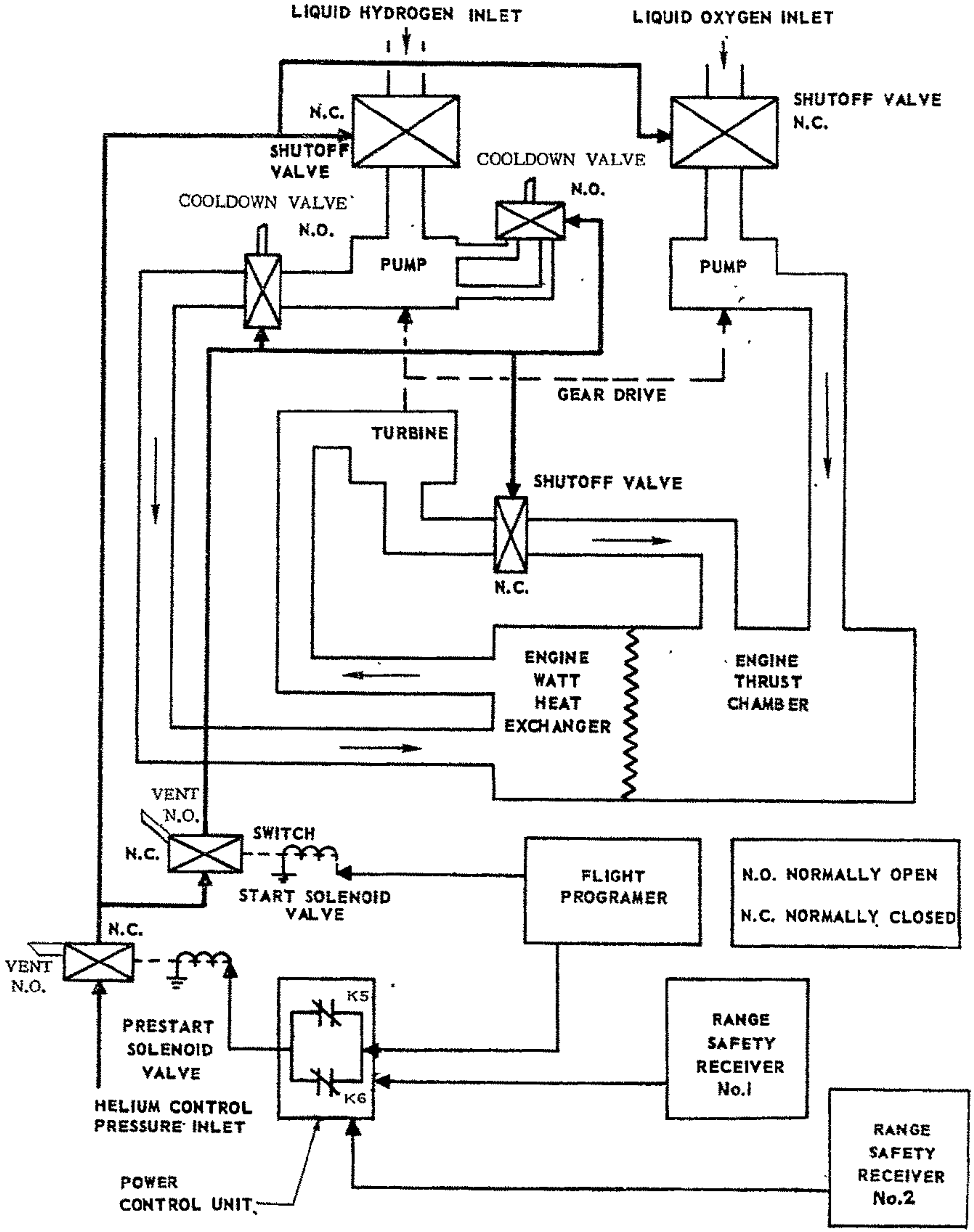

Figure A-1. Propulsion System Diagram

F-8

APPENDIX B

TEST PROGRAM OPERATIONS

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27-04306-803	RSC Destructor	Functionally tested in accordance with Beckman and Whitley Quality Control Form 175-4 and 5.
27-1254(	RSC-TLM Antenna	Applicable portions of 7-00209B
27-3623(	RSC Power and Signal Control Unit	Applicable portions of 7-00210
7-36044	RSC Ring Coupler	Applicable portions of 7-00209B

F-9

Changed 30 June 1965

B.3 CENTAUR AND SURVEYOR FLIGHT CERTIFICATION. The qualification status of all Centaur and Surveyor range safety components is shown in GD|C-BRW64-001.

B.4 SYSTEM-LEVEL TESTS. Each component of the RSC subsystem must meet the acceptance and test requirements called out in "Equipment Operation Procedures," prior to installation on the vehicle. Additional tests are required after installation to discover if any malfunction resulted from vehicle movement and to reveal, through combined operation of the subsystems, a malfunction not previously determined by tests of the individual units. Equipment for checkout of the complete system is installed in the blockhouse at the launching pad. Similar equipment is located in the assembly building for checkout prior to erection.

GENERAL DYNAMICS

Convair Division

CHANGE IN DOCUMENT STATUS

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3. Date issued 11 MAY 67

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5. Issued by: SUTTON/CLAY

6. Change..
☐ a. Cancel, duplicate of:
☐ b. Cancel, superseded by:
☐ c. Withdraw from public sale
☐ 1) Destroy doc & related papers
☐ 2) Return doc & related papers to:
☐ DDC-T ☐
☐ d. Change dist/avail code to:
☐ e. Other: NOT REPRODUCIBLE, NOT AVAILABLE.

7. Remarks
N66-21662 (NASA CR-71501)
N66-21769 (NASA CR-71410)
N66-21817 (NASA CR-71537)
N66-22208 (NASA CR-66050)
N66-22321 (NASA CR-71794)
N66-22894 (NASA CR-5/949)
N66-23649 (NASA CR-74072)

☐ CATALOG ☐ ABSTRACT ☐ FILES ☐ ☐ ☐

U.S. DEPARTMENT OF COMMERCE

1 STOCK LOCATION

2 DATE RECEIVED — YR 71 / MO 10 / DAY 15

12 SCREEN
- ☐ REJECT
- ☐ OBTAIN BETTER COPY
- ☐ OUT OF PRINT SOD
- ☐ OBTAIN AUTHORITY
- ☐ ERRATA

17 ACCESSION NUMBER: N66-22894

3 RECEIPT TYPE & FORMAT
- ☐ MAGNETIC TAPE
- ☐ LOAN
- ☒ PC
- ☐ 35 MM
- ☐ CARDS
- ☒ RETAIN
- ☐ MF
- ☐ 16 MM
- ☐ OTHER

13A ANNOUNCEMENT — VOL 68 / ISSUE 26
- ☐ USG
- ☐ TAB
- ☒ UNANN

13B FAS
- ☐ YES
- ☐ NO

18 PAGES: 155

19 SHEETS: —

20 LOW LIMIT — PC / MF

21 ☐ SUBSCRIPTION

4 STOCK RECEIVED FOR SALE — PC 0 / MF

14 REPRODUCTION INSTRUCTIONS

BLOWBACK →

PRINT	NO	1UP	2UP
NO	1	4	7
1UP	2	5	8
2UP	3	6	9
MIX	SAME SIZE	ORDER STOCK FROM	O

MAKE MICROFICHE
- ☐ YES
- ☒ NO

22 PRICES
- ☒ U UNIT
- ☐ P PC →
- ☐ E PC + MN BOX 16
- ☐ M MN →

23A CATEGORY

5 LOAN DOCUMENT — RETURNED

DUE

OUT

15 PRESTOCK

	NOI	# COPIES
PC		
MF		M
PC DUE IN		

SOURCE TO ORDER COPIES

24 DISTR CODE: —

25 INITIALS — ACC EC / A / B

23B CATEGORY

6 TRANSACTION
- NEW ITEM ☒
- DUPE ☐
- SUPERSEDES ☐
- PRIOR NUMBER ☐

26 FILL FROM
- PAPER COPY ETC: BW
- ☐
- MICRO-NEGATIVE: MF

7

27 PUBLIC RELEASABILITY: T

8 REPORT NUMBERS (XREF) ☐→

NASA-CR-54949

16 REMARKS

9 RELATED DOCUMENT ☐→

10 CONTRACTING OFFICE — BILLING CODE

NASA —

11 NOT FULLY
- LEGIBLE ☒
- COLOR ☐

28 FORM & PRICE

1 ARCHIVES

FORM NTIS-77
(10/70)

DOCUMENT TRAVELER

NATIONAL TECHNICAL INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE