SECTION 4
THOR GROUND SUPPORT EQUIPMENT

DESTRUCT SUBSTITUTION UNIT

The Destruct Substitution Unit (Igniter Signal Tester) contains two voltmeters that are substituted for the S & A mechanisms when destruct checks are made. The input load resistance is the same as the S & A mechanism so that the voltage readings will indicate the current required for destruct action. The configuration and schematic of the unit are shown in Figure 4-1.

IGNITER TEST SET

The Igniter Test Set is a special purpose multimeter used for electrically checking various circuits or components of the destruct system for:

a. Resistance measurements
b. Circuit continuity
c. Presence of stray current or voltage
d. Insulation breakdown
e. Shorts to "ground"

Figure 4-2 shows the set configuration; Figure 4-3, the circuit schematic.

OPERATION AND CONTROL CONSOLE

The operation and control console (shown in Figure 4-4) is used to:

a. Check range safety receiver operation
b. Run a closed-loop test of the DM-21 destruct system after mating
c. Monitor open-loop testing of the destruct system during the launch countdown

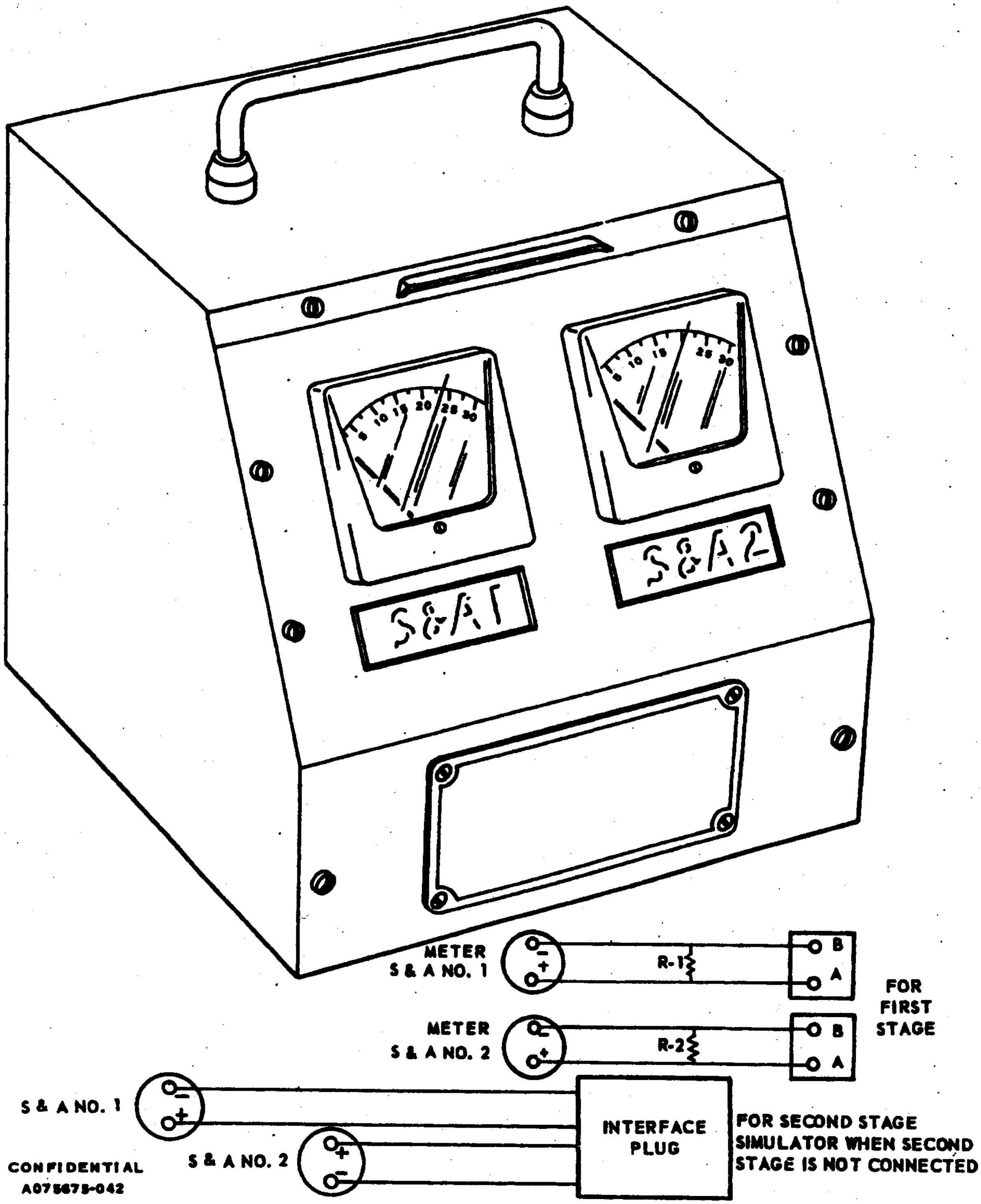

Figure 4-1 Destruct Substitution Unit

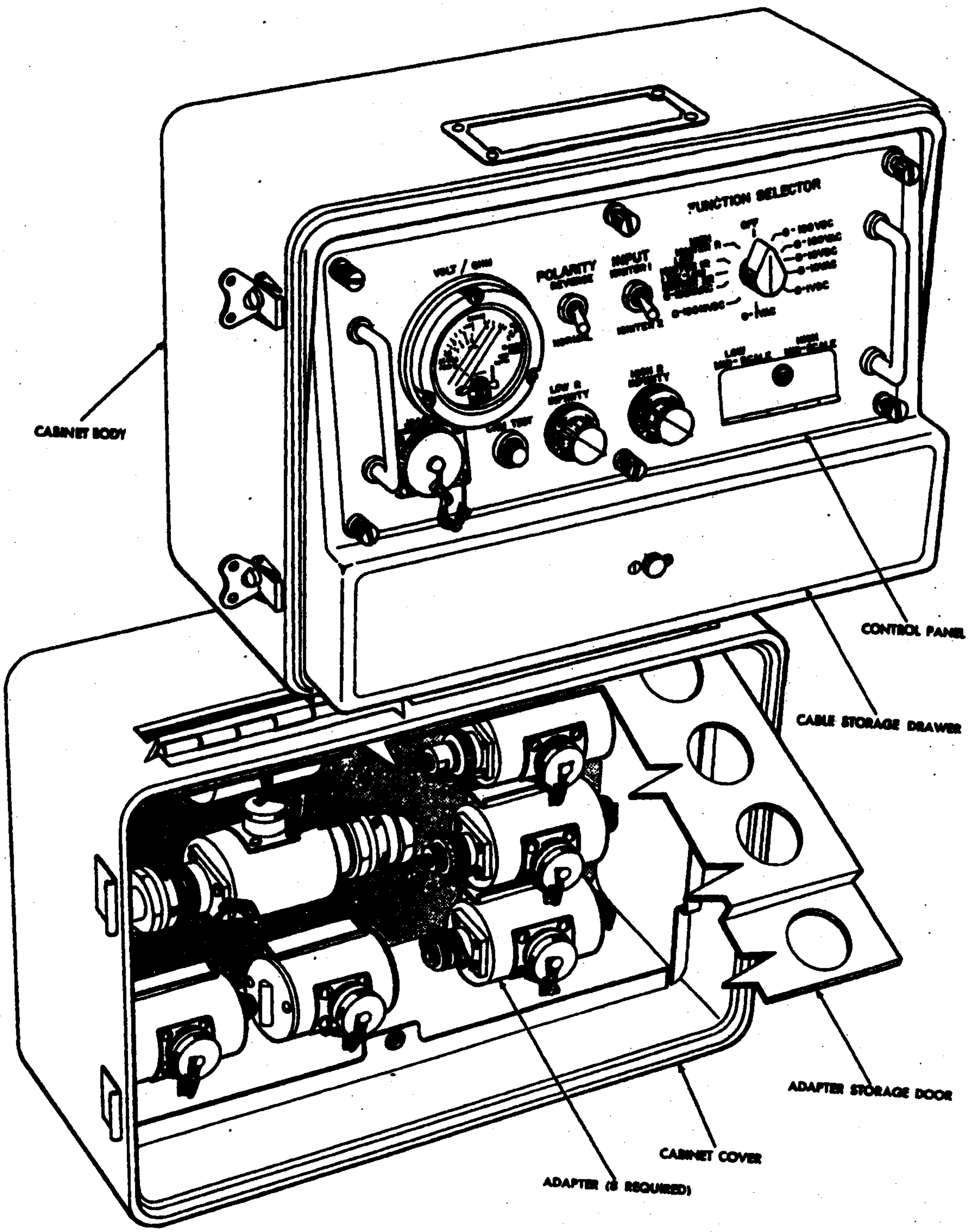

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Figure 4-2 Igniter Test Set

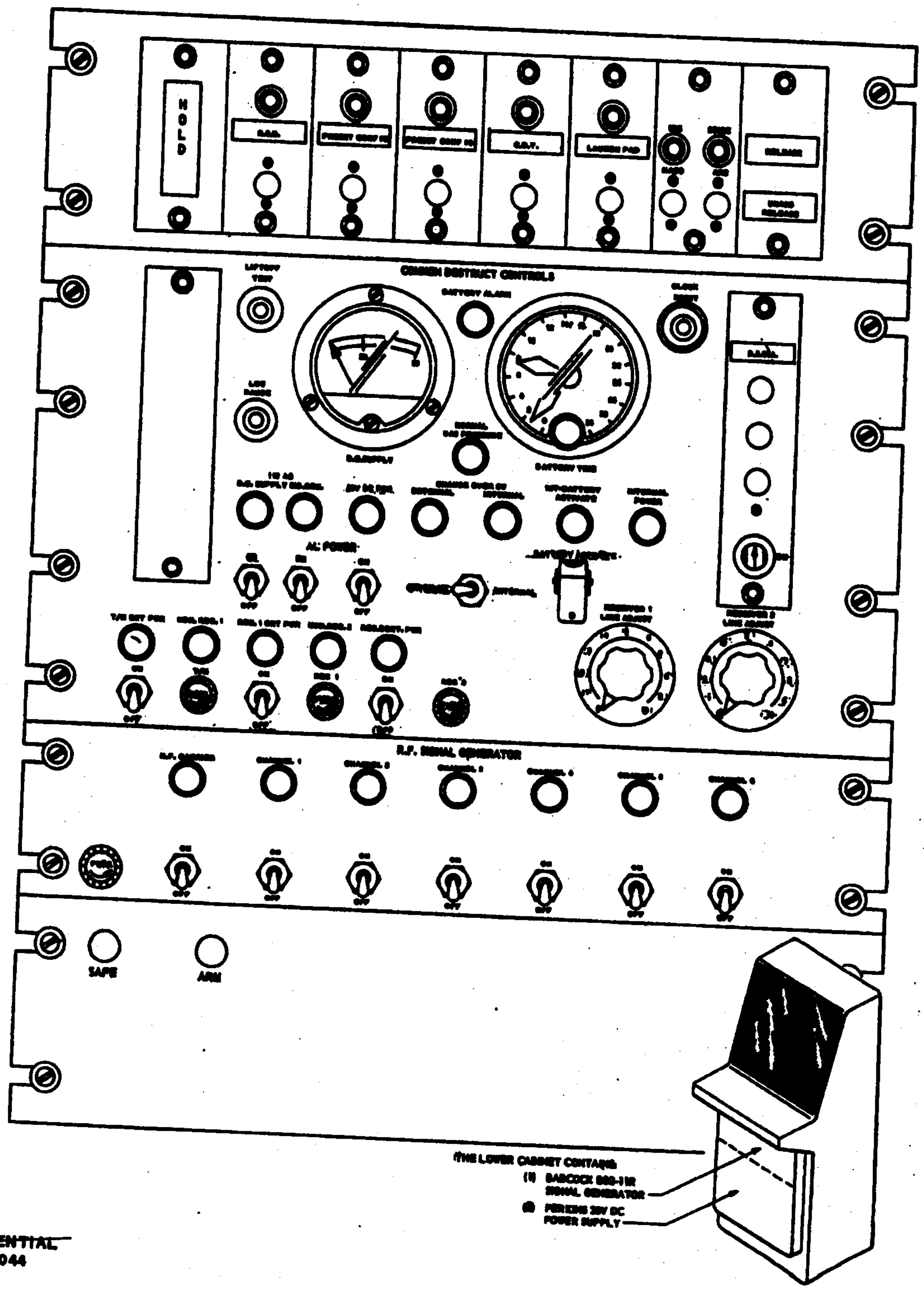

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Figure 4-4 Operation And Control Console

d. Check and monitor external power applied to the vehicle
e. Indicate SAFE/ARM condition of the S & A mechanism during countdown.

A portable version of this console is used in the vehicle assembly area for destruct assembly checks.

ANTENNA LOAD SIMULATOR AND COUPLER

All missile instrumentation systems will shortly be checked out by closed loop via coaxial, using Instrumentation Support Trailer DAC-2 (until closed loop capability is realized in CC-1 and CC-3). At the present time, the antenna load simulator is a reasonant hat whose configuration is such that it can be placed over any one of the vehicle cavity slot antennas. It shrouds the cavity slot antenna so that undesired external signals cannot enter and internal signals are not radiated. It is used during checkout of the receiving system in order to ascertain individual antenna and receiver sensitivities. A coupler assembly provides for coaxial connection between an RF signal generator and the antenna.

SPECIFICATIONS AND REFERENCES

Specifications

Each component in the system has been designed to operate under the environmental conditions expected to be encountered during the flight. Mechanical tests have been conducted to demonstrate adequacy of the explosive charge. All airborne electronic equipment installed conforms to the following military specifications:

MIL-E-9483	Electrical Equipment, Installation of, Guided Missiles and General Specifications for
MIL-E-8189A	Electronic Equipment, Guided Missiles, Installation of, General Specifications for

MIL-E-129A	Marking for Shipment and Storage
MIL-E-8500A	Interchangeability and Replaceability Physical Components for Aircraft (Including Guided Missiles)
MIL-E-5277A	Environmental Testing, Aeronautical and Associated Equipment

References

The following references provide additional information pertinent to the DM-21 flight termination system.

Douglas Aircraft Co., Inc. Report No. SM-37963 DM-21 Range Safety System, November 1960.

Douglas Aircraft Co., Inc. Report No. SM-27100 WS-315A Range Safety Command Destruct System, 3 August 1956, Revised June 1958.

Douglas Aircraft Co., Inc. Douglas Model DM-21 Space Research First Stage Vehicle DS-2110A Performance Specifications, 28 July 1960.

Douglas Aircraft Co., Report No. SM36031, Revision 1, Flight Test Vehicle Safety Proposal, Delta Program - Atlantic Missile Range, August 1960.

SECTION 5
ATLAS DESTRUCT SYSTEM DESCRIPTION

GENERAL DESCRIPTION

The Atlas booster contains a compact missile flight safety system (MFSS) and telemeter kit. The missile flight safety system operates independently of the telemetry system, however, the two are interrelated from the standpoint of reliable missile flight safety operation, in that the telemetry carrier reception at the ground stations provides the necessary missile position and impact data.

The booster destructor utilizes two physically separate primers, each with its own bridge wire. Ignition of a lead styphnate primer results in detonation of the high explosive when the device is armed. The function of the booster destruct system is to receive frequency-modulated signals from the ground transmitter, decode these signals into a command, and to destroy the flight vehicle upon command. The system has been designed to be compatible with the Pacific Missile Range Safety System ground equipment and operational procedures. A block diagram of the system is shown in Figure 5-1; in Figure 5-2, the arrangement of Atlas booster equipment is shown. Figure 5-3 is an integrated schematic of the booster flight termination system.

The basic destruct system consists of an omni-directional antenna, two range safety command receiving sets (operated in parallel for reliability and compatible with the Pacific Missile Range FRW-2 UHF ground destruct transmitter), power change-over switches, power sources, arming and safing devices capable of remote-control operations, and a destruct unit.

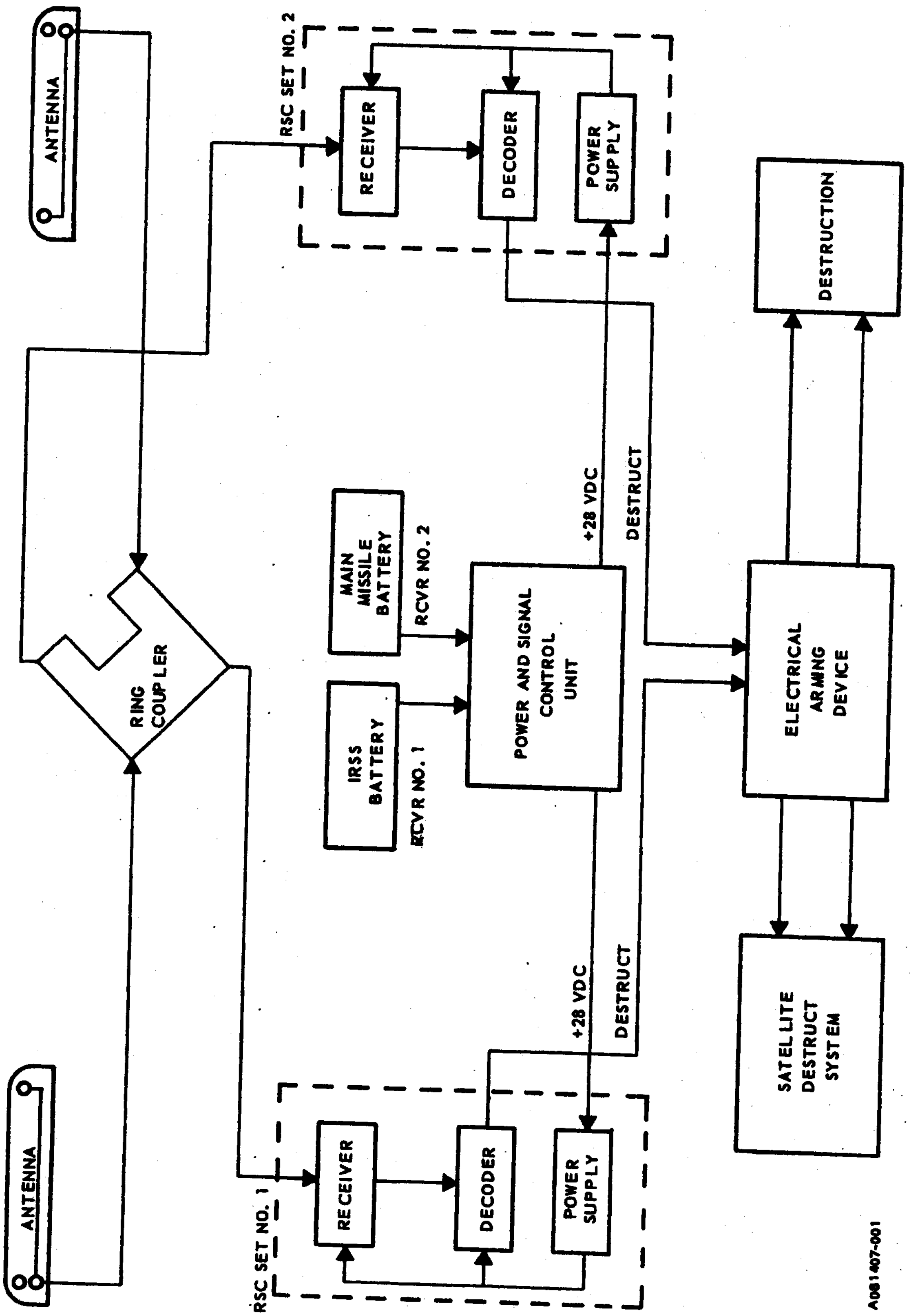

Figure 5-1 Flight Termination System in PG-1A Space

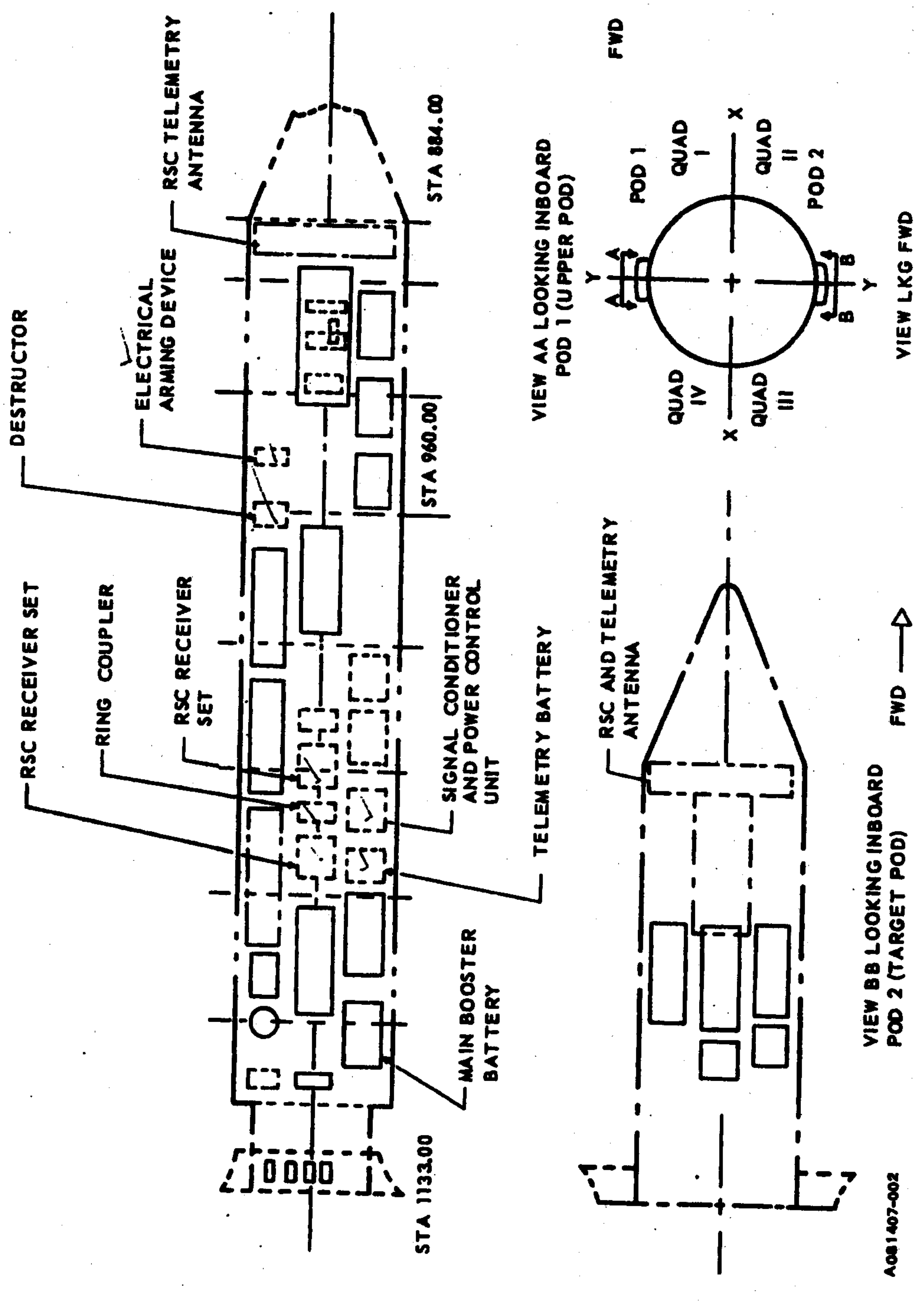

Figure 5-2 Atlas Booster Equipment Arrangement

INPUT SIGNAL CHARACTERISTICS

The Missile Flight Safety System is compatible with the range safety ground station in regard to input signal characteristics. The characteristics are:

a. Carrier frequency tolerance ±0.013%: ±0.010% allotted to the transmitter, and an additional 0.003% for doppler shift.

b. Carrier signal strength provided by the UHF ground transmitter is to be equivalent to, or greater than, 950 microvolts per meter.

c. A modulation deviation of 60 kc ± 10% peak deviation for any number of tones.

d. Equality of modulation-tone deviations ±10%.

e. Tone frequency tolerances ±1.0%.

ANTENNA SYSTEM

Two single-cavity antennas mounted opposite each other are utilized by the missile flight safety system and each cavity contains two range safety command probes.

The combined telemetry and command antenna system was designed to require the least amount of space in the PG-1A space booster and yet provide adequate antenna pattern coverage.

To prevent possible interference with the command subsystem at telemetering
frequencies, there is sufficient isolation between the telemetering antenna
probe, and the command antenna output. Figure 5-4 shows the intercon-
nection of the antenna system components. The antennas are coupled to the
receivers by a ring coupler. This assures that failure of the RF link to one
receiver package will not affect the other set in the dual system. The coupler
provides a minimum of 20 db isolation between receivers. The interconnec-
tion of antennas and receivers is accomplished by parallel junctions (ring
coupler) to a re-entrant transmission line 3/2 wavelengths in circumference.
Branch lines of 1/4 wavelength separate three of the junctions and a 3/4
wavelength separates the two remaining junctions. The antennas are con-
nected to one pair of opposite junctions, and the receivers to the other pair.

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Figure 5-3 Integrated Electrical Schematic of Booster Flight Termination System

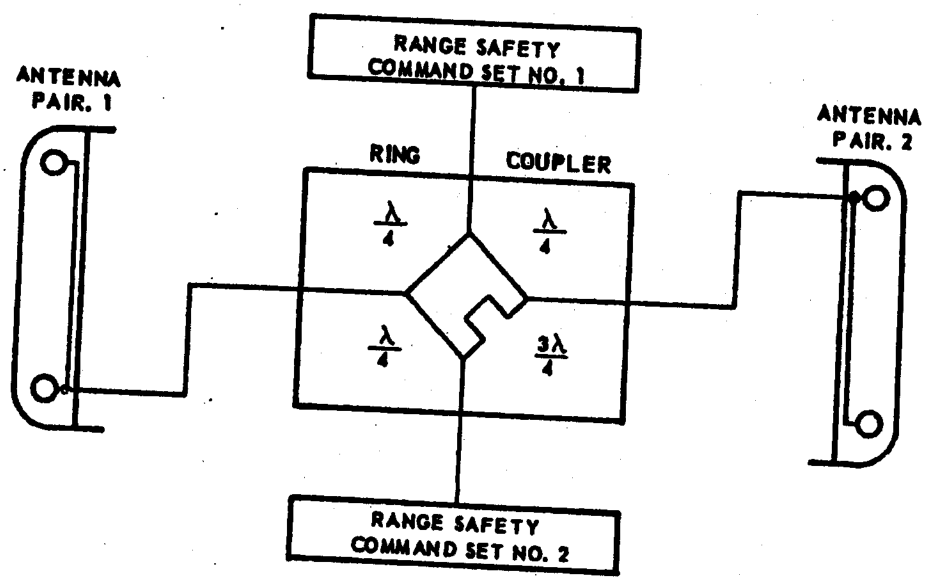

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Figure 5-4 Schematic of Antenna System

A signal arriving at No. 1 Antenna will be divided equally between the two branch lines and produce signals of equal amplitude and phase at each of the receiver terminals. At the other antenna terminal, the signals from Antenna No. 1 will be of equal amplitude, but in phase opposition because the 1/2 wavelength difference in transmission-line length along the two branches of this junction. The result, with no coupling between the junction of Antenna No. 1 and Antenna No. 2, is a voltage node at this point. Minimum isolation between antennas is 20 db. The loss from each antenna junction to each receiver is 6 db or less. There is a 3 db loss in obtaining a power division at the ring coupler. The remaining losses are in the RF cable and connectors. Besides providing the required isolation between antennas and receivers, the coupler serves to provide isotropic antenna radiation coverage about the missile. With the antennas mounted on opposite sides of the missile, the spacing between them is approximately four wavelengths. Separation of the antennas produces lobes at the small interference regions where the radiation patterns of the individual antennas overlap.

Signals from both antennas travel the same distance through the ring coupler to receiver No. 1. However, signals to receiver No. 2 must travel 1/2 wavelength farther from the target antenna than those from the upper antenna. Therefore receiver No. 1 acquires signals from both antennas in like phase, while receiver No. 2 acquires signals in opposing phase.

This arrangement makes the radiation pattern seen by one receiver complementary to that seen by the other receiver. When receiver No. 1 receives a strong signal, receiver No. 2 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, the radiation pattern presented to the other provides coverage for 84.7% of the solid angle before staging the booster engines of the Atlas, and 85.9% of the solid angle after staging.

RECEIVERS

Description

The command receiver sets used are two government-furnished AVCO AD-319600 units MK I. These sets are tunable in one-megacycle steps from 405 to 420 megacycles. Retuning requires only the replacement of one crystal and some minor adjustments. These receivers are pretuned to the standard Pacific Missile Range frequency.

The deviation which is specified for these frequency-modulated receivers is ± 60 kc for any number of tones. The GFAE specified sensitivity for the receiver is 3 microvolts, but it should be noted that the subsystem specification of 950 microvolts per meter was calculated on the basis of receiver sensitivity of 10 microvolts and a -10 db gain (with respect to an isotropic radiator) in the antenna system; thus, there is an inherent margin of safety of approximately 13 db between the subsystems maximum sensitivity and the specified sensitivity.

Radiation patterns are shown in Figures 5-5 and 5-6.

Operation

Radio command signals are received as a combination of audio tones. A specific sequence of tones must be received before the receiver can generate the destruct command. When the Pre-Arm button on the RSO console is depressed, the ground destruct transmitter sends a signal that is modulated by tone channels 1 and 5; when the Destruct button is pressed with the Pre-Arm button remaining in the depressed state, tone 5 is deleted and tone 2 is substituted. The desired result is for tones 1 and 2 to be transmitted and for tone 1 not to be deleted during the transition from Pre-Arm to Destruct.

On reaching the receivers the audio tones are separated by electrical filters located in the decoder portions of the receivers (see Figure 5-7). The filter output is rectified, smoothed, and applied as a dc voltage to the grids of the

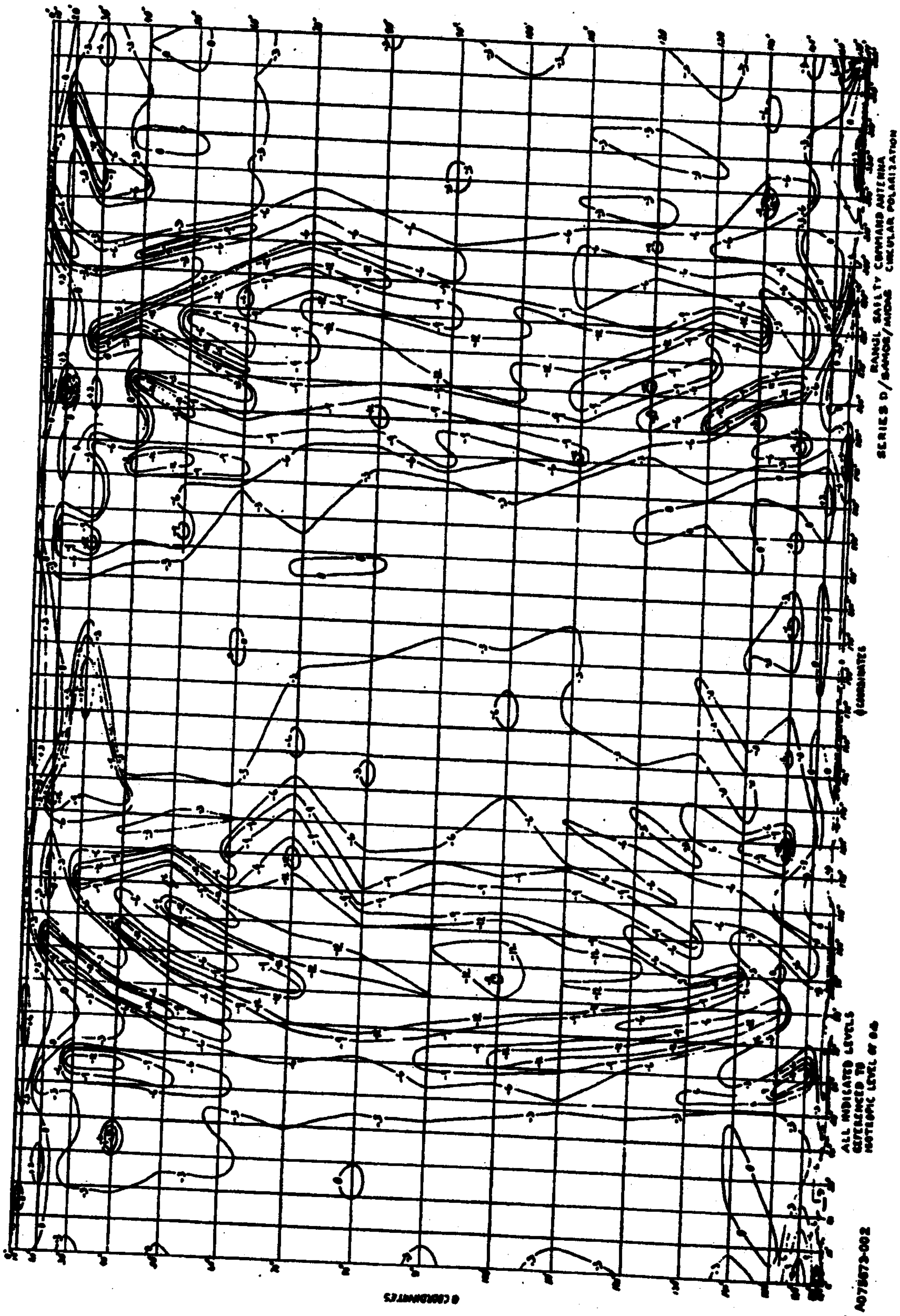

Figure 5-5 Antenna Radiation Pattern, Pre-Stage

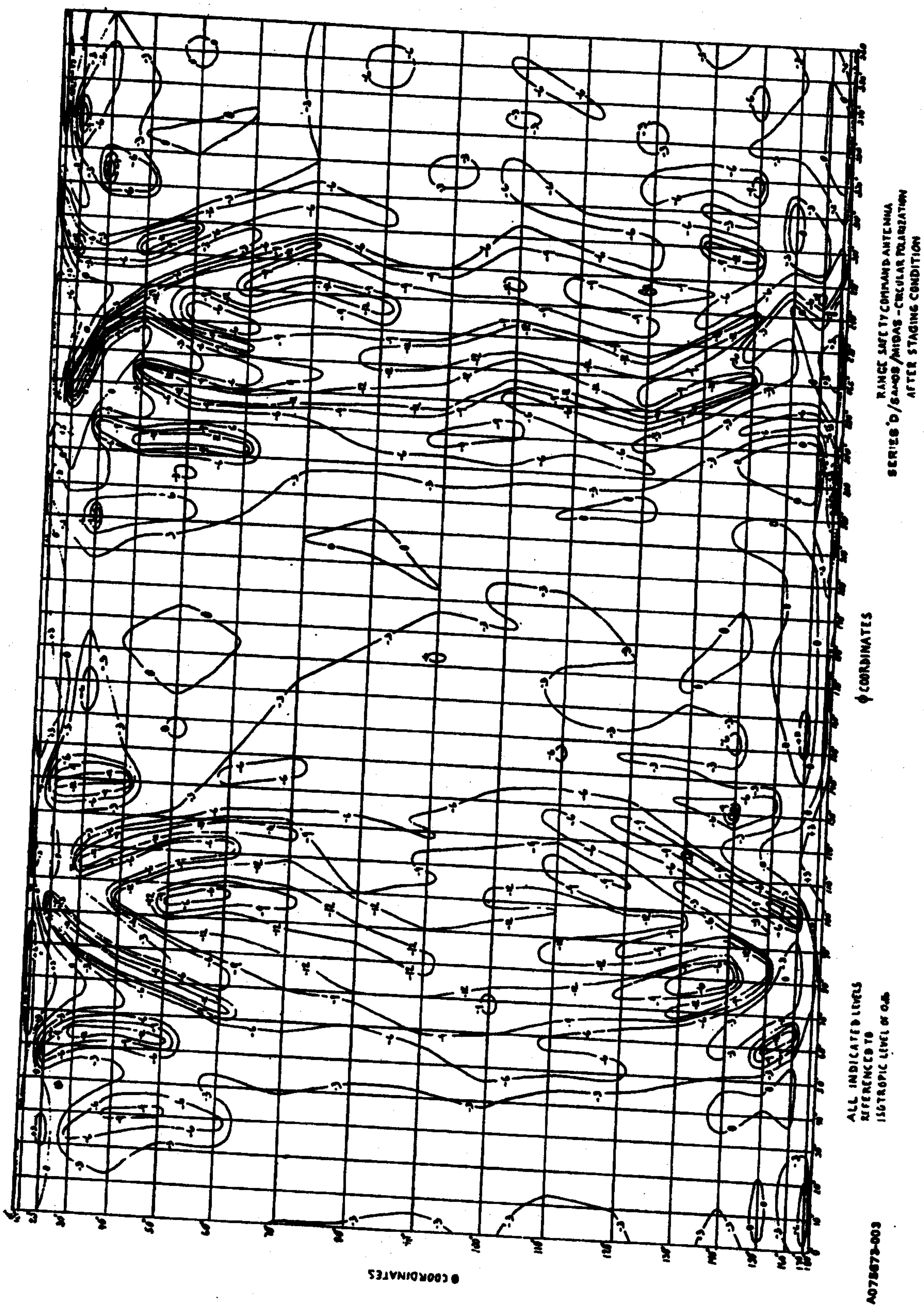

Figure 5-6 Antenna Radiation Pattern, Post-Stage

[redacted]

corresponding channel relay amplifiers. Two type 5906 pentodes operate as dc channel relay amplifiers in each channel relay unit, the common plate load of which is a channel relay coil. The amplifiers are held in a cutoff state due to the absence of grid voltage. When a filter output is received, the amplifier is driven to saturation and this results in plate current energizing the channel relays. The relays complete the logic circuit required to provide a destruct command.

As a safety factor, the tone 5 relay has been designed with a dropout time of 100 to 250 milliseconds, in case tone 1 is briefly removed in the transition from tones 1 and 5 to 1 and 2. Since the receiver procurement specification (GFAE) does not stipulate this dropout time, the dropout time of channel 5 can vary from 5 milliseconds to 250 milliseconds. The maximum elapsed time between the depression of the Destruct button and the actual destruction of the missile is 470 milliseconds: 250 milliseconds (max) for channel 5 dropout, 100 milliseconds (max) for ignition of the primers, and 120 milliseconds (max) for primer pyrotechnic delay.

BOOSTER SIGNAL CONDITIONER AND POWER CONTROL UNIT

Primarily, this unit serves the telemetry subsystem. It also performs two functions for the missile flight safety system. It changes the system from internal to external power sources and vice versa, by means of a power changeover switch and it also serves as a junction box for electrical connections in the subsystem.

BOOSTER ELECTRICAL ARMING DEVICE

The purpose of the electrical arming device is to provide a means for placing the destruct system in a SAFE or ARM condition. In the SAFE condition both satellite and booster vehicle destructors are electrically isolated from the command destruct signal and a short circuit is placed across the booster vehicle destruct primers. There is a destruct signal path from each receiver set leading to this device.

Design of the arming-device circuit isolates both sides of the destructor primers from the ground return and from the energizing voltage until a destruct command is received. This minimizes the possibility of stray currents causing premature operation of the primers. This isolation from structural ground and power sources is provided even in the ARM condition. A high-resistance leakage path to structural ground is provided within the destructor unit for safe drainage of static charges from the destructor circuit. The common return lines from the satellite destruct circuit are isolated from ground by the same leakage resistor (in the booster destruct unit), and the two destruct signal lines to the satellite are each shorted to the common return lines through separate current-limiting resistors until the destruct command is given. Direct shorts are also placed across the input to the booster destruct unit until the destruct command is received. Current limiting resistors are provided within the booster destructor unit. Contacts within the electrical arming device provide an electrical indication of SAFE or ARM on the Operation and Checkout Console in the LOB.

BOOSTER DESTRUCTOR

The reliability of the destructor has been proven through qualification tests and actual flights; therefore, only one is used. The destructor is enclosed in a red-anodized aluminum box which measures 5.0 x 5.5 x 5.5 inches. Glass wool insulation protects the switch and explosive charge from abnormal temperature and moisture conditions. The destructor is capable of operating at temperatures up to 160°F for a soak period of four hours, and at temperatures as low as -65°F for a soak period of eight hours. The destructor complies generally with Spec MIL-E-5272A for environmental testing.

PRIMER CIRCUIT

The primer circuit assures the firing of either or both primers within the destructor. The circuit has the primers in series and each primer is shunted by a resistance that requires only one-quarter of the current taken by the primer. This increases the reliability of igniting one primer should a broken wire or a short circuit occur in the other primer.

The BW 10081 primer is 5/16 inch longer than the BW 10004 primer, formerly used on the Atlas booster, in order to accommodate a pyrotechnic delay consisting of a slow-burning powder train. The delay time is 90 ± 30 milliseconds. This makes the minimum firing time equal to 60 milliseconds plus the ignition time. The BW 10081 primer will fire the high explosive within 60 to 120 milliseconds following ignition, even though the electrical signal is removed simultaneously with ignition.

The electrical characteristics (vendor's data)

a. Bridge-wire resistance: 0. 3 ± 0. 1 ohm at 70°F 0. 50 ± 0. 15 ohm at 350°F
b. Minimum firing current, 5 min: 0. 450 amp
c. Recommended minimum firing current: 1. 0 amp
d. Ignition time, 1 amp current: 58 ± 15 milliseconds
e. No-fire current (testing): 0. 2 amp
f. Spontaneous detonation temperature: 370°F.

EXPLOSIVE

Instantaneous 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 in the booster vehicle consists of approximately one pound of RDX (which consists of cyclonite, 3 to 5 percent wax, and from 1 to 1-1/2 percent graphite).

The RDX has a melting temperature of approximately 400°F and fumes at 550°F, but does not detonate at a temperature less than 680°F. It is not hygroscopic and has good storage stability. Destructive qualities are not affected by the environmental temperatures encountered during the flight. For normal storage conditions of -80°F to +160°F at 0 to 95 percent relative humidity, the RDX should be good in excess of five years.

MECHANICAL ARMING MECHANISM

The destructor is armed or disarmed mechanically by the rotation of a steel shaft located between the primer and the booster charges. There are two 1/8-inch holes in the shaft which are aligned or disaligned as it rotates between the primer and booster charges. An ARM or SAFE command from the Operation and Checkout Console produces a 28v dc 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 90° rotations of the shaft in the same direction, alternately aligning (ARM) and disaligning (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 of the unit when not in use.

The destructor is monitored by a three-wire, two-position microswitch that controls the 28v dc indicator lights on the Operation and Checkout Console. A cam on the arming shaft actuates the microswitch, energizing the appropriate light to indicate whether the unit is in the ARM or SAFE position.

The mechanical arming device is shown in detail in Figure 5-8, and a schematic of the mechanism in Figure 5-9.

BOOSTER BATTERIES

Batteries provide the power for internal operation of the destruct system. The IRSS battery feeds power through the signal conditioner and power control unit to receiver No. 1. The main missile battery sends power through the signal conditioner for receiver No. 2. Both batteries also serve other elements of the booster vehicle, the instrumentation and range safety battery

[redacted]

Figure 5-8 Mechanical Arming Device

[redacted]

Figure 5-9 Destructor And Mechanical Arming Schematic serving the telemetry subsystem, and the main missile battery serving all other electrical components in the booster.

INSTRUMENTATION

Telemetered Data

Range safety command data telemetered during flight are as follows:

Measurement No.	Description
D110X	Destruct

Provision has been made to monitor the destruct outputs of the command sets.

Destruct

The booster destruct output is instrumented by means of relay contact closure. These contacts are isolated from the destruct voltage. Upon receipt of a destruct command, contact closure occurs simultaneously with the destruct output. This information is recorded on a continuous channel by telemetry, to provide accurate time-correlation destruct data.