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DEVELOPMENT OF REMOTE CONTROL FOR THE JB-2 FLYING BOMB

By M. W. Rosen, M. L. Kuder and E. N. Pettitt

FR-2616

- Report R-2616 -

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ABSTRACT

The adaptation of remote control to the JB-2 Flying Bomb is presented. The primary purpose of the project was to increase the accuracy of the flying bomb by tracking it in flight with radar and by controlling its course to the target by remote radio control. In the development program the Naval Research Laboratory provided complete electronic engineering services, including: (1) the development and evaluation of beacons and beacon antennas for the vehicle, (2) the evaluation of radio command links and the design of a command receiving antenna, (3) the design and development of remote control equipment for controlling flight functions, (4) operational flight tests of all components of the system in a simulated flying bomb using the SP and Airborne Early Warning radars for tracking and (5) the coordination of planning, design, development and test of the complete system. Descriptions of equipments developed during the program are given. Details of equipment used in the system, but previously developed are referred to existing instruction manuals. Since this report presents instructions for installation of equipment, tuning, adjustments and operation, it may serve as a preliminary system instruction manual.

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AUTHORIZATION

1-1. Problem A61.3R-C requested NRL to develop a method including complete electronic systems engineering of operating the JB-2 flying bomb from a modified CVE aircraft carrier for use as a long range artillery weapon. Development of the various equipments required for the system was completed in June, 1945.

THE VEHICLE

2-1. The JB-2 flying bomb is a pilotless jet-propelled mid-wing monoplane lacking ailerons, but incorportating conventional fin, rudder, stabilizers, and elevators. It is 27 feet long; has a wing span of 17 feet, 8 inches and an approximate weight empty of 1965 pounds. Assembled views of the JB-2 are shown in Plates 1 and 2. The fuselage is approximately 23 feet, 6 inches long with a maximum diameter of 33-3/4 inches and is an assembly of four full monocoque sections as follows: (1) the nose section is of aluminum alloy construction and contains the air log and compass, (2) aft of the nose section is a warhead of 2080 pounds, which contains the explosive charge, (3) the center section is of steel construction and contains a pressurized fuel tank and two spherical bottles for storage of compressed air, (4) the aft section also of steel, contains the automatic pilot, automatic controls, and servo units for operation of the control surfaces. The empennage structure incorporates the conventional airplane surfaces. The power plant is an intermittent-firing duct engine which delivers a net thrust of 500 pounds. Firing occurs approximately 40 times per second, which is established by the natural period of resonance for the exhaust duct. This is the reason for the sound that characterized the German V-1 (of which the JB-2 is a copy) and led to its being called the "Buzz" bomb.

2-2. The flight control system (described with reference to Figure 1) obtains pneumatic power from the compressed air storage bottles. The rudder and the elevators are operated by push-pull air servos which are controlled from the automatic pilot through differential air valves. The automatic pilot is the "brain" of the flight control system and incorporates one free and two restrained air-driven gyros. It operates to stabilize the vehicle in yaw, pitch and roll. The vehicle includes various instruments as follows: (1) a barometric height setting device which influences the automatic pilot, (2) a magnetic compass which gives azimuth information to the automatic pilot, and (3) an air log which initiates warhead arming and final dive at preset ranges.

2-3. Launching is accomplished on an inclined ramp by means of either a power driven piston integral to the ramp or jatos attached to the vehicle. Two pre-set clock mechanisms are provided, one to delay application of azimuth control until the vehicle has gained sufficient speed and altitude, and the other to provide, when necessary, a timed turn to remove the azimuth launching error.

2-4. Additional information on the principles of operation, assembly, servicing, installation and launching of the JB-2 are available in Reference (a).

ADAPTATION FOR REMOTE CONTROL

AIMS OF THE SYSTEM

3-1. The primary purpose of the project was to increase the accuracy of the flying bomb by tracking it in flight with radar and by controlling its course to the target by means of remote radio control. With this as a basic concept, the following parameters were given: (1) The system should be capable of operation to at least 100 miles, (2) The target dimension should be taken as one square mile at the maximum range. (3) The cruising altitude of the flying bomb will be between 1,000 and 6,000 feet. (4) The final phase of this program will use the AEW (Airborne Early Warning System) for radar tracking purposes. The operating altitude of the radar tracking (AEW) plane will be between 5,000 and 20,000 feet. (5) The radio control system shall provide four independent functions, namely; left turn, right turn, dive initiation, and beacon identification. (6) The radio control system shall provide for the simultaneous operation of three flying bombs on a single radio frequency carrier. Since it is contemplated that at least eight and as many as thirty r-f carriers may be used at one time, a large number of flying bombs may be controlled simultaneously. (7) Equipment designed for use in the vehicle shall be capable of withstanding the acceleration and vibration normally encountered in launching and flight.

PRIMARY FUNCTIONS

3-2. In order to provide remote control for the flying bomb, three primary functions must be supplied. These are defined as follows: (1) TRACKING - continuous determination of the range and bearing of the flying bomb with respect to the target, (2) COMMAND - transmission of orders from the control station on the aircraft carrier to the vehicle in flight and (3) CONTROL - translation of the orders in the vehicle into the functions required for delivering the bomb to the target.

3-3. Tracking is accomplished through the use of a high-power search radar; initial phases of the program contemplated using the SP shipborne radar. It is ultimately expected to extend the operating range and permit radar view of the target by using the airborne AN/APS-20 radar of the AEW (Airborne Early Warning) system. Since the echo response of the flying bomb would not be sufficient for the intended range of operation, it was decided to obtain increased response by supplying the vehicle with an airborne radar transpondor or beacon.

3-4. It was decided to use a v-h-f radio command link for transmission of orders to the vehicle in flight. Since altitude is preset and maintained constant, flight orders consist only of azimuth direction and initiation of the final dive. Since three flying bombs are to be controlled simultaneously on a single r-f carrier, it was decided to identify any given one by extinguishing the beacon in that particular vehicle. By means of suitable coding, a total of twelve separate commands had to be set up to provide four control commands in each of three vehicles.

3-5. In regard to azimuth control, the following criteria were recommended by NRL early in the program: DECLASSIFIED

a. That the system be designed to place as little restriction as possible on the launching direction.
b. That the rate of turn of the flying bomb under control be as fast as is considered safe from aerodynamic limitations.
c. That the transmission of radio command signals be accomplished in a relatively short time interval.

With reference to dive initiation it was recommended that, in addition to the security obtained from coding, a command of specified duration should be required before this function could become operative. These recommendations were a direct outgrowth of two important requirements of the problem, namely: that the flying bombs be launched from aircraft carriers, and that the system be capable of controlling many vehicles simultaneously. This latter requirement made it necessary to share tracking attention and command time between several vehicles. It followed that command and control should be accomplished in the shortest possible time.

DEVELOPMENT PROGRAM

3-6. In order to provide complete electronic engineering services, a highly integrated program of development was planned and followed. Development was oriented with regard to both the subsequent evaluation program and the use in combat. In some cases, readily available equipment was chosen for the evaluation program with the expectation that it would be replaced for combat by equipment available at a later date. For purposes of exposition, this program is divided according to the three major functions; tracking, command, and control; however, all three parts progressed simultaneously.

Tracking

3-7. Various beacons including the AN/APN-7, Rosebud, and Black Maria were evaluated for possible use in the flying bomb. It was decided that a modified version of the AN/APN-7 (subsequently called AN/APN-33) would have the desired characteristics and be more readily available for the evaluation program. The development of a more compact beacon (AN/APN-41) for combat use was undertaken. Polycone receiving and transmitting beacon antennas were designed for installation on the JB-2. In preliminary airborne tests the AN/APS-2 radar was used to determine minimum and maximum beacon ranges and tracking accuracy. Later, these tests were repeated with the SP and AEW radars.

Command

3-8. The AN/ARW-17 five channel, frequency-modulated, radio command receiver was chosen for the evaluation program. A suitable receiving antenna was designed for installation on the vehicle. The companion transmitting equipment, AN/ARW-3, was chosen for ship installation. A flight control box was designed for remote operation of the transmitter and for keying the desired commands. For combat, it was expected that the AN/ARW-17 receiver would be replaced by the AN/ARW-37, and the AN/ARW-3 transmitter by the AN/ARW-34. Airborne tests were made of reliability and operating range of the command link.

Control

3-9. Flight control during the guiding period consists only of turning in azimuth. A change of heading is obtained by rotating the compass bowl through the required angle. As previously stated, the compass influences the automatic pilot which in turn operates the rudder through the pneumatic servo system. Rotation of the compass is performed in one degree increments. As an anti-jam measure, the system provides that only one degree of rotation shall result from a single command impulse, regardless of its duration. The normal JB-2 compass influences the automatic pilot at a rate of three degrees per minute, with an error sensitivity of ± 1/2 degree. The problem requirements definitely indicated that a higher maneuverability or faster rate of turn was necessary. In order to supply this, the compass was modified to provide an additional rate of turn which could be preset at any chosen value from 10 to 60 degrees per minute and with an error sensitivity of approximately plus or minus six degrees. The following new control equipments were developed: a compass motor drive, PU-95(XN-1)/ASW, and a control relay box, C-296(XN-1)/ASW which, in addition to providing the four control functions, serves as a junction box for the entire electronic system. Numerous flight tests of the control equipment were conducted in order to observe characteristics and determine design criteria.

3-10. It was recognized that considerable security should be provided for the dive initiation control. Some security is obtained by requiring a multi-tone command of specified duration. An additional feature requires arming of the remote dive control to be coincident with arming of the flying bomb's warhead. This was accomplished by using the warhead arming contact of the air-log counter to arm the dive control relay in the vehicle. Since arming occurs at some point distant from the launching ramp, dangerously premature dive cannot be commanded by enemy signal or friendly accident.

3-11. Beacon "off" control was accomplished by energizing a relay which shorts the beacon receiver's video output when the correct command has been received.

Mountings

3-12. All equipment designed for installation in the vehicle was tested for protection against the 40 cycle vibration due to the duct engine and an acceleration of 18g due to launching. As a result of these tests, special mountings were designed for the beacon and the command receiver. Rigid mounting was found to be satisfactory for the compass motor drive and the control relay box.

Flight Tests

3-13. In order to prosecute the program, it was necessary to convert an SNB-1 aircraft into a vehicle which simulated the flying bomb in flight.

The complete JB-2 electronic and flight control system was installed in the SNB and appropriate tie-in made to the rudder and elevator.

3-14. A test control station was set up at NRL using the AN/APS-2 radar for tracking and the AN/ARW-3 equipment for transmission of command. With this station and the simulated JB-2 aircraft, numerous bombing runs were made on a railroad bridge target at Fredricksburg, Virginia, range 43 miles. This range was chosen so that the elapsed time would correspond to the time of flight of the flying bomb to a range of 120 miles.

3-15. The simulated JB-2 aircraft was taken to Bedford, Massachusetts for extensive operational tests with the Airborne Early Warning System.

GENERAL DESCRIPTION OF SHIP EQUIPMENT

4-1. The shipboard equipment of the JB-2 remote control system performs the functions of tracking and of transmission of command.

TRACKING EQUIPMENT

4-2. The final phase of the JB-2 program will use the Airborne Early Warning system comprising, (1) an airborne, high powered, S-band, radar search system, (AN/APS-20), (2) a transmitting system for relaying radar signals from the AEW plane to the ship, (AN/ART-22), (3) equipment for receiving and displaying the relayed information, (PO), (4) associated radar beacon, (YQ), and identification, (AN/APX-13), and (5) auxiliary v-h-f communication and an associated radio relay.

4-3. The primary purpose of the AEW equipment is to extend the normal radar horizon by placing the radar set in an airplane and relaying the radar information to the AEW ship for presentation on the ship's indicators. By virtue of this, it is possible to track the beacon equipped flying bomb to its maximum range. Additional information on the AEW system may be obtained from Reference (b).

4-4. Initial phases of the program contemplated using the Navy model SP radar equipment. The SP is a shipboard, high powered, S-band, search radar system comprising conventional components of stabilized antenna, transmitter, modulator, receiver, console, and associated interconnecting and control equipment. Information on the SP may be obtained from Reference (c).

COMMAND TRANSMITTING EQUIPMENT

4-5. The command transmitting system, shown in the block diagram of Figure 4 and illustrated in Plate 3, includes the following units.

(1) T-24/ARW-3 is a crystal controlled transmitter with ten tone oscillators for frequency modulating an r-f carrier of assigned frequency between 30 and 42 megacycles. Only the five highest frequency oscillators, corresponding to channels 6, 7,

8, 9, and 10 are used in this system. For additional information see Reference (d).

(2) AM-10/ARW-3 is an amplifier unit used with transmitter T-24/ARW-3 to raise the power output of that unit from 25 to 250 watts. For additional information see Reference (d).

(3) 800-1-C is a motor alternator for converting power from 28 volts dc to 120 volts 800 cycles ac to provide power for amplifier, AM-10/ARW-3.

(4) J-174(XN)/ARW is a junction box for interconnection of the command transmitting system. Photographs of this unit are shown in Plates 7 and 8, and a schematic diagram in Figure 7.

(5) C-303(XN)/ASW is a flight control box for remote starting of the transmitting and amplifier units and for keying the twelve coded commands listed below. Photographs of this unit are shown in Plates 4, 5 and 6, and a schematic diagram in Figure 6.

A cabling diagram of the command transmitting system is given in Figure 8.

COMMAND CODES

4-6. Since only five tone channels were available it was necessary to set up coded combinations of these channels in order to provide the twelve separate commands required to operate three vehicles. The coded commands are tabulated below.

TABLE OF COMMAND CODES

VEHICLE	FUNCTION	TONE CHANNELS 6	7	8	9	10
1	Left Turn	X		X		
	Right Turn	X			X	
	Dive	X				X
	Beacon "off"	X				
2	Left Turn		X	X		
	Right Turn		X		X	
	Dive		X			X
	Beacon "off"		X			
3	Left Turn	X	X	X		
	Right Turn	X	X		X	
	Dive	X	X			X
	Beacon "off"	X	X			

GENERAL DESCRIPTION OF VEHICLE EQUIPMENT

4-7. The electronic equipment installed in the JB-2 vehicle performs the functions of reception of command and translation into the various controls. The electronic and flight control equipment is illustrated in Plate 9. Figure 12 is a complete schematic diagram of the JB-2 electronic control system. The additional equipment (including the modified compass) required to perform these functions is described below:

(1) RT-110/APN-33 is an S-band radar transpondor or beacon which has been adapted to operate from a 24 volt dc source. A circuit diagram is given in Figure 9. This unit, shown in Plates 10, 11 and 12, is located on the port side of the vehicle slightly forward of the autopilot. (See Figure 3 and the installation diagram of Figure 14). The genemotor shown in Plate 13, for supplying high voltage dc to the beacon, is separately installed directly aft of the batteries. Separate polycone antennas are used for beacon transmission and reception and are installed on both ends of the horizontal stabilizer as shown in Figures 2 and 20. Plate 14 is a photograph of a polycone antenna. Since this beacon is a modification of the AN/APN-7, information may be obtained from Reference (f).

(2) R-64/ARW-17 is a crystal controlled command receiver with five tone channel selectors for detecting a frequency modulated carrier between 30 and 42 megacycles. The five tone channels correspond to channels 6, 7, 8, 9 and 10 of command transmitter T-24/ARW-3. The five channel relays of this unit operate in response to the command tone combinations. This unit is shown in Plates 15 and 16, and an installation diagram is given in Figure 15. Additional information may be obtained from Reference (e). The receiver is fed by a balanced half wave dipole antenna for which Figures 18 and 19 are installation diagrams.

(3) The JB-2 compass has been modified to permit rotation in one degree steps through 360°, in either direction, when driven by an impulse motor. A 40" flexible shaft is provided for connection to the motor drive unit. Plates 17, 18 and 19 are photographs of the modified unit. An additional air-electric switch has been installed to provide faster slaving (faster rate of turn). The electrical wiring of the modified compass is shown in Figure 11.

(4) PU-95(XN-1)/ASW is a compass motor drive which incorporates a fast acting, reversible dc motor, and suitable gearing for coupling to the flexible drive shaft which makes one revolution per command impulse. Once per revolution, a cam switch on the output drive shaft opens the relay which controls rotation of the motor. As

shown in Figure 11, electrical connections to the compass are made through the motor drive unit. Photographs are shown in Plates 24, 25 and 26, and an installation diagram in Figure 17.

(5) C-296(XN-1)/ASW is a control relay box including three relays for controlling the compass motor drive unit, and one relay for firing the dive detonators. A selector switch is provided for setting up each of the three vehicle codes. The unit also serves as a junction box for the complete electronic system as shown in the schematic diagram of Figure 10. The unit is installed on the port side of the vehicle below the autopilot (see Figures 3 and 16). Plates 20, 21, 22 and 23 are photographs of the unit.

(6) A diagram of interconnections between all units of the electronic control system is given in Figure 13. These connections are made with open wires protected by vinylite sheathing.

OPERATION OF THE SYSTEM

5-1. Assembly of the flying bomb, installation and servicing of flight controls, and final check of the latter are described in Reference (a). Tuning and adjustments of the electronic control system are described in Section 9 of this report and installation of electronic equipment in Section 8.

5-2. A final check of the electronic control system is made prior to launching with the vehicle on the launching ramp. A test rack is provided for this purpose and it includes (1) Test Set TS-155c/UP, for beacon check, specifically for measuring transmitter and receiver frequency, transmitter power output and receiver sensitivity, (2) Test Set TS-306/ARW, which simulates the command transmitter and is used for checking the command receiver and the electronic control system, (3) a modified flight control box C-303(XN)/ARW, which has been adapted for keying Test Set TS-306/ARW to provide the coded commands and (4) an indicator panel which includes a meter for measuring slaving coil current and indicator lights for the four control functions: left turn, right turn, dive and beacon "off". Instructions for use of the test rack are supplied with it.

5-3. Special attention is directed to several adjustments which must be preset prior to launching. The control code (1, 2, or 3) must be chosen by setting the selector switch on the control relay box. The fast slave rate-of-turn must be set by adjustment of the potentiometer on the control relay box. The approximate course for interception of the target may be preset by rotation of the compass as described in Reference (a). This rotation may be performed through the electronic control system by keying the test rack with the appropriate commands. The time delay clock should be set for the required delay. This breaks the circuit for both slow and fast slaving currents until the clock has run to zero and thus prevents turning during the early period of flight. The timed turn clock is not used in the remote control system and should be set to zero.

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5-4. Launching instructions are provided in Reference (a). After launching the major function of tracking must be performed continually until the vehicle reaches the dive point. Tracking attention may have to be shared alternately between three vehicles, however a continual series of range and bearing readings must be taken on each vehicle, identifying it by means of its beacon "off" code. Since only instantaneous point readings are obtained from the search radar presentation, the readings must be transferred to a plotting chart so that successive points define the course or track of the vehicle in two dimensions. When the course has been so defined, the angle between the vehicle track and the bearing line between vehicle and target represents an azimuth error. To correct this error the appropriate turning command is transmitted to the vehicle. It is important that the command be transmitted on the code of the vehicle to be turned (as identified by its beacon). Commands are keyed by use of the flight control box as described in detail in Section 10. It must be noted that the vehicle, moving forward at a rate of 6 to 7 miles per minute, increases range during the e. ecution of an azimuth correction. This requires that the corrections commanded be somewhat greater than the error angle indicated on the plotting chart.

5-5. In the vehicle, the receiver relays respond to the command tones. These in turn operate relays in the control relay box for controlling the compass drive motor. When the compass is rotated to a new bearing and the correction is large (6° or greater), the insensitive air-electric switch closes causing fast slaving of the autopilot. Small corrections are made at slow slave rate. The autopilot operates the rudder through the air servo system (as previously described) to produce turning of the vehicle.

5-6. In addition to the target location, the plotting chart must show a point of dive, displaced from the target, to allow for the diving trajectory of the flying bomb. It is important to know and allow for this trajectory, since it is an accuracy determining factor over which the operator has no control. The dive trajectory is obviously a function of altitude which must be taken as the preset reading of the barometric height control. The final dive is initiated by transmitting the proper coded dive command. The dive initiating relay in the control relay box has a time delay of at least 0.1 second in order to pervent accidental closing on noise or interference and hence requires that the dive command be of greater duration. The dive function cannot be operated by radio command until it has been armed by the air-log counter. The contact used for warhead arming also arms the radio controlled dive at the chosen preset range. As an optional feature, dive may be preset to operate at some range in excess of the expected dive point by setting an additional count on the air-log counter. When preset this function is independent of the remote control system.

DETAILED DESCRIPTION OF SHIP EQUIPMENT

COMMAND TR.NSMITTER AND POWE. AMPLIFIER T-24/ARW-3 and AM-10/ARW-3

6-1. Description, operation and maintenance of the T-24/ARW-3 transmitter and AM-10/ARW-3 power amplifier are covered in detail in Reference

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(d). The power amplifier is used without modification. In all cases one modification is necessary in the T-24/ARW-3 transmitter. Pin N of receptacle J-204 should be connected to pin 5 (plate) of relay Tube V-208. This modification enables the carrier control relay K-201 to be controlled remotely from the flight control box C-303(XN)/ARW. In some cases it may be necessary to rewire the power receptacle J-205 so that it agrees with the receptacle for serial numbers 101 and up of Figure 8-8 in the instruction book, Reference (d). For remote operation the FILAMENT and PLATE switches on both the transmitter and the power amplifier must be in the ON position and the TUNE-OPERATE switch on the power amplifier must be in the OPERATE position.

FLIGHT CONTROL BOX- C-303(AN)/ARW

6-2. The flight control box, finished in black-crackle, water-resistant paint, is a rectangular aluminum box with a sloping top. All the controls are mounted on the top panel. At one end is a receptacle, type AN-3102-36-1P, fitted with a plug, type AN-3108-36-1S, for the cable running to the junction box. The control box is shown in Plates 4 and 5. Plate 5 shows the controls mounted on the box. The top panel has been removed and the internal wiring is shown in Plate 6. The control box is used to control the power and to key the modulation channels of a T-24/ARW-3 transmitter and an AM-10/ARW-3 amplifier from a remote point. The power controls along the left hand side of the box are: the reset for a 10 ampere circuit breaker through which all of the 28 volt dc power flows, the FILAMENT switch which controls the filaments of the T-24/ARW-3 transmitter, the AMPLIFIER switch which controls the 800-1-C motor alternator furnishing power for the AM-10/ARW-3 power amplifier and the CARRIER switch which determines whether the T-24/ARW-3 transmitter carrier is on constantly or is keyed on by the modulation. Referring to Figure 6, the control box schematic diagram, it is seen that neither the T-24/ARW-3 plate nor the AM-10/ARW-3 power can be turned on unless the FILAMENT switch is closed. It will also be noticed that the pilot light is turned on only when all three power switches are on, indicating that all units have power to them. The CARRIER switch grounds one end of a 20,000 ohm resistor mounted in the box. The other end of this resistor goes, through the control cables and junction box, to the carrier control relay K-201 of the T-24/ARW-3 transmitter. In the CONSTANT position the CARRIER switch grounds the 20,000 ohm resistor completing the circuit energizing the carrier control relay. The control box makes the combinations of the modulation channels of the T-24/ARW-3 transmitter tabulated in Paragraph 4-6. From this table it is seen that for vehicle 1 the code channel is 6, for vehicle 2 channel 7 and for vehicle 3 channels 6 and 7 simultaneously. The three position rotary switch marked CODE SELECTOR makes connections in the box so that selected code channels are sent whenever a command is sent. The BEACON switch operates only the code channels which also turn the beacon off. Note that the beacon is turned off whenever any command is sent as the vehicle code channels are sent with every command signal. Channels 8 and 9, those for left and right turn respectively, are selected by the switch marked LEFT-RIGHT. No turn can be sent when the LEFT-RIGHT switch is in the center or off position.

The LEFT-RIGHT selector switch does not in itself send a turn signal but selects the turn signal to be sent when either the MANUAL TURN switch or the DIAL TURN switch is operated. Although the selected turn signal is sent as the MANUAL TURN switch is held down, only one degree of rotation is commanded for each signal regardless of its duration. The DIAL TURN switch is used to send a series of modulation impulses corresponding in number to digit dialed. To circumvent possible trouble caused by the carrier control relay K-201, of the transmitter T-24/ARW-3 not following the dial pulsing, constant carrier is switched on by two contacts, in parallel with the CARRIER switch on the control box, which close whenever the dial is displaced from its rest position. Channel 10, the dive channel is controlled by the DIVE switch which is protected from accidental operation by a switch guard. Referring to the diagram in Figure 6, it is seen that the break contacts of the BEACON switch make it impossible for a turn signal to be sent by the BEACON switch even when the LEFT-RIGHT switch is in the left or right position. As the DIVE switch does not have this protection THE LEFT-RIGHT SWITCH MUST BE IN THE CENTER OR OFF POSITION WHEN A DIVE COMMAND IS SENT. As shown in Figure 12 the DIVE SECURITY relay can not operate if either the channel 8 or 9 relay of the receiver is closed.

JUNCTION BOX J-174(XN)/ARW

6-3. The junction box is a rectangular aluminum box finished with black-crackle, water-resistant paint. Plates 7 and 8 show this unit which is used to interconnect the power and control leads of the T-24/ARW-3 transmitter, the AM-10/ARW-3 power amplifier and the C-303(XN)/ARW flight control box used for the transmission of command to the JB-2 flying bomb. On one side of the box is a receptacle, type AN-3102-36-1S, fitted with a plug, type AN-3106-36-1P, for the cable from the flight control box C-303(XN)/ARW. On each of the other sides of the junction box there are two type AN-3064 fittings with AN-3057 cable clamps through which the remaining cables enter the box. On one side there is also a 125 ampere circuit breaker, K-101. The box contains four terminal boards: E-101, E-102, E-103 and E-104. The terminals on E-101 correspond to the terminals of the power plug AN-3108-24-12S for the power amplifier AM-10/ARW-3. The terminals on E-102 correspond to the terminals of the power plug AN-3108-20-4S of the driver unit T-24/ARW-3. E-103 is for the input and output 28 volts dc. The terminals of E-104 correspond to the terminals of the control plug AN-3108-28-2P for the driver unit T-24/ARW-3. Figure 7 is a wiring diagram of J-174(XN)/ARW while Figure 8 shows the cabling for the junction box and command transmitting equipment.

INTERCONNECTIONS

6-4. The interconnections are of AN approved open wiring. Figure 4 shows a block diagram of the units and interconnecting cables and Figure 8 shows the individual wires and sizes for each cable.

DETAILED DESCRIPTION OF VEHICLE EQUIPMENT

BEACON RT-110/APN-33

7-1. The RT-110/APN-33 is a converted AN/APN-7 radar transpondor beacon.

See Plates 10 and 11. It operates from a 28 volt dc. supply which maintains the input voltage to the beacon at 18 volts (nominal). All power, except filament power, is supplied by a genemotor, Plate 13, the required negative voltages being obtained by introducing a bleeder in the high voltage return lead to the genemotor. The equipment uses two antennas and therefore contains no TR box. Each antenna feed line is matched by means of a tunable quarter wave stub. See Plates 10 and 12.

7-2. The receiver is a superheterdyne with an i.f. of 30 megacycles which is approximately 12 Mc wide at 6 db down. The receiver sensitivity is approximately 76 db below 6 mw. It is tunable over a range of approximately 50 Mc from the front panel, but can be tuned from approximately 2600 Mc to approximately 3000 Mc by means of an internal adjustment. See Plates 11 and 12.

7-3. The modulator is a thyratron (2D21) which is coupled to the transmitter circuit by means of a pulse transformer. The maximum repetition rate to which the modulator can respond is approximately 3000 pps. and at p.r.f.'s above 2000 pps, the transmitted power is somewhat reduced. The transmitter is a 2C43 light house tube in an AN/APN-7 cavity. The transmitted pulse is approximately 1 microsecond wide with a peak power in excess of 200 watts. The tuning range of the transmitter from the front panel, like that of the receiver, is rather limited, but complete coverage of the 2750 to 2950 Mc range is obtainable by internal adjustments.

7-4. The filament circuit of the AN/APN-33 is a series-parellel combination consisting of three 6.3 volt banks in series across 18.9 volts. The total power drain of the unit is approximately 6.5 amperes from the 28 volt source. If the carbon pile regulator is properly adjusted, the equipment may be operated from any voltage between 23 and 28 volts. Details of the circuit are shown in the schematic diagram of Figure 9.

7-5. The beacon receiving and transmitting antennas are identical. Each consists essentially of a circular, solid dielectric (polystyrene), wave guide fed by a probe from a 50 ohm coaxial cable and matching section. The open end of the wave guide is terminated in a truncated cone of the dielectric. See Plate 14. This construction gives a conical radiation pattern approximately 70 degrees wide at the half power points.

COMMAND RECEIVER R-64/ARW-17 AND ANTENNA

7-6. Description, operation and maintenance of the R-64/ARW-17 receiver are given in detail in Reference (e). The balanced input of the receiver lends itself to use of a doublet antenna. Installed on the JB-2 bomb, the two legs of the doublet running from the fuselage out to each wing tip form a V as seen in Figure 18. The antenna is connected to the wing tips by means of a hook, a tension insulator and a strain insulator shown in Figure 19. Each leg of the antenna enters the fuselage through a stand-off, feed-through insulator mounted on the skin of the ship. A piece of 50 ohm coaxial cable (RG-8/U) runs from each leg of the antenna to a Y-connector. The other end of the Y-connector is joined to a piece of RG-22/U 95 ohm balanced cable which feeds the balanced input of the R-64/ARW-17 command receiver. Details of the antenna installation are shown in Figures 18 and 19.

MODIFIED JB-2 COMPASS

7-7. The JB-2 compass shown in Plate 17 is a magnetic compass which has a differential air pick-off controlled by a cam attached to the needle shaft. In the on-course position the air pressures from each side of this pick-off are equal. When the needle is displaced from the on-course position a pressure differential is developed between the two sides of the pick-off. These two pressures are brought to opposite sides of a diaphragm type air-electric switch. The air-electric switch is essentially a single pole three position switch; the diaphragm being the moving contact which, when displaced, touches one of the contacts placed on either side. Actually there are two of these air switches with their air supplies in parallel. One of the switches is sensitive to a pressure differential equivalent to approximately ± 0.5 degrees displacement of the compass needle. When the air switch closes it completes a circuit putting current through one of the two slaving coils which applies a torque to the main gyro in the autopilot. The gyro, precessing under the influence of this torque, applies azimuth correction to bring the vehicle on course. The slaving coil current controlled by this switch turns the vehicle at the rate of approximately 3 degrees per minute. In order to turn the vehicle at a faster rate, when large turns are desired, the second air switch, made sensitive ± 6 degrees displacement of the compass, controls a larger slaving current which turns the vehicle at a rate adjustable up to 60 degrees per minute. Plate 18 shows the air hose connections to the two air switches one of which is labeled sensitive and the other labeled insensitive. In Plate 19 the electrical connections to the switches are shown.

7-8. The electrical schematic wiring and the cable for the compass are shown in Figure 11. The electrical connections between the compass air switches and the autopilot are shown in Figure 12. Note: The wiring of the autopilot has been modified by bringing a wire out to pin A of the autopilot receptacle. This modification was necessary to return the movable contact of the insensitive, fast slave air switch to ground through the time delay clock. There is an interlock in the delay time clock which prevents current flow through the slaving coils until after a preset time delay. It is thus impossible to turn the vehicle by compass influence until time has elapsed for it to have gained cruising speed and altitude.

7-9. A change in course is dictated by rotating the compass bowl which changes the position of the stationary part of the differential air pick-off. The compass bowl is rotated by means of the large 360 tooth ring gear and worm drive shown in Plates 18 and 19. One revolution of the worm, turned by the compass motor drive through a flexible drive shaft, rotates the compass bowl one degree.

COMPASS MOTOR DRIVE PU-95(XN -1)/ASW

7-10. The compass motor drive consists of a reversible dc motor with magnetic clutch coupling to the output shaft, a Lear, Inc. model AA 100, driving a 14:1 reduction gear box. The final driven shaft turns a cam switch and also has a fitting to receive the flexible drive shaft from the compass. The cam switch is part of an electrical lock-up which furnishes power to the motor until the cam shaft has made one complete revolution. This cam switch enables the drive unit to operate on impulses giving one revolution of the output shaft in 0.06 to 0.07 seconds. There are two receptacles mounted on the unit. One, type AN-3102-18-1P connects to the control relay box, the other type, AN/3102-14S-5S connects to the cable running to the compass. The wiring of the motor drive is shown in Figure 11. Note that the motor has a center tapped field winding and the direction of rotation is determined by the half of the field which is energized.

CONTROL RELAY BOX C-296(XN-1)/ASW

7-11. The control relay box, a rectangular box finished in black-crackle paint, is shown with its mounting bracket M-517/ASW in Plate 20. Three AN type receptacles are mounted on one end of the box and three receptacles and two slotted shaft screw driver adjustments are mounted on one of the sides as shown in Plates 20, 21, 22 and 23. The unit serves as a junction box for the complete electronic control system and contains the impulsing circuits for the compass motor drive PU-95(XN-1)/ASW, the vehicle command code selector switch, and the dive security relay. Figure 10 shows the complete wiring of the relay box. The AN receptacles and their functions are tabulated below:

AN RECEPTACLES OF CONTROL RELAY BOX

RECEPTACLE LABEL	RECEPTACLE TYPE	CABLE NO.	UNIT CONNECTED
COMPASS	AN-3102-18-1S	1	Compass Motor Drive PU-95(XN-1)/ASW
AUTOPILOT	AN-3102-18-8S	4	Autopilot
COUNTER	AN-3102-18-12P	3	Counter Box
BEACON	AN-3102-16S-8S	2	Beacon RT-110/APN-33
RECEIVER	AN-3102-22-14S	5	Command Receiver R-64/ARW-17
TEST	AN-3102-20-1S		External Test Instruments

7-12. The slotted shaft labeled CODE SELECTOR is a three position, rotary, wafer switch which selects the command code for the vehicle. The slotted shaft labeled TURN RATE adjusts the fast turn rate of the vehicle. This adjustment is the variable resistor, R_1 in Figures 10 and 12, which controls the current through the autopilot slaving coils for fast slaving.

7-13. Of the four relays in the box, one, the dive security relay, is a slow make type used to initiate the dive. The delay action of the relay is protection against a burst of static or noise causing a premature dive. To prevent accidental diving of the vehicle near the launching area, the circuit from the dive relay contacts to the dive detonators is completed through the warhead arming circuit. See Figure 12. The warhead is armed by the mechanical counter actuated by the air log as described in Reference (a). Referring to Figure 12 it is seen that the dive detonator can also be controlled by one of the cams of the mechanical counter. This allows the vehicle to be put into its dive at a range preset on the counter. Note: A preset range for dive greater than that anticipated must be set on the counter to make certain that the dive will be controlled remotely, Reference (a) describes the method for setting the dive range on the counter.

7-14. The other three relays comprise the impulsing circuit for the compass motor drive PU-95(XN-1)/ASW. The anti-jam relay, energized in standby, is a slow opening type. As seen in Figures 5 and 12 the circuits to the left and right impulse relays are made through the contacts of the slow release anti-jam relay. As the left and right impulse relays are self locking only a momentary impulse is required from the contacts of the anti-jam relay. One set of contacts of the impulse relays furnish power to the compass motor drive. After one revolution of the compass drive shaft the camswitch momentarily breaks the circuit to the impulse relay coil, thus unlocking the relay and shutting off the power to the drive motor. The function of the anti-jam relay is to convert any signal or more than sufficient length to a short impulse for the motor drive. Figure 5 shows schematically the impulsing and anti-jam system and Figure 12 shows in detail the wiring, including the tone channel coding from the command receiver relays.

7-15. The TEST receptacle affords means for a preflight check of the electronic control system. By plugging proper test instruments into the TEST receptacle the battery voltage, the voltage across the left and right slaving coils for fast and for slow slave, and the operation of the left and right impulse relays may be checked. The connections to the TEST receptacle are shown in Figures 10 and 12. Note that the delay time clock on the autopilot must be set at zero in order to energize the slaving coils. In subsequent models it will be possible to check the beacon operation and the dive relay operation by leads which are to be brought out to presently unused pins of the TEST receptacle.

INTERCONNECTIONS

7-16. The interconnections are of AN approved wires strung in cables through vinylite tubing. The cable and wire specifications and a block diagram of interconnections are shown in Figure 13. The following modifications to the JB-2 electrical wiring have been made for the adaption of remote control:

(1). The compass bowl has been modified so that it may be rotated by means of the compass motor drive PU-95(XN-1)/ASW .

(2). Wires to the compass air switches now pass through the motor drive unit.

(3). An insensitive air switch which controls slaving current for fast turns has been added to the compass. A connection to Pin A of the auto-pilot receptacle has been made to return the fast turn air switch through the time delay clock.

(4). The control relay box C-296(XN-1)/ASW is now the main junction box rather than the counter box. Cables from the autopilot and compass enter the control relay box.

(5). Originally all the electrical power for the JB-2 went through the MASTER switch and the LAUNCHING switch in series. Now the power for all the electronic remote control equipment: the command receiver, the beacon, the compass and motor drive, the slaving coils, and the control relay box is controlled only by the MASTER switch. This enables a preflight test to be made of the electronic control system.

(6). The circuit for remote control of the dive by means of the dive relay is made through the warhead arming circuit. This makes it impossible to initiate dive unitl the warhead has been armed by the air log and counter.

(7). A doublet antenna for the command receiver is installed from the wingtips to the fuselage as shown in Figures 3, 18 and 19.

(8). Polycone antennas for the beacon are mounted at the tips of the horizontal stabilizer as shown in Figures 3 and 20, and the beacon antenna cables are brought into the fuselage of the vehicle through the inside of the horizontal stabilizer.

INSTALLATION OF VEHICLE EQUIPMENT

8-1. The beacon RT-110/APN-33 is installed on the port side of the vehicle behind the rear air sphere as shown in Figure 3. The exact location of the beacon and the method of mounting by means of spring shock mounts are shown in Figure 14. There is no detailed drawing showing the mounting of the beacon genemotor but Figure 3 shows its location. The genemotor is mounted rigidly to the plate above the battery compartment.

8-2. The polycone beacon antennas are mounted at the tips of the horizontal stabilizer as shown in Figure 3. Figure 20 shows the details of mounting these antennas.

8-3. After mounting the beacon and its genemotor, cable No. 2 of Figure 13, the power and control cable from the control relay box, should be connected to the receptacle on the beacon marked 28 VDC. One end of cable No. 6 of Figure 13 should be connected to the beacon receptacle marked DYN and the other end to the receptacle on the genemotor. See Plates 10 and 11. Cables No. 7 and 8 of Figure 13, the antenna cables for the beacon should be connected one to the beacon receptacle marked XMTR and the other to the receptacle marked RCVR. See Plates 10 and 11. Note: The toggle switch labeled OFF ON must be left in the ON position in order for the beacon to operate when the MASTER switch is turned on.

COMMAND RECEIVER R-64/ARW-17

8-4. The command receiver R-64/ARW-17 is installed directly above the batteries as shown in Figure 3. The exact location and the method of mounting with spring shock mounts are shown in Figure 15. Before mounting in the vehicle the dust cover of the receiver must be removed and cable No. 5, Figure 13, the power and relay connection cable, attached to the receiver receptacle J-101 shown in Figure 4 -1 of Reference (e). The dust cover should then be replaced and the cable brought out through the notch in the top front edge of the cover. After mounting in the vehicle the antenna cable, cable No. 9 of Figure 13, should be attached to the two conductor antenna receptacle which protrudes through the cover as shown in Plate 15.

8-5. The antenna for the command receiver is in two sections, each of which is strung from a wingtip to the fuselage as shown in Figures 3 and 18. Details of mounting the antenna and antenna cable are shown in Figure 19. The cabling diagram of Figure 13 shows the lengths and types of cable to be used for the antenna.

MODIFIED COMPASS

8-6. The modifications made to the JB-2 compass do not alter its mounting which is in the nose section as described in Reference (a).

COMPASS MOTOR DRIVE

8-7. The compass motor drive PU-95(XN-1)/ASW is located in the nose section as shown in Figure 3. The mounting M-518/ASW for the compass motor drive is rigidly riveted to the skin of the vehicle as shown in Figure 17. One end of the flexible drive shaft is fastened to the fitting on the motor drive and the other end to a similar fitting on the compass. The cable from the compass is connected to the receptacle labeled COMPASS on the motor drive while cable No. 1 from the control box, Figure 13, is connected to the receptacle labeled RELAY BOX on the motor drive.

CONTROL RELAY BOX

8-8. The control relay box C-296(XN-1)/ASW is mounted on the lower port side of the vehicle, below and to the side of the autopilot as shown in Figure 3. The mounting M-517/ASW for the control relay box is riveted rigidly to the skin of the vehicle as shown in Figure 16. Cables No. 1 through No. 5, Figure 13, are connected to the proper receptacles on the control relay box.

TUNING AND ADJUSTMENTS

COMMAND TRANSMITTER T-24/ARW-3 AND POWER AMPLIFIER AM-10/ARW-3

9-1. Complete instructions for alignment and adjustment of the transmitter and power amplifier are given in Reference (d).

BEACON RT-110/APN-33

9-2. The procedure required for bench checking the beacon is as follows: With the equipment connected to a 28 volt dc supply and having been allowed to run for a 5 minute warm up period, the receiver frequency is adjusted to the desired value. Initial adjustments are made using a one-milliampere meter connected to an ordinary phone plug. The crystal current will change when the local oscillator frequency is changed. When the local oscillator is finally set to the proper frequency, the crystal current should be adjusted to some value between 200 and 500 microamperes by varying the depth of the local oscillator feed probe into the crystal mixer cavity.

9-3. There are two methods by which the local oscillator can be set to proper frequency. One method is to disconnect the local oscillator coaxial cable feed from the crystal mixer, insert a six inch piece of wire into the center conductor of the loose Sperry fitting and bring a wavemeter, such as the TS-46/AS, (which also should have a small antenna projecting from it) near the wire. A strong reading should show on the meter. The frequency of the local oscillator should then be set to a frequency either 30 Mc above or 30 Mc below the radar frequency. There will be no crystal current reading while this is being done, but if no wavemeter deflection is obtained after any change of local oscillator frequency, the coax should be reconnected to the mixer cavity and the cathode bias potentiometer of the 2K28 readjusted until crystal current is again obtained. (The potentiometer is adjusted for maximum crystal current). Normally, failure to oscillate will not occur unless rather extreme changes of frequency are made. If the desired frequency is not attainable from the front panel it is only necessary to adjust the one odd slug in the local oscillator cavity to attain it.

9-4. The alternative method of setting the receiver on frequency is to use a signal generator and an oscilloscope. An ordinary 3" oscilloscope should be sufficient but a synchroscope would be more desirable if the signal generator can be synchronized from it. The synchroscope could then be used as a pulser when tuning up the transmitter. The procedure in either case would be to present the receiver output on the scope and, with the signal generator set to the radar frequency, tune the receiver to maximum signal on the scope. It is very convenient at this point in the process of tuning to adjust the tuning stub unitl a maximum signal is seen on the scope. As in the other method of tuning, the crystal current should be observed when any change of local oscillator frequency is made.

9-5. When the frequency is properly set, the receiver output is connected to the upper half of the chassis through the short green cable and the signal generator output is attenuated until the magic eye does not quite close. At this point the signal level at the receiver should be at least 70 db below 6 mw. If the sensitivity should be below this value, it may be increased by reducing the bias on V106-1. This reduction must be done carefully in order to avoid reaching the point at which ripple from the genemotor commutator causes firing of the 2D21 modulator. The test for such a condition is to turn off the signal generator and note whether or not a pulse can be seen at terminal #5 of the 3-winding pulse transformer or at the plate of the transmitter tube, both of which are accessible. If the required sensitivity cannot be attained by this adjustment, the crystal should be examined. It is entirely possible to have good crystal current but poor sensitivity.

9-6. In tuning the transmitter, a positive pulse of 20 volts or more is introduced into the coaxial jack marked CODER IN. The pulse width is not important. If the magic eye is closed, the transmitter should be operating. The TS-46/AP (or similar) wavemeter is brought near the transmitter antenna and then the frequency is adjusted to the desired value. If the desired frequency cannot be attained from the front panel, the black bakelite wheel just inside the panel may be adjusted. WARNING--- a pulse voltage of 1200 to 1400 volts is present near the bakelite wheel.

9-7. It is possible that the desired frequency may not yet be attainable, particularly if AN/APS-20 frequencies are required. Normally, the transmitter will not cover the entire band, including both SP and APS-20 frequencies. The units are shipped to operate on the lower band (SP). If it is required to operate on the higher band, the light house tube should be removed and the grid cylinder, which will probably be found set on its first groove, moved to its second groove. The proper frequency should then be attainable.

9-8. In checking power, any standard method of measuring peak power may be used. While the power adjustment is being taken, the stub tuner should be adjusted for maximum power output. Where the repetition rate is 2000 pps or greater a simple check involves the use of 1/25 watt neon bulb. In such a case, the power should be sufficiently high if it is possible to light the neon bulb at the surface of the antenna. If the power output is not sufficient, it can be raised by increasing the coupling to the transmitter cavity. This coupling must not be increased too much for two reasons: (1) Loss of output, instead of gain, results if coupling is too close. (2) Frequency instability results from too tight coupling. It should be remembered that changing the coupling affects the frequency. Therefore, the frequency should be rechecked after any change of coupling.

COMMAND RECEIVER R-64/ARW-17

9-9. Complete instructions for alignment and adjustment of the command receiver are given in Reference (e).

MODIFIED COMPASS

9-10. The air electric switches mounted on the compass are single pole three position switches. The diaphragm, the moving contact, is electrically common to most of the air switch structure and one of the rim screws is made a terminal as seen in Plate 19. On each side of the switch is a piece of insulating material with a screw passing through its center. See Plates 18 and 19. These screws are the fixed terminals with which the moving diaphragm makes contact. With no pressure differential applied to the switch the diaphragm should make contact with neither side terminal. Under pressure differential the diaphragm moves toward one or the other side contacts and the sensitivity of the switch is determined by the spacing of the side contacts from the diaphragm in its undeflected position.

9-11. To check and adjust the air switches a U-tube water manometer, a rubber bulb and an electrical continuity indicator are needed. After disconnecting the air hoses from one of the switches connect both of the hose connections of this switch to the water manometer. Insert a T connection in one of these hose lines and attach the rubber bulb. A closed system now exists and squeezing the rubber bulb will apply a differential pressure to the air switch as indicated by the water manometer. The pressure differential indicated by the water manometer is increased until the switch closes as indicated by the electrical continuity meter. The other side of the switch may be checked by inserting the T connector and bulb in the other air line.

9-12. The sensitive or slow slave air switch should be adjusted, by means of screws on the side contacts (See Plate 18), to close on a pressure differential of 0.62 ± 20% cm of water. The insensitive or fast slave air switch should be adjusted to operate on a pressure differential of 8 ± 10% cm of water. The following table summarizes the adjustments for obtaining the required deflection sensitivities of the compass:

	Pressure in cm of water	Compass Displacement in Degrees
Supply to differential air valve	30 ± 10%	
Maximum pressure differential from air valve	14 ± 10%	± 8 and over
Differential pressure to operate sensitive or slow slave air switch	0.62 ± 20%	± 0.5
Differential pressure to operate insensitive or fast slave air switch	8 ± 10%	± 6

9-13. Reference (a) describes methods for additional adjustments to the compass and autopilot.

CONTROL RELAY BOX C-296(XN-1)/ASW

9-14. The TURN RATE should be adjusted to give the desired rate of turn in the manner described in Reference (a) for adjusting the slaving rates.

OPERATING PROCEDURE FOR TRANSMISSION OF COMMANDS

TURNING ON COMMAND TRANSMITTING EQUIPMENT

10-1. Determine that the FILAMENT and PLATE switches on the transmitter T-24/ARW-3 and power amplifier AM-10/ARW-3 are in the ON position, that the CARRIER switch on the transmitter is in the KEYED CARRIER position and that the TUNE-OPERATE switch on the power amplifier is in the OPERATE

10-2. Turn on the main power switch K-101 mounted on the side of the junction box J-174(XN)/ARW. On the flight control box C-303 (XN)/ARW turn on the FILAMENT switch, and wait one minute. Turn on the PLATE switch and the AMPLIFIER switch; then the pilot lamp should light. Wait 2 minutes to allow time for the thermal relay in the plate circuit of the power amplifier to close. For normal operation the CARRIER switch should be in the KEYED position. The system is now ready for operation.

OPERATION OF TRANSMITTING EQUIPMENT

10-3. The search radar is used to track the course of the vehicle to be controlled. As the vehicle carries a beacon whose response may be extinguished by operation of the beacon switch on the flight control box, the vehicle's response on the radar display may be identified. After finding the vehicle's response on the radar take a series of position readings and plot the vehicle's track. From the track plotted determine the azimuth correction necessary to bring the vehicle on a course to the target. Send this azimuth correction by means of the dial on the flight control box. Set the turn selector switch to the right or left, whichever turn is necessary, and dial the required number of degrees of turn. Allow time for the vehicle to complete its turn (rate of turn for large turns is 10 to 60 degrees per minute as preset by TURN RATE adjustment) and again plot its course to see if additional azimuth correction is necessary. The course of the vehicle must be continuously plotted and corrected and when the vehicle has approached the target to the dive point the dive command is sent by operating the dive switch on the flight control box. The operation described above assumes only one vehicle to be under control. The channel coding of the command system makes it possible to control three vehicles simultaneously. The vehicles are launched successively and each of the three vehicles is set on a different command code. On the radar display the responses of all three vehicles will appear the same. Control of the beacon response is the method used for identification. With the CODE SELECTOR switch set to Code 1 operate the BEACON switch and notice which missile response is extinguished. Identify the vehicles on Code 2 and Code 3 in the same manner. Take position readings, plot the courses, and determine the azimuth corrections for each. When sending command signals to a vehicle the CODE SELECTOR switch must be in the position corresponding to vehicle's code. As each vehicle arrives at the dive point send the dive command on the appropriate code.

ACKNOWLEDGMENTS

Acknowledgment is made to Dr. E. H. Krause and Mr. C. H. Smith, Jr. for their encouragement and guidance. Dr. E. H. Harrington was largely responsible for the development of beacons used in this project. The success of the numerous flight tests was aided by the services of H. C. Hanks, Lt. (jg) U.S.N.R. Mr. C. H. Hoeppner directed the tracking tests with the Airborne Early Warning System at Bedford, Massachusetts. The modification of the SNB aircraft to simulate the JB-2 flying bomb was performed by NAMU.

REFERENCES

(a) Assembly, Preparation and Launching of Pilotless Aircraft Type JB-2 T.O. No. 11-75BA-3

(b) Handbook of Maintenance Instructions for Airborne Early Warning System CO-NAVAER 16-5QS-501

(c) Section II Instructions for Navy Model SP Radar Equipment

(d) Handbook of Maintenance Instructions for Models AN/ARW-2, AN/ARW-2X and AN/ARW-3 Aircraft Radio Equipment CO-AN 08-20-10

(e) Handbook of Maintenance Instructions for Radio Receiver Unit R-64/ARW-17 CO-AN 08-25R64-2

(f) Handbook of Maintenance Instructions for Model AN/APN-7 Radar Transpondor Beacon CO-AN 08-20APN7-2

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R-2616

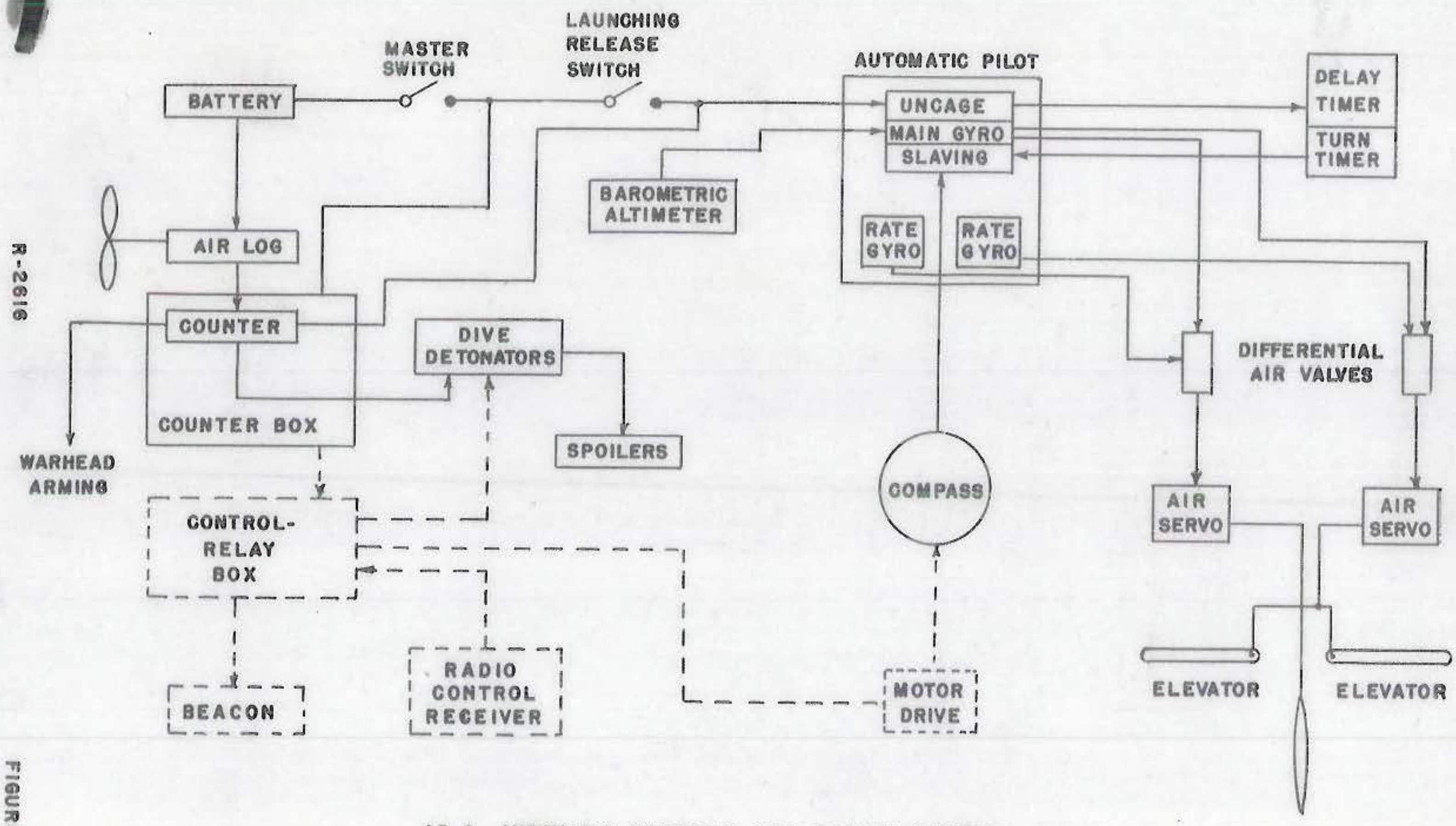

FIGURE I

JB-2 AUTOMATIC CONTROLS AND REMOTE CONTROL TIE-IN

BLOCK DIAGRAM

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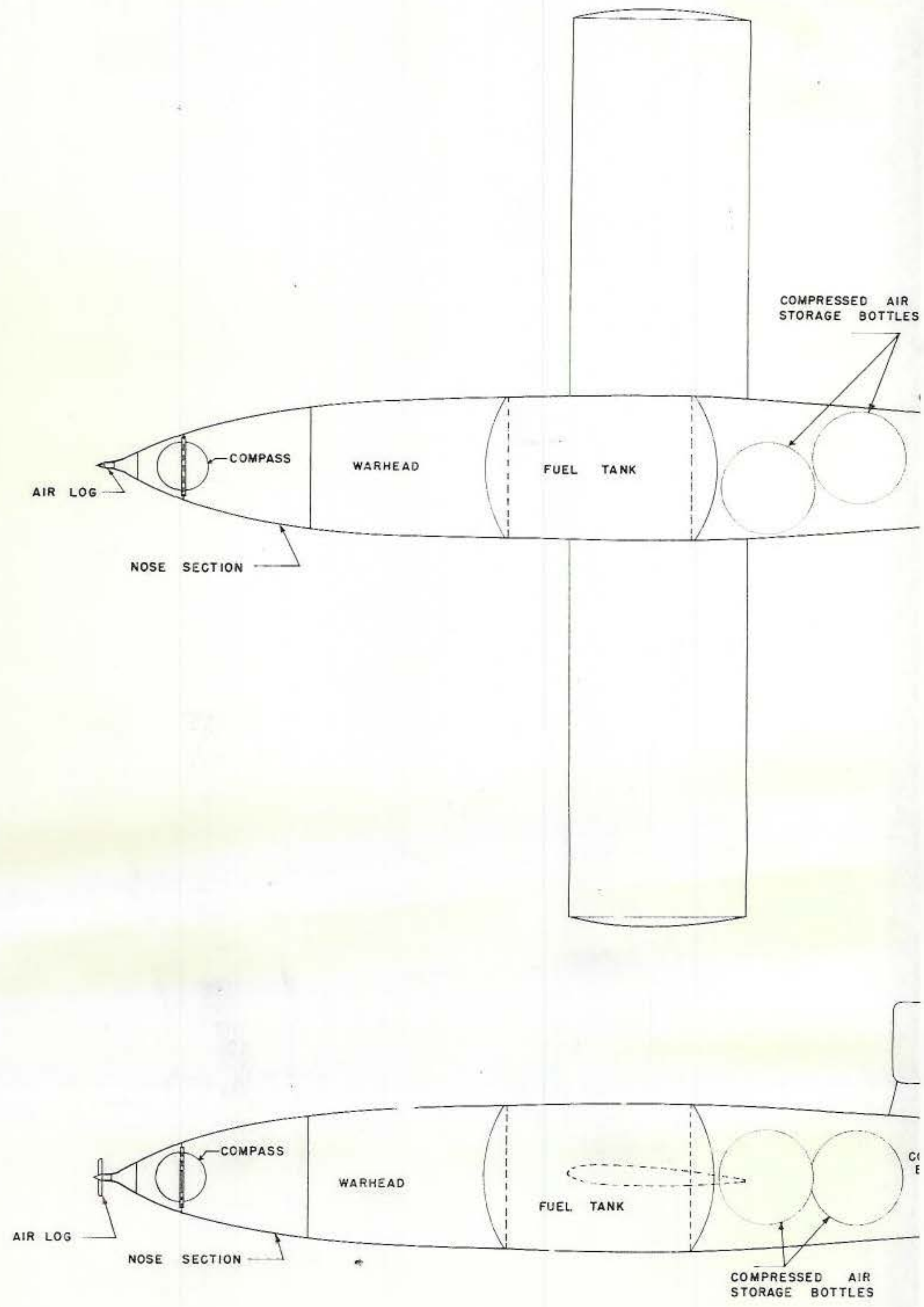

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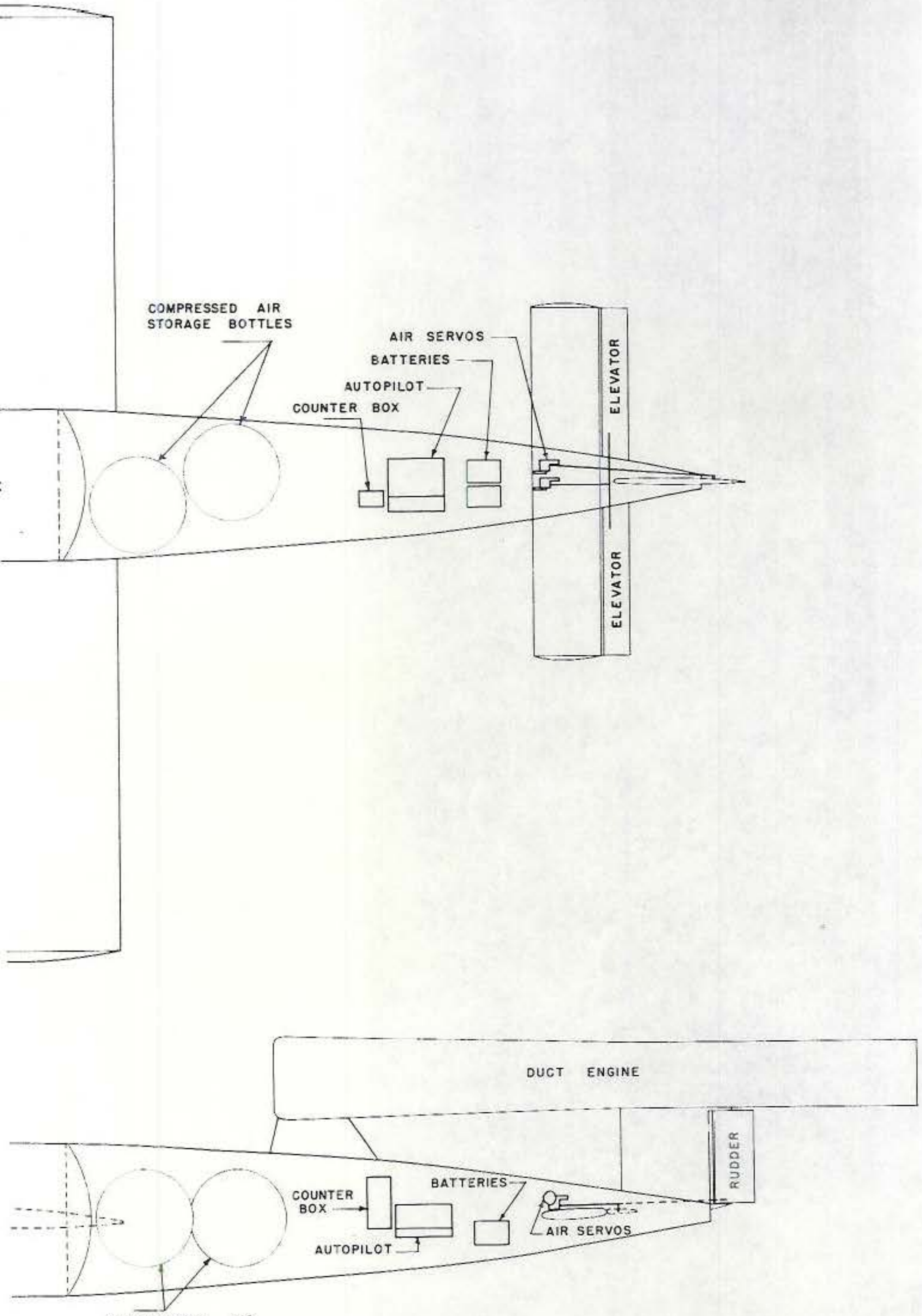
1 of 2



U. S. NAVAL RESEARCH LABORATORY WASHINGTON 20, D. C.		SCALE	JB-2 FLYING BOMB, LOCATION OF FLIGHT CONTROLS, SCHEMATIC DIAGRAM	
		DR'WN.		
B'LD'G.	PHONE	CH'K'D.		FIGURE 2
ROOM	DATE	APPR'V'D.	UNLESS OTHERWISE SPECIFIED, TOLERANCES ARE ±	SHEET OF

R 2616

2 of 2

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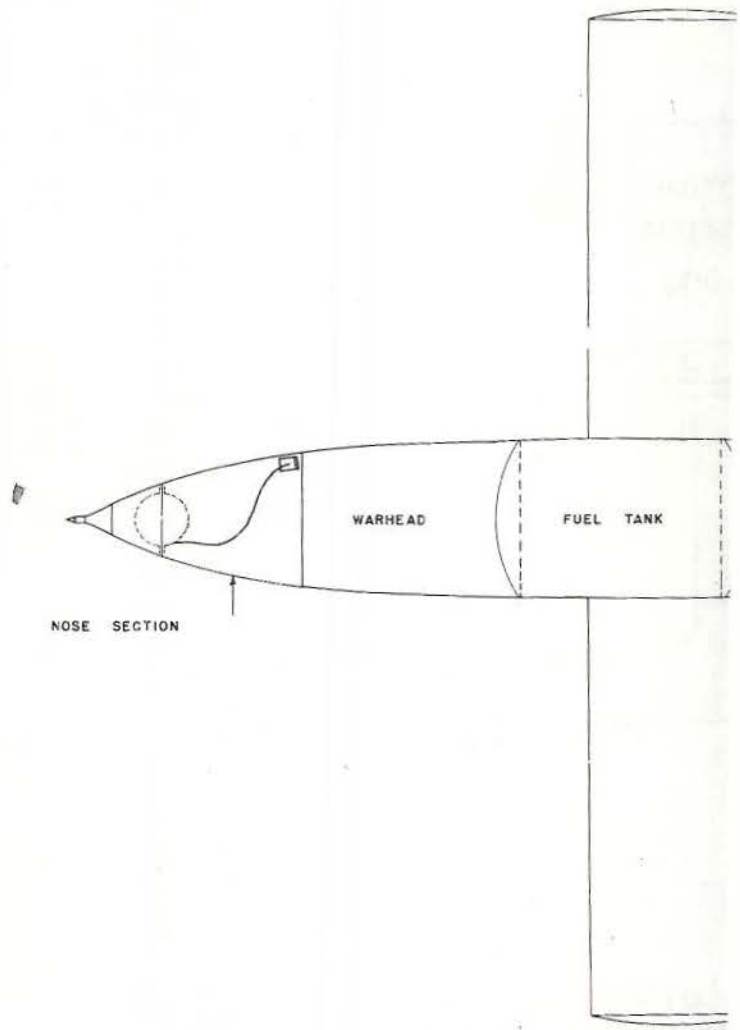

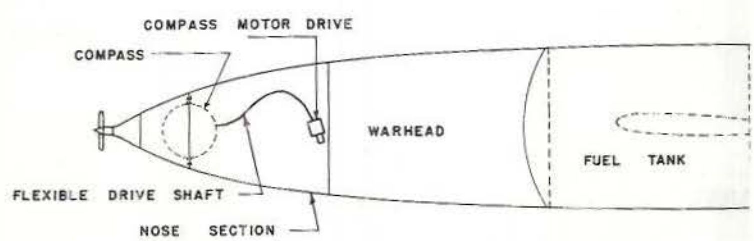

NOTE: Flight controls of Figure 2 shown dot

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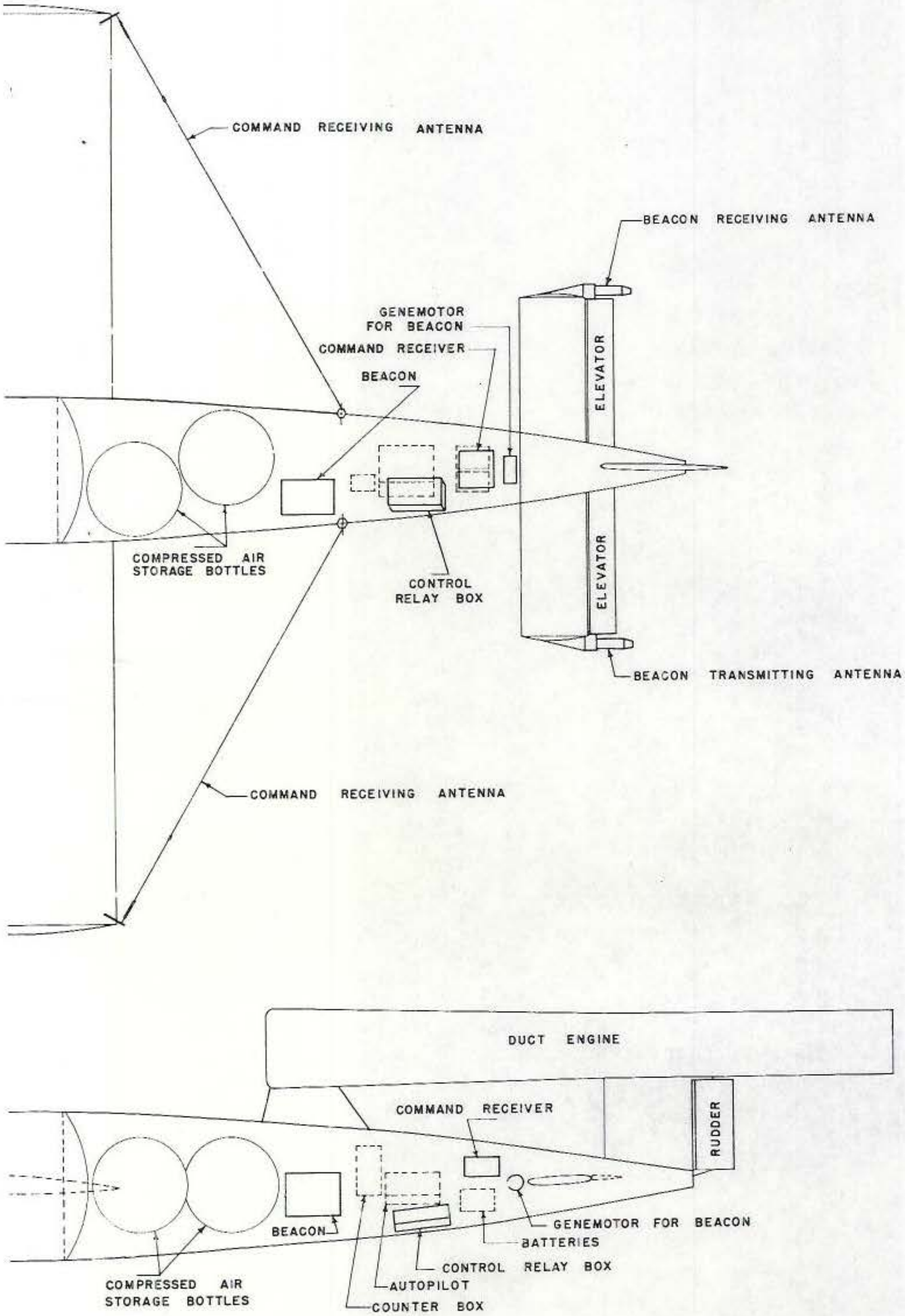
[redacted]



rn dotted.

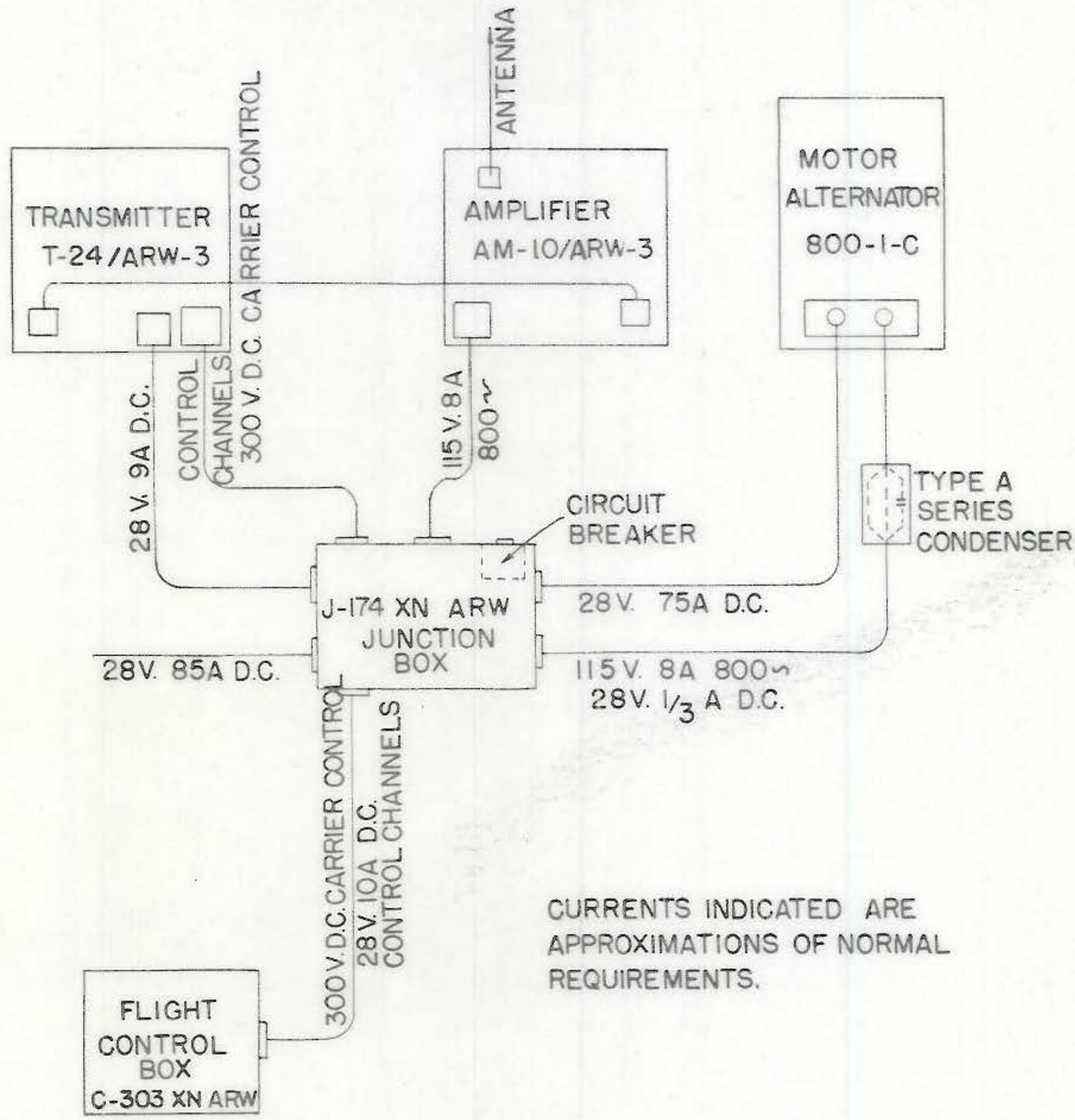
R 2616

U. S. NAVAL RESEARCH LABORATORY WASHINGTON 20, D. C.		SCALE	JB-2 FLYING BOMB, LOCATION OF ELECTRONIC CONTROLS, SCHEMATIC DIAGRAM
		DR'WN.	
B'LD'G.	PHONE	CH'K'D.	FIGURE 3
ROOM	DATE	APPR'V'D.	UNLESS OTHERWISE SPECIFIED, TOLERANCES ARE ±

SHEET OF

2083

DECLASSIFIED



CURRENTS INDICATED ARE APPROXIMATIONS OF NORMAL REQUIREMENTS.

COMMAND TRANSMITTING EQUIPMENT

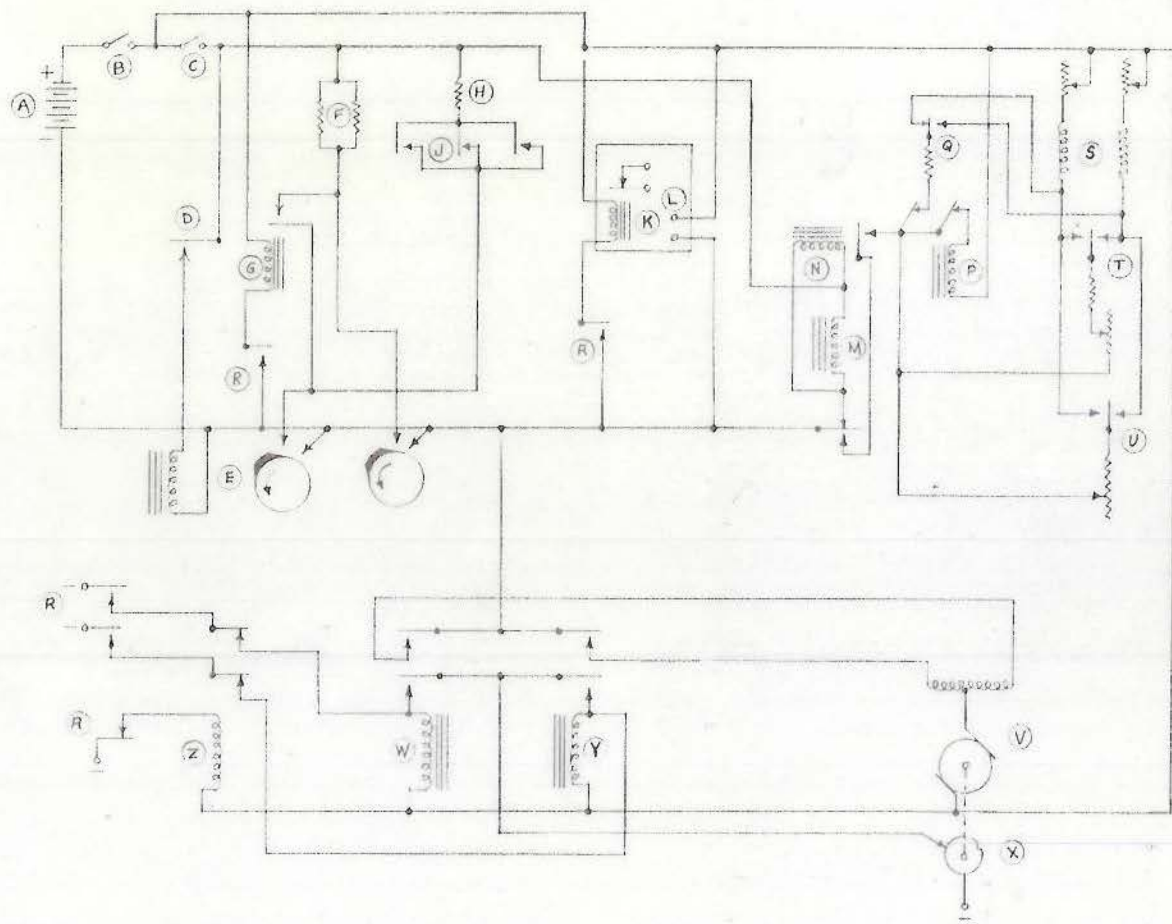
BLOCK DIAGRAM

[redacted] R-2616 FIGURE 4

DECLASSIFIED

List of Components

- (A) Battery, 28 Volt
- (B) Master Switch
- (C) Launching Release Switch
- (D) Air Log
- (E) Counter
- (F) Spoiler Detonators
- (G) Dive Security Relay
- (H) War Head Detonator Fuses
- (J) War Head Detonator Switches
- (K) Beacon "off" Relay
- (L) Beacon Power
- (M) Uncaging Relay
- (N) Delay Timer
- (P) Turn Timer
- (Q) Left-Right Switch
- (R) Radio Control Receiver Relays
- (S) Slaving Coils
- (T) Sensitive Air-Electric Switch (Slow slave)
- (U) Insensitive Air-Electric Switch (Fast slave)
- (V) Compass Drive Motor
- (W) Left Impulse Relay
- (X) Cam Switch
- (Y) Right Impulse Relay
- (Z) Anti-Jam Relay



JB-2 ELECTRONIC CONTROL SYSTEM - SIMPLIFIED SCHEMATIC DIAGRAM

[redacted]

R 2616

FIGURE 5

DECLASSIFIED

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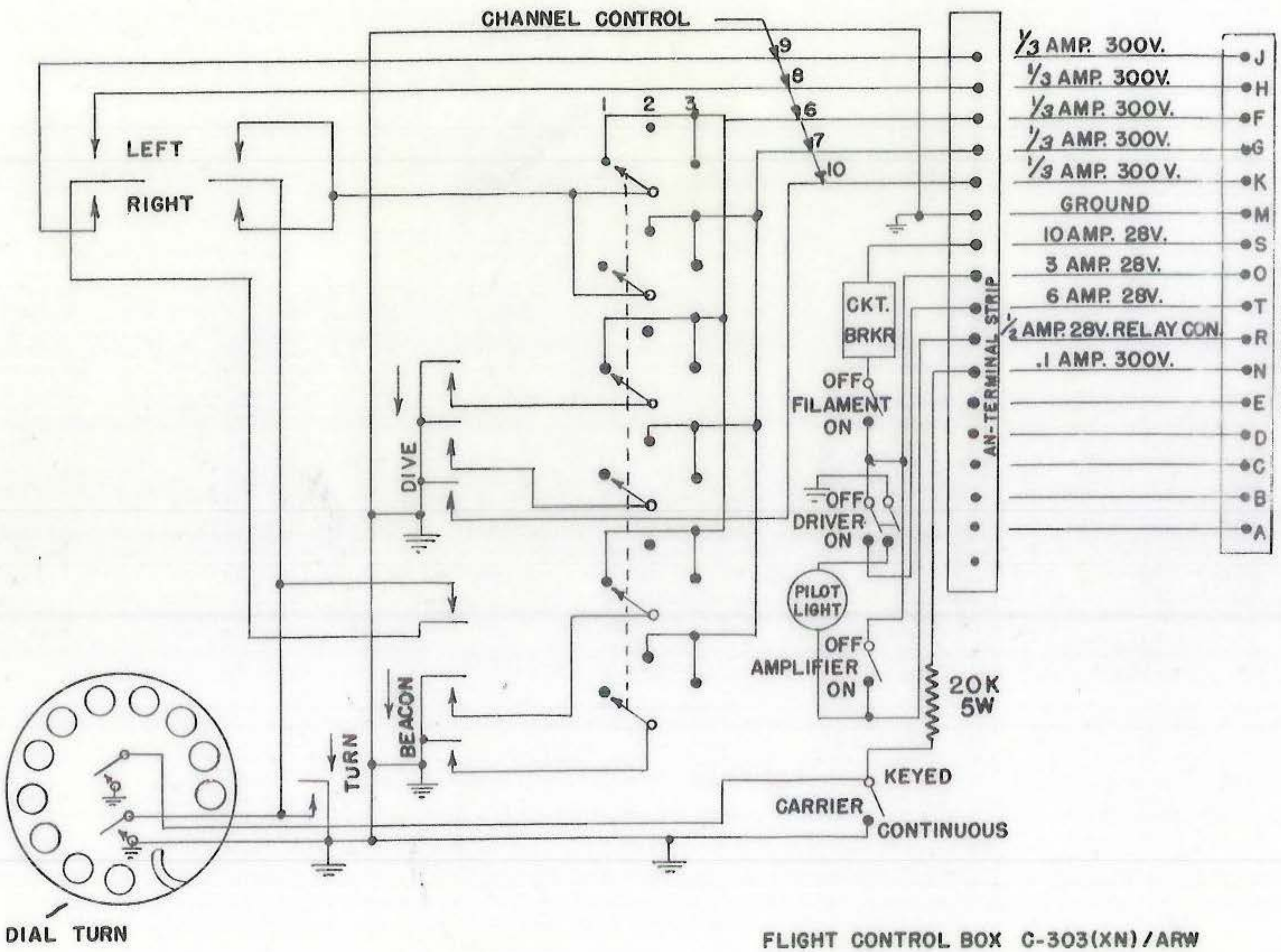
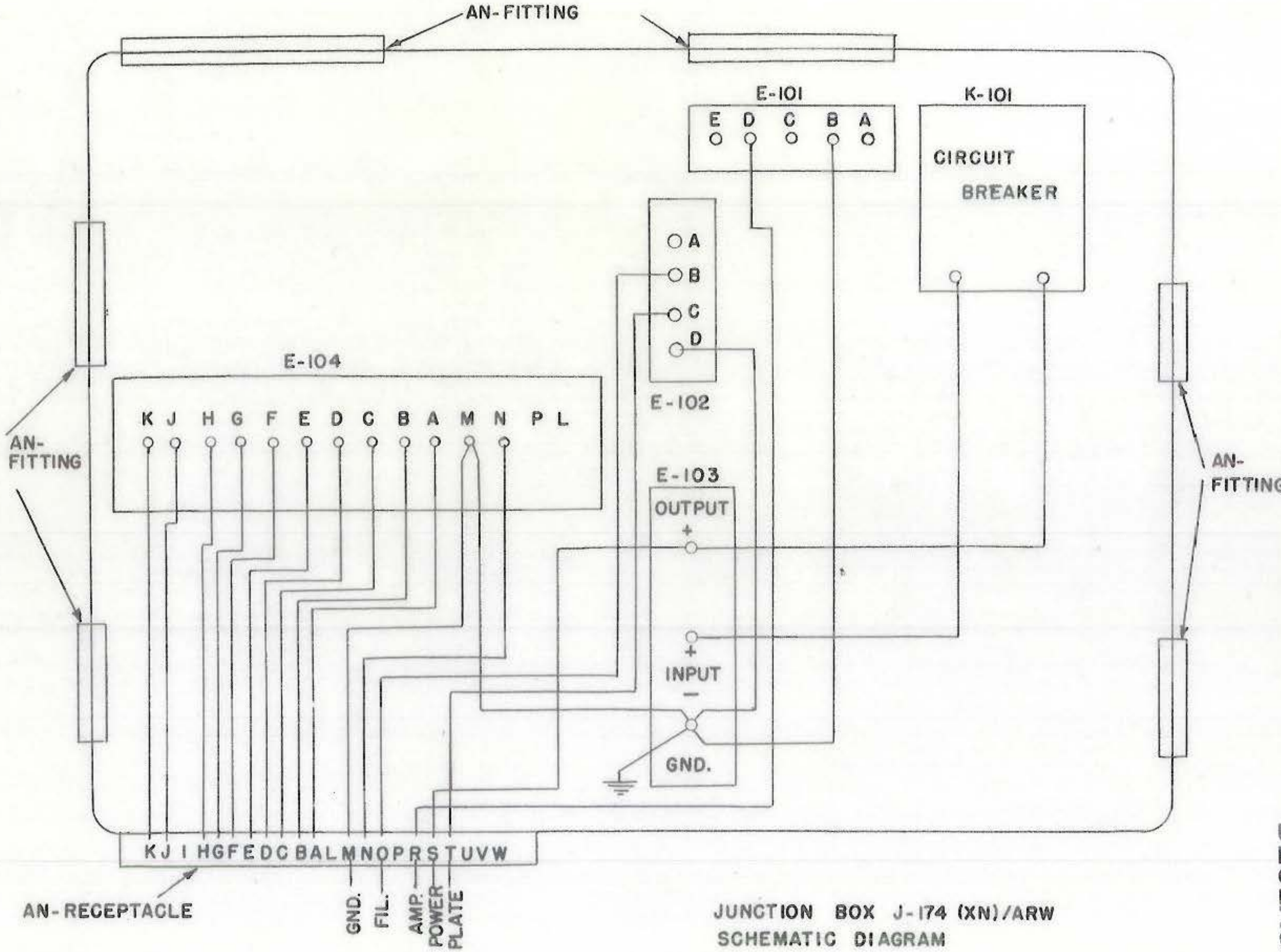


FIGURE 6

FLIGHT CONTROL BOX C-303(XN)/ARW

SCHEMATIC DIAGRAM

[redacted]

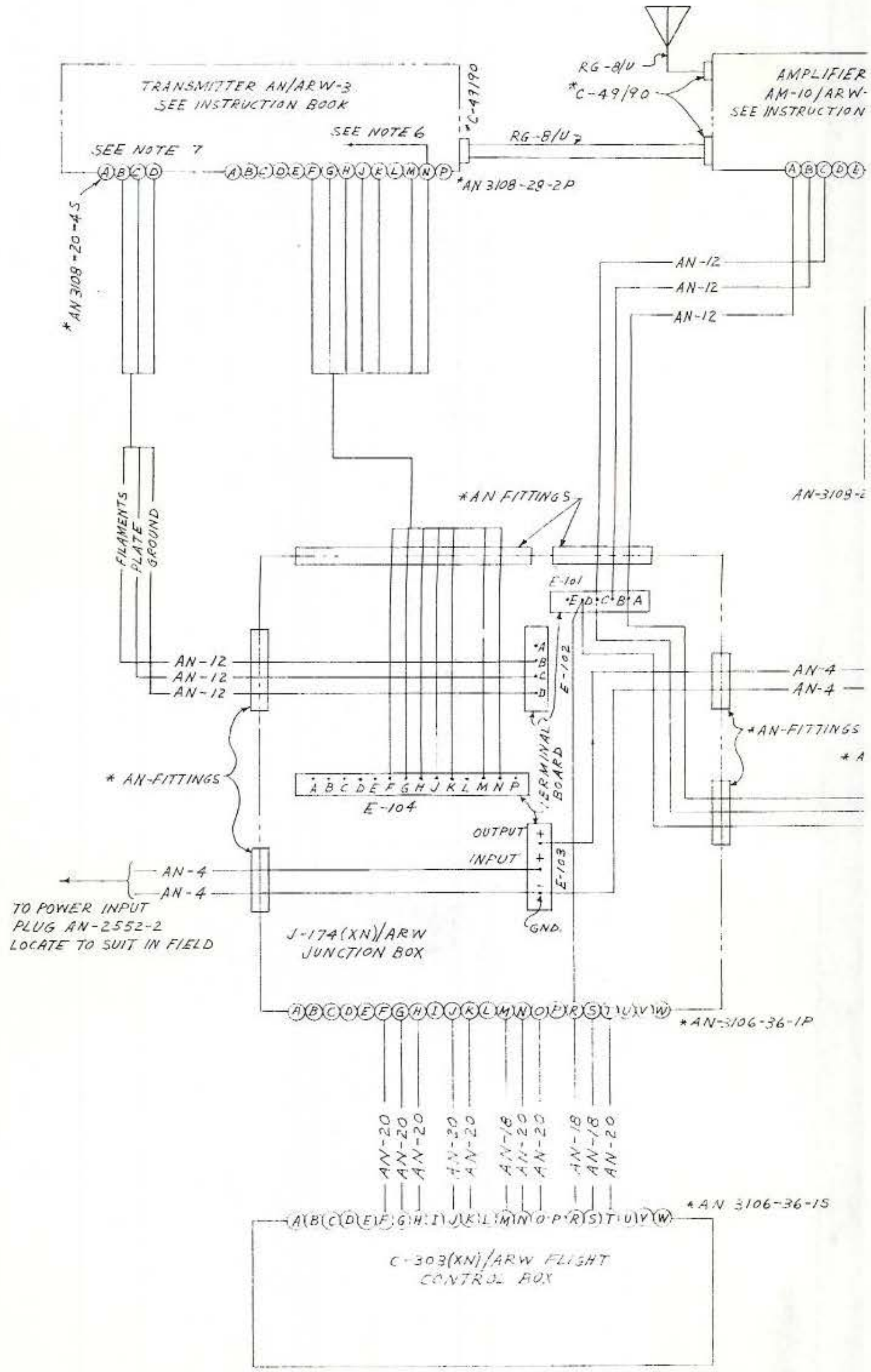


JUNCTION BOX J-174 (XN)/ARW
SCHEMATIC DIAGRAM

R-2616

FIGURE 7

DECLASSIFIED



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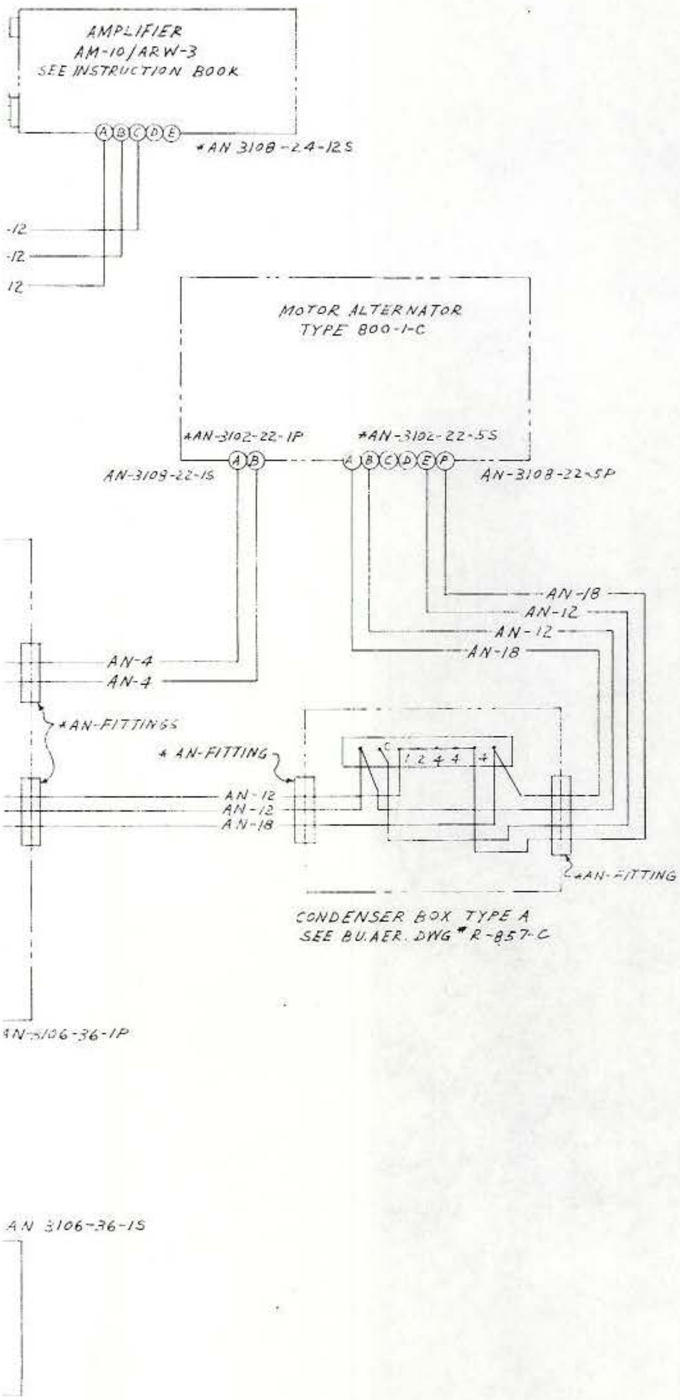

NOTES

1. AN Cable Type Numbers Refer To Cable Spec. AN-J-C-48a.
2. All Plugs And Fittings Marked With An Asterisk Furnished With Equipment.
3. All Cable Lengths To Be Determined In The Field.
4. Terminate Cables To Terminal Boards With Type AN Solderless Terminals.
5. Location Of Units To Be Determined In The Field.
6. Connect Pin N Of J-204 Of AN/ARW-3 To Pin 5 Of Relay Tube V 208.
7. Check Input Power Receptacle J205 Of AN/ARW-3. Should Be Wired As Shown In Fig 8-8 Of Instruction Book For Serial Numbers 101 And Up.

FIGURE 8

R-2616

U. S. NAVAL RESEARCH LABORATORY WASHINGTON 20, D. C.		SCALE DR'WN.	COMMAND TRANSMITTING EQUIPMENT CABLING DIAGRAM
B'LD'G.	PHONE	CH'K'D.	
ROOM	DATE	APPR'V'D.	UNLESS OTHERWISE SPECIFIED, TOLERANCES ARE -

SHEET OF

2 of 8

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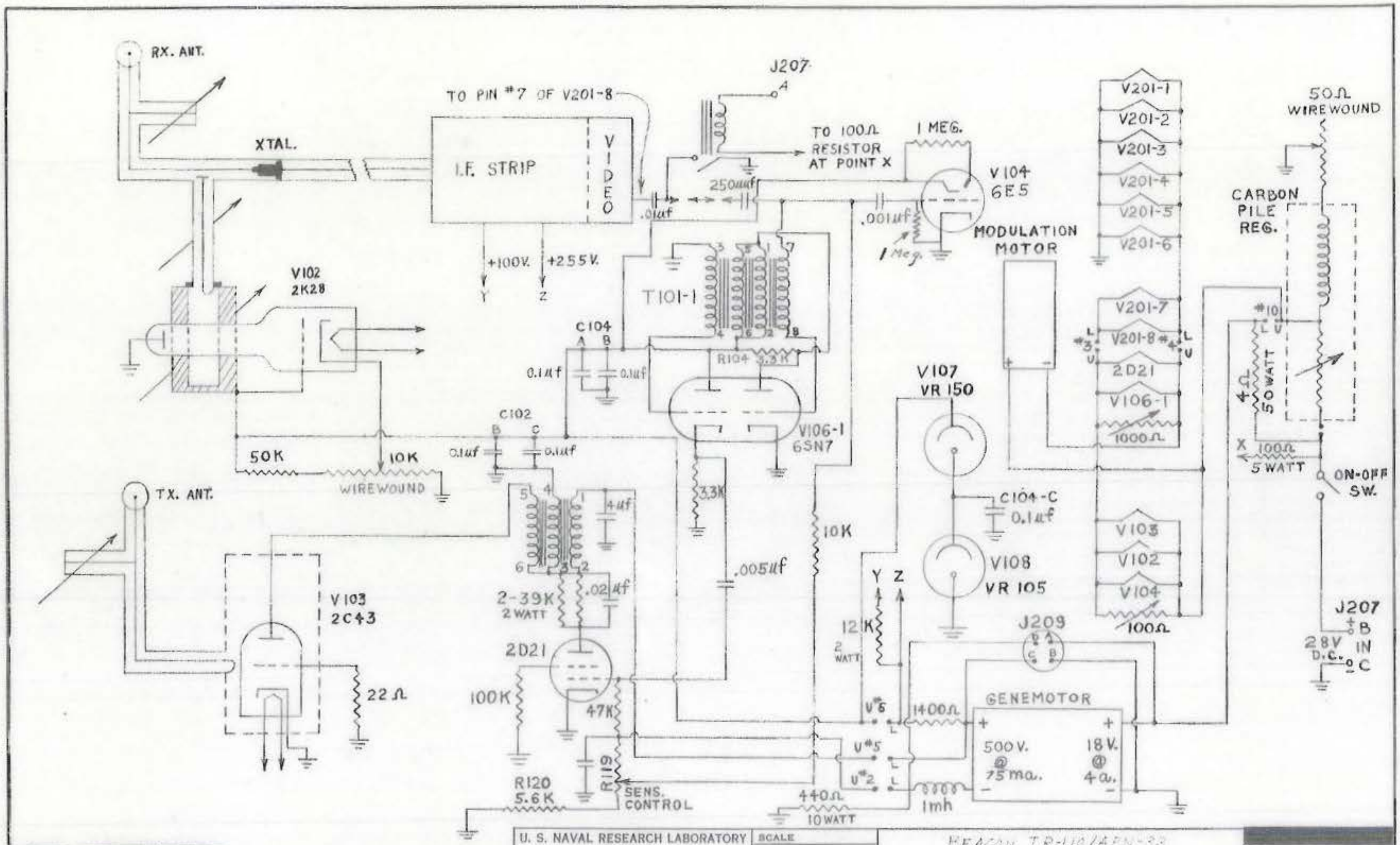

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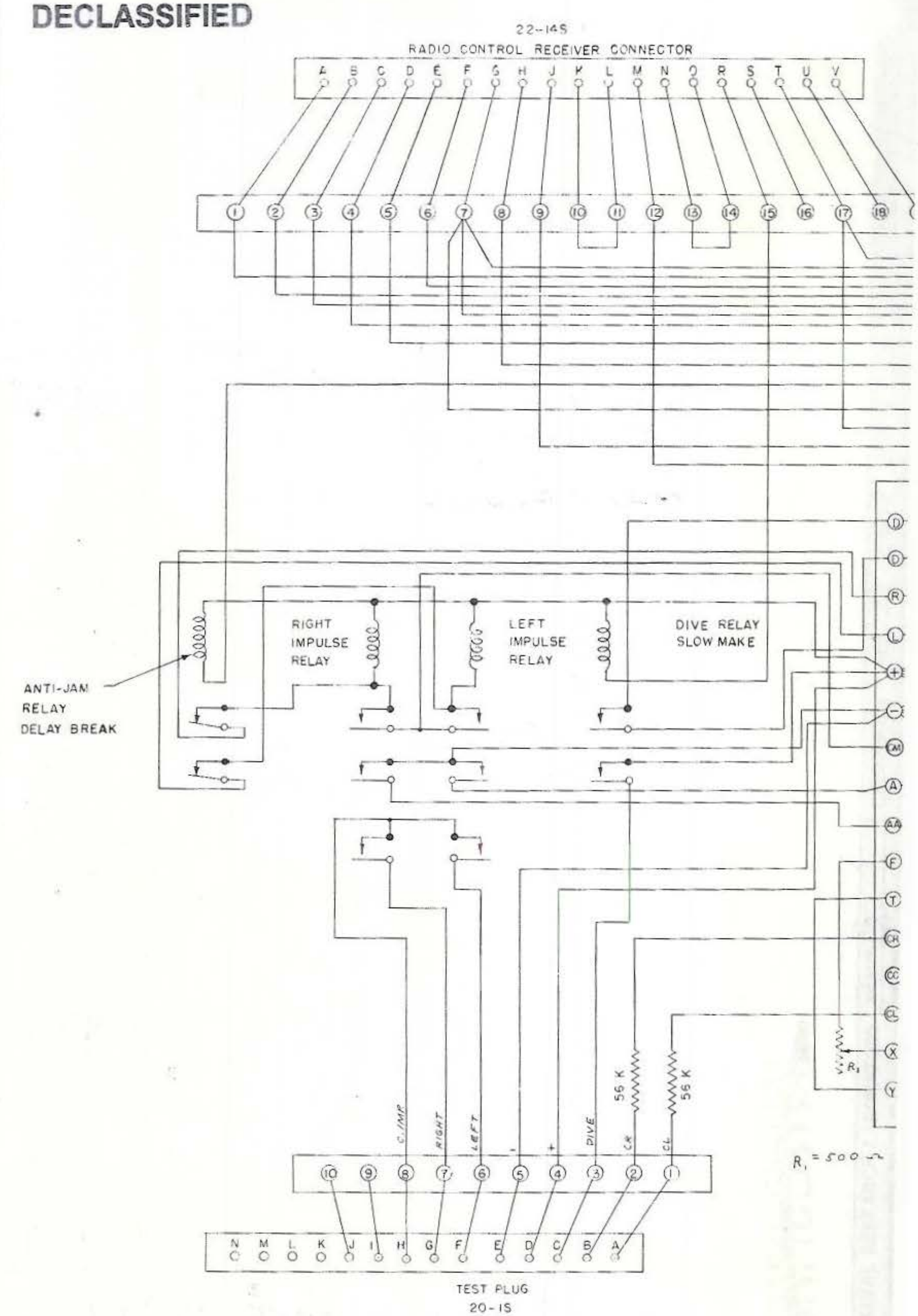
R-2616

U. S. NAVAL RESEARCH LABORATORY
WASHINGTON 20, D. C.

BEACON TR-110/APN-38
SCHEMATIC DIAGRAM

FIGURE 9



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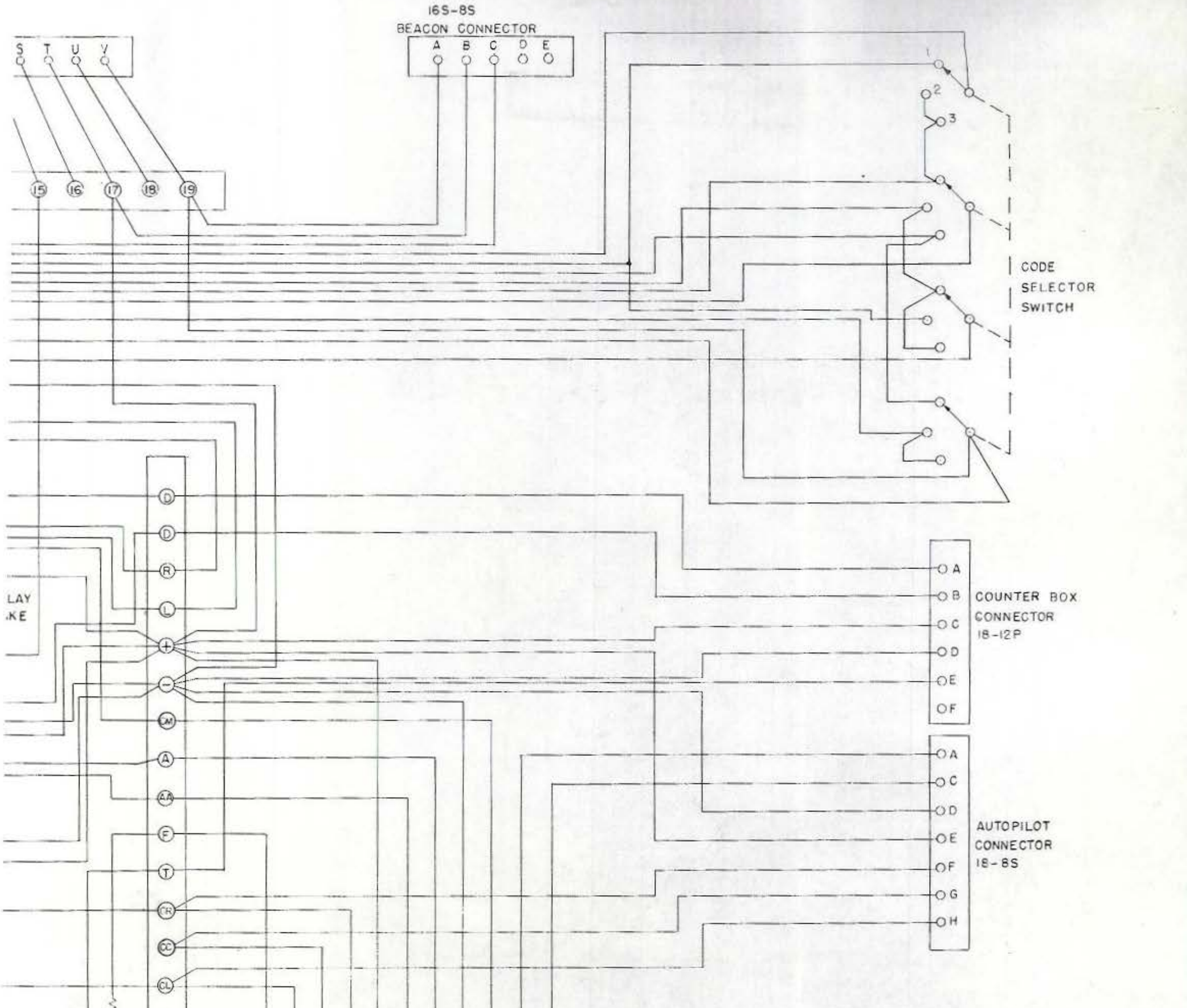
1 of 10



ALTERATION TABLE

REFERENCE DRAWINGS

DRAWN	PyoTS1M 1SP(X)	IN CHARGE OF DESIGN	SUPT. DESIGN & DRAFTING DIVISION
TRACED		CRS.	DIRECTOR
CHECKED			MC Carter
APPR'V'D			LT. U.S.N.R.

SYMBOLS AND THEIR EQUIVALENT TOLERANCES (UNLESS OTHERWISE NOTED)

SYMBOL 1 .... ± .0005 SYMBOL 3 .... ± .0050
SYMBOL 2 .... ± .0010 SYMBOL 3½ .... ± .0100
SYMBOL 2½ .... ± .0030 SYMBOL 4 .... ± .0250
SYMBOL 5 ....

NAVAL RESEARCH LABORATORY
WASHINGTON 20, D. C.

CONTROL RELAY BOX
C-296(XN-1)/ASW

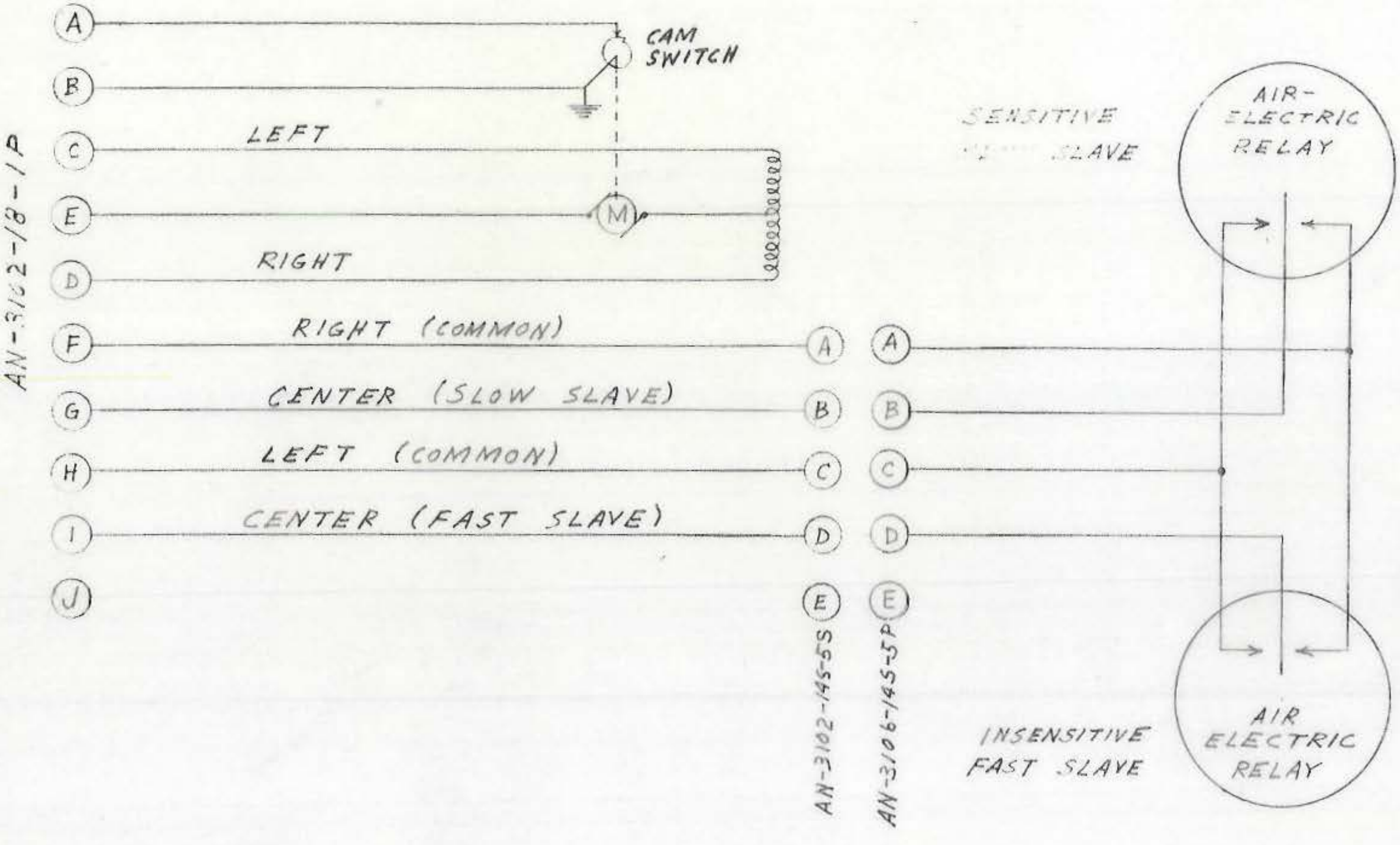
SCHEMATIC DIAGRAM

RA 23F 284 A

SHEET 1 OF 1

FIGURE 10

2 of 10



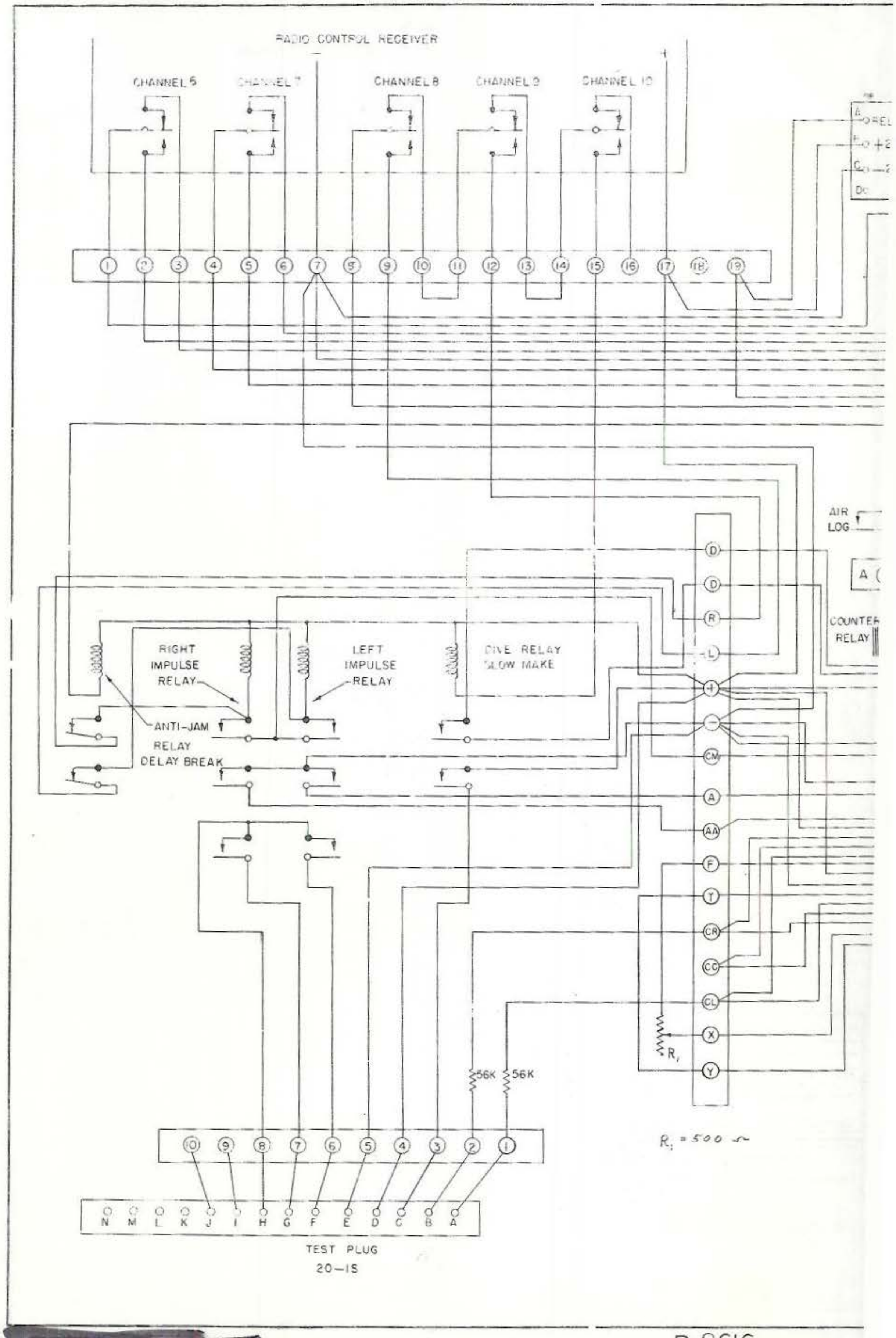
[redacted]

R-2616

U. S. NAVAL RESEARCH LABORATORY WASHINGTON 20, D. C.	SCALE DR'WN.	COMPASS MOTOR DRIVE PU-95(XN-1)/ASW AND COMPASS, SCHEMATIC DIAGRAM	
B'LD'G. — PHONE	CH'K'D.		FIGURE 11
ROOM — DATE	APPR'V'D.	UNLESS OTHERWISE SPECIFIED, TOLERANCES ARE ±	

SHEET OF

DECLASSIFIED



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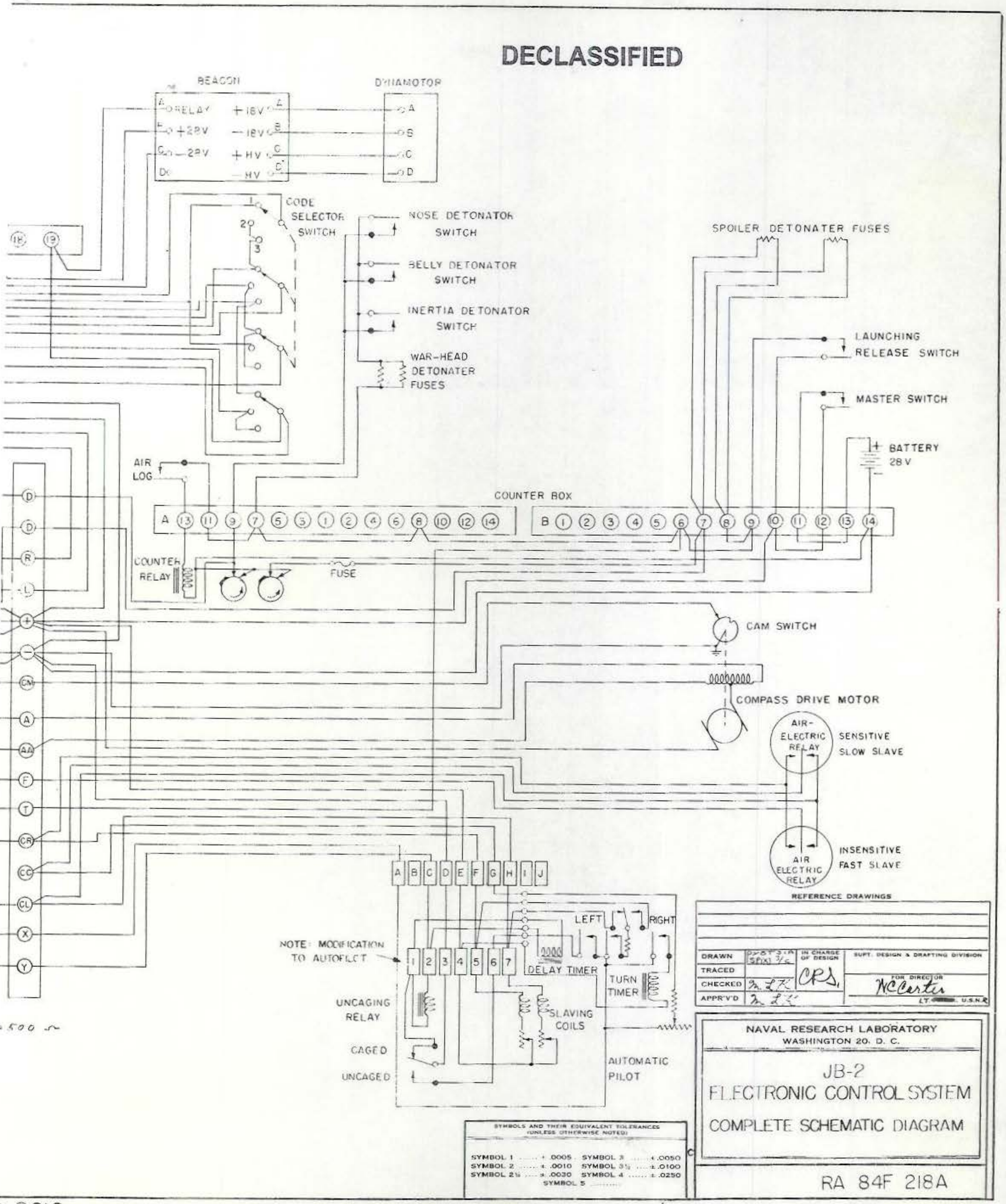

R-2616

FIGURE 12

SHEET 1 OF 1

2 of 12

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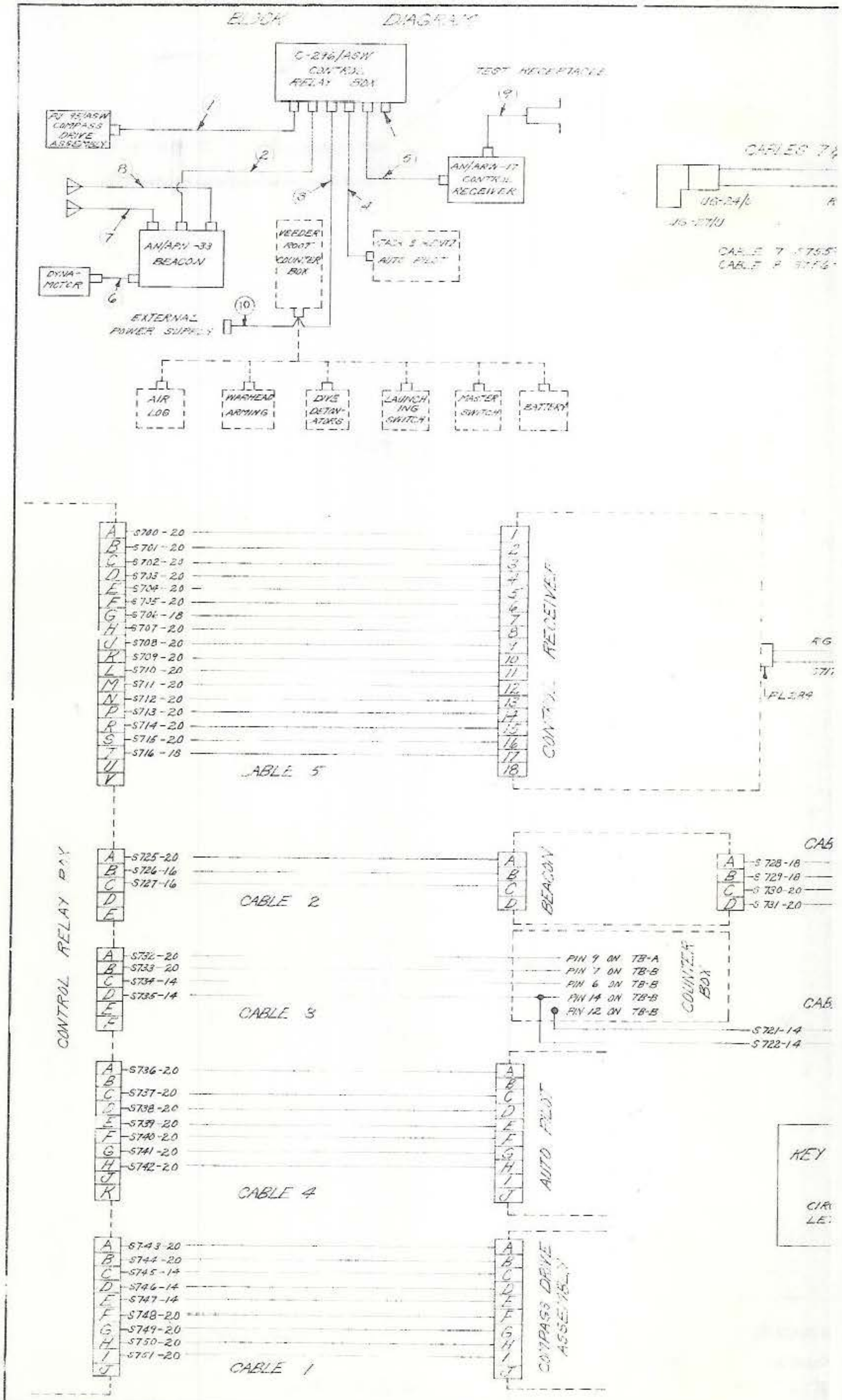

1 of 13

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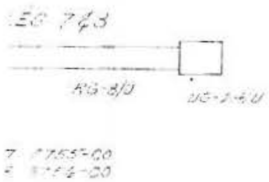
CABLES FOR JB-2 INSTALLATION

CABLE NO.	FROM	STYLE PLUG	TO	STYLE PLUG	CABLE TYPE	NUMBER OF CONDUCTORS	LENGTH	I.D. OF VINYLITE TUBING
1	C296/ASW	AN-3106-18-1P	PU 95/ASW	AN 3106-18-1S	OPEN WIRE	9 {3-#14, 6-#20}	20'	.5"
2	C296/ASW	AN-3106-16S-8P	AN/APN-33	AN 3108-18-4S	OPEN WIRE	3 {2-#16, 1-#20}	2' 7"	.25"
3	C296/ASW	AN-3106-18-12S	COUNTER BOX	—	OPEN WIRE	4 {2-#14, 2-#20}	2' 7"	.25"
4	C296/ASW	AN-3106-18-8P	AUTO PILOT	AN 3106-18-1S	OPEN WIRE	7 7-#20	2' 3"	.25"
5	C296/ASW	AN-3108-22-14P	AN/ARW-17	ARC 2963	OPEN WIRE	17 {2-#18, 15-#20}	2' 9"	.75"
6	AN/APN-33	AN-3108-18-4P	DYNAMOTOR	AN 3106-18-4S	OPEN WIRE	4 {2-#18, 2-#20}	4' 4"	.25"
7	AN/APN-33	{UG-24/U, UG-27/U}	{POLYSTYRENE ANTENNA}	UG-24/U	RG-8/U	1	9' 8"	
8	AN/APN-33	{UG-24/U, UG-27/U}	{POLYSTYRENE ANTENNA}	UG-24/U	RG-8/U	1	9' 8"	
9	AN/ARW-17	PL-284	R/C ANTENNA	—	{RG-22/U, RG-8/U}	2	{22/U-3'-6", 8/U-2'}	
10	COUNTER BOX	—	{EXTERNAL SUPPLY}	AN 3102-18-3P (RECEPTACLE)	OPEN WIRE	2 2-#14	3'	



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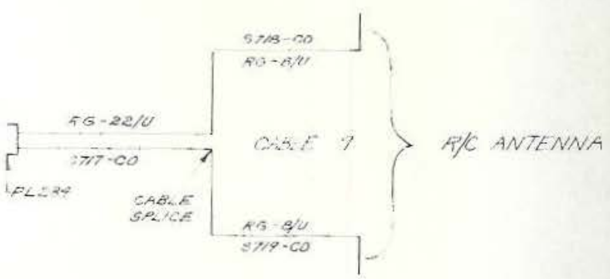
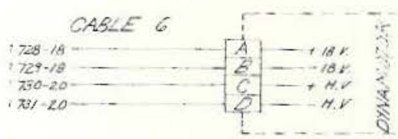


NOTES:

1. ALL UNITS SHOWN IN DOTTED LINES, IN "BLOCK DIAGRAM" ONLY, ARE FURNISHED WITH MISSILE.
2. WIRE SPEC. AN-J-C-48a
3. ALL PLUGS FURNISHED WITH EQUIPMENT
4. TERMINATE WIRES IN COUNTER BOX WITH AN659-2 SOLDERLESS TERMINAL "A50" STOCK # R17-T-3609-125 AND CRIMPING TOOL "A50" STOCK # R17-T-6885

CABLE 6



CABLE 10

KEY TO WIRE DESIGNATIONS

S 721 - 18

CIRCUIT LETTER — WIRE NUMBER — WIRE SIZE

ALTERATION TABLE

SYMBOLS AND THEIR EQUIVALENT TOLERANCES (UNLESS OTHERWISE NOTED)

SYMBOL 1	±.0005	SYMBOL 3	±.0050
SYMBOL 2	±.0010	SYMBOL 3½	±.0100
SYMBOL 2½	±.0030	SYMBOL 4	±.0250
SYMBOL 5			

REFERENCE DRAWINGS

DRAWN	G.L.M. 5/6	IN CHARGE OF DESIGN	SUPT. DESIGN & DRAFTING DIVISION
TRACED		CRS.	FOR DIRECTOR
CHECKED	M.H.R.		
APPR'V'D	M.W.R.		CONDR. U.S.N.

NAVAL RESEARCH LABORATORY
WASHINGTON 20, D. C.

JB-2 ELECTRONIC CONTROL SYSTEM

CABLING DIAGRAM

SCALE — DATE JUNE-1-1945

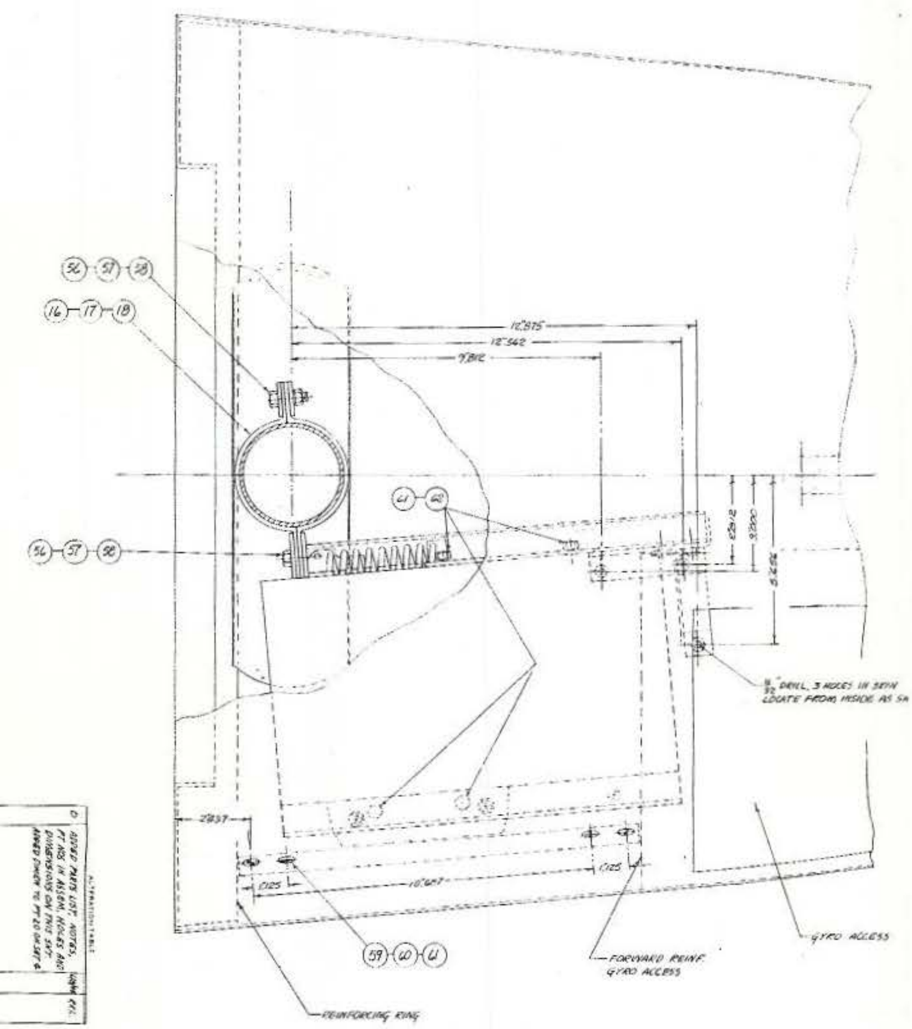
RA 23F 283A

FIG. 13

1 SHEET SHEET 1

2 of 13

DECLASSIFIED



ALTERATION TABLE

O — ADDED PARTS LIST, NOTES, PT NOS IN ASSEM, HOLES AND DIMENSIONS ON THIS SHT. ADDED DIMEN TO PT 20 ON SHT 4

NAVAL RESEARCH LABORATORY
WASHINGTON 20, D. C.

VIBRATION MOUNT FOR AN/APN-33 BEACON

ASSEMBLY

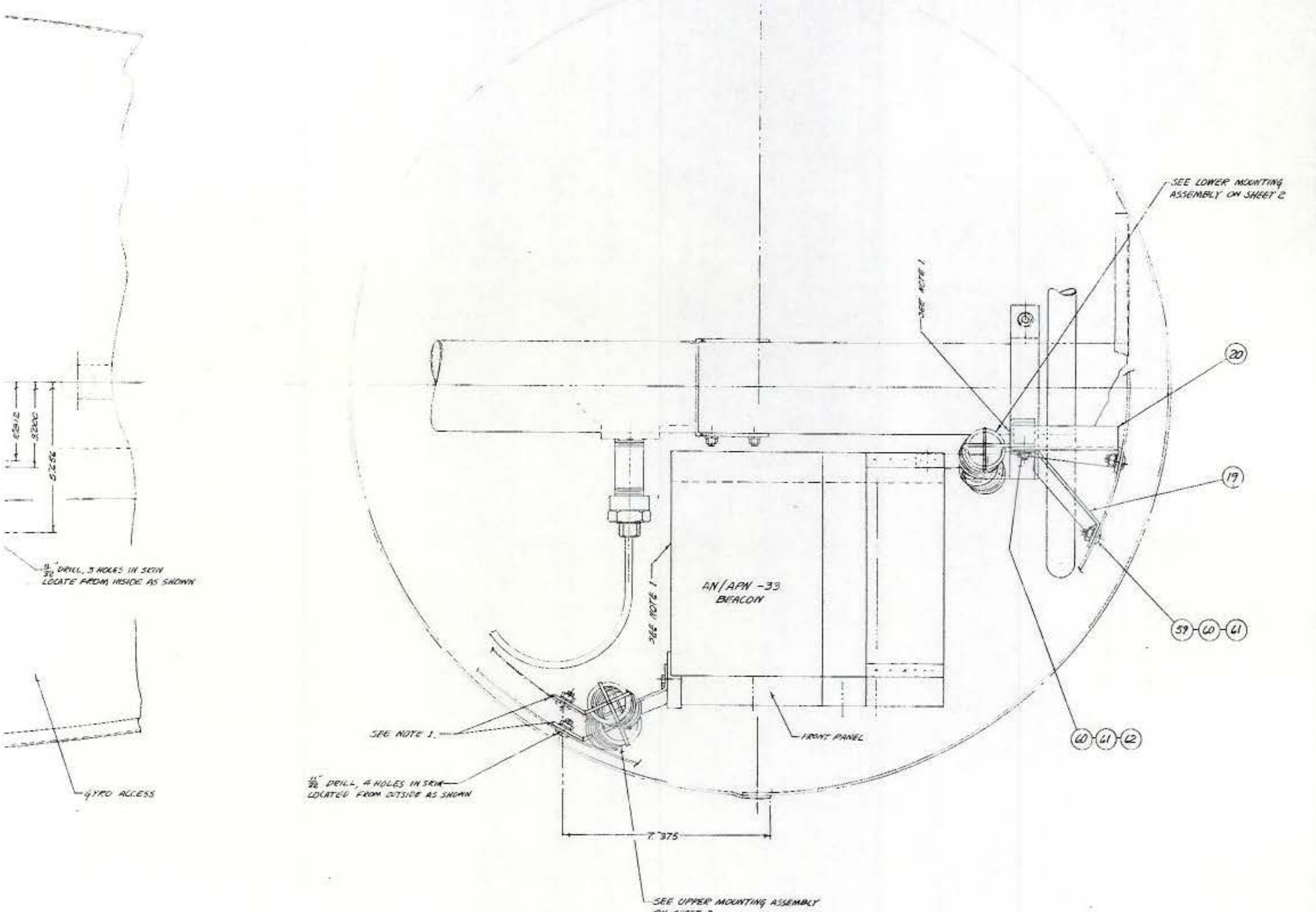
SCALE 6 IN = 1 FT DATE 5-9-45

DRAWN: CARANICON TRACED: CHECKED: APPR'VD:

RA 10 J 480B

PART NO.	NO. REQD	MATERIAL	DESCRIPTION	SUPPLIED BY OR EQUAL
51b	1		JB-2 EQUIPMENT	COMM'RCIAL
52b	1		AN/APN-33 BEACON	
56b	2	STEEL	5/16"-18 HEX HD CAP SCREW. 1" LONG	COMMERCIAL
57b	2	"	5/16-18 AM. STD HEX STEEL MACH SCREW NU	"
58b	2	"	5/16" STD SPRING LOCKWASHER	"
59b	7	"	1/4"-20 TRUSS HD SCREW 1/2" LONG	"
60b	9	"	1/4"-20 AM. STD HEX STEEL MACH SCR. NUT	"
61b	13	"	1/4" STD SPRING LOCKWASHER	"
62b	6	"	1/4"-26 HEX HD CAP SCREW. 3/4" LONG	"

1 of 14



NOTES:
1. TOP EDGES OF PARTS 12, 13 & 52 ARE LEVEL WHEN FUSELAGE AXIS IS LEVEL.
2. HOLE LOCATION DIMENSIONS ARE BASED ON MEASUREMENTS OF THE JB-2 AT N.R.L.

BEACON RT-110/APN-33

INSTALLATION DIAGRAM

FIGURE 14

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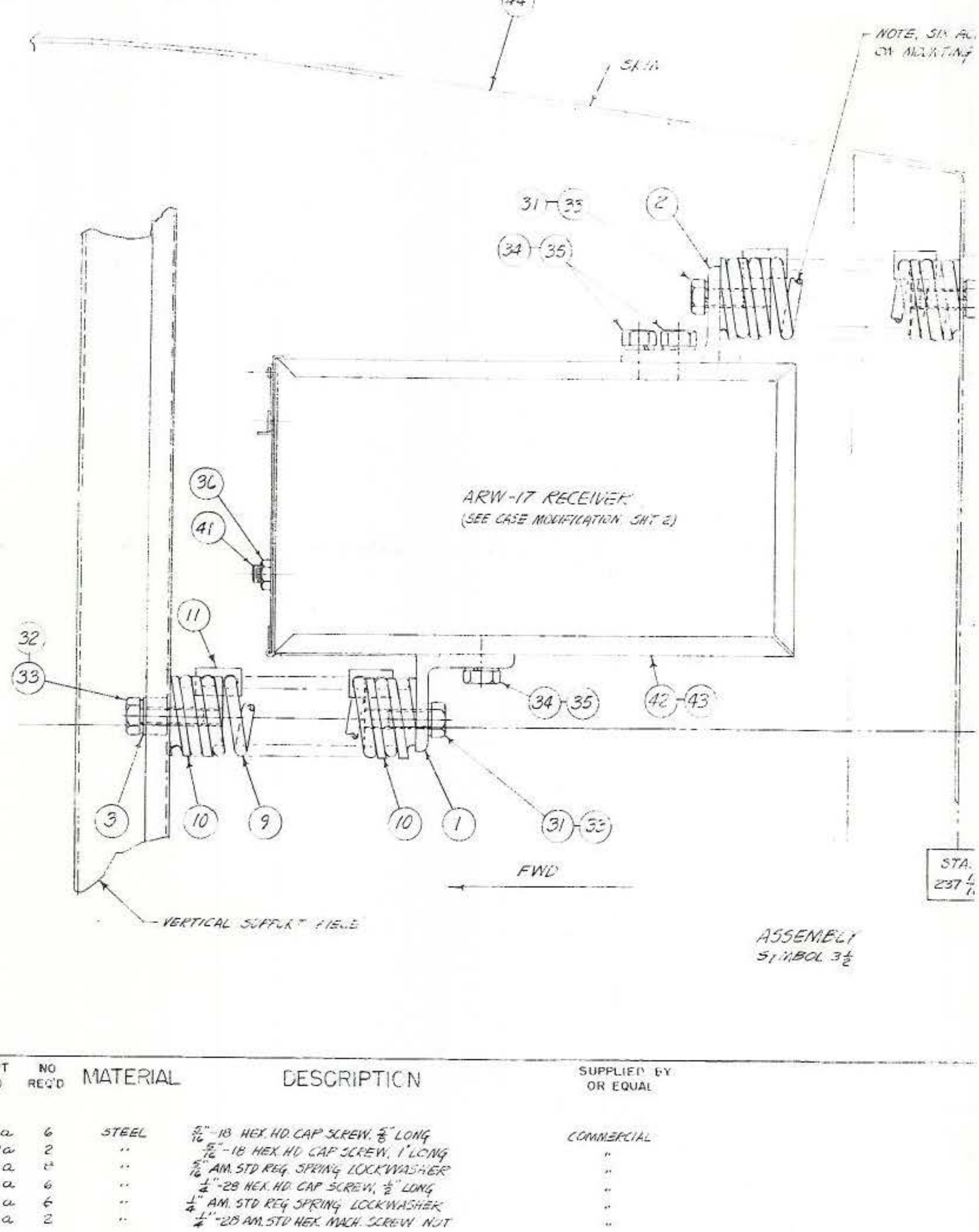
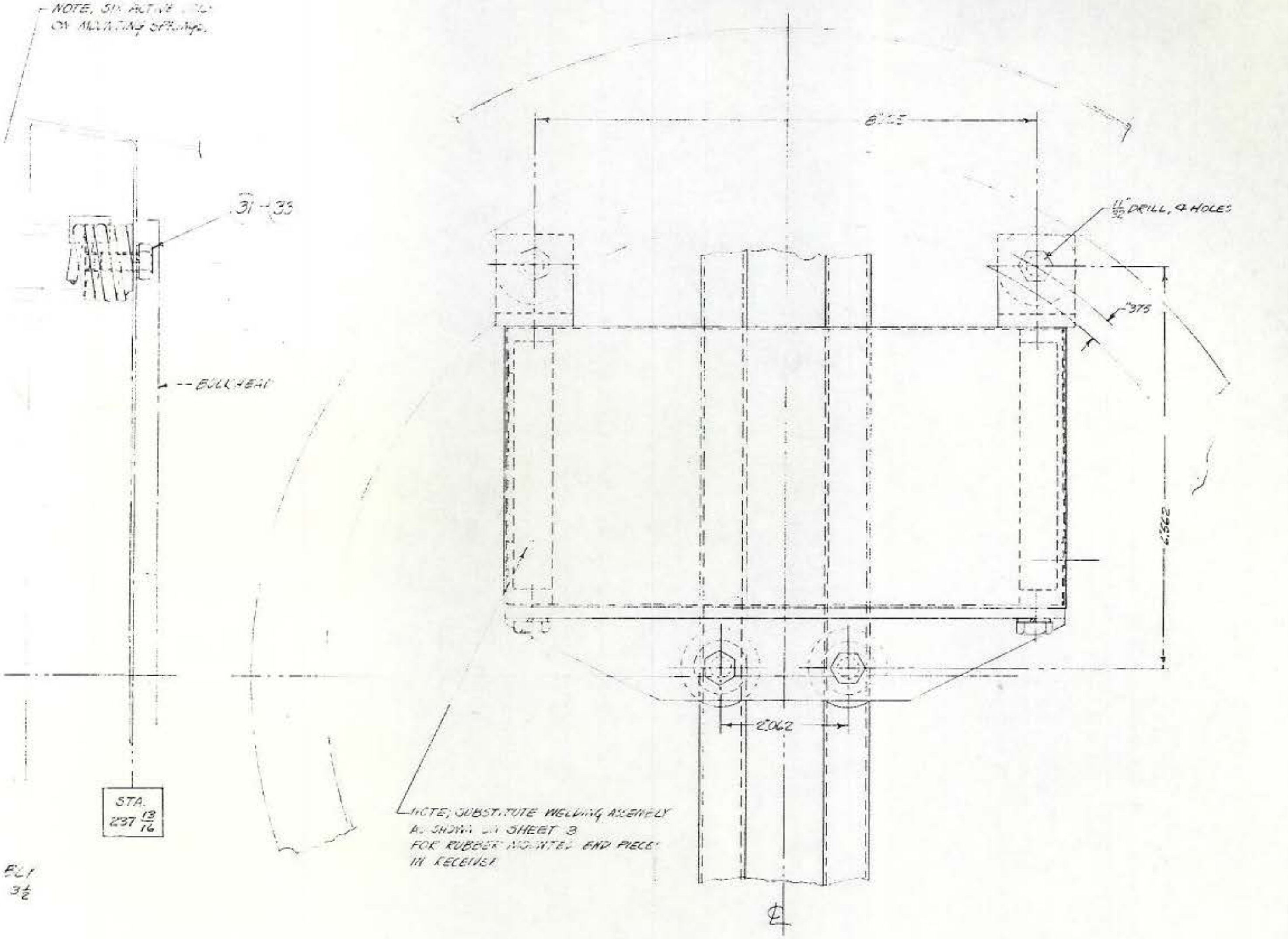


PART NO	NO REQ'D	MATERIAL	DESCRIPTION	SUPPLIED BY OR EQUAL
31a	6	STEEL	5/16"-18 HEX. HD. CAP SCREW, 5/8" LONG	COMMERCIAL
32a	2	"	5/16"-18 HEX. HD. CAP SCREW, 1" LONG	"
33a	2	"	5/16" AM. STD REG. SPRING LOCKWASHER	"
34a	6	"	1/4"-28 HEX. HD. CAP SCREW, 1/2" LONG	"
35a	6	"	1/4" AM. STD REG SPRING LOCKWASHER	"
36a	2	"	1/4"-28 AM. STD HEX. MACH. SCREW NUT	"
41a	2	STEEL	1/4"-28 HOLLOW SET SCREW 5/8" LONG	ALLEN MFG CO.
42a	1		ARW-17 RECEIVER	PHILCO RADIO
43a	1		CASE (PT. OF ARW-17 RECEIVER) SEE MODIF SHT 2	" "
44a	1		J B 2 EQUIPMENT (SEE ASSEM. THIS SHT)	REPUBLIC AVIATION

[redacted]

DECLASSIFIED



ALTERATION TABLE	

REFERENCE DRAWINGS

DRAWN	CHAIKSON	IN CHARGE OF DESIGN	SUPT. DESIGN & DRAFTING DIVISION
TRACED		CPS.	
CHECKED			FOR DIRECTOR M.C. Carter
APPR'V'D	J. P. Walsh		LT. ..., U.S.N.R.

SYMBOLS AND THEIR EQUIVALENT TOLERANCES (UNLESS OTHERWISE NOTED)

SYMBOL 1 ...... ± .0005 SYMBOL 3 ...... ± .0050
SYMBOL 2 ...... ± .0010 SYMBOL 3½ ...... ± .0100
SYMBOL 2½ ...... ± .0030 SYMBOL 4 ...... ± .0250
SYMBOL 5 ....

NAVAL RESEARCH LABORATORY
WASHINGTON 20. D. C.

RECEIVER R-64/ARW-17

INSTALLATION DIAGRAM

RA ... 4562

R-2616

FIGURE 15

SHEET

2 of 15

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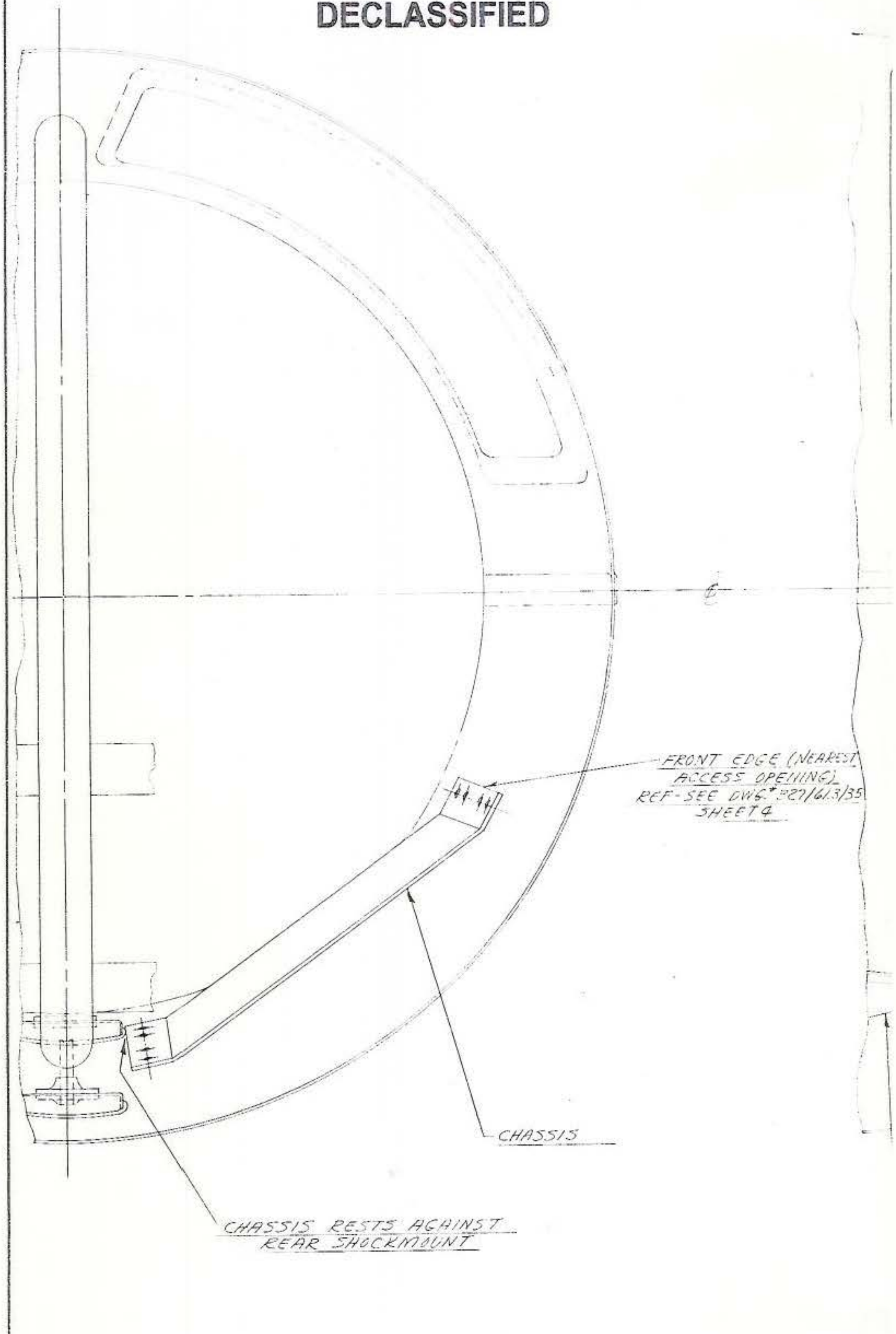

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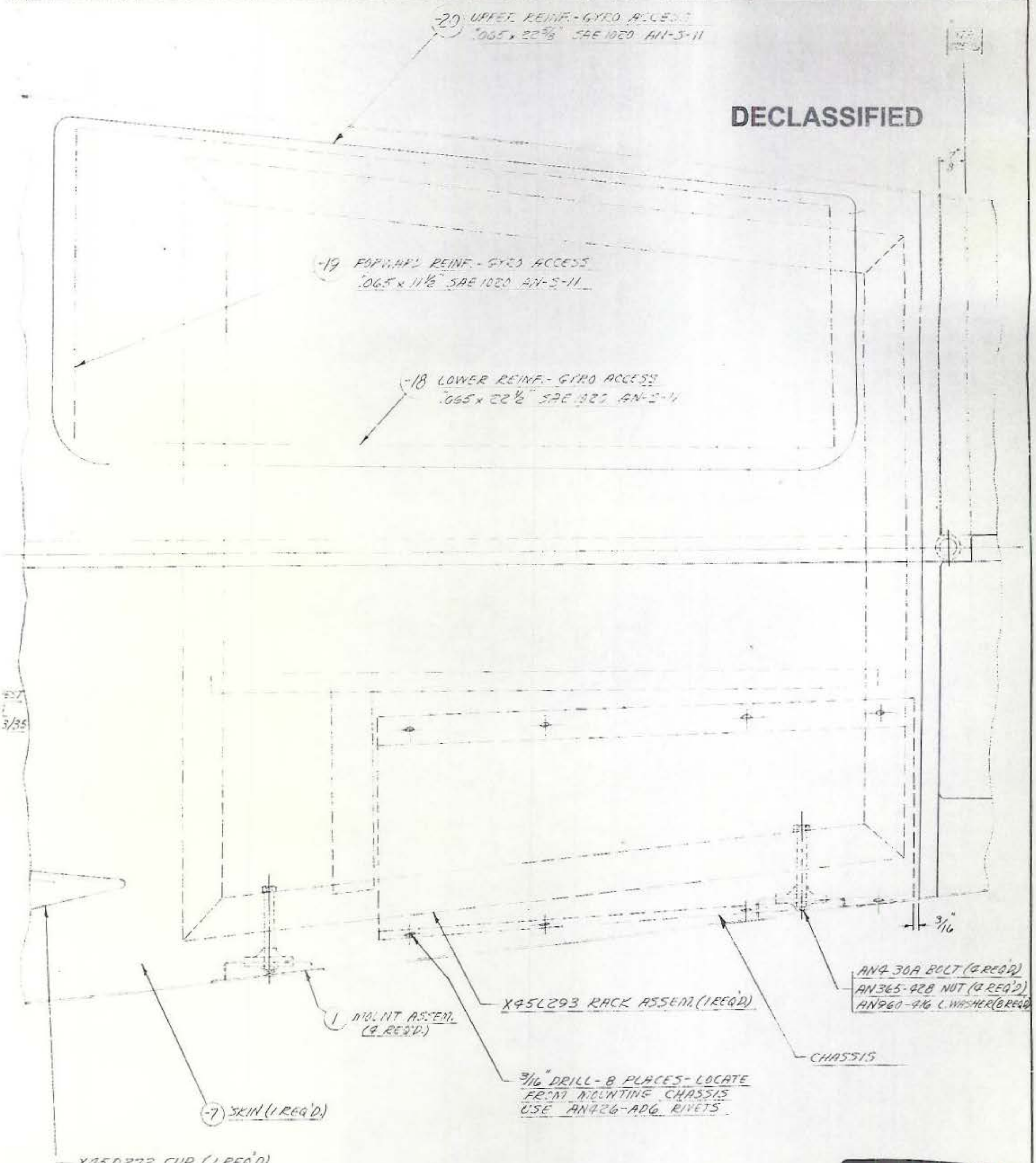


[redacted]

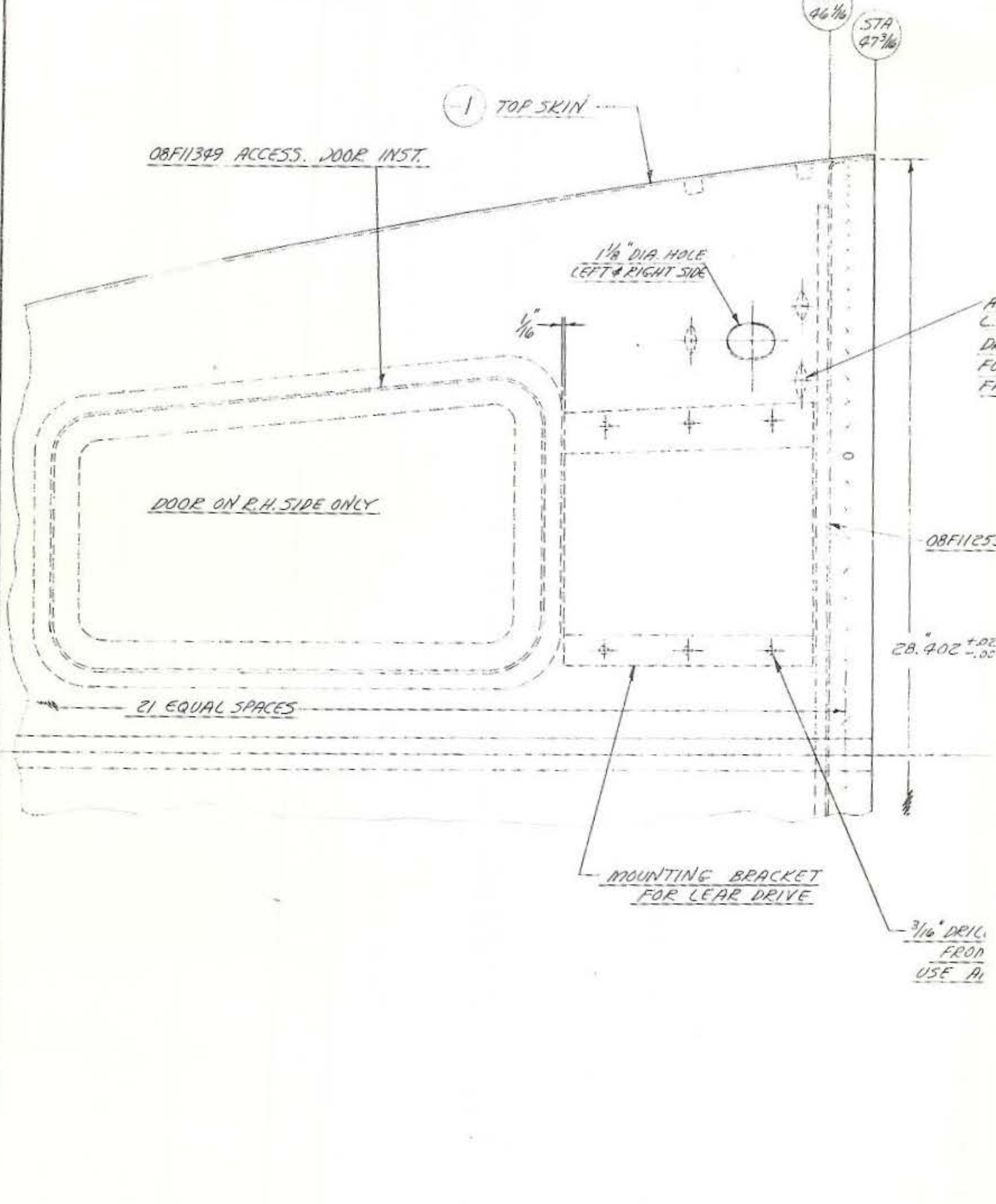
FIGURE 10

R-2616

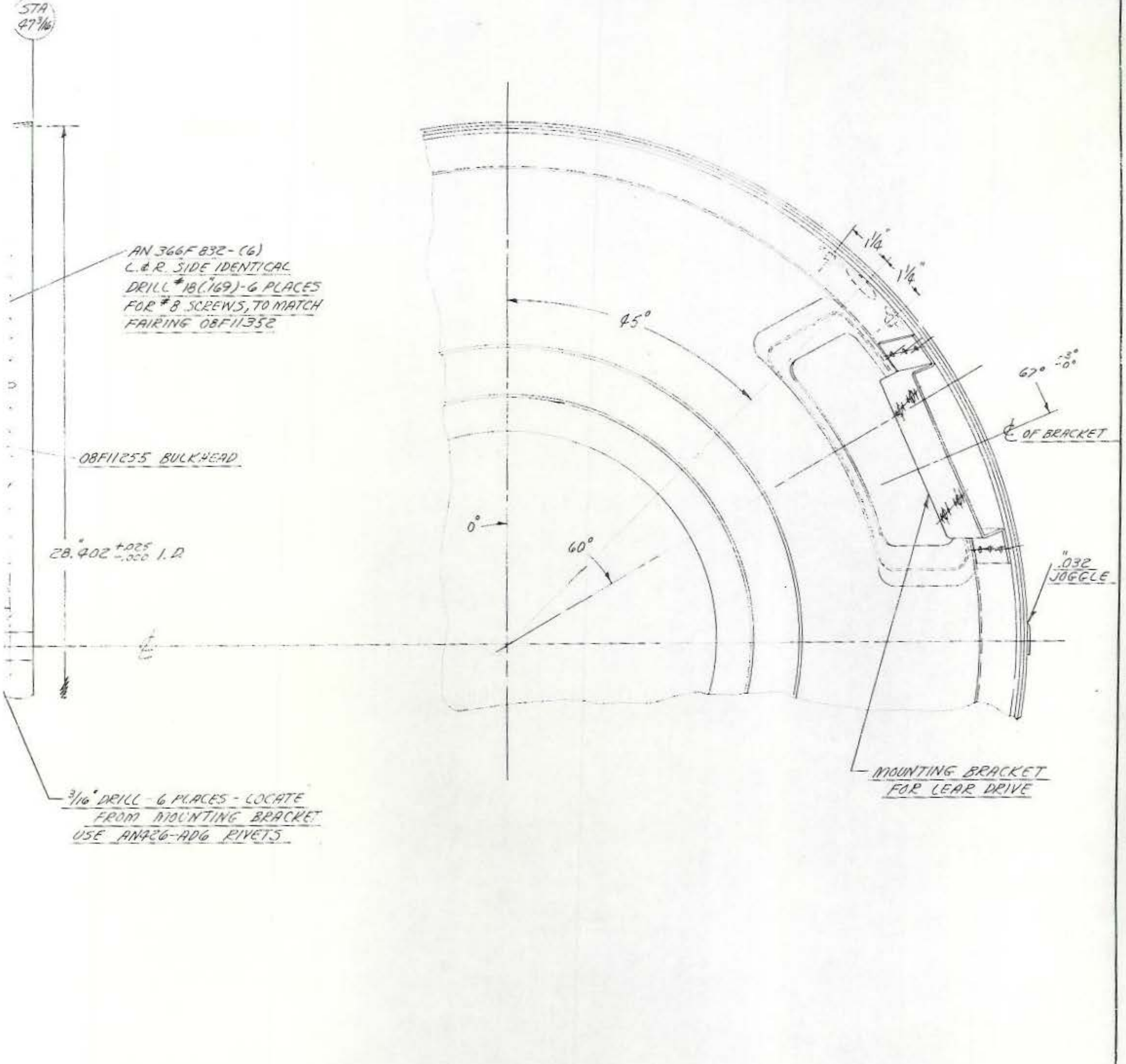
U. S. NAVAL RESEARCH LABORATORY WASHINGTON 20. D. C.		SCALE 6 IN.=1 FT.	CONTROL RELAY BOX C-39.(XN-1)/ASW INSTALLATION DIAGRAM
		DR'WN. R.H.G.	
B'LD'G.	PHONE	CH'K'D.	
ROOM	DATE	APPR'V'D.	UNLESS OTHERWISE SPECIFIED, TOLERANCES ARE ± 1/32"

SHEET 1 OF 1

DECLASSIFIED



1 of 17 DECLASSIFIED



[redacted]

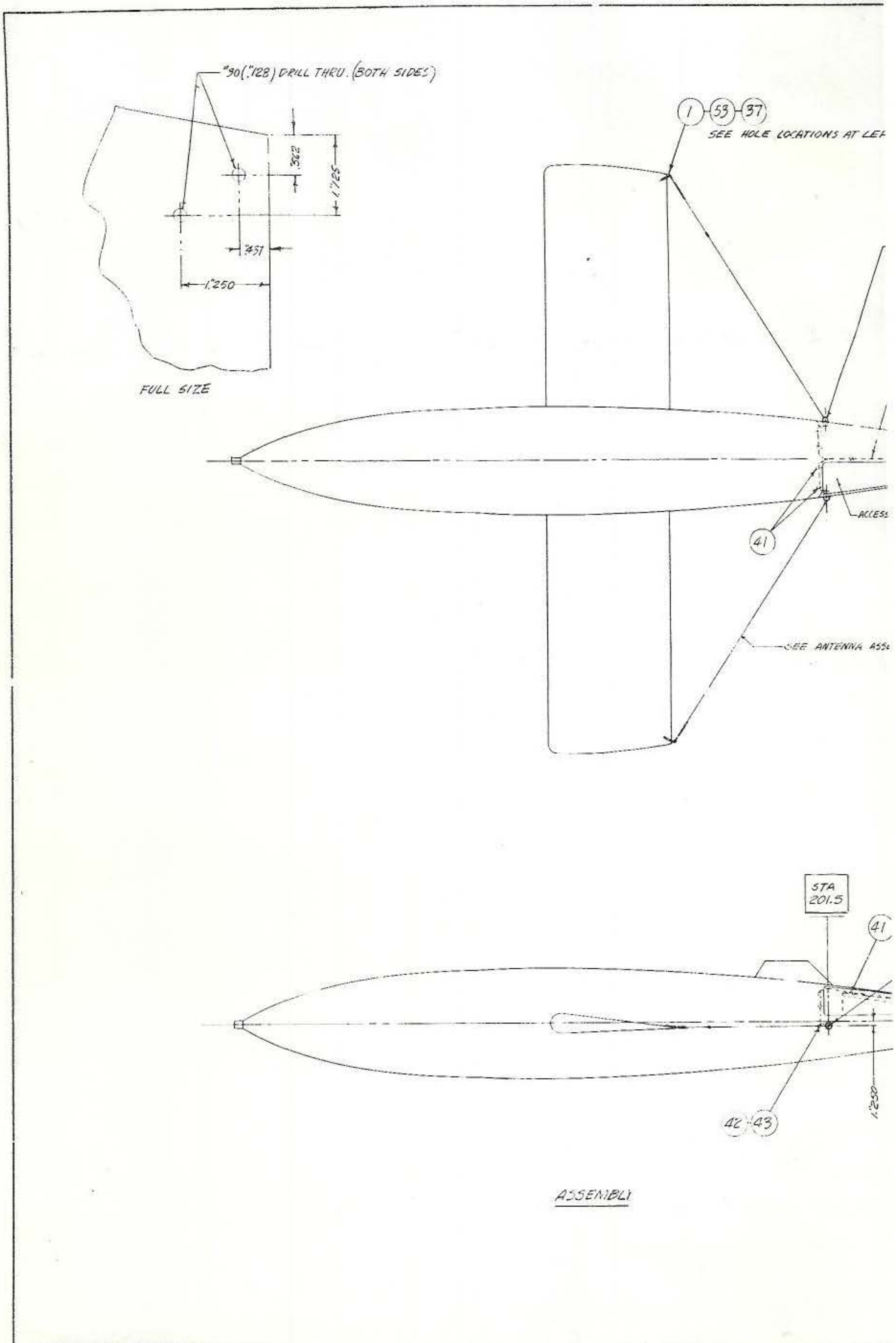
FIGURE 17

R-2616

U. S. NAVAL RESEARCH LABORATORY WASHINGTON 20, D. C.		SCALE: 6 IN - 1 FT.	COMPASS MOTOR DRIVE PU-95(XN-1)/ASW INSTALLATION DIAGRAM
BLDG.	PHONE	DR'WN. R. H. G.	
ROOM	DATE	CHK'D.	
		APPR'VD.	UNLESS OTHERWISE SPECIFIED, TOLERANCES ARE ± 1/32"

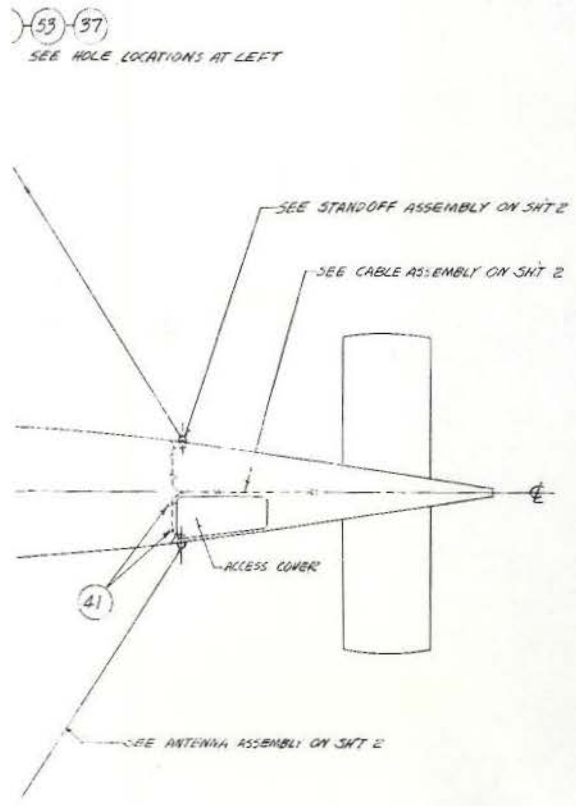
SHEET 1 OF 1

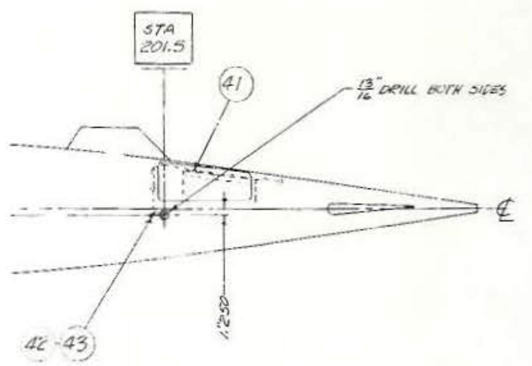
2 of 17



#30(.128) DRILL THRU. (BOTH SIDES)
.362
1.725
.437
1.250
FULL SIZE
1 53 37
SEE HOLE LOCATIONS AT LEF
41
ACCESS
SEE ANTENNA ASS
STA 201.5
41
42 43
1.250
ASSEMBLY

[redacted]





PART NO	NO REQD	MATERIAL	DESCRIPTION	SUPPLIED BY OR EQUAL
31a	2	PORCELAIN	FEED THRU INSULATOR 1" DIAM #32103	MILLEN
32a	2	"	ANTENNA INSULATORS (STRAIN) ½" X 1½" #1033-00	GENERAL CERAMIC
34a	1		SMALL TWIN PLUG (ARMY TYPE # PL 284)	AM. PHENOLIC CORP.
35a	2	STEEL	3" HOOK #150	AM. CHAIN & CABLE
36a	2	BRASS	#8-32 MACH. SCREW HEX NUT TYPE M	ELASTIC STOP NUTS
37b	8	STEEL, CAD. P.	#8-32 X 5/16" TYPE 1 THD CUTTING SCREW TRUSS HEAD	SHAKE PROOF
41a	5		CLAMP AN 744-8 C	COMMERCIAL
42a	2		CLAMP AN 735-6 (LOOP TYPE BONDING)	"
43a	2		JUMPER AN 749-1-2	"
44a	2		ANT INSULATOR (TENSION) R-16-L-5085 ASO. ½" X 5"	"
45a	1 LGTH		ANT WIRE TYPE J 7 STRANDS PHOS. BRONZE WITH CORD CENTER, 20 FEET LONG	"
46a	1 LGTH		RG-8/U CABLE 5 FEET LONG	"
47a	1 LGTH		RG-22/U CABLE 4 FEET LONG	"
48a	4	COPPER	CABLE LUGS 50 AMP	"
51a	2	BRASS	#8-32 RH MACH SCREW 2½" LONG	COMMERCIAL
52a	2	BRASS	#8 FLAT WASHER	"
53b	10	STEEL, CAD. P.	#8 EXTERNAL TOOTH STD LOCK WASHER	"
54a	2	BRASS	#8-32 AM STD HEX MACH SCREW NUT	"

ALTERATION TABLE

b	HOLE LOCATIONS ADDED. PARTS LIST CHANGED	RKC	1/1/45

REFERENCE DRAWINGS

DRAWN	R. CHAMSON	IN CHARGE OF DESIGN: CRS.	SUPT. DESIGN & DRAFTING DIVISION
TRACED			
CHECKED	GPB		FOR DIRECTOR: W. Curtis
APPR'V'D	GPM		LT. U.S.N.R.

SYMBOLS AND THEIR EQUIVALENT TOLERANCES (UNLESS OTHERWISE NOTED)

SYMBOL 1 ...... ±.0005 SYMBOL 3 ...... ±.0050
SYMBOL 2 ...... ±.0010 SYMBOL 3½ ...... ±.0100
SYMBOL 2½ ...... ±.0030 SYMBOL 4 ...... ±.0250
SYMBOL 5 ....

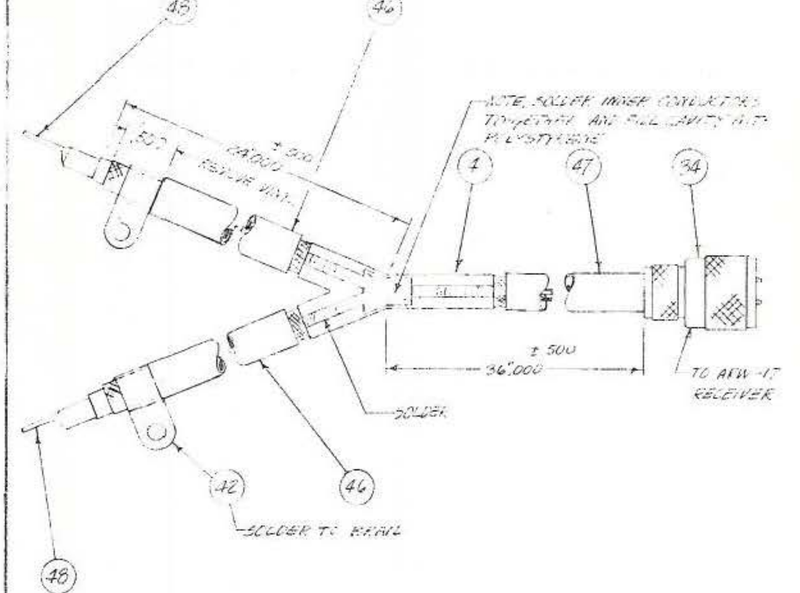
NAVAL RESEARCH LABORATORY
WASHINGTON 20, D. C.

COMMAND RECEIVING ANTENNA
INSTALLATION DIAGRAM
LOCATION

RA 66F 325B

FIGURE 18

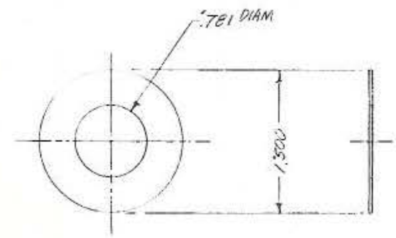
SHEET 1



CABLE ASSEMBLY

SCALE - FULL SIZE

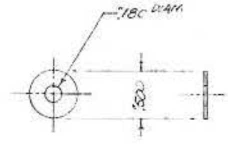
RA 66F 325



a (2) WASHER
VELLUTEX 1/32" TH'K
SYMBOL 3½
4 REQ'D

SCALE - FULL SIZE

RA 66F 325



a (3) WASHER
VELLUTEX 1/32 TH'K
SYMBOL 3½
4 REQ'D

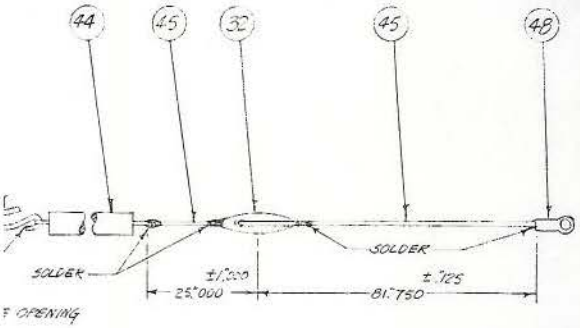
SCALE - FULL SIZE

RA 66F 325

[redacted]

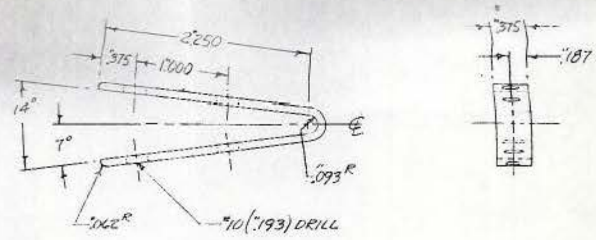
1 of 19

DECLASSIFIED



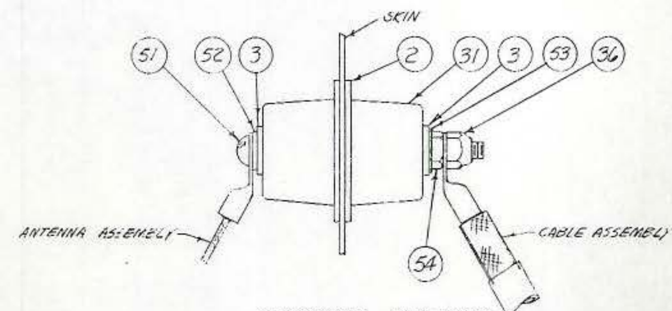
ANTENNA ASSEMBLY

NO SCALE
RA 66F 325



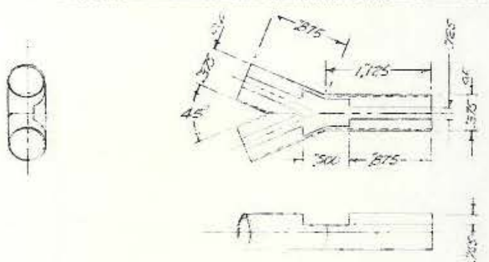
① BRACKET
BRASS (COMPO B-1) 3/32" THK
SYMBOL 3½
2 REQ'D

SCALE - FULL SIZE
RA 66F 325



STANDOFF ASSEMBLY

SCALE - FULL SIZE
RA 66F 325



④ YOKE
BRASS (COMPO B-1) .060 THK
SYMBOL 3½
2 REQ'D

SCALE - FULL SIZE
RA 66F 325

ALTERATION TABLE

REFERENCE DRAWINGS

DRAWN	R. CHAMBERLAIN	IN CHARGE OF DESIGN	SUPT. DESIGN & DRAFTING DIVISION
TRACED		CPS	FOR DIRECTOR
CHECKED	OPB		
APPR'V'D			COMDR. U.S.N.

NAVAL RESEARCH LABORATORY
WASHINGTON 20, D. C.

COMMAND RECEIVING ANTENNA

INSTALLATION DIAGRAM
DETAIL

SYMBOLS AND THEIR EQUIVALENT TOLERANCES (UNLESS OTHERWISE NOTED)

SYMBOL 1 ...... ±.0005	SYMBOL 3 ...... ±.0050
SYMBOL 2 ...... ±.0010	SYMBOL 3½ ...... ±.0100
SYMBOL 2½ ...... ±.0030	SYMBOL 4 ...... ±.0250
SYMBOL 5	

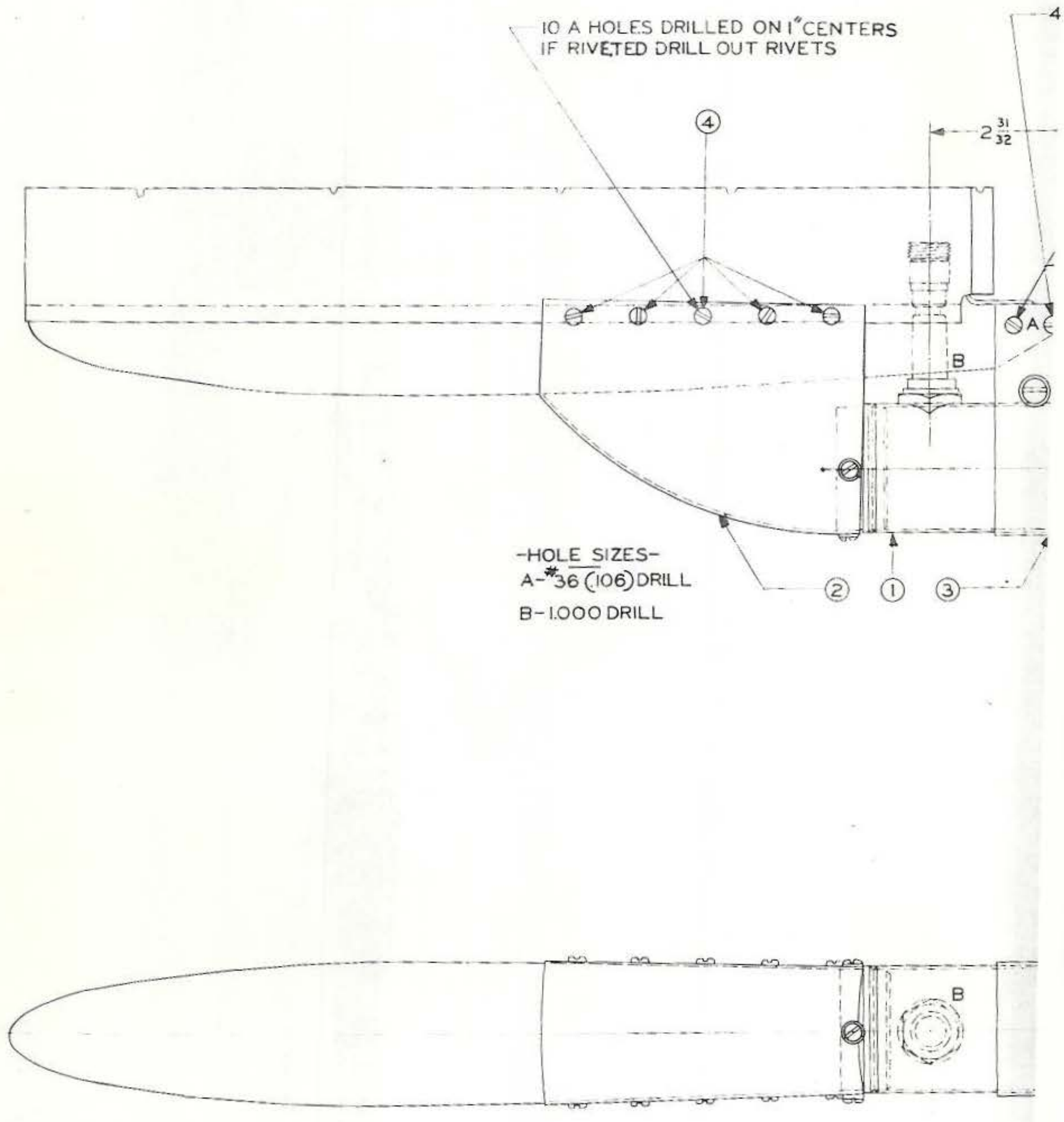
RA 66F 325

R-2616

FIGURE 19

SHEET 2A

2 of 19

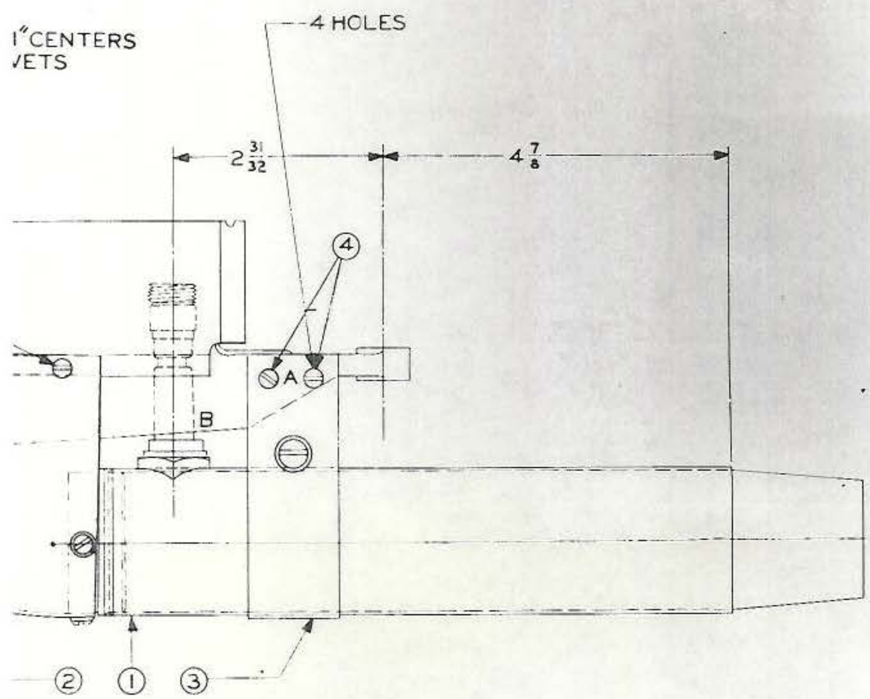


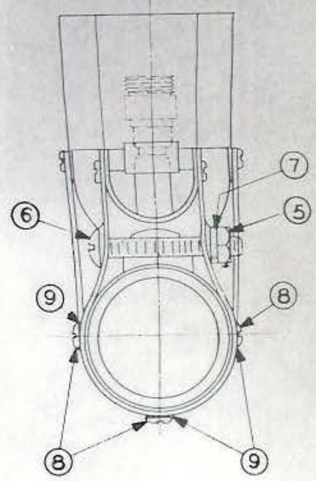
R-2616

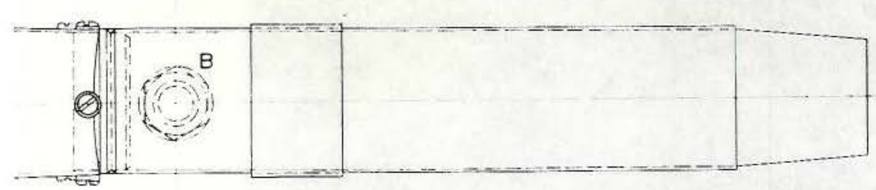
[redacted]

1 of 20

DECLASSIFIED







MAJ. PART NO.	NO	DESCRIPTION	REQ
P68N69	9	#10 SPLIT LOCK WASHER	3
P68N68	8	10-32×$\frac{1}{2}$ BINDING HEAD MACH. SCREW	3
P68N69	7	$\frac{1}{4}$ SPLIT LOCK WASHER	1
P68N65	6	$\frac{1}{4}$-20×2 MACH. SCREW	
P68N66	5	$\frac{1}{4}$-20 HEX. NUT	1
P68N64	4	*8 - $\frac{5}{16}$ PARKER KALON BIND HEAD SELF TAPPING SCREW	14
P68N64	3	CLAMP	1
P68N63	2	ANTENNA FAIRING	1
P68N24	1	ANTENNA	1

BEACON ANTENNA, INSTALLATION DIAGRAM

R-2616

FIGURE 20

THE JB-2 FLYING BOMB - SIDE VIEW

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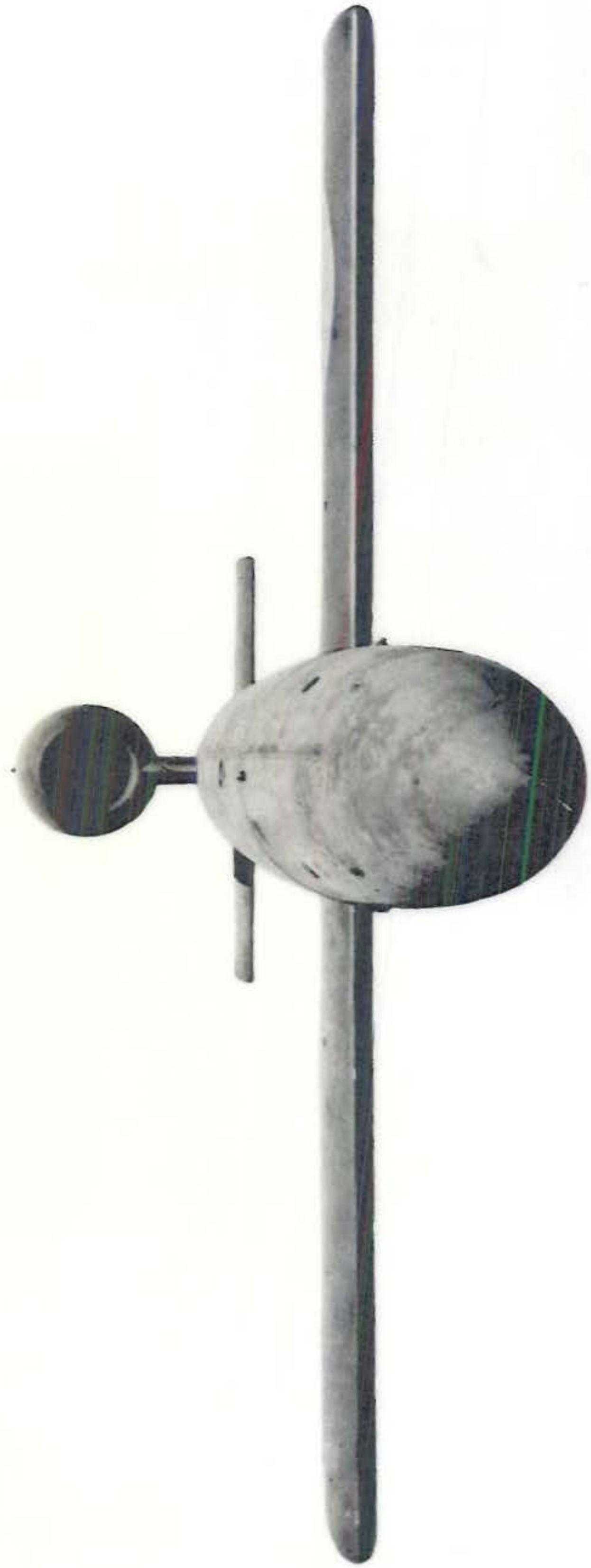
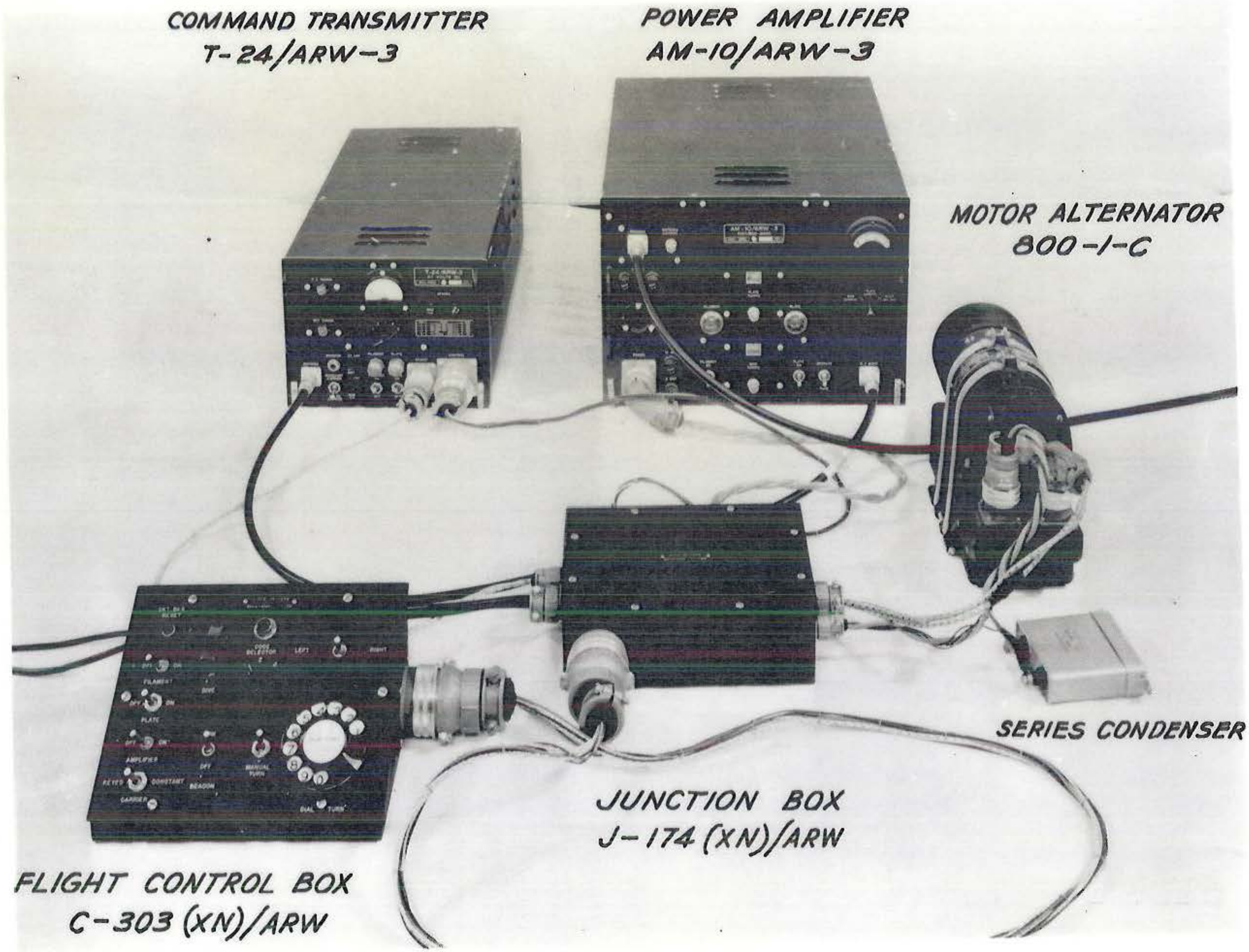


THE JB-2 FLYING BOMB - FRONT VIEW

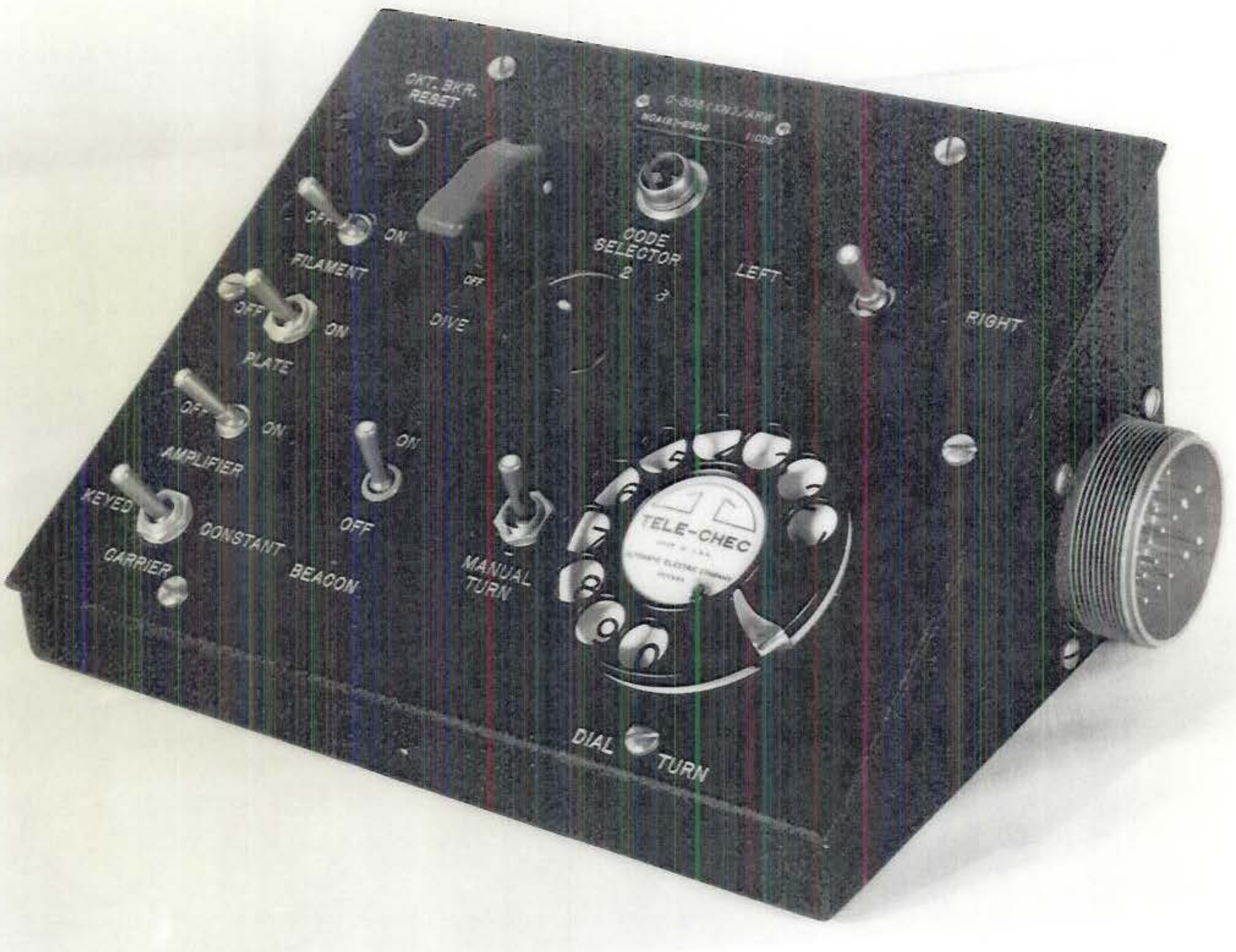
[redacted] DECLASSIFIED

[redacted]

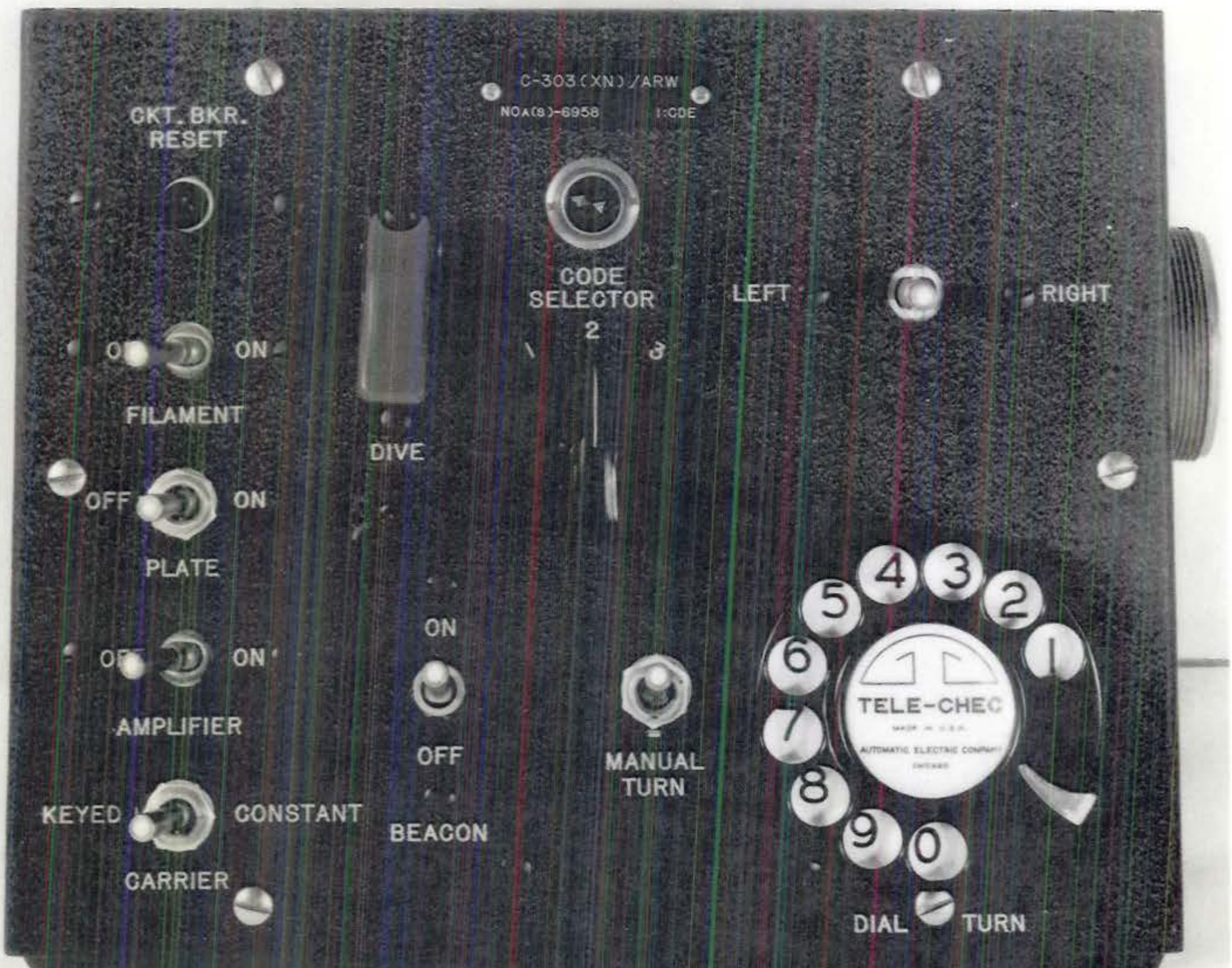


COMMAND TRANSMITTING EQUIPMENT

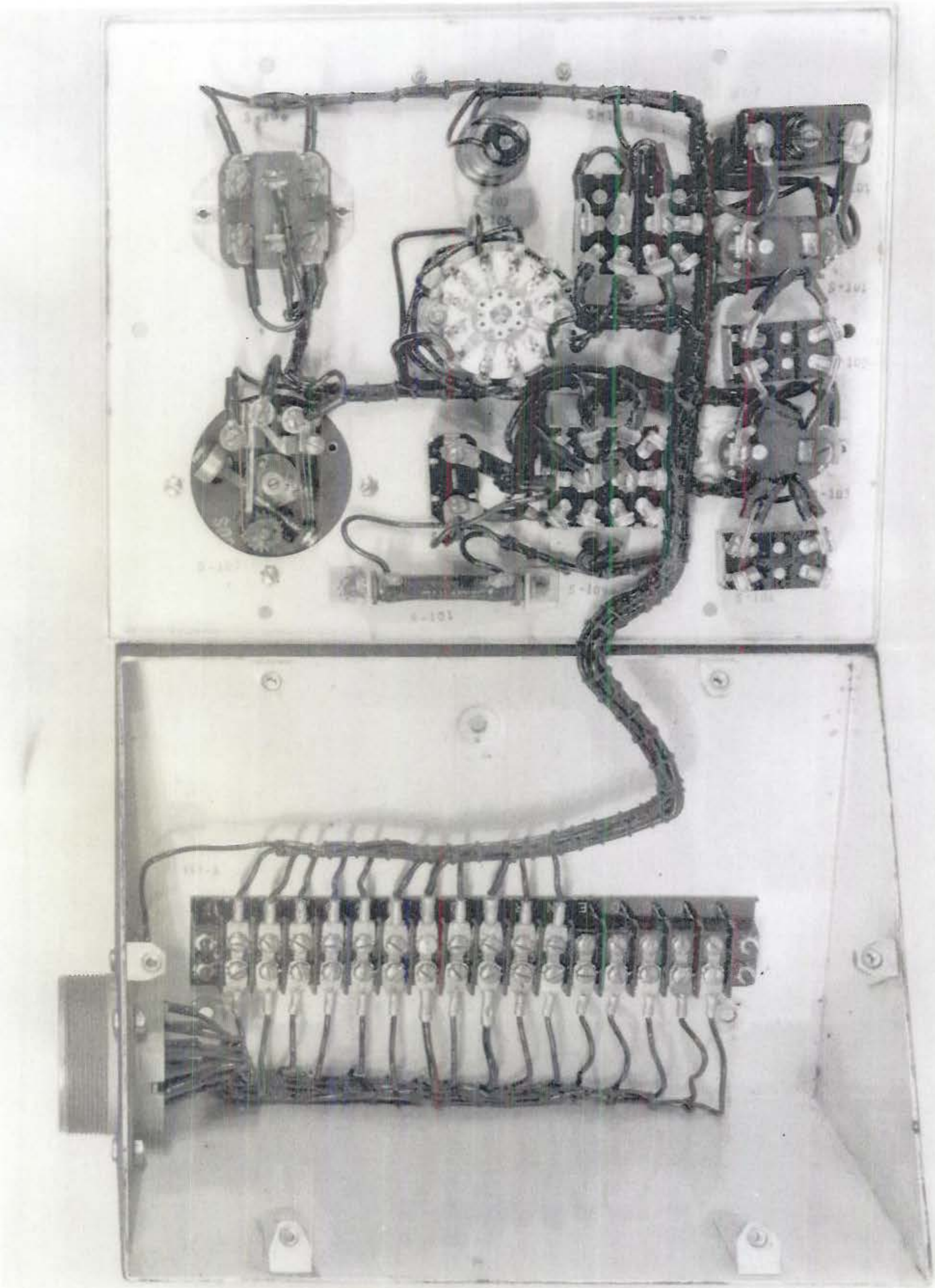
PLATE 3



FLIGHT CONTROL BOX C-303(XN)/ARW

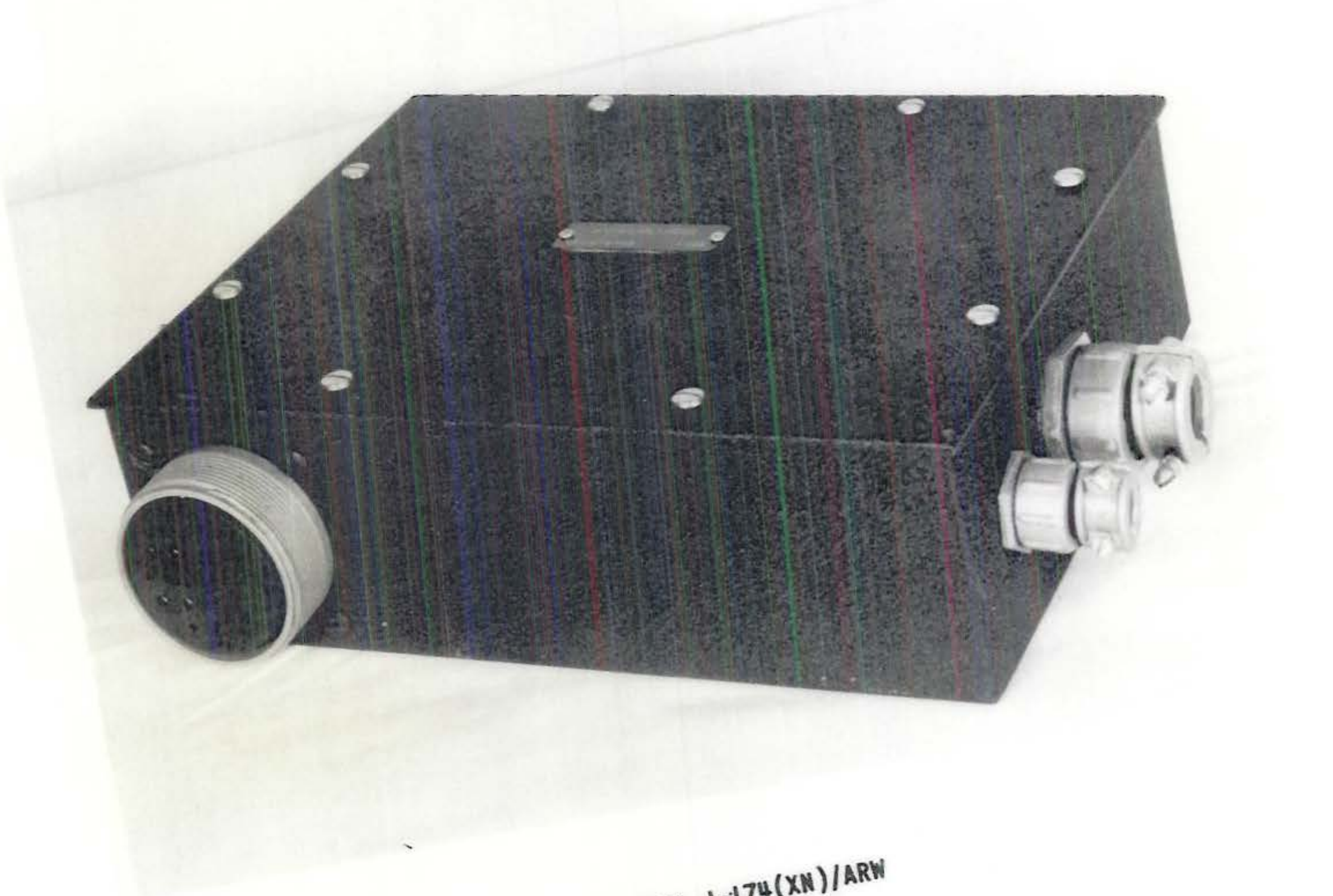


FLIGHT CONTROL BOX C-303(XN)/ARW - TOP VIEW



FLIGHT CONTROL BOX C-303(XN)/ARW - INTERIOR VIEW

DECLASSIFIED



JUNCTION BOX J-174(XN)/ARW

PLATE 7

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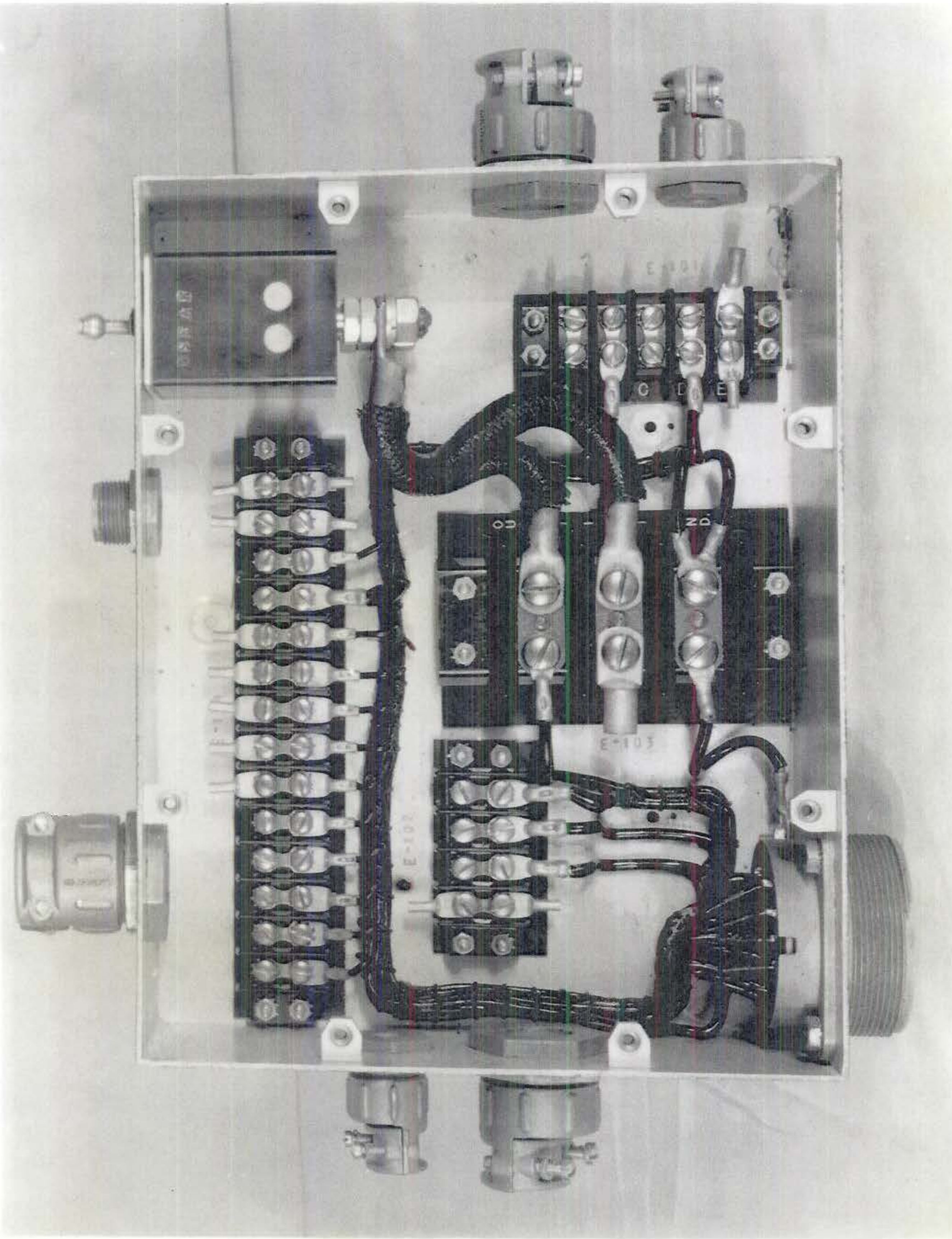
CONFIDENTIAL



JUNCTION BOX J-174(XN)/ARW - INTERIOR VIEW

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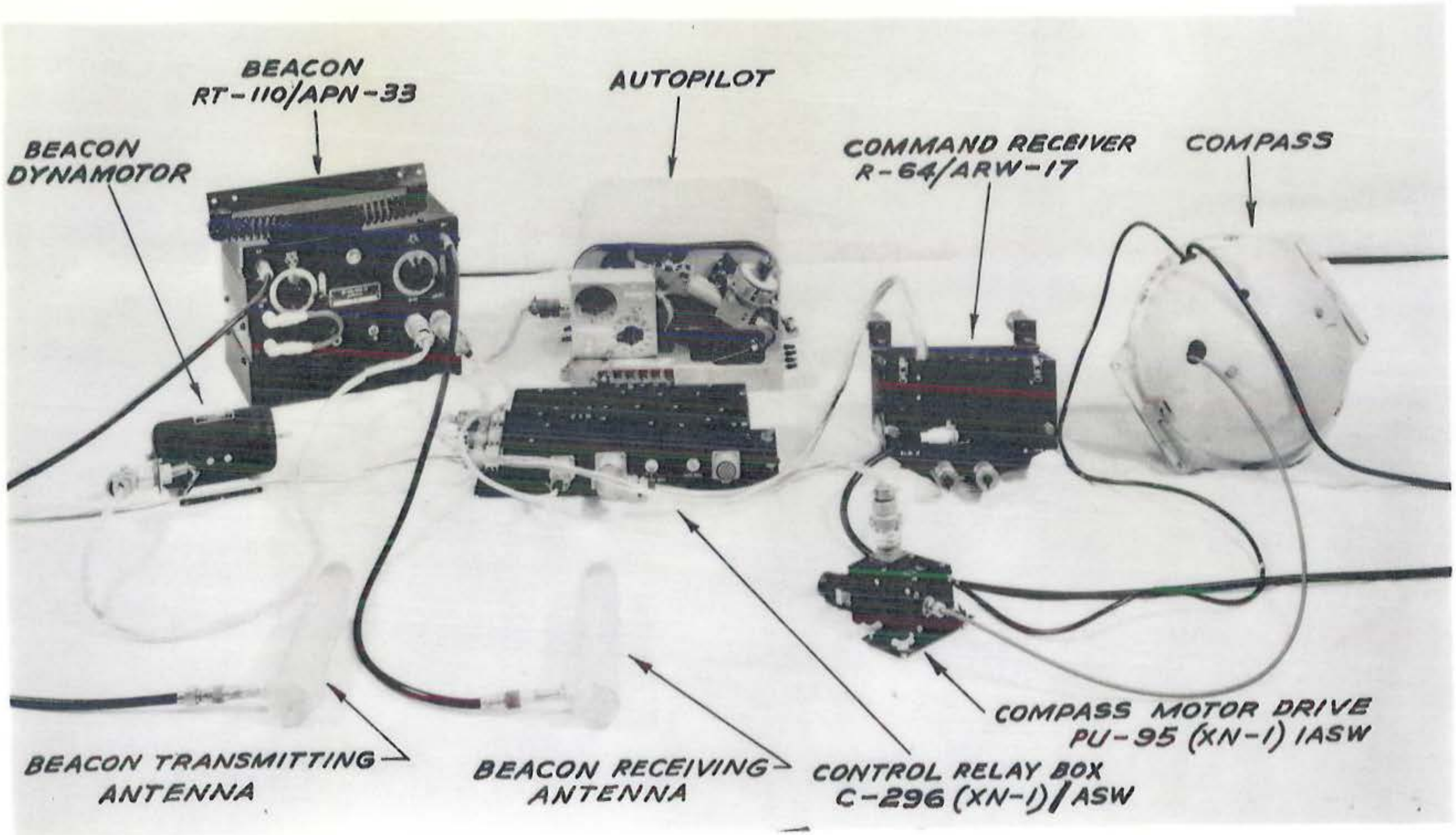
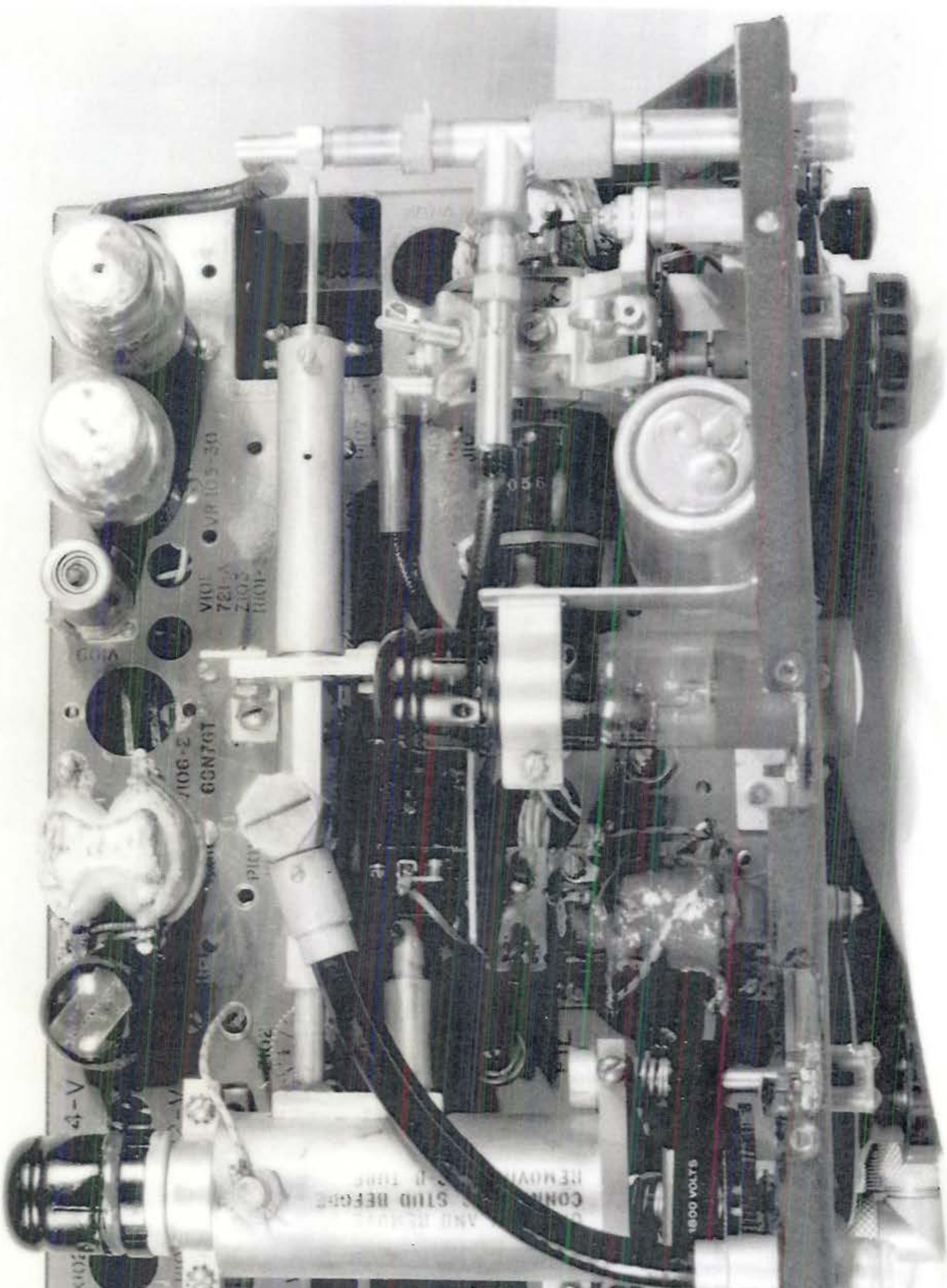


JB-2 ELECTRONIC AND FLIGHT CONTROL EQUIPMENT

BEACON RT-110/APN-33 INCLUDING DYNAMOTOR AND ANTENNAS

PLATE 10

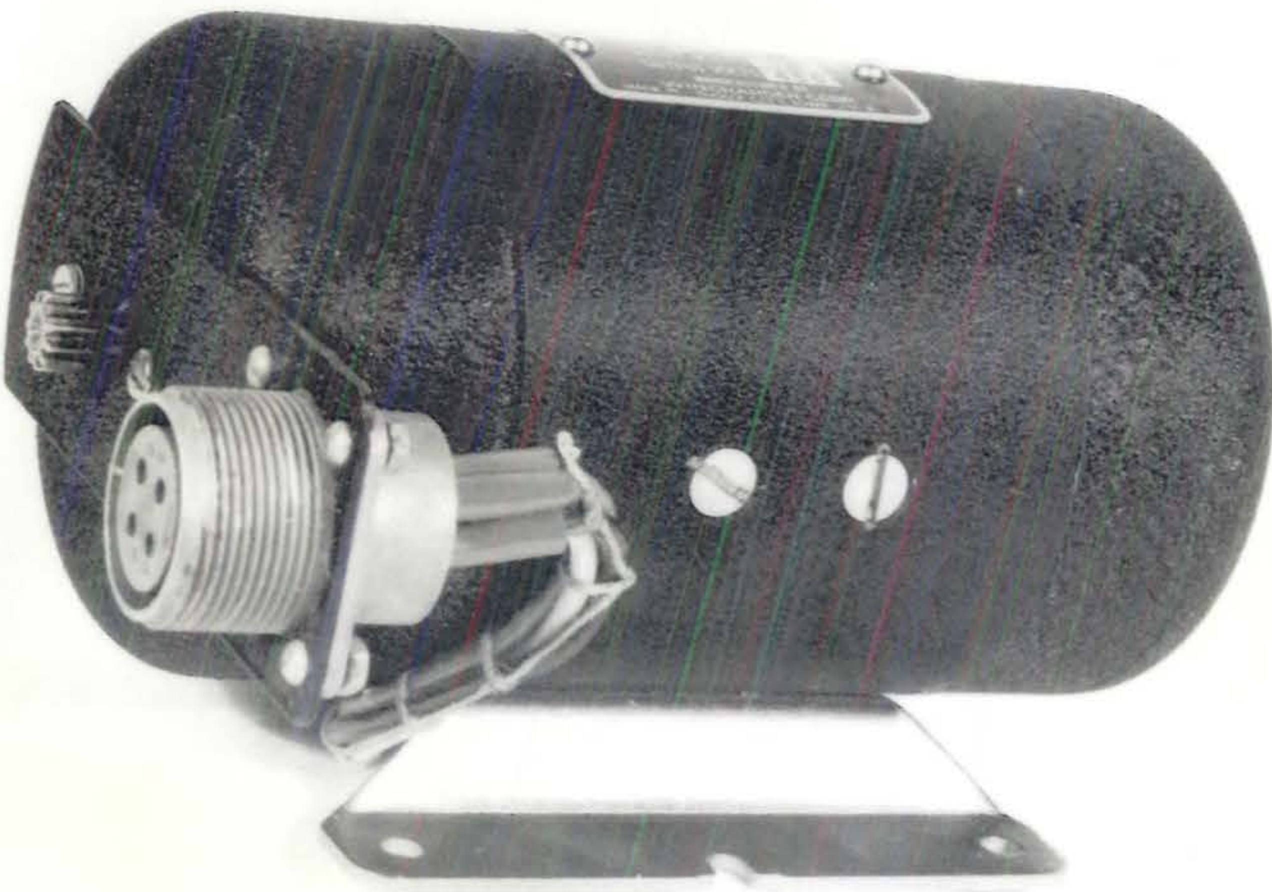
BEACON RT-110/APN-33 - FRONT PANEL



BEACON RT-110/APN-33 - INTERIOR VIEW

[redacted]

DECLASSIFIED



BEACON DYNAMOTOR

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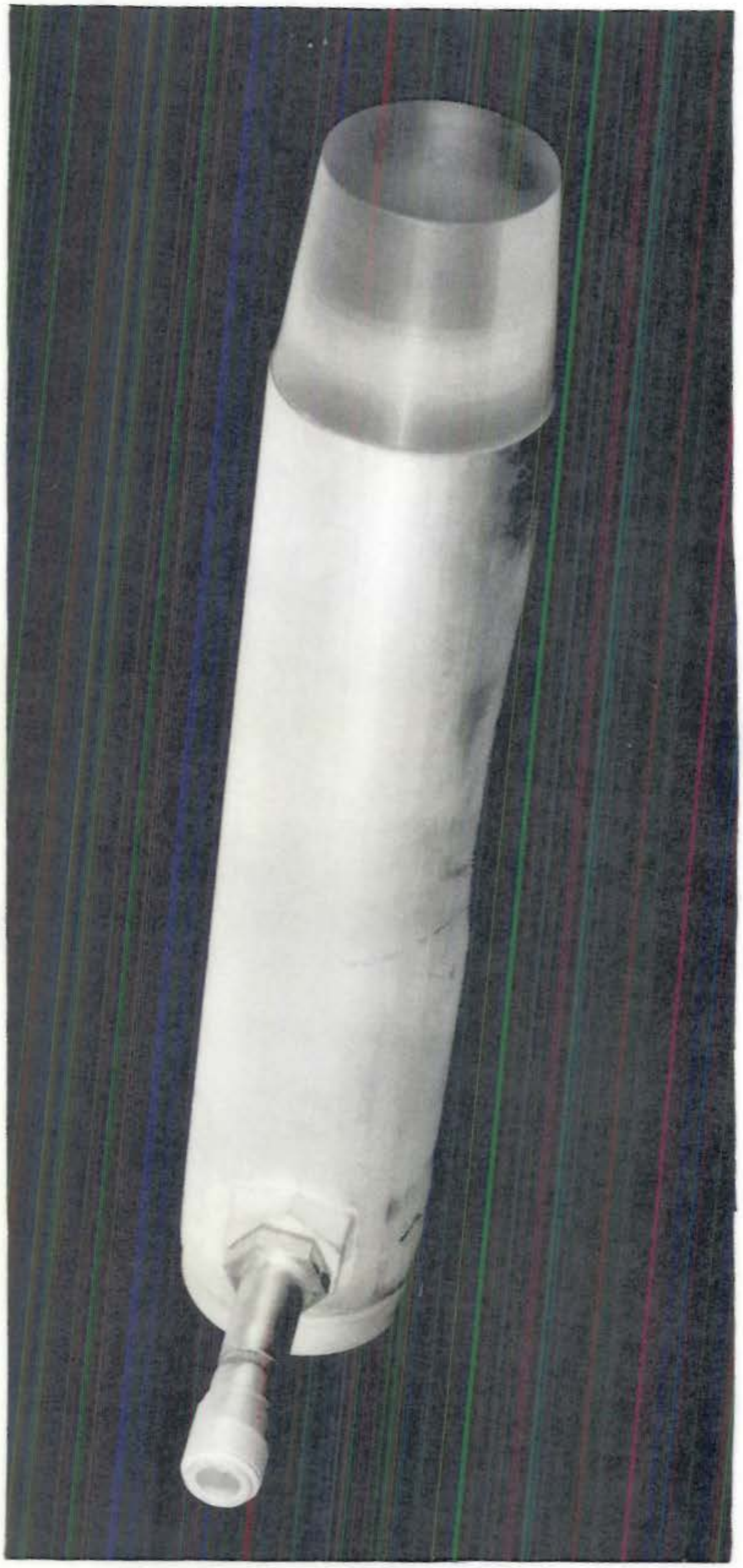
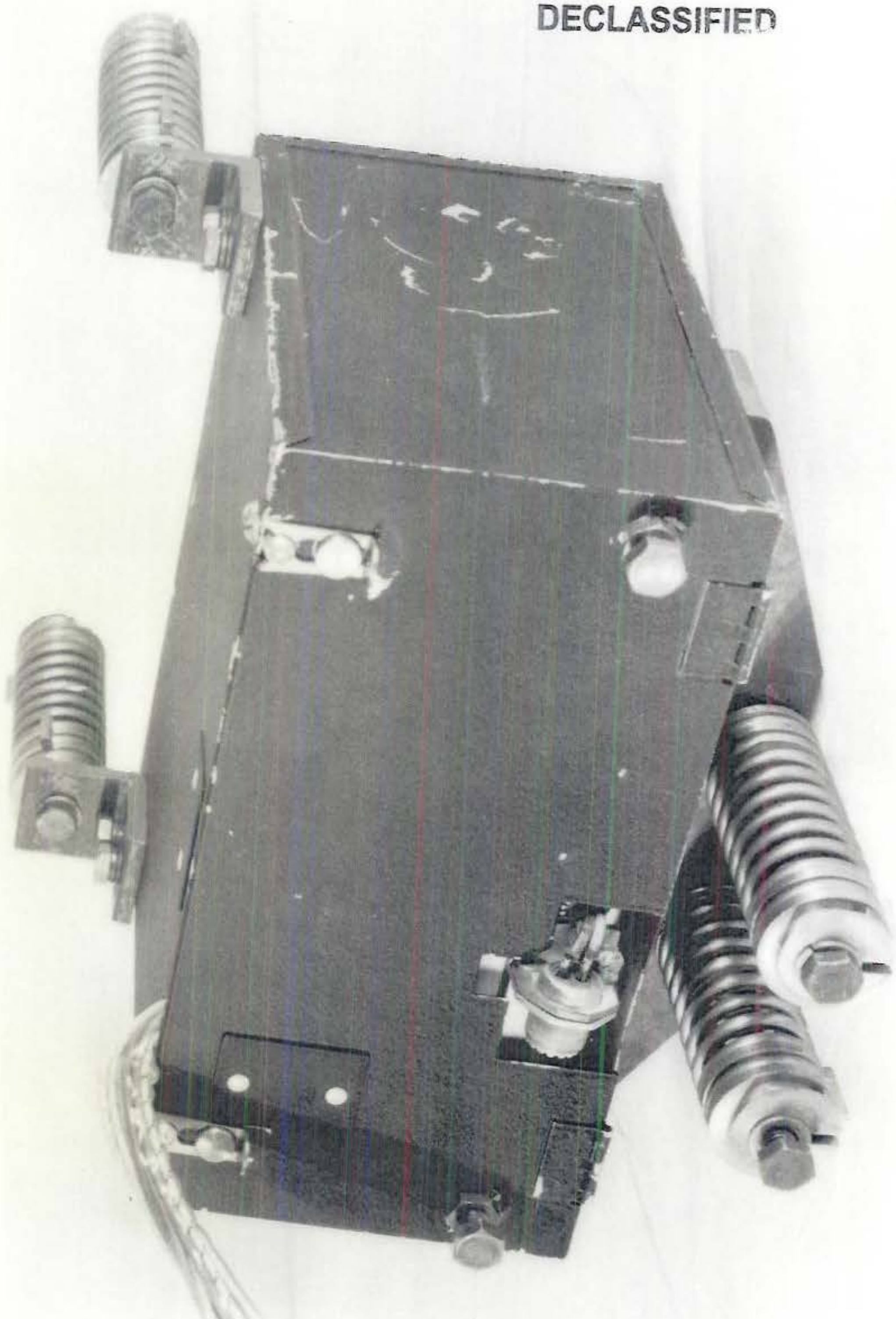


BEACON ANTENNA, "POLYCONE"



COMMAND RECEIVER R-64/ARW-17

[redacted] DECLASSIFIED