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REPORT NO. ZM 7-227T
DATE: 3 October 195
MODEL: 7

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15

AUTOPILOT CONTROL SYSTEM REQUIREMENTS

CAPTIVE FIRING

S-1 (SYCAMORE) SITE

REPORT NO. ZM 7-227 TN

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FOREWORD

This report is published as a preliminary copy, Revisions will be made at a later date to include design changes, operating changes, maintenance data, drawings, and illustrations.

For comment and additional information, please contact the Design Engineer concerned.

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FT 914	AUTOPILOT CONTROL PANEL ACCELEROMETER MONITOR AND EXERCISE
FT941	SIMPLIFIED DIAGRAM - AUTOPILOT READY CIRCUIT
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AUTOPILOT CONTROL SYSTEM REQUIREMENTS

CAPTIVE FIRING

S-1 (SYCAMORE SITE)

1.0 INTRODUCTION

1.1 GENERAL

The Autopilot Control System comprises the GROUND EQUIPMENT to perform FUNCTIONAL TESTS and CONTROL OPERATIONS on the Missileborne Atuopilot during countdown, static firings, and simulated launchings. Major components of the system are:

(1) Autopilot Control Console

(2) Autopilot Test Programmer Console

(3) Autopilot Transducer Excitation Unit

(4) Autopilot Monitor and Control Unit

1.1.1 PURPOSE

The Autopilot Control System was designed to permit operation and test of the Missileborne Autopilot from the blockhouse. The Autopilot Control System for the CAPTIVE FIRING test program at S-1 (~~Sycamore~~), differs from the AFMTC system as the AUTOPILOT TEST PROGRAMMER and TEST MONITORING UNIT are added to the blockhouse control equipment. (Also, there are minor differences in the standard blockhouse control equipment.) ~~It is~~ the purpose of this report to describe the Autopilot Control System as used at ~~the S-1 (Sycamore)~~ Stand 1.

1.1.2 AUTOPILOT CONTROL CONSOLE - S-1 (Sycamore) - (7-68602)

1.1.2.1 DESCRIPTION

The Autopilot Control Console contains the following units:

(1) Autopilot Auxiliary Control Console

(2) Decade Event Timer Panel

(3) Autopilot Control Console Panel

Figure 1 is a drawing of the Autopilot Control Console as used at S-1.

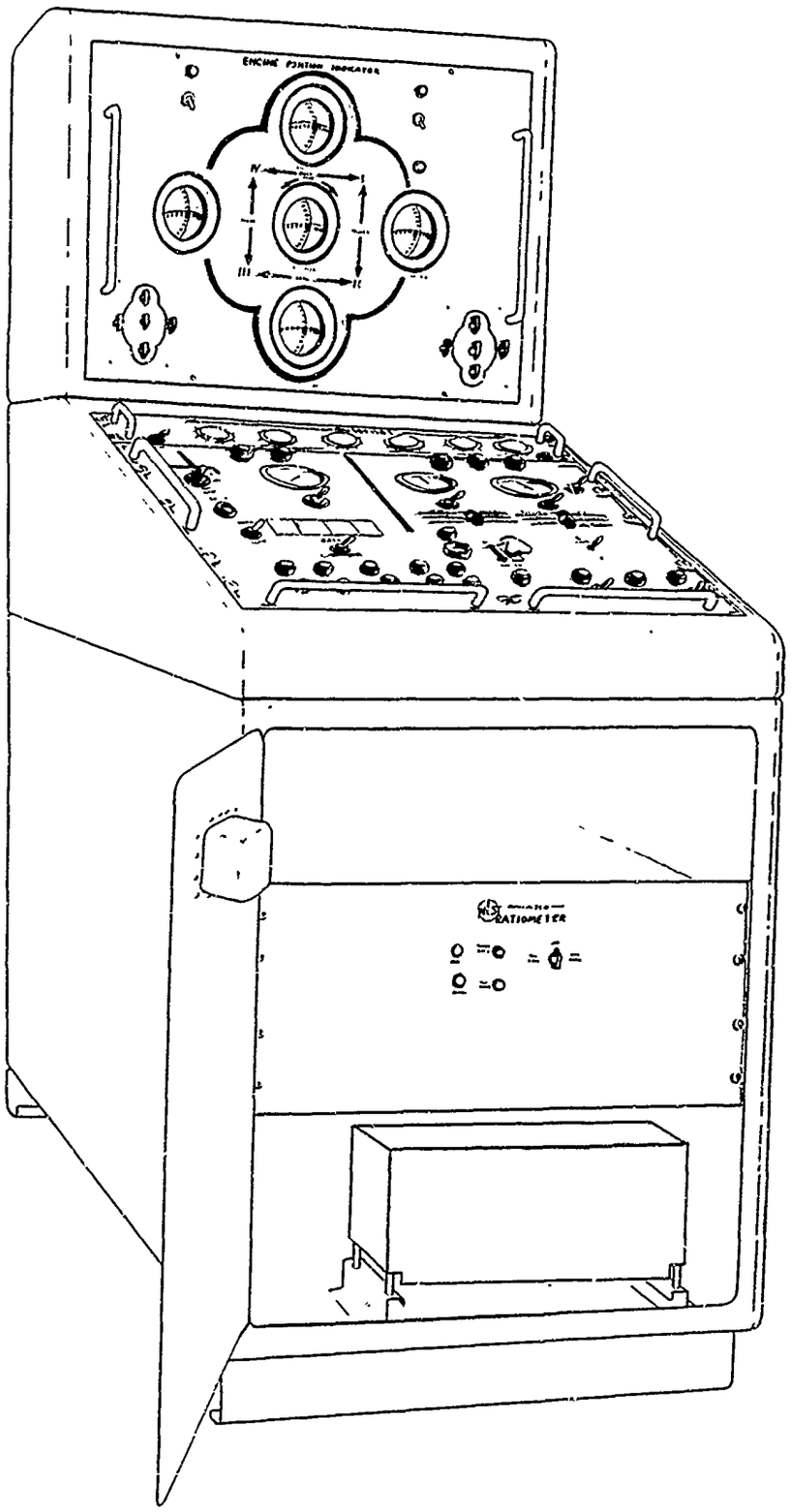

FIG. 1

1.1.2.2 ENGINE POSITION INDICATOR PANEL (AUTOPILOT AUXILIARY CONTROL CONSOLE)

As may be seen in Figure 1, the Engine Position Indicator Panel is mounted on the Autopilot Control Console, directly above the Decade Event Timer. The Engine Position Indicator Panel contains the following component parts:

(1) Engine Position Zero Indicator

This is a GREEN Press-to-Test light and an ON-OFF toggle switch which are located in the UPPER LEFT corner of the panel. When the switch is closed the light may come "ON", indicating when all the thrust chambers are ALIGNED. The switch is connected to a GREEN Press-to-TEST light on the Function Safe Panel in the Test Conductors Console, so the operator in that area will know when the thrust chambers are aligned. It is also connected to a GREEN Press-to-Test light in the LOWER RIGHT of the Autopilot Control Console Panel marked "ENGINE ZERO". The reliability of the thrust chamber alignment indication depends on the accuracy of calibration obtained for the Engine Position Indicator meters and associated circuitry. The calibration procedure for these meters is described in the maintenance section of this report. (Figure 3 is a simplified schematic of the calibration circuit as applies to the Booster Engine Position Indicators.)

(2) Coarse and Fine Scale Indicators

The Coarse and Fine Scale Indicators are AMBER Press-to-Test lights located below and above a toggle switch which selects the desired scale to be read on the Engine Position Indicator Meters. These are contained in the UPPER RIGHT panel.

(3) Engine Position Indicator Meters

There are five (5) cross pointer meters which indicate ENGINE-POSITION or THRUST CHAMBER ALIGNMENT. Their position in the CENTER of the Engine Position Indicator Panel is arranged in the same order as the five (5) Missile engines they represent. (i.e., were the operator viewing the missile from the rear.)

(4) Scale Increments and Arrangement

The Engine Position Indicator meter scale for the Booster Engine Position is shown in Figure 2. The value of the scale increment changes according to the position of the COARSE-FINE toggle switch. This switch controls a relay in the calibration circuit

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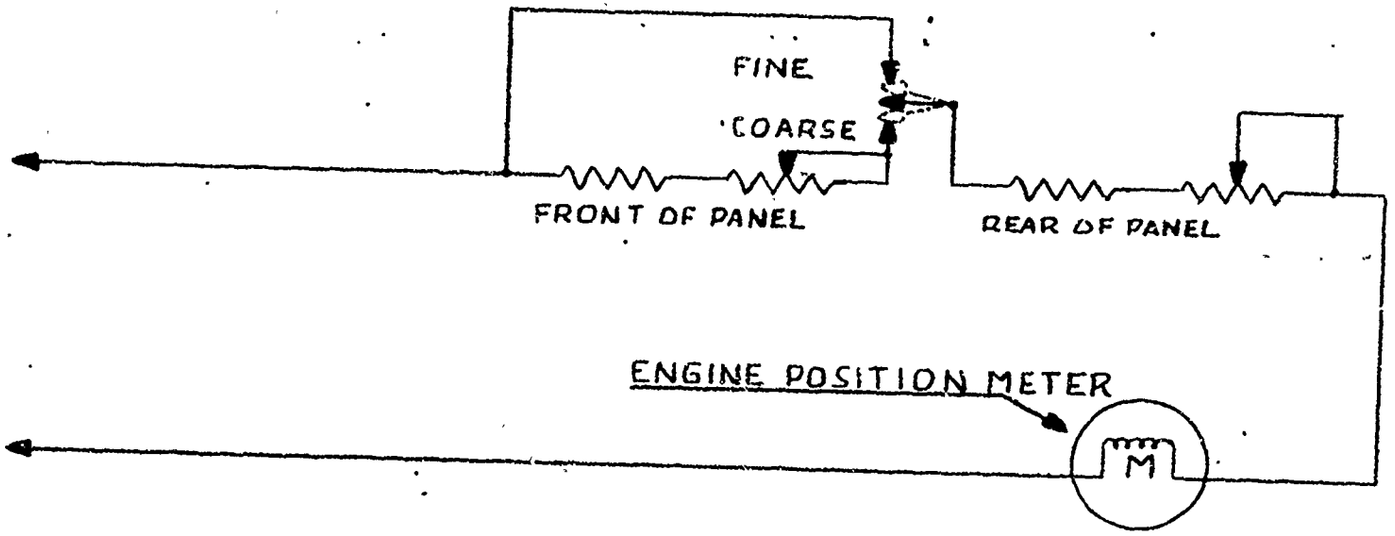
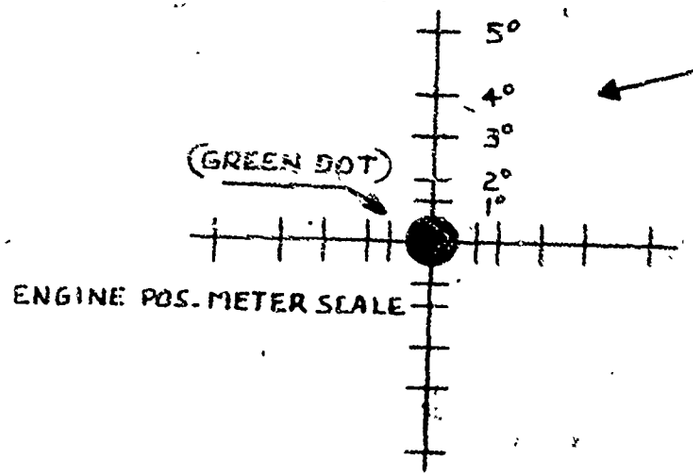


BOOSTER ENGINE SCALE

FINE SCALE = .5 VOLT PER 1° SCALE DEFLECTION
COARSE SCALE = .1 VOLT PER 1° SCALE DEFLECTION



ENGINE POSITION METER CALIBRATION
(SYCAMORE S-1 ONLY)
FIG. 2

1.1.2.2 (Continued)

which selects a lesser resistance when the switch is on the FINE position and a greater resistance when on the COARSE position. Using the Booster Engine Position Meter as an example; each scale increment equals 0.5 degrees when on "FINE" and 1.0 degree when on "COARSE". There are ten increments each for pitch and yaw. These are arranged VERTICALLY and HORIZONTALLY; five (5) increments on either side of a GREEN DOT which has a diameter of 1.0 scale division. The marking is black on a white background with the cross pointers superimposed.

(5) Pitch and Yaw Calibration Potentiometer (Figure 2)

(a) The pitch calibration potentiometers are located in the LOWER LEFT corner of the Engine Position Indicator Panel. These are eight (8) LOCKING potentiometers, four for "COARSE" calibration and four (4) for "FINE" calibration. Only the "COARSE" calibration potentiometers are accessible from the FRONT of the panel. The "FINE" calibration potentiometers are accessible from the REAR of the panel and are located directly behind the "COARSE" potentiometers. Both "COARSE" and "FINE" potentiometers are arranged to correspond with the Engine Position Meter they represent.

(b) The yaw potentiometers are identical to those for pitch and are located in the lower right corner of the panel.

1.1.2.3 DECADE EVENT TIMER UNIT

The Decade Event Timer Unit is located at the top of the Autopilot Control Console Panel. The unit provides a means of timing the Airborne Autopilot Programmer from BOOSTER START to BOOSTER CUTOFF and the Integrating Accelerometer from INTEGRATOR NULL to the BOOSTER CUTOFF. Numerical indications of elapsed time appear on six (6) circular counter tubes arranged in a single row. The tubes are the glow-transfer type and the top of each protrudes through the panel which is radially numbered 0 through 9. (Figure 3 is a block diagram of the unit and Figure 4 is a simplified schematic of the Decade Timer Selector Circuit.)

(1) Timing Range

The six counter tubes, in combination, provide a timing range of .001 to 999.999 seconds with an accuracy of ±.002% between start and stop impulses.

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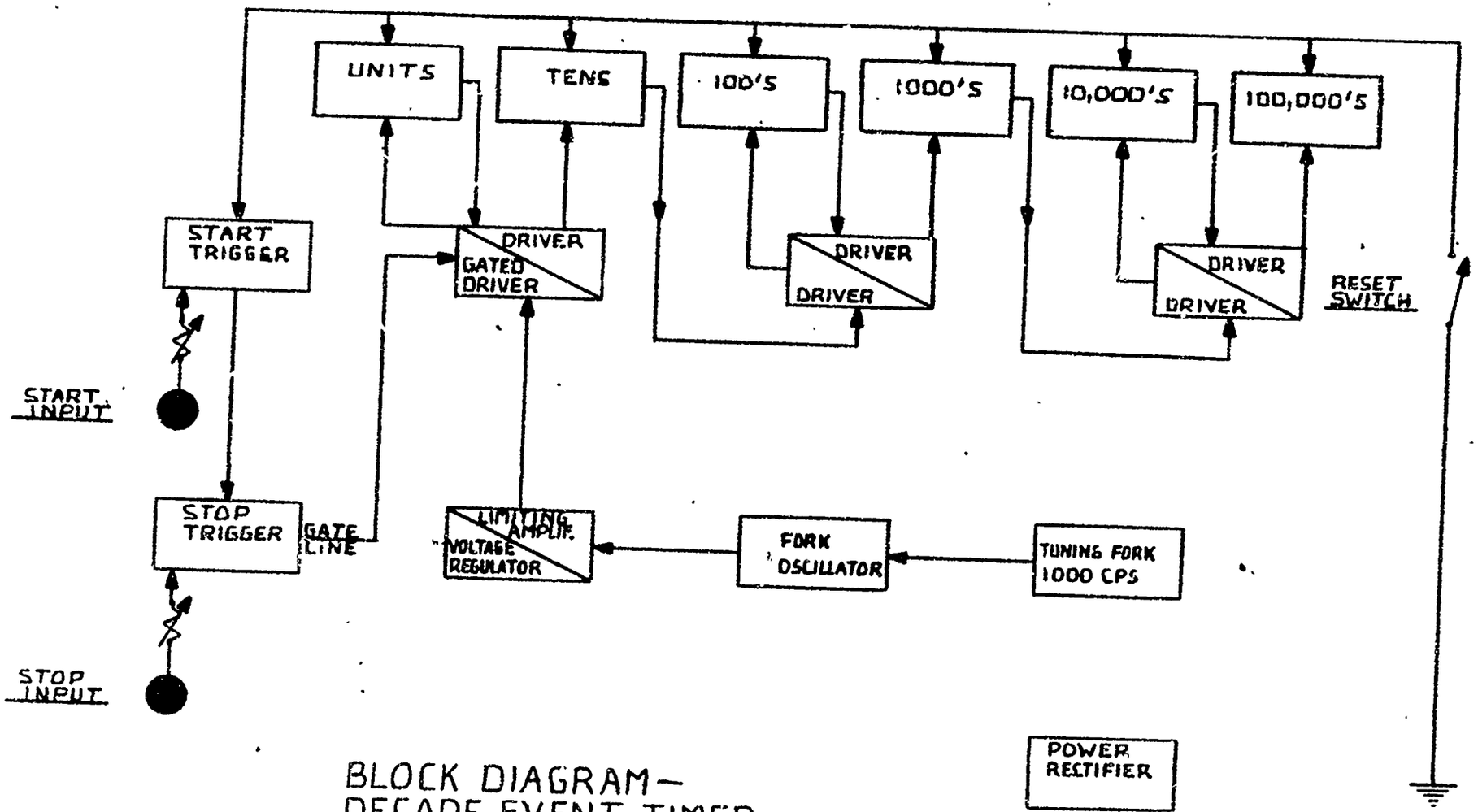

BLOCK DIAGRAM—
DECADE EVENT TIMER

FIG. 3

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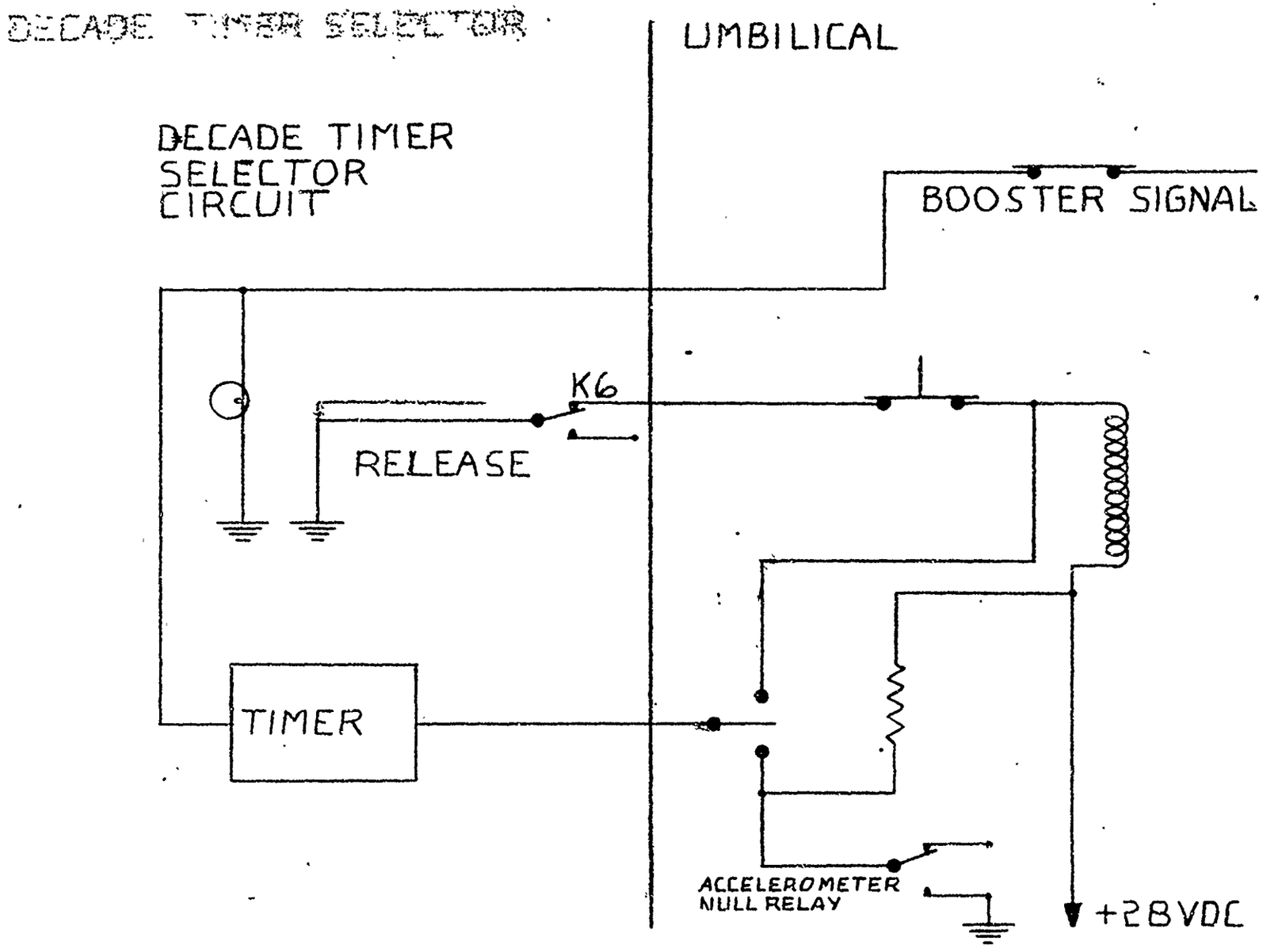

FIG. 4

1.1.2.3 (Continued)

(2) Timer ON-OFF Switch

The Timer ON-OFF switch is located on the LEFT SIDE of the panel. When closed, power is supplied to the Timer Unit.

(3) Reset Switch

The Reset switch is located on the RIGHT SIDE of the panel and is a pushbutton type. This switch is pressed after the aforementioned tests to return the counter tubes to the zero position.

(4) Counter Tubes

The six (6) counter tubes are Sylvania number 6802 type, or equivalent, and as shown in Figure 5, are arranged to count 100,000's, 10,000's, 1000's, 100's, 10's and UNITS, (reading from left to right on the panel).

(5) Starting Impulses

The Starting Impulse for both the FLIGHT PROGRAMMER and the INTEGRATING ACCELEROMETER is applied via switches on the Autopilot Control Console and are described in paragraph (1) of Section 1.1.2.4.

1.1.2.4 AUTOPILOT CONTROL CONSOLE PANEL

This panel is located directly below the Decade Event Timer Panel. Figure 5 shows the Autopilot Control Console Panel which consists of the following component parts:

(1) Decade Timer Selector Switch

The Decade Timer Selector is located in the UPPER LEFT CORNER of the panel. It is an ON-OFF-ON toggle switch which selects either the INTEGRATING ACCELEROMETER or the FLIGHT PROGRAMMER PROGRAM for the Decade Event Timer, (as noted in paragraph (5) of Section 1.1.2.3).

(2) Programmer Zero Indicator

The Programmer Zero Indicator is a GREEN Press-to-Test light, located above the Decade Timer Selector Switch. This light indicates that the Flight Programmer is on "ZERO". The light will go "OFF" during the FLIGHT PROGRAMMER TEST CYCLE.

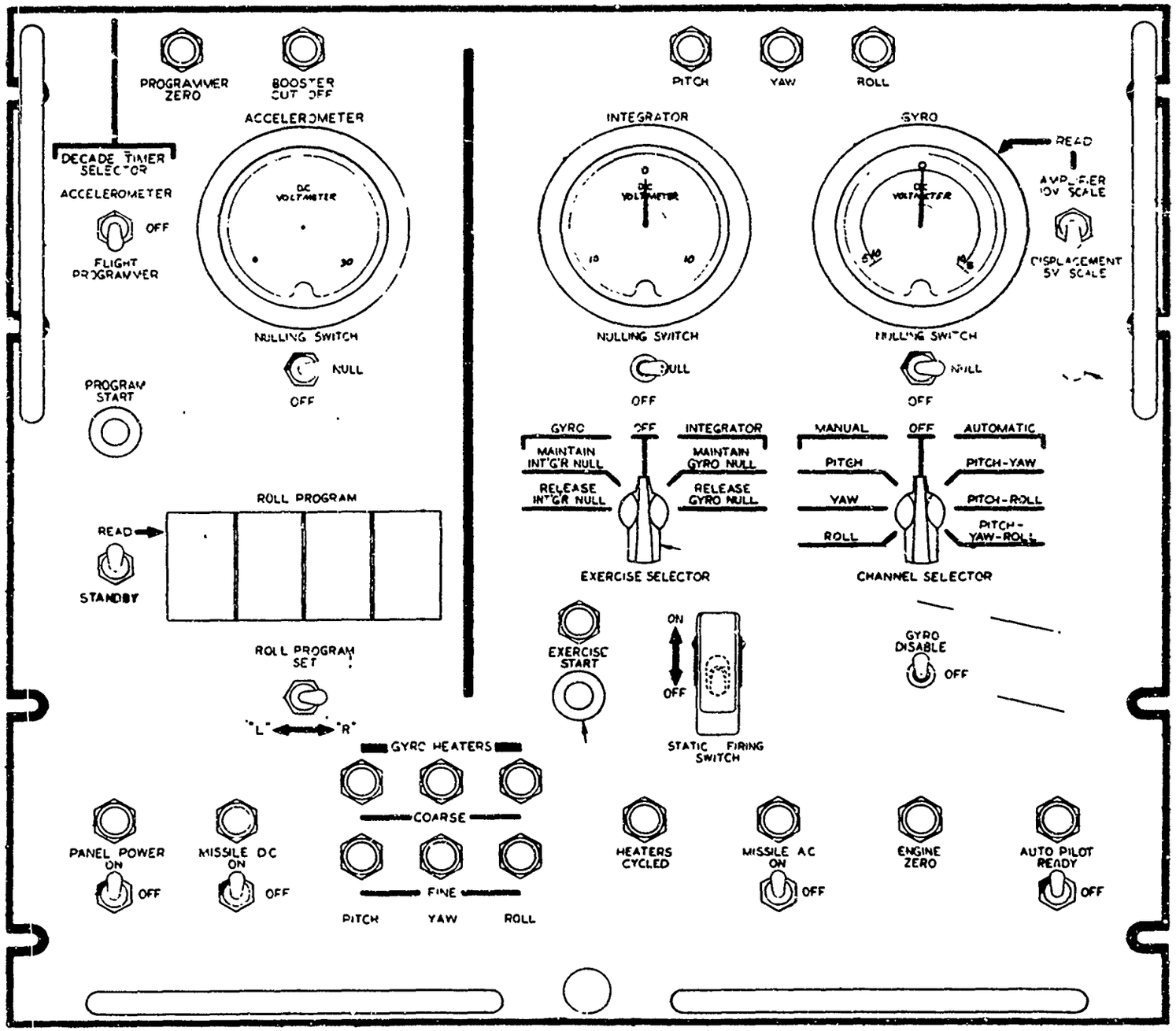
PROGRAMMER ZERO
BOOSTER CUT OFF
ACCELEROMETER
DECADE TIMER SELECTOR
ACCELEROMETER
OFF
FLIGHT PROGRAMMER
DC VOLTMETER
30
NULLING SWITCH
NULL
OFF
PROGRAM START
ROLL PROGRAM
READ
STANDBY
ROLL PROGRAM SET
"L"
"R"
PITCH
YAW
ROLL
INTEGRATOR
DC VOLTMETER
10
10
NULLING SWITCH
NULL
OFF
GYRO
DC VOLTMETER
5V
5V
NULLING SWITCH
NULL
OFF
READ
AMPLIFIER 10V SCALE
DISPLACEMENT 5V SCALE
GYRO
OFF
INTEGRATOR
MAINTAIN INT'G'R NULL
RELEASE INT'G'R NULL
MAINTAIN GYRO NULL
RELEASE GYRO NULL
EXERCISE SELECTOR
MANUAL
OFF
AUTOMATIC
PITCH
YAW
ROLL
PITCH-YAW
PITCH-ROLL
PITCH-YAW-ROLL
CHANNEL SELECTOR
EXERCISE START
ON
OFF
STATIC FIRING SWITCH
GYRO DISABLE
OFF
GYRO HEATERS
COARSE
FINE
PITCH
YAW
ROLL
PANEL POWER ON
OFF
MISSILE DC ON
OFF
HEATERS CYCLED
MISSILE AC ON
OFF
ENGINE ZERO
AUTO PILOT READY
OFF

FIG. 5

1.1.2.4 (Continued)

(3) Booster Cutoff Indicator

The Booster Cutoff Indicator is an AMBER Press-to-Test light, located to the right of the Programmer Zero Indicator. This light comes "ON" at the during the FLIGHT PROGRAMMER TEST CYCLE, and INTEGRATING ACCELEROMETER TEST, indicating Booster cutoff.

(4) Program Start Switch

The Program Start switch is a NORMALLY CLOSED pushbutton switch, located directly below the Decade Timer Selector switch. Pressing the Program Start Switch starts the Flight Programmer.

(5) Accelerometer Nulling Switch

The Accelerometer Nulling Switch is a two-position toggle switch, located directly below the Accelerometer Null Voltmeter. This switch APPLIES or RELEASES the Accelerometer Null for TEST PURPOSES. (See Figure 6.)

(6) Accelerometer Voltmeter

This meter is used in conjunction with the Accelerometer Nulling Switch. It has a full scale range of 0 to 30 volts DC. When the Accelerometer Nulling Switch is on "NULL", the meter should indicate fourteen (14) volts, or MID-SCALE.

(7) Roll Program Readout

The Roll Program Readout consists of a digital type meter which displays the appropriate numerals and symbols. [illegible] displayed.

(8) Read-Standby Switch

The Read-Standby Switch places the Roll Program Readout Meter in the "OPERATE" (READ) or "STANDBY" condition.

(9) Roll Program Set-Switch

Figure 7 is a simplified schematic of the Roll Program Set-Switch and associated circuitry. The Roll Program Set-Switch is located directly below the Roll Program Readout Meter. It is a two-position toggle switch which enables the operator to pre-set the AMOUNT and DIRECTION of missile roll. The "L" indicates a PLUS (+) or clockwise roll when looking forward towards the nose of the missile, and the "R" is a MINUS (-) or counter-clockwise roll. This is related to a LEFT or RIGHT heading after the missile leaves

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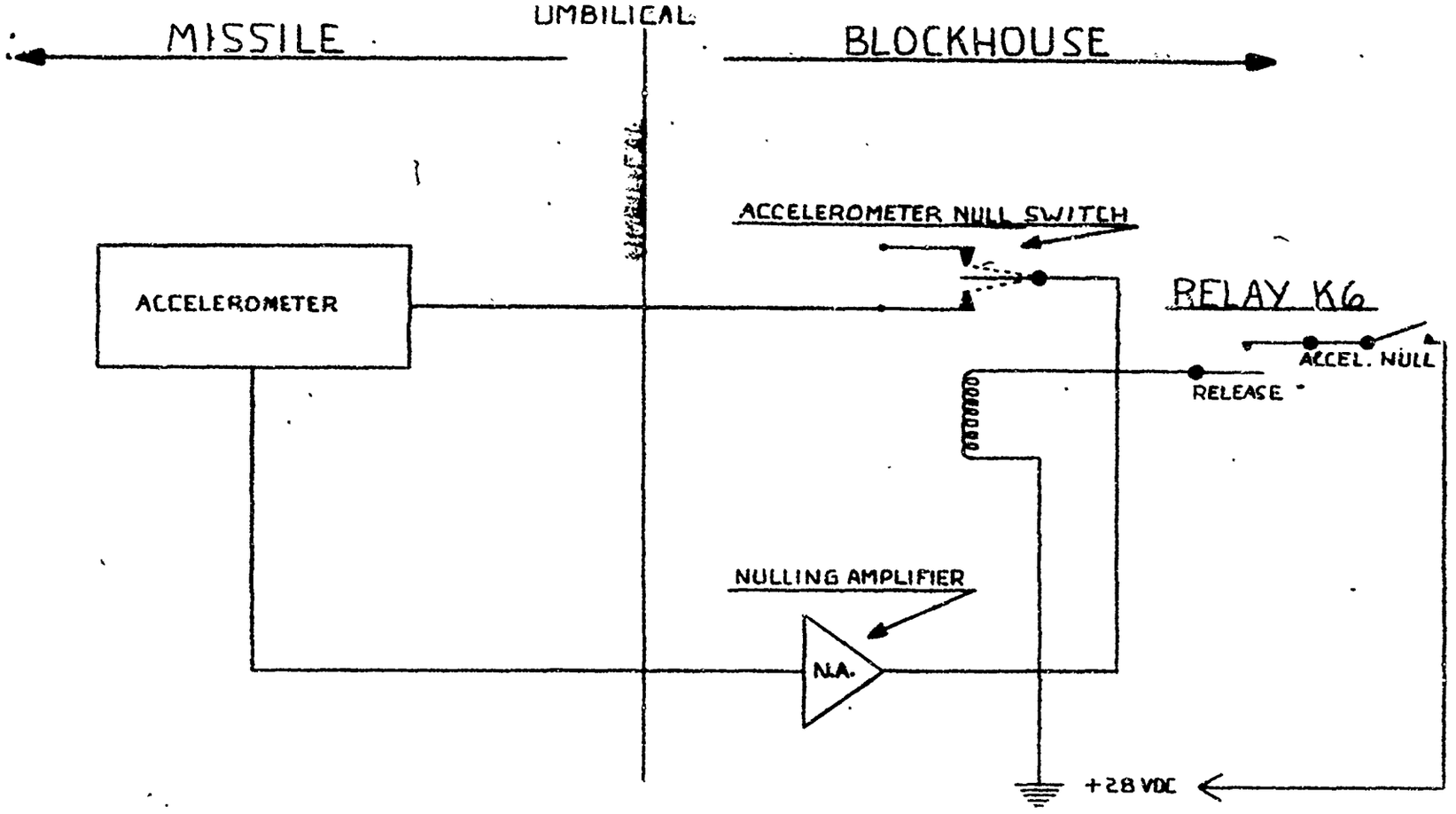

ACCELEROMETER NULL CIRCUIT

FIG. 6

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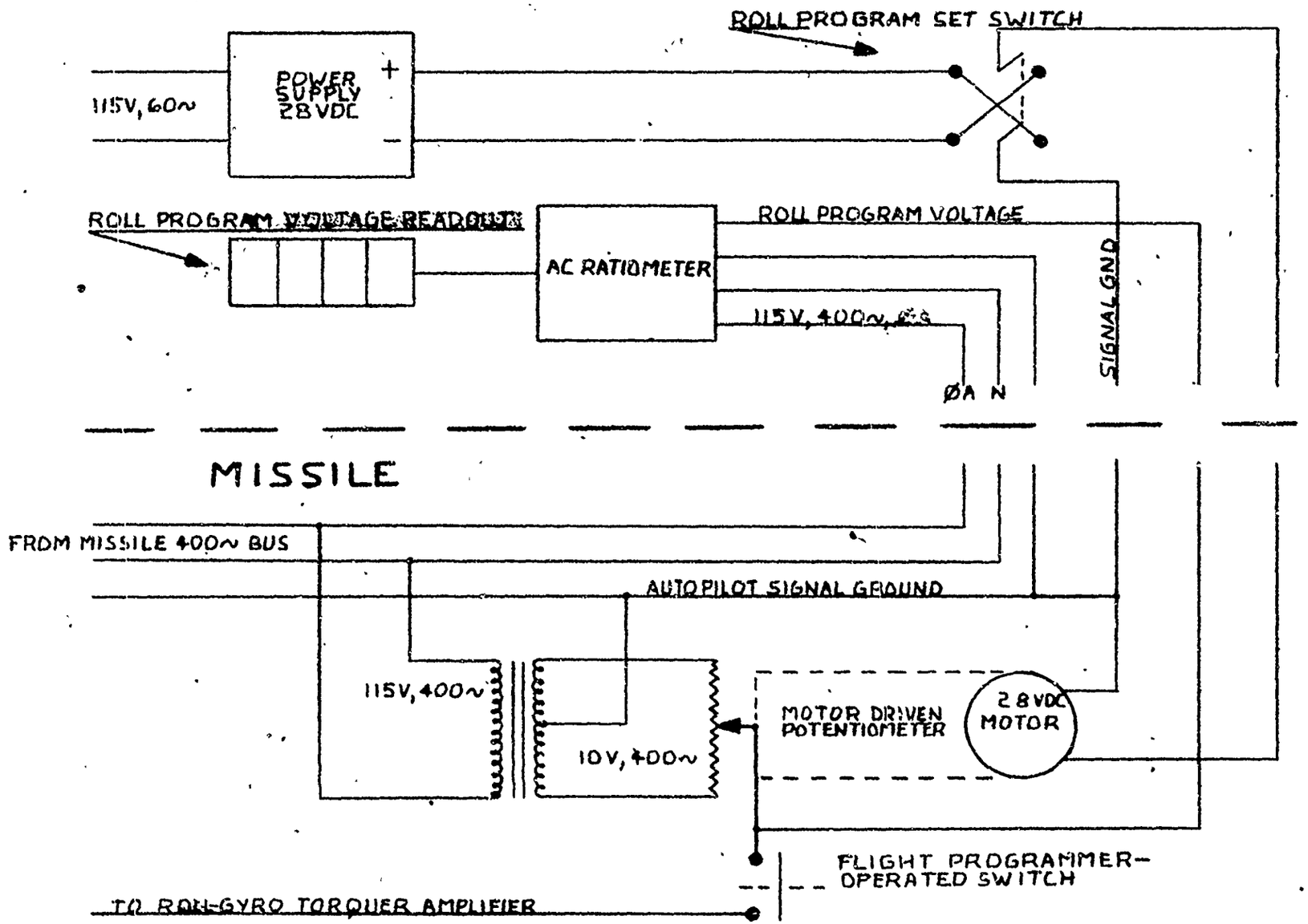

FIG. 7

1.1.2.4 (Continued)

the launcher.

(10) Pitch, Yaw, and Roll Indicators

The Pitch, Yaw, and Roll Indicators are three (3) AMBER Press-to-Test lights located at the TOP RIGHT of the Panel. These lights indicate which channel is being exercised, either MANUALLY or AUTOMATICALLY. The Channel Selection is made by the Channel Selector Switch which is described in paragraph (16) of this section.

(11) Integrator Nulling Switch

The Integrator Nulling Switch is a two-position toggle switch located directly under the Integrator Nulling Voltmeter. This switch controls the Integrator Nulling when the missile engines are NOT being exercised by the Engine Exercise Unit. The primary purpose of this switch is to NULL the integrators prior to a simulated launch.

(12) Integrator Voltmeter

This meter is a CENTER-READING DC voltmeter with a 0 to 10 volt scale each side of center. It should read "ZERO" volts when the Integrator Nulling Switch is in the "NULL" position, provided the Engine Exercise Unit is not operating. When the Engine Exercise Unit is in operation, the Integrator Null Switch is LOCKED OUT and each channel is exercised and the meter will fluctuate as the exercise progresses.

(13) Gyro Nulling Switch

This switch is located directly under the Gyro Nulling Voltmeter and serves the same purpose for the gyros as the Integrator Nulling switch does for the integrators.

(14) Gyro Voltmeter

The Gyro Nulling Meter indicates when the gyros are nulled. In this respect it functions identically to the Integrator Nulling Meter. There is, however, a MAJOR DIFFERENCE in that the Gyro Nulling Meter is a Dual Scale center reading DC voltmeter. There is a ten (10) volt scale (CENTER READING) and a five (5) volt scale (CENTER READING). The ten volt scale represents the INPUT to the meter from the GYRO AMPLIFIER, and the five volt scale represents the DISPLACEMENT GYRO INPUT to the meter. The scale selection is made by the Amplifier-Displacement switch.

1.1.2.4 (Continued)

(15) Amplifier - Displacement Switch

This switch is located to the right of the Gyro Nulling Meter. It is a two-position toggle switch and selects one of the two scales described in paragraph (14) of this section. There are three (3) channels possible on either AMPLIFIER or DISPLACEMENT positions. These are PITCH, YAW, and ROLL. The Channel Selector Switch selects the desired channel.

(16) Channel Selector Switch

The Channel Selector switch is a rotary seven-position switch located directly below the Gyro Nulling Switch. Positions to the left are for "MANUAL" and those to the "RIGHT" are for "AUTOMATIC" operation. When on any of the "MANUAL" positions, the Integrator and Gyro voltmeters will indicate the voltages of the channel selected according to the position of the AMPLIFIER - DISPLACEMENT SWITCH. When the Channel Selector switch is on the "AUTOMATIC" side, (RIGHT side of "OFF"), the channels selected will be exercised in the order shown on the panel.

(17) Exercise Selector Switch

This switch is a rotary five (5) position switch, located directly below the Integrator Nulling switch. When to the LEFT of "OFF", the Engine Exercise signal is applied to the Gyro and there is a CHOICE of either maintained or releasing the INTEGRATOR NULL of the channel being exercised. When on the RIGHT side of "OFF", the Engine Exercise signal is applied to the Integrator input through the Integrator Nulling circuit of the channel being exercised. There is a CHOICE of releasing or maintaining GYRO-NULL as the test requires. The channel exercised is chosen by the Channel Selector Switch. (Paragraph (16) of this section.)

(18) Exercise Start

The Exercise Start consists of an AMBER Press-to-Test light and the Exercise Start switch directly below it. These are located below the Exercise Selector Switch. The Exercise Start Switch is a MOMENTARY type pushbutton switch. When pressed, it will start the Engine Exercise Program. The Exercise Start light should come "ON" when the switch is pressed, indicating that the Exercise Program is underway.

(19) Static Firing Switch

The Static Firing switch is a two-position ON-OFF GUARDED SWITCH. This switch must be "ON" during a static firing. When in the "ON"

1.1.2.4 (Continued)

position, it BY-PASSES the Exercise Selector switch interlock. (The necessity for the interlock around the Exercise Selector circuit is that during a static firing it is desirable to have selected the Engine Exercise PRIOR to or DURING firing of the engines.)

(20) Gyro Disable Switch

This switch is a two-position toggle switch located directly below the Channel Selector switch. In the DISABLE position this switch GROUNDS the OUTPUTS from being fed into the Integrators and Servo Amplifiers. (This is required so as to eliminate the possibility of severe structural autopilot oscillations that could occur during a static firing.)

(21) Panel Power

The Panel Power is applied by closing the two-position toggle switch located in the BOTTOM LEFT CORNER of the panel. When the switch is closed, the AMBER Press-to-Test light, directly above it, comes "ON", indicating that 115-208 volts AC, 60 cycle, 3 phase power (supplied by the PAD FACILITY SYSTEM) has been applied to the Autopilot Control Console, including the Decade Event Timer. This power is also supplied to the Autopilot Monitor and Control Unit and the Transducer Excitation Unit.

(22) Missile DC

This control consists of a two-position toggle switch and an AMBER Press-to-Test light directly above it. These are located to the RIGHT of the Panel Power Controls. Closing the switch applies +28 volts DC to the COARSE GYRO HEATERS, located in the Missile Displacement Gyros, and simultaneously to the COARSE GYRO HEATER INDICATOR LIGHTS.

(23) Coarse Gyro Heater Indicator Lights

These lights comprise the TOP ROW of AMBER Press-to-Test lights to the RIGHT of the Missile DC Switch. There is one light for each Displacement Gyro Coarse Heater (PITCH, YAW, and ROLL). When the Coarse Heaters bring the Displacement Gyro up to "NEAR OPERATING TEMPERATURE" which is 140 degrees, ±5 degrees Fahrenheit, a thermostat on each Displacement Gyro cuts the power to that Gyro, cutting off the Coarse Heater Voltage on the associated channel. The COARSE HEATER INDICATOR LIGHTS go "OUT" as Coarse Heater Power is cutoff to the PITCH, YAW, or ROLL Displacement Gyro.

1.1.2.4 (Continued)

(24) Fine Gyro Heater Indicator Lights

These comprise the BOTTOM ROW of AMBER Press-to-Test lights, directly below the Coarse Gyro Heater indicator lights. Approximately FIFTEEN (15) minutes FINE warm-up time is required after the COARSE HEATERS have cycled, to bring the Displacement Gyros to the "OPERATIONAL FINE" temperature of 150 degrees ±1 degree Fahrenheit. During this FINE warm-up time the FINE GYRO HEATER INDICATOR LIGHT will come "ON", (NOTE: The MISSILE AC SWITCH must be closed to energise the gyro cannister circuitry that controls the +28 VDC to the Fine Heaters. (See Paragraph (26) this section.)

(25) Heaters Cycled Indicator Light

This is a GREEN Press-to-Test light, located to the RIGHT of the Gyro Heaters lights. As soon as the "COARSE HEATERS" have warmed up the Displacement Gyros to "NEAR OPERATING TEMPERATURE", (as described in paragraph (23), they have "CYCLED" and the "HEATERS CYCLES LIGHT" will come "ON" as the last "COARSE GYRO HEATER LIGHT goes "OFF".

(26) Missile AC

This control consists of a two-position toggle switch and an AMBER Press-to-Test light, directly above it. (NOTE: Due to an interlock in the Coarse Heater relay circuit, this switch is ineffective until all the Coarse Heaters have cycled.) When the Coarse Heaters Cycled light comes "ON", the MISSILE AC SWITCH may be closed, applying 400 cycle power to the MISSILE AC BUS. This 400 cycle power also controls a +28 volt DC source to the "FIN" Gyro Heaters which will bring the Displacement Gyros to "OPERATIONAL FINE" temperature. (NOTE: SERIOUS DAMAGE to the Displacement Gyro Spin Motors would occur if AC power were applied prior to the Coarse Heater Cycle as they are immersed in a lubricating fluid which is almost a solid at ambient temperatures.)

(27) Engine Zero Indicator

The Engine Zero Indicator is a GREEN Press-to-Test light located to the RIGHT of the Missile AC Indicator light. This light comes "ON" when all Thrust Chambers are ALIGNED. It receives its signal via the Engine Position Zero Switch located in the UPPER LEFT CORNER of the Engine Position Indicator Panel. (Refer to paragraph (1) of Section 1.1.2.2)

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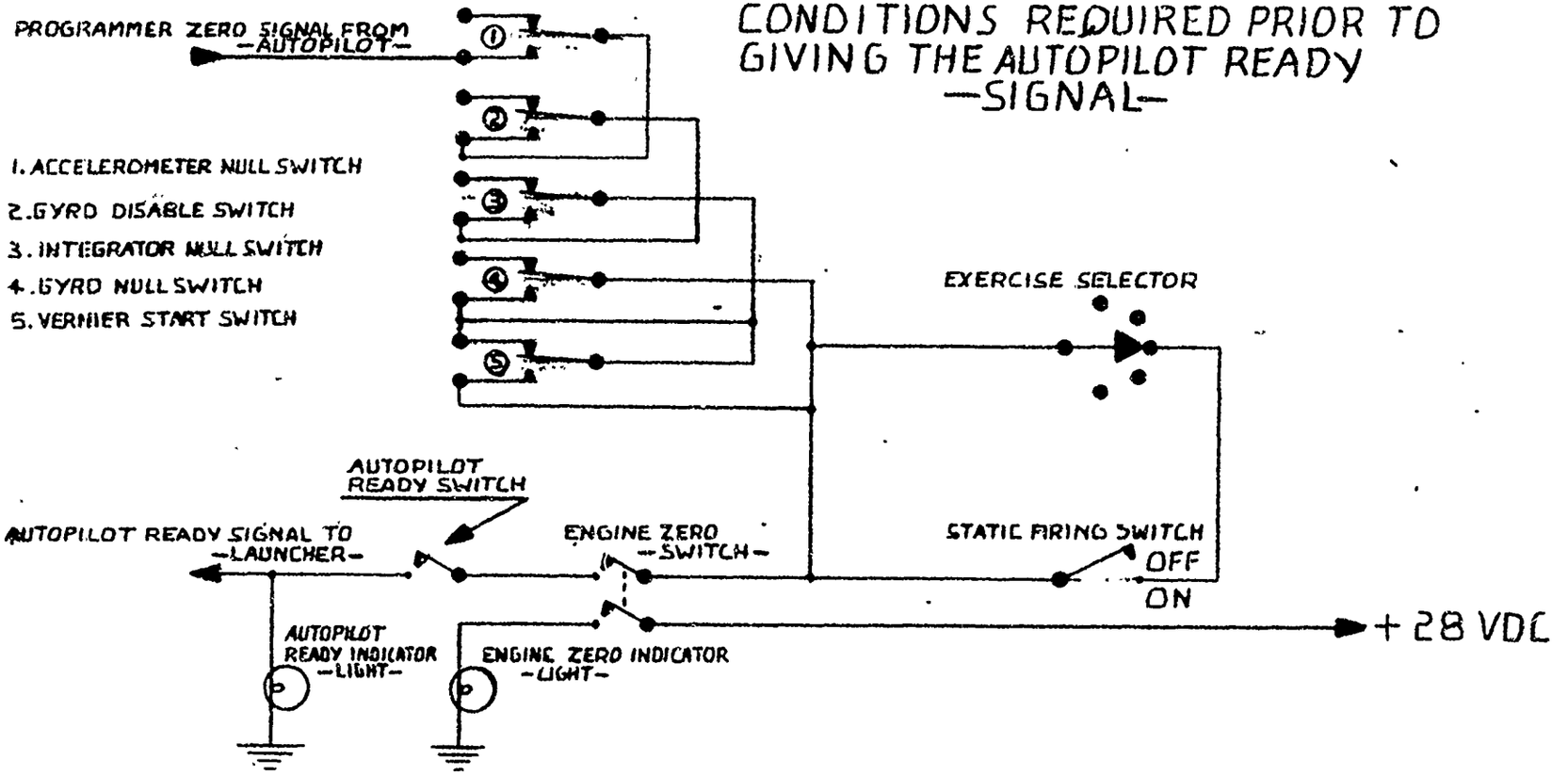

FIG. 8

1.1.2.4 (Continued)

(28) Autopilot Ready

This control consists of a two-position toggle switch and a GREEN Press-to-Test light, directly over it. The Autopilot Control Console operator may close the Autopilot Ready Switch, causing the "AUTOPILOT READY" light to come "ON" - both in the Control Console Panel and the PRE-START Panel of the TEST CONDUCTORS CONSOLE. The following conditions must be met PRIOR to giving the AUTOPILOT READY SIGNAL. (Figure 8 shows conditions required prior to giving the Autopilot Ready Signal.)

(a) Programmer MUST be on "ZERO".

(b) Integrating Accelerometer "NULLED".

(c) Gyros "DISABLED".

(d) Gyros "NULLED", or Vernier Start Relay "ENERGIZED".

(e) Exercise Selector "OFF", or the Static Firing Switch "ON".

(f) Engine Zero Switch "ON".

1.1.3 ENERGIZING THE AUTOPILOT CONTROL CONSOLE - (Refer to 7-68602)

The following is an analysis of circuit behavior when power is applied t to the Autopilot Control Console:

(1) Panel Power

The Autopilot Control Console is energized by closing the PANEL POWER SWITCH (S1), applying +28 volts DC to the console unit. The PANEL POWER RELAY (K1) "CLOSES". This relay controls the 115/208, 60 cps, 3 phase power (supplied by the PAD FACILITY SYSTEM).

(2) Panel Power Relay (K1)

The Panel Power Relay (K1) contacts D_1 and D_2 is connected to one side of the Decade Event Timer ON-OFF switch, and through contacts C_1 and C_2 Phase A, to the Decade Event Timer circuitry; i.e., filament heaters, etc., and also to the Normally Open contact of the Roll Programmer Voltage Adjust Switch (S18); through contacts A_1 and A_2 to contacts C_3 and C_2 in the three phase, 60 cycle Power Relay, (located in the TRANSDUCER EXCITATION UNIT) and then to the Blower Motor in the Transducer Excitation Unit.

1.1.3 (Continued)

UNIT. (NOTE: The Transducer Excitation Unit is located in the Blockhouse Control Center, and the Autopilot Monitor and Control Unit is located in the Transfer Room. Both units are described in this report).

(3) Thermal Time Delay Relay (K2)

+28 volts DC is applied to the Normally Open contact of the Thermal Time Delay Relay (K2).

(4) Gyro Meter Selector Relay (K4)

+28 volts DC is applied to one of the moving contacts of the Gyro Indicator Switch (S17) which applies power to the Gyro Meter Selector Relay (K604), mounted in the Relay Chassis of the Autopilot Monitor and Control Unit. (This relay selects either a -10-0-+10 Gyro Amplifier Signal, or a -5-0-+5 Displacement Gyro Signal.) The meter scale is changed depending on the position of the Amplifier-Displacement Switch (S17), (located on the Autopilot Control Console). (Refer to Section 1.1.2.4, Paragraph (15).

(5) Booster Ignition Start Relay (K618)

+28 volts DC is applied to the Gyro Null Switch (S16). This is a SPST switch which, when closed, applies power through contacts of the Booster Ignition Start Relay (K618) located in the Autopilot Monitor and Control Unit; then to the coil of the Gyro Null Relays (K614 and K615). When the Booster Ignition Start Relay (K618 is energized, (by closing the Ignition Start Switch in the Propulsion Engine Control System), the Gyro Null Relays (K614 and K615) power is removed and the Gyros cannot be nulled, irrespective of the position of the Gyro Null Switch (S16).

(6) Accelerometer Nulling Relay (K619)

+28 volts DC is applied through the Normally Closed contacts A_2 and A_3 of the Release Relay (K6) to the Accelerometer Null Switch (S15). This is a SPST switch which, when closed, applies power to the Accelerometer Nulling Relay (K619), located in the Autopilot Monitor and Control Unit. Upon application of the Umbilical Eject Signal, the Release Relay (K6) is energized, opening the contacts which apply power to the Accelerometer Null Switch (S15), and the accelerometer cannot be nulled, irrespective of the position of the switch (S15).

(7) Integrator Nulling Relays (K616 and K617)

+28 volts DC is applied through the Normally Closed contacts C_2 and C_3

1.1.3 (Continued)

of the Release Relay (K6) to the Integrator Null switch (S7). Closing the Integrator Null Switch (S7) energizes the Integrator Nulling Relays (K616 and K717), (located in the Autopilot Monitor and Control Unit). The sequence of operation for the Integrator Null Switch (S7) and Relays (K616 and K617) is the same as that described in the preceding paragraph and, therefore, the Integrators cannot be Nulled after application of the Umbilical Eject Signal, irrespective of the position of the Integrator Null Switch (S7).

(8) Gyro Disable Relays (K605 and K606)

+28 Volts DC is applied through the Normally Closed contacts D2 and D3 of the Release Relay (K6) to the Gyro Disable Switch (S8), and then to the Gyro Disable Relays (K605 and K606), (located in the Autopilot Monitor and Control Unit), which are energized-grounding the Gyro Amplifier Outputs. This is provided as a Safety Factor for Static Firing Tests and eliminate the possibility of Structural Vibration causing damage to the missile. An interlock is provided across the Gyro Disable Switch (S8) and the contacts of the Release Relay (K6), insuring that the Gyros are disabled during a Static Firing. When a launch is planned and the Static Firing Switch (S11) is "OFF", the Gyros cannot be disabled once the Release Relay (K6) has closed, (UMBILICAL EJECT SINGAL), irrespective of the position of the Gyro Disable Switch (S8).

1.2 MISSILE POWER - AC AND DC

Missile Power is supplied from the Secondary Distribution Center. The following is an analysis of how it is applied to the Missile Bus via the Autopilot Control Console:

(1) DC Voltage

By closing the Missile Power Switch (S2), +28 volts DC is applied to one side of the coils of the Gyro Coarse Heater Relays (K3, K4, and K5). The other side of the coils are connected to +28 volts DC at the Gyro Coarse Heaters. (Figure 9 is a simplified schematic of the Coarse Heater Relays and associated circuitry). When the Gyro Coarse Heaters have come up to temperature, (140 degrees, +5 degrees Fahrenheit), a thermostat opens, removing the +28 volts DC from the Gyro Coarse Heater Relay coils allowing current to flow through the heater windings to -28 volts DC. (This flow of current energized the Coarse Heater Relays, causing them to Lock in a Closed position). When all three (3) Heater Relays (K3, K4, and K5) are closed, +28 volts DC is applied to the filament of the Thermal Time Delay Relay (K2). Five seconds later the Thermal Time Delay Relay (K2) closes

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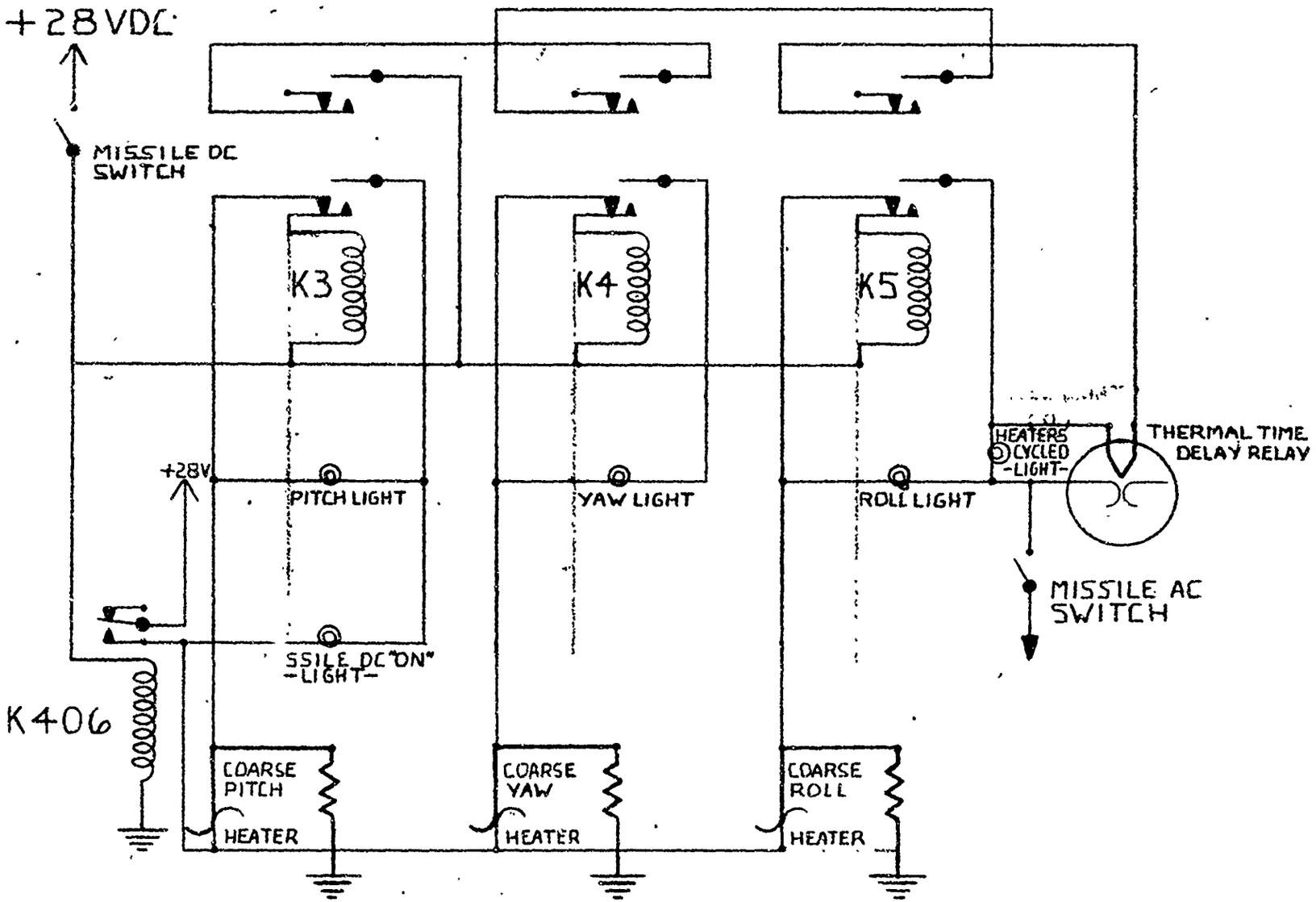

FIG. 9

1.2 (Continued)

applying +28 volts DC to one side of the Missile AC Power Switch (S3), which, when closed, applies +28 volts to the coil of the three (3) phase, 115/208, 400 cycle Power Relay (K417), thus applying power to the Missile AC Power Bus. (NOTE: The Gyro Course and Fine Heater Indicators on the Autopilot Control Console Panel are lighted when the Heaters are energized, and unlighted when the Heaters are de-energized. The +28 volts DC for the indicators is supplied from within the missile).

(2) AC Voltage

(a) The AC Power is applied to the Missile by closing the Missile AC Power Switch (S3), (located on the Autopilot Control Console Panel). DC Power is then applied to one side of the switch after the heaters have cycled. Closing the Missile AC Power Switch (S3 energizes Relay K417.

(b) The voltage required to energize the Autopilot Ready System is applied from the Flight Programmer within the Missile. This voltage is available only when the programmer is on "ZERO". This condition is noticed by the Programmer Zero Indicator light coming "ON". This is a GREEN press-to-test light located on the Autopilot Control Console Panel, (refer to Section 1.1.2.4, paragraph 2). This indicator gets its voltage from the same source as the Autopilot Ready System. In order for the Autopilot to be "Ready", the Accelerometer Nulling Relay (K619), the Integrator Nulling Relays (K616 and K617), the Gyro Disable Relay (K5), and the Gyro Nulling Relays (K614 and K615) must be CLOSED. To insure that the Autopilot Ready Signal is maintained after Booster Ignition Start, the Booster Ignition Relay (K618) parallels the Gyro Nulling Relays (K614 and K615). When the Static Firing Switch (S11 is "ON", (or the Exercise Selector Switch (S6) is in the "OFF" position), the voltage is applied to the Engine Position Zero Switch (S204), (located in the Autopilot Auxiliary Control Console. This switch is closed when the engines are on Zero Position. Closing the Autopilot Ready Switch (S12), will then light the Autopilot Ready Indicator (I17) on the Autopilot Control Console Panel, and send the Autopilot Ready Signal to the Launch Panel.

1.3 DISPLACEMENT GYRO WARM-UP PERIOD

A. Description of Operation

(1) Panel Power Switch (S1)

Close the Panel Power Switch (S1) to "ON". +28 volts DC lights

1.3 (Continued)

the Panel Power Indicator press-to-test light (I-1), and Power Relay (K1) is energized, applying 115 volt AC, 60 cycle power to the Autopilot Control Panel.

(2) Missile DC Switch (S2)

Close the Missile DC Switch (S2) to "ON". +28 volts DC flows through K601 when internal DC power is "OFF", and K602 when external DC power is "ON". When the Missile DC switch is closed, relay K406 is energized and +28 volts DC lights the Missile DC Indicator (I-2) and applies +28 volts DC to the Gyro Coarse Heaters. The Gyro Coarse Heaters come "ON" as a result of voltage to P1001-34. (NOTE: The Gyro Course Heater Relays (K3, K4, and K5) are NOT energized initially because BOTH sides of the Relay Coil have +28 volts DC applied to them.)

(3) Gyro Coarse Heaters

As Coarse Gyro Heater Power is "CUT OFF" by a thermostat in each channel, current flows through the relays K3, K4, or K5. As soon as current is applied, the relay operates and remains energized. When all three relays are energized, +28 volts DC is applied to the Time Delay Relay (K2) closing it. +28 volts DC from the Panel Power Switch (S1) will now light the Coarse Heater Cycle Indicator (I-4).

(4) Missile AC Switch

Turn the Missile AC Switch (S3) to "ON". +28 volts DC energizes relay K417 via the time Delay Relay (K2) and the Missile AC Power Switch (S3). The AC Power Indicator light (I-3) comes "ON" and 400 cycle power is applied to the Missile Autopilot bus. Displacement Gyro Spin Motors and the FINE heaters are energized from the bus. Fifteen (15) minutes MUST be allowed for the Fine Temperature of 150 degrees, ±1 degree Fahrenheit to be attained before exercising the displacement Gyros.

2.0 AUTOPILOT TEST PROGRAMMER (ATP)

2.1 GENERAL

The Autopilot Test Programmer comprises the equipment required to effect a complete simulated operation of the Airborne Flight Control System or components thereof. The Autopilot Test Programmer consists of the following major components:

(1) Autopilot Test Programmer Console

(2) Autopilot Test Programmer Auxiliary Console

2.1 (Continued)

(3) Autopilot Test Programmer Quarter Rack.

2.2 PURPOSE

The purpose of the Autopilot Test Programmer (ATP) is to rapidly program simulated inputs into components of the Flight Control System. In addition, it can, at the discretion of the operator, join the components to effect a complete simulated operation of the Airborne Flight Control System. (This is accomplished by by-passing the Engine Exercise Portion of the Autopilot Control Console by means of a Relay and Buckout Amplifier Unit, (which is a component of the Autopilot Monitor and Control Unit, described in section 4.0 of this report). The Schematic Diagram 7-68602 consists of seven (7) sheets showing the entire Autopilot Control System - Sheets 4 and 5 are of the Autopilot Test Programmer. The ATP provides the gyro test signal and servo test signal, monitors them, and automatically controls their introduction and routing into the system. It simultaneously gives a visual monitor of test conditions to the operator - as pertains to program time.

2.3 DESCRIPTION

(1) Six-Channel Paper Tape Punch

This unit punches a pre-arranged program into a 7/8-inch wide paper tape (See Figure 10). When an automatic program is required the prepunched tape is fed through a six-channel paper tape reader.

(2) Six-Channel Paper Tape Reader

This unit reads the punched holes and interprets the punched code into any one of sixty-two (62) selections through a relay tree selection matrix.

(3) Relay Tree Selection Matrix

This group of relays interprets the code to a given selection, - makes the selection and holds it until signaled to clear it by another punched code.

NOTE: One row of punched holes is required to make a given selection; however, the reader operates at ten (10) steps or rows per second, so that coordinated inputs as close as one-tenth (1/10) second apart may be effected.

(4) Signal Generator

This unit provides Sine Wave, Ramp, and Sweep frequency functions of various frequencies and amplitudes upon command of the selection matrix.

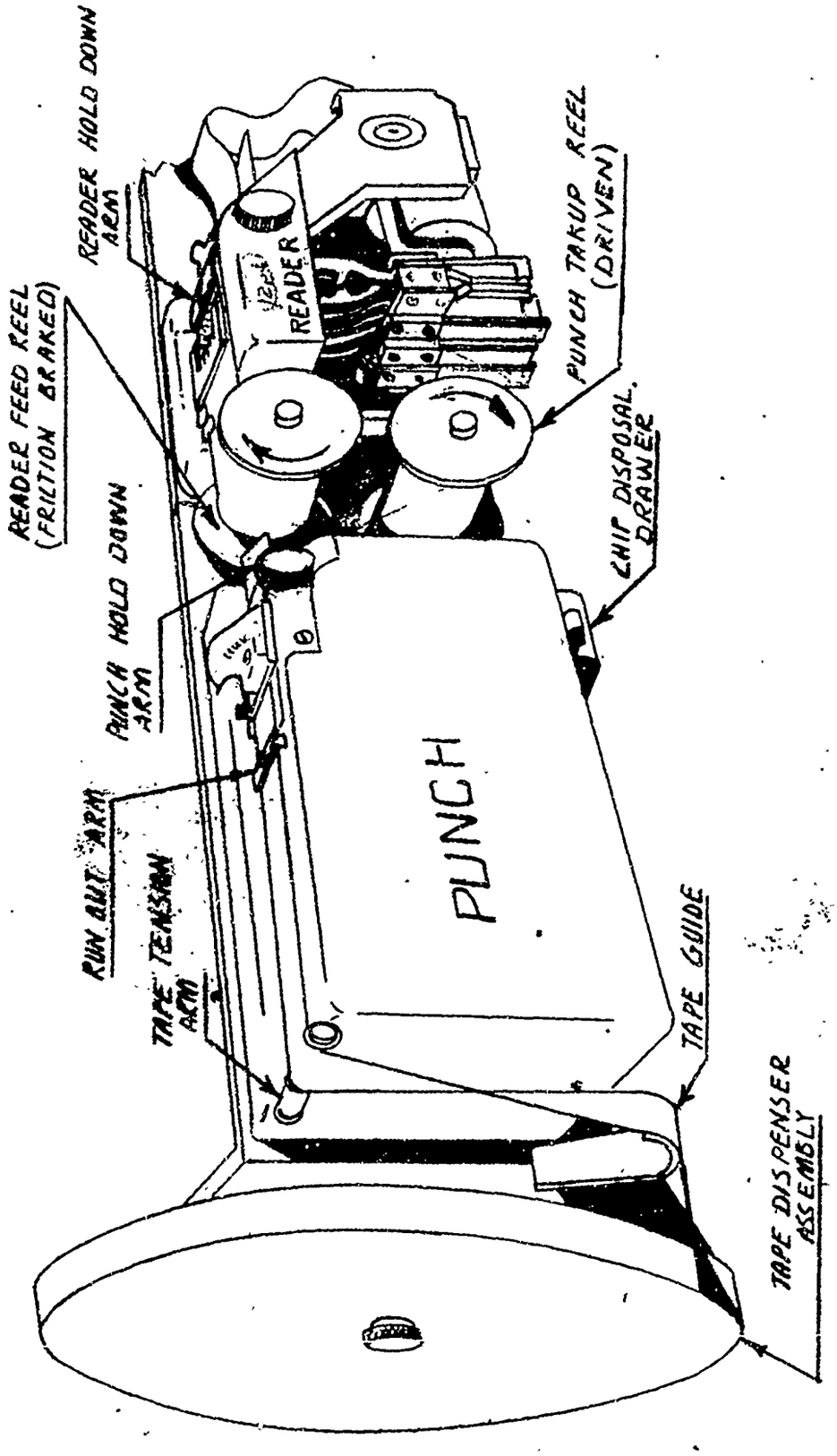
READER HOLD DOWN ARM
READER FEED REEL (FRICTION BRAKED)
PUNCH TAKUP REEL (DRIVEN)
READER
CHIP DISPOSAL DRAWER
PUNCH HOLD DOWN ARM
PUNCH
RUN OUT ARM
TAPE TENSION ARM
TAPE GUIDE
TAPE DISPENSER ASSEMBLY

FIG. 10

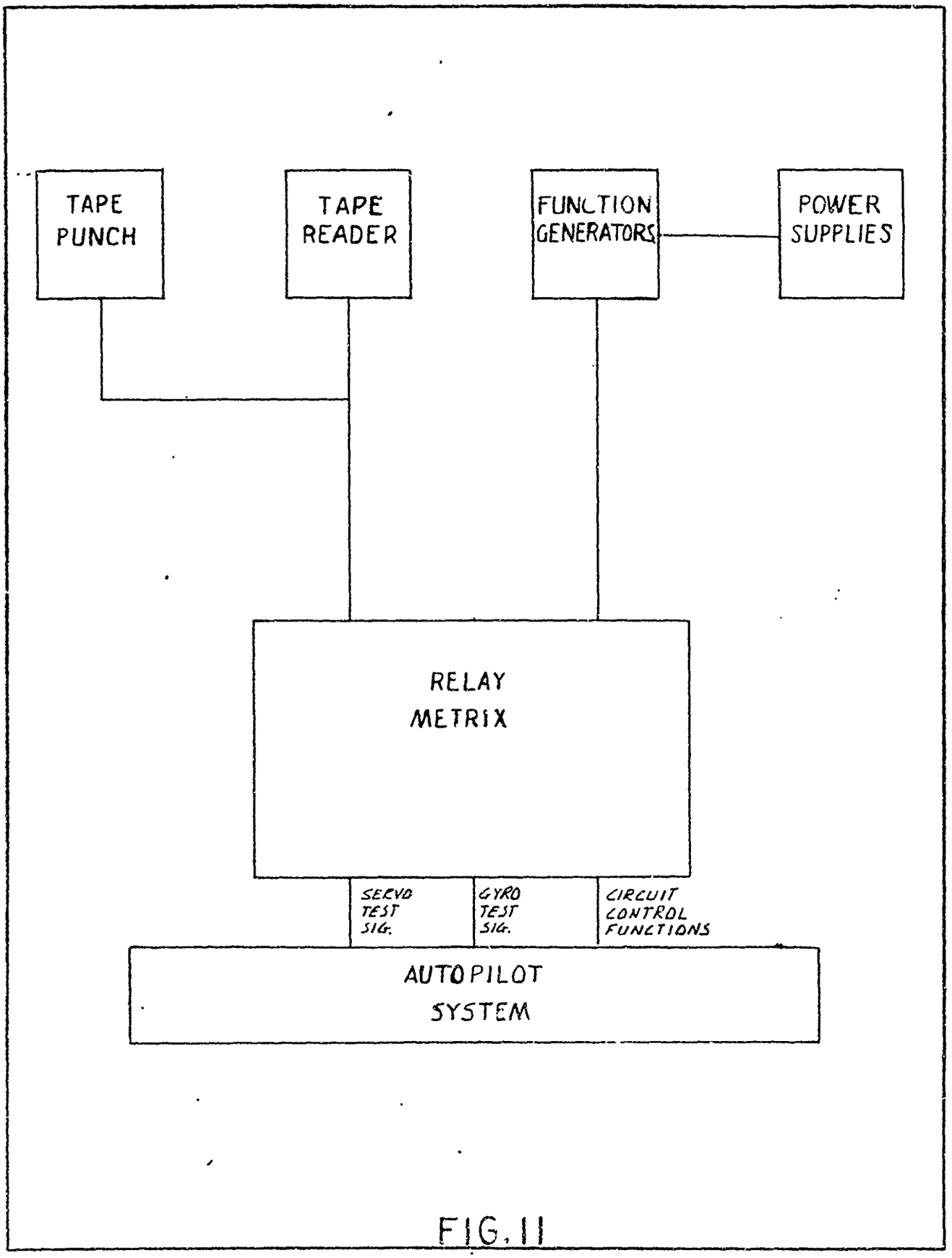
TAPE PUNCH
TAPE READER
FUNCTION GENERATORS
POWER SUPPLIES
RELAY METRIX
SERVO TEST SIG.
GYRO TEST SIG.
CIRCUIT CONTROL FUNCTIONS
AUTOPILOT SYSTEM

FIG. 11

2.3 (Continued)

(5) Manual Selection (Control and Monitor Panel)

This unit permits the operator to:

(a) Control POWER to the ATP

(b) Manually PRE-PUNCH a tape program

(c) Automatically READ a taped program

(d) Observe the PROGRESS of a program

(e) Manually CHECK and TEST certain components

NOTE: A block diagram of the system is shown in Figure 11.

2.3.1 Automatic and Manual Selection

The Programmer is capable of making ONE selection AT A TIME of 62 possible selections. When reading a PRE-PUNCHED tape, it is capable of making such a selection TEN times every SECOND. When operating manually, the switches on the ATP MANUAL CONTROL PANEL provide the electrical selection impluses to the Channel Relays, which in turn operate the Tape Punch and Selection Matrix.

NOTE: It is possible to make MANUAL SELECTIONS without punching the tape by using the Operational Mode Rotary switch in the Reader-Punch Control Field by switching to MANUAL-TEST. Under this condition, functions involving the SIGNAL GENERATOR; namely, FIXED FREQUENCY, SWEEP FREQUENCY, and RAMP, are generated as usual. In the MANUAL-PUNCH tape position the Signal Generator will not be driven. (The selections, whether made MANUALLY or AUTOMATICALLY, will be displayed by the indicator lights adjacent to the Selector Switches.

2.3.2 Panel Arrangement

The Test Panel is arranged with switch groupings as follows: (Refer to Figure 12):

(1) Servo Test Signal

(2) Engine Position Output Mode

(3) Gyro Test Signal

(4) Servo and Integrator Control

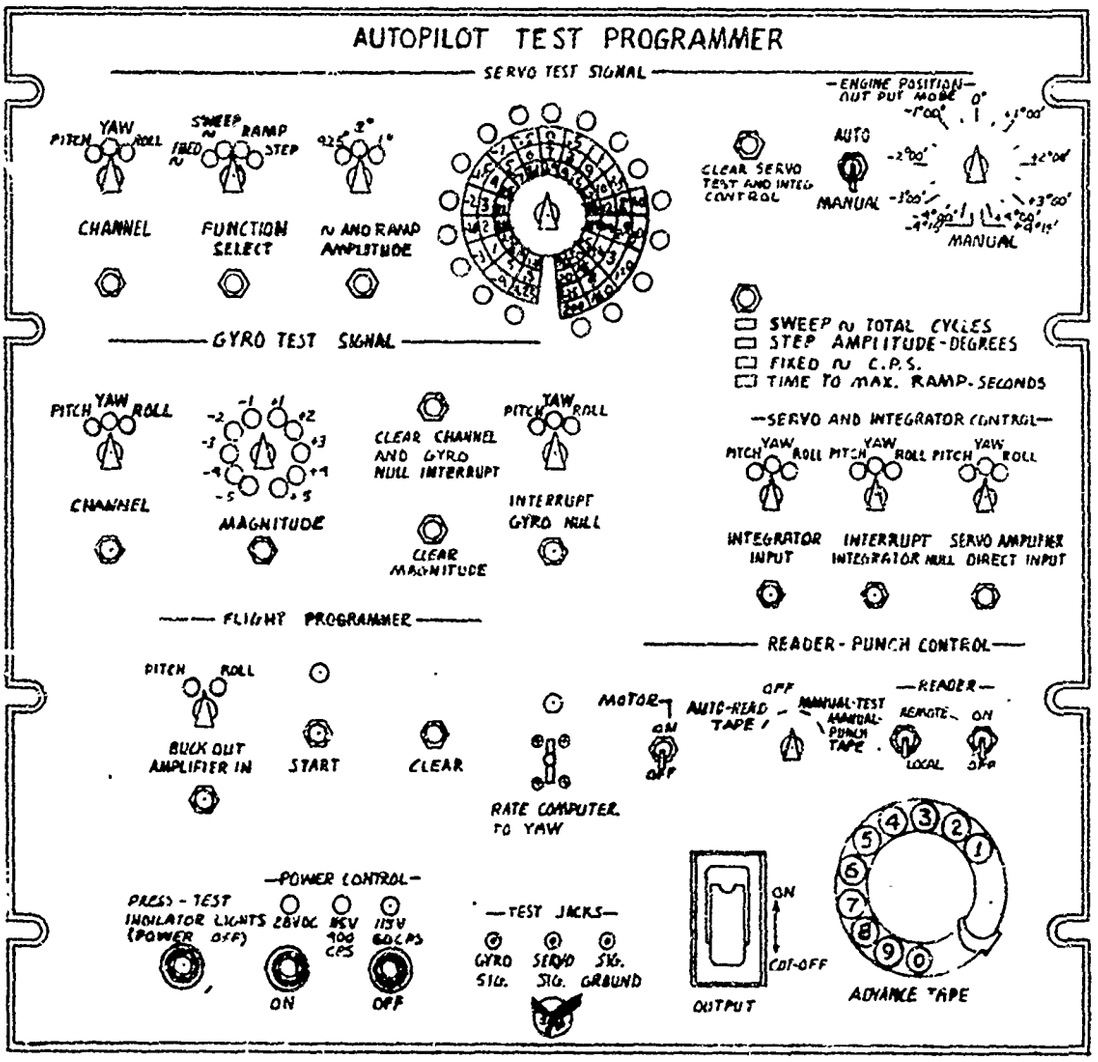
AUTOPILOT TEST PROGRAMMER
SERVO TEST SIGNAL
PITCH YAW ROLL
CHANNEL
SWEEP ∿ RAMP
FIXED ∿ STEP
FUNCTION SELECT
∿ AND RAMP AMPLITUDE
CLEAR SERVO TEST AND INTEG CONTROL
ENGINE POSITION OUT PUT MODE
AUTO
MANUAL
MANUAL
GYRO TEST SIGNAL
PITCH YAW ROLL
CHANNEL
MAGNITUDE
CLEAR CHANNEL AND GYRO NULL INTERRUPT
CLEAR MAGNITUDE
PITCH YAW ROLL
INTERRUPT GYRO NULL
SWEEP ∿ TOTAL CYCLES
STEP AMPLITUDE-DEGREES
FIXED ∿ C.P.S.
TIME TO MAX. RAMP-SECONDS
SERVO AND INTEGRATOR CONTROL
PITCH YAW ROLL
INTEGRATOR INPUT
INTERRUPT INTEGRATOR NULL
SERVO AMPLIFIER DIRECT INPUT
FLIGHT PROGRAMMER
PITCH ROLL
BUCK OUT AMPLIFIER IN
START
CLEAR
RATE COMPUTER TO YAW
MOTOR
ON
OFF
READER - PUNCH CONTROL
OFF
AUTO-READ TAPE
MANUAL-TEST MANUAL-PUNCH TAPE
READER
REMOTE
LOCAL
ON
OFF
POWER CONTROL
PRESS-TEST INDICATOR LIGHTS (POWER OFF)
28VDC
115V 400 CPS
115V 60 CPS
ON
OFF
TEST JACKS
GYRO SIG.
SERVO SIG.
SIG. GROUND
ON
CUT-OFF
OUTPUT
ADVANCE TAPE

FIG. 12

2.3.2 (Continued)

(5) Flight Programmer

(6) Reader-Punch Control

(7) Power Control

(8) Test Jacks

(9) The Rate Computer to the Yaw Function Switch is Yaw Function ISOLATED. It is cleared by the "CLEAR" switch under the Flight Programmer.

2.3.3 Analysis of Operation

This section describes what the switches and indicators in the ATP do and how it is accomplished.

(a) Selection

During MANUAL selection the basic selection devise is a rotary switch. (Refer to Figure 12.) To make a selection, the switch is set to the desired position and the momentary pushbutton directly below it is depressed. If the ATP makes the selection, the indicator light OPPOSITE the selected setting will light. The momentary pushbutton switch associated with the large rotary selector switch in the CENTER of Servo Test Signal grouping is to the right and above the FOUR color codes designating the units of the quantities it is capable of selecting. Other SINGLE selections are made by toggle switches, both MOMENTARY and LOCKING. Each particular switch (FUNCTION and OPERATION), is described as follows, commencing at the UPPER RIGHT SIDE of the panel:

2.3.3.1 SERVO TEST SIGNAL

(1) CHANNEL

To select the channels into which the test signal will be introduced, the Selector Knob is rotated to the desired po itions and the MOMENTARY pushbutton switch, directly below, depressed. The indicator lamp opposite the selection will light. It is possible to introduce the signal into any or all channels by making the selections one at a time, depressing the bushbutton after EACH SELECTION. The lights remain "ON" until cleared by the Clear Servo Test and Integrating Control Switch. As each selection is made (if the unit is set for MANUAL-PUNCH TAPE), the tape is AUTOMATICALLY advanced one step preparatory to receiving the next signal.

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2.3.3.1 (Continued)

(2) FUNCTION SELECT

This switch operates in the same manner as the Channel Switch. ONE FUNCTION SELECTION ONLY should be made for a given test.

(3) RAMP AMPLITUDE

This switch operation is the same as above. ONLY ONE SELECTION for a given test should be made, depending on the MAXIMUM ANGLE of engine deflection desired.

(A) The large rotary switch in the CENTER of the Servo Test Signal Field selects the various magnitudes of the quantities selected by the Function Select Switch. Switch operation is the same as above, EXCEPT that the momentary pushbutton associated with this switch is located to the RIGHT and ABOVE the four color codes which identify the units. FOR EXAMPLE: If a fixed frequency SINE WAVE input has been chosen with the Function Select Switch, then the ring of figures identified by the BLUE color around the large switch indicates that a frequency from .3 cycles per second may be chosen. The other three colors identify the other quantities associated with the Function Selections:

BLACK for SWEEP FREQUENCY in total cycles.

RED for STEP AMPLITUDE in degrees

GREEN for TIME to MAXIMUM RAMP in seconds

NOTE: The selection of these quantities begins the test.

(B) To SUSTAIN the test, it is necessary to advance the tape by use of the Telephone Dial in the LOWER RIGHT corner of the panel; each digit advances the tape one (1) step. When the tape is being read, this is equivalent to one-tenth (1/10) second REAL time. Therefore, for each 0.1 second test duration, the corresponding number on the dial should be used. FOR EXAMPLE:

(a) Dialing 5 will sustain the test 0.5 or 1/2 second; dialing 0 will sustain it 1.0 second, etc. A Program Continuity Counter located in the MONITOR PANEL above the Control Panel indicates the PROGRESS of the program by steps (Refer to Figure 14).

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2.3.3.1 (Continued)

NOTE: Dividing this total by TEN (10) will indicate the TOTAL number of seconds a given program HAS RUN.

(4) CLEAR SERVO TEST AND INTEGRATING CONTROL

This switch sets up the code which MOMENTARILY disconnects the holding bus for ALL the Servo Test Signal Selections. It is a MOMENTARY type toggle switch which is depressed DOWNWARD to operate. Upon operation, all the indicator lights in the Servo Test Signal Field will go "OUT" indicating they have been cleared.

NOTE: It is suggested that a complete test be planned by use of a TABULATED FORM such as shown in Figure 13. (The remarks column has been shown for explanation only.) In the Servo Test Program ONLY, it is possible to change the values of the quantities chosen by the large selector switch; rotating the switch to the new value desired and AGAIN depressing the momentary push-button switch, will apply the new value before the previously selected one is cleared.

EXAMPLE: A test involving a step deflection of -2 degrees may be INCREASED TO -3 degrees without cancelling the signal for an instant, which would permit the Servos to begin Nulling. (When SWEEP frequency is chosen, it is NOT possible to change quantities as described above; the CLEAR SERVO TEST CODE must be used.)

(5) ENGINE POSITION OUTPUT MODE

The operator may effect MANUAL DISPLACEMENT of the engines by use of the controls under Engine Position Output Mode. (For the AUTOMATIC OPERATIONS previously described, the switch would have been set to the AUTO POSITION.) Operation of this switch to MANUAL activates the MANUAL Potentiometer Control. For this test ONLY, the channel desired should be selected. The Engine Servos are then controlled by the MANUAL KNOB and will displace at the rate and to the MAXIMUM deflection called for, (as the operator rotates this knob), provided the output switch is closed.

2.3.3.2 GYRO TEST SIGNAL

(1) CHANNEL

Gyro Test Channel Selection is effected the same way as Servo Test Channel Selection. Again, the signal may be routed into any or all

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CHECKED BY
REVISED BY

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
SAN DIEGO

PAGE
REPORT NO. ZM 7-227 TN
MODEL 7
DATE 3 October 1956

TEST PROGRAM NO. _____

OBJECT OF TEST

ENGINEER _____

TEST CONDUCTOR _____

STEP NO.	ACCUMULATED TIME IN SEC.	FUNCTION	REMARKS
0	0	Reader remote start signal from vernier complete indication.	
1	.1		Dial number of digits on dial for tenths of seconds desired before actual test begins.
2	.2		
3	.3		
4	.4		
5	.5		
6	.6		
7	.7		
8	.8	Servo test pitch channel	Note: because step function has been selected that the N and ramp amplitude switch does not apply and is not used.
9	.9	Servo test roll channel	
10	1.0	Servo test step channel	
11	1.1	Servo test step amplitude +15°	
12	1.2		Dial number of digits on dial equivalent to test duration in tenths or seconds, in this case ten tenths or one second.
13	1.3		
14	1.4		
15	1.5		
16	1.6		
17	1.7		
18	1.8		
19	1.9		
20	2.0		
21	2.1		
22	2.2	Clear servo test	

FIG. 13

FORM 1612-A

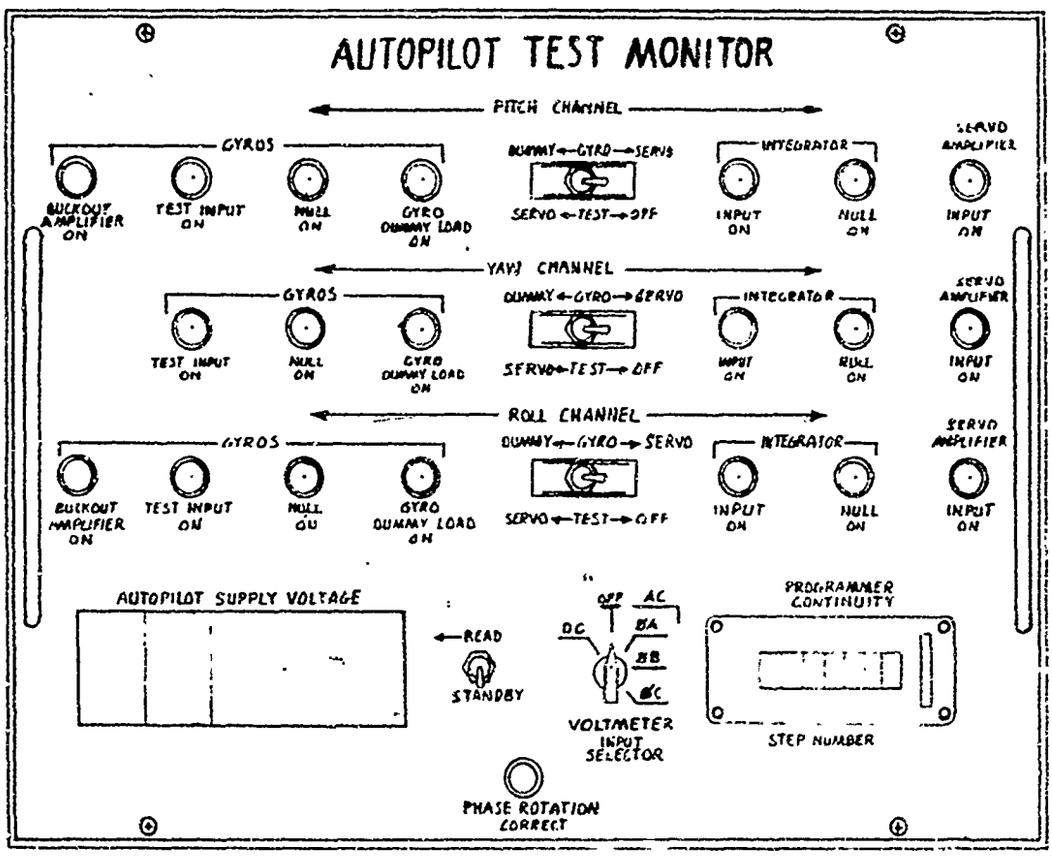
AUTOPILOT TEST MONITOR
PITCH CHANNEL
GYROS
BUCKOUT AMPLIFIER ON
TEST INPUT ON
NULL ON
GYRO DUMMY LOAD ON
DUMMY ← GYRO → SERVO
SERVO ← TEST → OFF
INTEGRATOR
INPUT ON
NULL ON
SERVO AMPLIFIER
INPUT ON
YAW CHANNEL
GYROS
TEST INPUT ON
NULL ON
GYRO DUMMY LOAD ON
DUMMY ← GYRO → SERVO
SERVO ← TEST → OFF
INTEGRATOR
INPUT ON
NULL ON
SERVO AMPLIFIER
INPUT ON
ROLL CHANNEL
GYROS
BUCKOUT AMPLIFIER ON
TEST INPUT ON
NULL ON
GYRO DUMMY LOAD ON
DUMMY ← GYRO → SERVO
SERVO ← TEST → OFF
INTEGRATOR
INPUT ON
NULL ON
SERVO AMPLIFIER
INPUT ON
AUTOPILOT SUPPLY VOLTAGE
READ
STANDBY
OFF
AC
DC
BA
BB
BC
VOLTMETER INPUT SELECTOR
PROGRAMMER CONTINUITY
STEP NUMBER
PHASE ROTATION CORRECT

FIG. 14

2.3.3.2 (Continued)

three of the channels by making the selections one at a time and depressing the momentary pushbutton directly below it after each selection. The lighted indicators serve as a "memory" to indicate which channels have been chosen.

(2) MAGNITUDE

Magnitude selection of the Gyro Test Signal is accomplished in the same manner as above. The units +1 through +5, and -1 through -5 are dimensionless units representing relative magnitude of a step input voltage; either in phase or out-of-phase with the reference voltage. The actual voltage provided is adjustable by an AC potentiometer accessible from the control panel. It is to be noted that the Gyro Test Signal is referred to in reference 4 as the Ground Test Input, and will command the Autopilot System unless the Gyro Amplifier outputs are MANUALLY set to their dummy load by the Guarded Switches in the Auxiliary Control Panel directly above ATP control panel.

(3) CLEAR CHANNEL AND GYRO NULL INTERRUPT

This switch (a MOMENTARY toggle switch) will encode the signal to "CLEAR" the indicated functions when pressed. The indicator lights will go OUT as these functions are cleared.

(4) CLEAR MAGNITUDE

This is a MOMENTARY toggle switch which, when pressed DOWNWARD will "CLEAR" the previously chosen Gyro Magnitude.

(5) INTERRUPT GYRO NULL

This switch will interrupt Gyro Nulling in any or all of the control channels. It is operated in the same manner as the Channel Switches. (To select more than one channel, the switch must be set and the pushbutton directly below pressed each time.)

2.3.3.3 SERVO AND INTEGRATOR CONTROL

(1) INTEGRATOR INPUT

After the Servo Test Signal has been defined as to CHANNEL, FUNCTION, and MAGNITUDE, it may be routed to the Integrator through this switch. Provided the corresponding Servo Test Signal Channel is closed through, more than one channel may be chosen.

2.3.3.3 (Continued)

(2) INTERRUPT INTEGRATOR NULL

The Integrator INPUT and OUTPUT is bridged by a Nulling Amplifier. Using this switch will interrupt the Nulling Path and prevent the Integrator OUTPUT into the Servo Amplifier from being Nulled.

(3) SERVO AMPLIFIER DIRECT INPUT

Any of these selections UNGROUNDS the Servo Amplifier INPUT and connects it to the Test Signal OUTPUTS from ATP (through the GUARDED switches in the Autopilot Test Monitor Panel directly above.) (See Figure 14.)

NOTE: The function of these switches may best be described as "SPLITTING" the Autopilot System. When the switch guard is closed, the Gyro Amplifier is "SPLIT" from the Servo Amplifier Summing Junction and connected to a dummy load.

The test signal path from the Programmer is connected to the Servo Amplifier INPUT in its place. With the switch guard RAISED and the switch operated to the RIGHT, the dummy load is REMOVED from the Gyro Amplifier OUTPUT. The Gyro Amplifier OUTPUT is connected to the Servo Amplifier INPUT as it would be for NORMAL Autopilot operation. Simultaneously, the ATP Servo Test Signal is DISCONNECTED from the Servo Amplifier INPUT.

2.3.3.4 FLIGHT PROGRAMMER

(1) BUCK-OUT AMPLIFIER

Buck-Out Amplifiers are provided to "buck-out" the Flight Programmer Signal at the Summing Junction of the PITCH and ROLL Gyro torquers. This switch selects and closes this "buck-out" path.

(2) CLEAR

Depressing this MOMENTARY toggle switch CLEARS Buck-Out Amplifier selection, Flight Programmer Start selection, and Rate Computer to Yaw selection.

(3) START

Depressing this MOMENTARY toggle switch starts the Flight Programmer.

NOTE: This is, in effect, equivalent to Missile Umbilical Plug "BLOW OFF".

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2.3.3.4 (Continued)

(4) RATE COMPUTER TO YAW

These computers "READ OUT" the pitch component rates UNLESS the Rate Computer to Yaw Lever switch is depressed DOWNWARD.

NOTE: This function selection is cleared by the Clear Switch, located UNDER the Flight Programmer.

2.3.3.5 READER-PUNCH CONTROL

(1) MOTOR

The Tape PUNCH and Tape READER are clutch driven by an AC Motor. The Motor Switch must be "ON" when READING or PUNCHING tape. The Motor Switch should be "OFF" when "SHUTTING-DOWN", or during MANUAL-TEST operation.

(2) OPERATIONAL MODE SELECTOR SWITCH

This switch is rotated to the desired position to PUNCH TAPE, READ TAPE, or CHECK-OUT the Programmer Selection Circuitry.

(a) Auto-Read Tape Position

In this position the Telephone Dial, Selector, and Clear switches are DISABLED. The Engine Position Output Mode controls are NOT effected, therefore, the AUTO-MANUAL toggle switch must be set to AUTO when reading a PRE-PUNCHED tape. The tape reader contacts are now ENERGIZED and the unit is ready to READ a PRE-PUNCHED tape program.

(b) OFF Position

In this position, the Punch, Reader, Program Step Counter, and Relay Matrix Signal Generator OUTPUTS are DISABLED. Power is still being supplied to the Servo Amplifier, Signal Generator Motor, Panel Indicator lights, Function Generator Transformers, and Servo Drive Precision Resistor. The unit is in STANDBY condition PROVIDED the power is "ON".

(c) Manual-Test Position

In this position the Program Step Counter is DISABLED. The remaining components are operative and a program may be chosen, selection checked, and outputs MONITORED at the test jacks which are connected AHEAD of the output cutoff switch.

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2.3.3.5 (Continued)

(d) Manual-Punch Tape Position

In this position the Signal Generator is DISABLED. (This is done to permit the operator to select the program without unnecessary wear on the signal generator gear train and clutches).

2.3.3.6 READER SWITCHES

(1) REMOTE-LOCAL SWITCH

When this switch is in the LOCAL POSITION, the Reader ON-OFF switch controls the reader engage clutch. When the switch is in the REMOTE position, a signal indicating "GAS GENERATOR VALVE OPEN" from the ENGINE CONTROL SYSTEM ACTUATES the Reader Engage Clutch.

2.3.3.7 POWER CONTROL

(1) PRESS-TO-TEST INDICATOR LIGHTS (POWER OFF)

This pushbutton switch, ISOLATES ALL the indicator lights on the panel and provides them with +28 volts DC for a check of lamp continuity.

NOTE: The Master Power Control MUST BE OFF to make this test.

(2) ON SWITCH

Momentary depression of this pushbutton applies the three (3) types of power required for Programmeroperation to the system. The indicator lights directly above indicator when the power is being supplied. The power will be applied until the hold circuit is BROKEN by an OFF SWITCH (described below).

(3) OFF SWITCH

This MOMENTARY pushbutton INTERRUPTS the Power Hold circuit and disconnects all power from the Programmer Systems.

NOTE: A Pilot Relay connected to the +28 volts DC power control OPENS the indicator light circuits in the Autopilot Test Monitor Panel so the nulling and dummy load indicator lights will NOT light when ATP is not in use.

(4) TEST JACKS

The Gyro Signal and Servo Signal Jacks are connected to the respective outputs ahead of the Output Cutoff Switch to permit monitoring of these signals, whether or not the outputs are closed through.

2.3.3.7 (Continued)

(5) OUTPUT SWITCH

All outputs from the Programmer to the respective Autopilot components will NOT be closed through UNLESS the guard on this switch has been raised and the switch thrown UP to the ON position.

(6) ADVANCE TAPE DIAL

Use of the Telephone Dial to advance tape in MANUAL operating mode has been described in Paragraph (B) of Section 2.3.3.1 of this report.

2.3.3.8 AUTOPILOT TEST MONITOR PANEL

(A) The Autopilot Test Monitor Panel is located in the Autopilot Test Programmer Auxiliary Console (see Figure 15). It contains one row of indicator lights for each channel which indicate the signal routing being effected by the Programmer, and the guarded switch which closes the Gyro Signal through to the Servo Amplifier (as mentioned above). A digital voltmeter read-out with a rotary switch for selecting the various power sources, and a read-standby switch (so that the voltmeter need not sample the voltages continuously).

(B) The Programmer continuity step counterindicates progress of the program (AS INDICATED ABOVE). A monitor of correct phase rotation is maintained by an indicator light. If this light goes out, connections of the three (3) phase, 400 cycle power must be re-arranged.

2.3.3.9 TEST PROGRAMMER QUARTER RACK

The base supporting the ATP Console and Auxiliary Console comprises the Quarter Rack. It houses the power supply which is used with the Signal Generator Servo Amplifier. Front Panel access to the power supply, for output monitoring and adjustment, is through the double doors on the front of the cabinet. (The digital voltmeter equipment box is also mounted here. See Figure 15.)

3.0 TRANSDUCER EXCITATION UNIT (7-68025)(TEU)

3.1 GENERAL

The Transducer Excitation Unit (TEU) contains equipment for TEST and SIGNAL MEASUREMENT throughout the Autopilot Control System. It is located in the Control Center Blockhouse. The unit operates in conjunction with all major components of the Autopilot Control System.

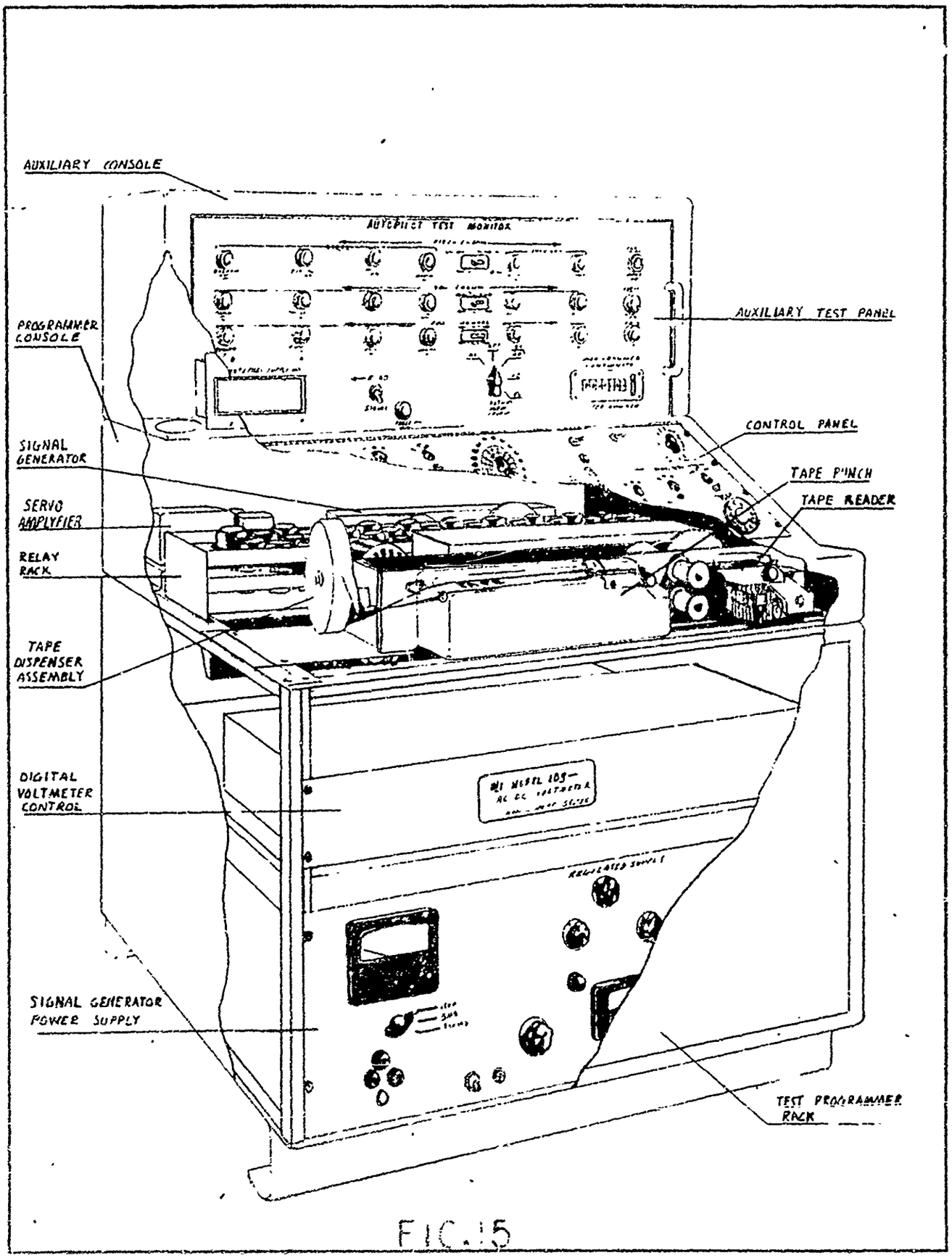
AUXILIARY CONSOLE
AUXILIARY TEST MONITOR
AUXILIARY TEST PANEL
PROGRAMMER CONSOLE
CONTROL PANEL
SIGNAL GENERATOR
TAPE PUNCH
TAPE READER
SERVO AMPLYFIER
RELAY RACK
TAPE DISPENSER ASSEMBLY
DIGITAL VOLTMETER CONTROL
SIGNAL GENERATOR POWER SUPPLY
TEST PROGRAMMER RACK

FIG. 5

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3.2 PURPOSE

The purpose of the Transducer Excitation Unit (TEU) is to provide Test and Measurement of Autopilot Control System components from the Control Center Blockhouse PRIOR to and DURING tests of the Missile. The Transcuder Excitation Unit (TEU) provides all the equipment required for its function in one location, thereby making Test and Measurement an easier, more rapid procedure.

3.3 DESCRIPTION

The TEU is comprised of a 72" by 24" by 24" steel cabinet containing eight (8) rack-mounted drawers and panels which may be drawn out on "chassis-traks" for servicing, maintenance, or calibration of the sub-assemblies contained therein. At the foot of the TEU is a screened and grilled compartment which contains the blower motor which provides cooling for the TEU. The drawers are vertically mounted as follows:

(a) 7-66850 - BOOSTER RATE COMPUTER PANEL

(b) 7-66850 - VERNIER RATE COMPUTER PANEL

(c) 7-68025-3 - RATIO TRANSFORMER PANEL

(d) 7-68025-27 - TEST PANEL

(e) (No Drawing available at this time) - CONSTANT CURRENT EXCITATION PANEL

(f) 7-68058 - DEMODULATOR PANEL

(g) 7-66851 - SUMMING AMPLIFIER PANEL

(h) 7-68056 - DC POWER SUPPLY PANEL

(i) - - - - - BLOWER MOTOR

(1) BOOSTER RATE COMPUTERPANEL (7-66850)

There are three Booster Rate Computer Units contained in this panel. Switches are provided to select inputs from either the Booster Engine Position Transducer Signals or the Integrator outputs. When Booster Engine Position Transducer Signals are being tested, the Rate Computers can be switched from PITCH CHANNEL to YAW CHANNEL by a signal from the AUTOPILOT TEST PROGRAMMER. (See Paragraph (5) Section 2.3.3.1.)

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3.3 (Continued)

(2) VERNIER RATE COMPUTER PANEL (7-66850)

There are two Vernier Rate Computer UNITS contained in this panel. The Vernier Rate Computer Panel performs the same function in respect to the Vernier Engine Position Transducer Signals and Integrator outputs as the Booster Rate Computer Panel does for the Booster Engine Position Transducer Signals and Integrator outputs and the procedure followed is the same.

(3) RATIO TRANSFORMER PANEL (7-68025-3)

This is a vendor furnished item. The Ratio Transformer provides calibration voltages for the Engine Position Indicator circuits (see Paragraph (1), Section 1.1.2.2), and the Autopilot Signal Monitoring circuits (see Section 4.0). The OUTPUT TO INPUT RATIO is set by FIVE rotary switches and a potentiometer. The OUTPUT signal is connected into a switching system on the TEU Test Panel (see Paragraph (4), Section 3.3).

(4) TEST PANEL (7-68025-27)

The Test Panel controls the TEST and CALIBRATION SIGNALS from the Ratio Transformer to the Autopilot Control System. Switches are provided to control TEST SIGNAL PHASING. The 115 volt, 400 cycle line voltage and the Ratio Transformer output voltage can be tested from the panel via test jacks. If no 400 cycle line voltage is available, a PORTABLE 115 volt, 400 cycle source can be connected into the system through a pair of jacks on the panel. The TEU can be energized LOCALLY, without turning on the Autopilot Control Console, by a switch on the panel.

(5) CONSTANT CURRENT EXCITATION PANEL (No Drawing available at this time)

This panel contains the Constant Current Power Supply which supplies a CONSTANT 45 Milliampere, 400 cycle current to the Engine Position Transducers (MICROSYNS) on the Booster Engines. The position Signal output from each transducer is DIRECTLY PROPORTIONAL to the excitation current. Therefore, to maintain accuracy, the Constant Current Power Supply STABILIZES LINE VOLTAGE VARIATIONS and CHANGES IN LOAD RESISTANCE. This is a vendor furnished item.

(6) DEMODULATOR PANEL (7-68058)

This panel contains TEN (10) Phase Sensitive Demodulator Units. These CONVERT 400 cycle PHASE-REVERSING signals into POLARITY-REVERSING DIRECT CURRENT signals. Inputs to the Demodulators are the Engine

3.3 (Continued)

Position Transducer Signals. The Direct Current Output Signals are connected to the Engine Position Indicator Meters on the AUTOPILOT AUXILIARY CONTROL CONSOLE (see Paragraph (3), Section 1.1.2.2). Each demodulator consists of a transistorized demodulating circuit and a Reference-Voltage Phase-Shifter. Each demodulator circuit can be corrected for transducer and line-phase shifts by the Phase-Shifter. There is a GAIN and PHASE SHIFT control located in each demodulator unit. (These require a screwdriver for adjustment.) Test jacks are provided on the panel at SIGNAL INPUT and SIGNAL OUTPUT points.

(7) SUMMING AMPLIFIER PANEL (7-66851)

There are FOUR (4) Summing Amplifier UNITS in this panel. These provide a SUM (DIFFERENCE) signal from a pair of Engine Position Transducer Signals (Microsyns). Each Summing Amplifier Unit provides one of the following SUM (DIFFERENCE) outputs:

(a) BOOSTER NO. 1 and BOOSTER NO. 2 - PITCH

(b) BOOSTER NO. 1 and BOOSTER NO. 2 - YAW/ROLL

(c) VERNIER NO. 1 and VERNIER NO. 2 - PITCH/ROLL

(d) VERNIER NO. 1 and VERNIER NO. 2 - YAW

From these output signals, INSTANTANEOUS POSITION DIFFERENCES between pairs of engines (operating in similar axis) can be determined. The major components of each Summing Amplifier Unitare TWO (2) transformers, a duo-triode vacuum tube, FOUR (4) padder capacitors, and a Test Selector Switch.

(8) DC POWER SUPPLY (7-68056)

The DC Power Supply is a vendor furnished item. It supplies B+ and bias voltages to the Rate Computers and Summing Amplifiers.

(9) BLOWER MOTOR

The Blower Motor is a SPLIT-PHASE, sleeve bearing, 1/4 H.P., 1725 RPM, 110 volt AC, 60 cycle motor, resilient mounted. The pulleys will deliver 600 to 800 cubic feet per minute; reversed they will deliver up to 1,000 cubic feet per minute. The motor assembly is mounted behind a filter system which may be removed for cleaning. The cleaning should be done according to the amount of dust, sand, moisture, etc., in the particular location of the TEU.

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4.0 AUTOPILOT MONITOR AND CONTROL UNIT (7-66900)

4.1 GENERAL

The Autopilot Monitoring and Control Unit serves as a terminal point for Control, Test, and Measurement signals between the Missile Autopilot and the Control Center Blockhouse.

4.2 PURPOSE

The purpose of the Autopilot Monitor and Control Unit is to provide a compact, convenient package for the various control circuits and electronic components required to perform the functions for which the Autopilot Control System was designed.

4.3 DESCRIPTION

The Autopilot Monitor and Control Unit is housed in a 72" by 24" by 24" steel cabinet located in the Fuel Transfer Room. It contains the following sub-assemblies:

(a) 7-66908 - TEST PANEL

(b) 7-66916 - SIGNAL ISOLATION UNIT

(c) 7-66921 - ISOLATION AMPLIFIER

(d) 7-66955 - NULLING AMPLIFIER PANEL

(e) 7-66971 - NULLING AMPLIFIER

(f) 7-66989 - TEST RELAY AND CALIBRATION PANEL

(g) 7-66990 - RELAY AND BUCKOUT AMPLIFIER PANEL

(h) 7-66894 - BUCKOUT AMPLIFIER

(i) 7-66988 - ENGINE EXERCISE PROGRAMMER

(j) 7-66935 - POWER SUPPLY PANEL

(k) - - - - - BLOWER

The entire unit is vendor furnished. The major components are contained in nine panels (including the BLOWER which provides cooling for the unit). Eight of these panels are mounted in chassis tracks and can be pulled outward, drawer fashion, for maintenance or calibration work and all are mounted vertically. The following list of panels is as they appear in the unit from top to bottom:

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4.3 (Continued)

(a) TEST PANEL

(b) SIGNAL ISOLATION UNIT (1)

(c) SIGNAL ISOLATION UNIT (2)

(d) NULLING AMPLIFIER UNIT

(e) TEST RELAY AND CALIBRATION PANEL

(f) RELAY AND ENGINE EXERCISE PROGRAMMER

(g) RELAY AND BUCKOUT AMPLIFIER PANEL

(h) POWER SUPPLY

(i) BLOWER

(1) TEST PANEL (7-66908)

The Test Panel provides a means for testing the PHASE and GAIN of the Isolation Amplifiers. It contains Filament power and Quadrature Signal circuitry, Mixing Network, DC Amplifier, Cathode Follower, and Meter circuitry.

(2) SIGNAL ISOLATION UNITS (7-66916)

There are TWO (2) PANELS of Signal Isolation Units. Each contains fifteen (15) "ACTIVE" Isolation Amplifiers and five (5) SPARE Isolation Amplifiers. Each Isolation Amplifier has a gain of one (1). (Reference Schematic Drawing No. 7-66934.) The main chassis and panel contain a Selector switch, three (3) Filament Transformers, fifteen (15) Isolation Amplifiers, and five (5) spare Isolation Amplifiers. The Selector switch is capable of connecting a TEST INPUT from J501 to a selected Isolation Amplifier. At the same time it can connect the output of the selected amplifier to J501. Each of the three (3) Filament Transformers supply 6.3 volts filament power to five (5) plug-in Isolation Amplifiers. Test points are available for checking voltage from the Filament Transformers T301, T302, and T303.

(3) INDIVIDUAL ISOLATION AMPLIFIER (7-66921)

Relative importance of the Isolation Amplifier in regards to the Autopilot Monitor and Control Unit merits a description of it aside from the Isolation Amplifier Unit Panel. (Reference schematic drawing No. 7-66928.) Each Isolation Amplifier has a gain of 1±.04%

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4.3 (Continued)

which can be adjusted by R103. The gain should remain within 0.1% over an input range of 0 to 10 volts rms, 390 to 410 cps, and during a continuous operating period of twelve (12) hours. The phase shift of the amplifier is adjustable by C102 to 180 degrees and should retain a phase shift of 180 degrees ±0.50 degrees for a continuous operating period of twelve (12) hours. Each Amplifier has an input impedance of not less than one (1) megohm and an effective output impedance of less than ten (10) ohms. Minimum load impedance is 10,000 ohms. The Isolation Amplifier is designed to provide a low drain of the source signal when relaying a signal to the recorder and with a minimum of phase shift.

(4) NULLING AMPLIFIER PANEL (7-66955)

There are six (6) Nulling Amplifiers in this panel. Each with a gain of 20. The function of the Nulling Amplifiers is to Null the Displacement Gyro and Integrator Outputs.

(5) TEST RELAY AND CALIBRATION PANEL (7-66989)

This panel has 6 relays, 10 resistors, and 10 precision potentiometers. The potentiometers are used to control the INPUT SIGNALS to the Isolation Amplifiers. The relays provide switching for the INPUT SIGNALS to the Amplifiers.

(6) RELAY AND ENGINE EXERCISE PROGRAMMER (7-66988)

This panel contains nineteen (19) relays which direct signals throughout the Autopilot Control System. The Programmer consists of a MOTOR-DRIVEN, CAM-ACTUATED SET of eight (8) switches. This panel is used to program a REPEATABLE SEQUENCE of signals into the system. It is used when the Autopilot Test Programmer is DISCONNECTED from the Autopilot (Airborne).

(7) RELAY AND BUCKOUT AMPLIFIER PANEL (7-66990)

This component contains twenty-six (26) relays and two (2) Buckout Amplifiers. The relays provide switching of the INPUT and OUTPUT signals to the Autopilot. Each Buckout Amplifier receives signal INPUTS from three (3) sources, and supplies a Buckout Signal to a Gyro Torquer Input Mixer. This unit is used in conjunction with the AUTOPILOT TEST PROGRAMMER which is located in the blockhouse. (See Section 2.0)

(8) POWER SUPPLY PANEL (7-66935)

The Power Supply is regulated and supplies PLATE VOLTAGE to the

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4.3 (Continued)

various vacuum tubes within the Autopilot Monitor and Control Unit. The Power Supply also contains a three (3) phase Circuit Breaker which controls power to the Power Supply itself as well as to the other electrical components within the Unit, such as the blower, filament transformers, etc.

(9) BLOWER MOTOR

The Blower Motor is a SPLIT-PHASE, sleeve bearing, 1/4 H.P., 1725 RPM, 110 volt AC, 60 cycle motor, resilient mounted. Pulleys will deliver 600 to 800 cfm; reversed they will deliver up to 1,000 cfm. The Motor Assembly is mounted behind a filter panel, element, and removable grill. The filter element may be removed for cleaning. The frequency with which this cleaning is done will depend on the particular location of the unit (i.e., amount of dust, sand, moisture, etc.)

5.0 OPERATION OF THE AUTOPILOT CONTROL SYSTEM

5.1 GENERAL

The Autopilot Control System at the Sycamore (S-1) site will be used to conduct both the SIMULATED LAUNCH (AFMTC TYPE) tests and the CAPTIVE FIRING (SYCAMORE S-1 TYPE) tests of the Missile Autopilot. The TWO (2) types of tests will utilize the Autopilot Control Console and the Autopilot Test Programmer respectively. The TWO (2) tests will be described separately in this report.

5.1.1 SIMULATED LAUNCH (AFMTC TYPE) TESTS - DESCRIPTION

(1) GIMBALING TEST

The Gimbaling Tests exercise the Booster Engines in PITCH, YAW, and ROLL channels, (one at a time) from one extreme, through center, to the other extreme and back to center.

(a) PRIOR to the Gimbaling Tests the PROGRAMMER ZERO INDICATOR (Paragraph (2), Section 1.1.2.4) on the Autopilot Control Console Panel MUST be lighted. (This is a GREEN Press-to-Test light located above the Decade Event Timer Switch.)

(2) INTEGRATING ACCELEROMETER TEST

This test consists of measuring the time from RELEASE of the ACCELEROMETER NULL to BOOSTER CUTOFF. (The Decade Event Timer will record the elapsed time - See Section 1.1.2.3).

5.1.1 (Continued)

(a) Booster Cutoff Indicator - See Paragraph (3), Section 1.1.2.4. This is an AMBER Press-to-Test light which comes "ON" during the Flight Programmer Tests and the Integrating Accelerometer Tests the moment Booster Cutoff occurs.

5.1.1.1 WARM-UP AND PRE-OPERATION CHECKOUT

(1) ENGINE EXERCISER CHASSIS (Ref. Paragraph (6) Section 4.3)

This chassis is located in the Autopilot Monitor and Control Unit in the Transfer Room. It must be checked prior to Simulated Launch Tests to determine that the Autopilot Control Console is connected into the system via the plugs at the rear of this chassis.

NOTE: Because the Autopilot Monitor and Control Unit is located in the Transfer Room, the plug connections must be checked PRIOR to fueling the Missile as the transfer room CANNOT be entered during or after fueling.

(2) POWER

(a) The Blockhouse power must be available to the Autopilot Control System via the PAD FACILITY CONSOLE. This consists of:

28 volts DC

115 volts AC, 400 cycle

115 volts AC, 60 cycle

(b) The Secondary Distribution Power (28 volts DC) is also applied via the PAD FACILITY CONSOLE.

(3) DISPLACEMENT GYRO WARM-UP (Ref. Section 1.3)

OPERATION	OBSERVE
(a) Close Panel Power Switch	AMBER Press-to-Test light above switch comes "ON".
(b) Close Missile DC Switch	AMBER Press-to-Test light above switch comes "ON". The three (3) AMBER Gyro Coarse Heater lights come "ON".

5.1.1.1 (Continued)

CAUTION: The Gyro Coarse Heaters (Displacement Gyros) are now energized. The operator must now allow approximately FIFTEEN (15) MINUTES FOR the heaters to bring the Displacement Gyros up to temperature. As the Gyros reach the required temperature, the AMBER Gyro Coarse Heater lights will go "OFF" and the GREEN "Heaters cycled" light will come on.

(c) Close Missile AC Switch — AMBER Press-to-Test light above switch comes "ON".

The Three(3) AMBER Gyro Coarse Heater lights come "ON".

NOTE: The Gyro Fine Heaters (Displacement Gyros) are now energized. The operator must now allow approximately FIFTEEN (15) MINUTES for the heaters to reach "OPERATIONAL FINE TEMPERATURE" and the Displacement Gyro Spin Motors to come up to speed. When this has taken place, the AMBER Gyro Fine Heater lights will go "OFF". and the GREEN "Heaters cycled" light will come "ON".

5.2 BOOSTER ENGINE AND GYRO EXERCISE (MANUAL)

(1) PRE-EXERCISE CHECKOUT

(a) Meter Selector Switch — "AMPLIFIER"

(b) Integrator Null Switch — "NULL"

(c) Gyro Null Switch — "NULL"

(d) Exercise Selector — "GYRO EXERCISE-RELEASE INTEGRATOR NULL"

(e) Gyro Disable Switch — "OFF"

(f) Channel Selector Switch — *"PITCH CHANNEL" (For this particular example.)

*NOTE: The procedure for exercising the Yaw and Roll channels is identical.

(2) PROCEDURE OF OPERATION - (Pitch Channel)

OPERATE	OBSERVE
(a) Press Exercise Start Switch.	AMBER Press-to-Test light

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5.2 (Continued)

above switch comes "ON".

AMBER "Pitch" Channel light comes "ON" indicating that this channel is being exercised.

NOTE: The Exercise Sequence is now underway. The AMBER Press-to-Test light above the Exercise Start Switch and the AMBER "Pitch" Channel light will remain "ON" during the exercise cycle (approximately 13 seconds) and then will go "OFF".

The OUTPUT VOLTAGE from the Pitch Gyro Amplifier is indicated on the Gyro Voltmeter.

Observe the Booster Engine Travel on the ENGINE POSITION INDICATORS located on the ENGINE POSITION PANEL of the Auxiliary Autopilot Console.

Three (3) seconds is required for the Booster Engines to travel from center (zero) to one extreme and then six (6) seconds through center to the other extreme. They then return to zero in three (3) seconds. (Total of 13 seconds.)

(3) GYRO EXERCISE - (Independent of Booster Engines)

The Gyros may be exercised WITHOUT exercising the Booster Engines by:

(a) Placing the Exercise Selector Switch on - "GYRO EXERCISE-MAINTAIN INTEGRATOR NULL".

(b) Placing the Meter Selector Switch on - "DISPLACEMENT".

NOTE: The exercise program is the same as above except there is NO SIGNAL to the Servo Amplifiers and the Booster Engines remain at ZERO POSITION.

(4) INTEGRATOR AND ENGINE EXERCISE (Static Firing)

"CAUTION": PLACE GYRO DISABLE SWITCH ON "DISABLE".

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5.2 (Continued)

(This is to preclude the possibility of the built-in interlock failing, thus permitting excess structural vibration from oscillation of the gyros.)

(1) PRE-EXERCISE CHECKOUT

(a)	Channel Selector Switch	On "SELECTED CHANNEL", (PITCH, YAW, ROLL).
(b)	Exercise Selector Switch	"INTEGRATOR EXERCISE-MAINTAIN GYRO NULL".
(c)	Static Firing Switch	"ON"
(d)	Integrator Null Switch	"NULL"
(e)	Gyro Null Switch	"NULL"
*(f)	Gyro Disable Switch	"DISABLE"

(2) PROCEDURE OF OPERATION

NOTE: The exercise cycle is the same as when there is NO static firing.

5.2.1 AUTOMATIC MULTI-CHANNEL EXERCISE

To AUTOMATICALLY EXERCISE more than one (1) channel, the following procedure of operation is used:

NOTE: The Pitch and Yaw Channels will be described as an example - all other combinations are operated identically.

(1) PRE-EXERCISE CHECKOUT

(a)	Channel Selector Switch	"PITCH-YAW" (On the "Automatic" side.)
(b)	All other switches	SAME AS DESCRIBED FOR "MANUAL" EXERCISE.

(2) PROCEDURE OF OPERATION

NOTE: The Procedure of Operation is the same as that for "MANUAL EXERCISE" - EXCEPT, IMMEDIATELY on completion of the "PITCH" Channel Exercise Cycle, the "YAW" Channel commences to exercise.

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5.3.4 AUTOPILOT ROLL PROGRAM SET-UP (Refer to Figure 7, Section 1.1.2.4)

The Roll Program is set for the AMOUNT and DIRECTION OF ROLL required of the Missile "after launch". PRIOR to operating the FLIGHT PROGRAMMER, the Roll Programmer is set as follows:

(1) PRE-OPERATION COMPUTATION

PRIOR to setting the Roll Programmer it is necessary to compute the voltage required to effect the desired DIRECTION and AMOUNT of roll. This consists of establishing a RATIO of ROLL VOLTAGE to REFERENCE VOLTAGE, (Phase A on the Missile Bus), TIMES TEN (10).

i.e., $\frac{\text{ROLL VOLTAGE}}{\text{PHASE "A" REFERENCE VOLTAGE}} \times 10 = \text{RATIO}$

EXAMPLE: If, during a Roll Program Set-up, the Phase "A" Reference Voltage is 115 volts and the desired Roll Program requires 1 volt to effect the required amount of roll, then:

$\frac{1 \text{ volt}}{115 \text{ volts}} \times 10 = .0869$

NOTE: The quotient of this ratio is read by the operator on the ROLL PROGRAM VOLTMETER as follows:

OPERATE	OBSERVE
(a) Press the MOMENTARY "ON-OFF-ON" Roll Program Set Switch to either the "R" or "L" position (RIGHT or LEFT) depending on the desired direction of heading.	The four (4) readout "windows" in the ROLL PROGRAM VOLTMETER will indicate as follows: (Set-up for RIGHT heading - viewing the Missile from the rear). R .0 8 7

CAUTION: ROLL RATIO MUST NOT EXCEED .450.

NOTE: PRIOR to above operation check that all switches on the Autopilot Control Console pertaining to ENGINE EXERCISE are "OFF" and throw the "READ-STANDBY" switch to the "READ" position.

(b) Once the desired roll program is set, return the "READ-STANDBY" switch to the "STANDBY" position. (So that unnecessary wear will not be imposed on the Roll Program Voltmeter circuit).

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5.3 (Continued)

(c) Place the Decade Timer Selector Switch on the "FLIGHT PROGRAMMER" position. The ROLL PROGRAM is now "SET" and will be operated by pressing the Program Start Switch.

5.4 AUTOPILOT READY SIGNAL (Refer to Figure 8)

The Autopilot Ready Signal is an indication to the operator at the TEST CONDUCTORS CONSOLE that the FLIGHT PROGRAMMER is on ZERO and the Autopilot Control System is ready for "launch".

(1) PRE-OPERATION CHECKOUT

(a)	Integrator Nulling Switch	"NULL"
(b)	Gyro Disable Switch	"DISABLE"
(c)	Gyro Nulling Switch	"NULL"
(d)	Exercise Selector Switch -OR- Static Firing Switch	"OFF" "ON"
(e)	Engine Zero Switch (Located on the Autopilot Auxiliary Control Console - Engine Position Panel.)	"ON"
(f)	Check affected indicator lights for above positions.	Either "ON" or "OFF" accordingly.

(2) PROCEDURE OF OPERATION

When the PRE-OPERATION CHECKOUT is completed:

(a) Autopilot Ready Switch "AUTOPILOT READY"

The GREEN light above the switch comes "ON" and a GREEN light on the "PRE-START" panel of the TEST CONDUCTORS CONSOLE comes "ON".

5.5 CAPTIVE FIRING (SYCAMORE S-1) TESTS

Tests of the Autopilot during Captive Firing at the SYCAMORE S-1 site will be conducted from the AUTOPILOT TEST PROGRAMMER CONSOLE (ATP).

(1) PRE-OPERATION CHECKOUT

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5.5 (Continued)

(a) Relay and Buckout Amplifier Chassis

PRIOR to operation, the ATP must be connected through this chassis which is located in the Autopilot Monitor and Control Unit in the Transfer Room. If the Simulated Launch (AFMTC TYPE) tests are conducted prior to the Captive Firing (Figure S-1) tests, it will be necessary to change the plug connections from the rear of the Engine Exercise Chassis to the Relay and Buckout Amplifier Chassis. This must be accomplished prior to fueling of the Missile, as the Transfer Room CANNOT BE ENTERED during or after fueling of the Missile.

(b) The power requirements for these tests are the same as those for the Simulated Launch (AFMTC TYPE) tests. (Refer to Paragraph (2), Section 5.1.1.1)

(2) Autopilot Test Monitor Panel

(a)	Pitch, Yaw, and Roll Channel Switches	"OFF"
(b)	Read-Standby Switch	"STANDBY"
(c)	Voltmeter Input Selector Switch	"OFF"
(d)	Programmer Continuity Step Counter	"00000" (Use reset wheel.)

(3) Autopilot Test Programmer Panel (Figure 12)

(a)	Engine Position Output Mode Switch	"AUTO"
(b)	Reader-Punch Control - Motor Switch	"OFF"
(c)	Reader-Punch Control - Mode Selector	"OFF"
(d)	Reader Remote-Local Switch	"LOCAL"
(e)	Reader ON-OFF Switch	"OFF"
(f)	Output Switch (guarded)	"CUTOFF" (Guard closed)

(4) Autopilot Test Programmer Power Supply (Figure 15)

(a)	All Control Knobs	Extreme Counter-Clockwise position. (Minimum voltage)

7.3 (Continued)

(5) POWER CONTROL - PRE-OPERATION

OPERATE	OBSERVE
(a) Press the Press-Test Indicator lights (Power OFF) Switch.	"ON" (This Switch isolates all the indicator lights on the panel and provides them with 28 vdc for a check of lamp continuity. NOTE: The Power Control "OFF" switch must be "OFF" to use this test.)
(b) Power Control On Switch	Following lights come "ON": 28 V DC 115 V, 400 CPS 115 V, 60 CPS

These three (3) types of power, required for Autopilot Test Programmer operation, have now been applied to the system. The power will remain applied until a "hold circuit" is broken by the OFF Switch located to the right of the ON Switch.

NOTE: Allow suitable warm-up period. (Mainly for the Autopilot Supply Voltage Meter.)

(c)	OBSERVE	GREEN Phase Rotation light should be "ON" indicating that Missile AC power is applied. (This light, located at bottom-center of ATP Test Monitor Panel.)
(d)	Autopilot Supply Voltage "READ-STANDBY" Switch	"READ"
(e)	Voltmeter Input Selector Switch - Rotate through "DC", "AC", "ØA", "ØB", "ØC".	Read voltage of each Input Selector Switch position on the AUTOPILOT SUPPLY VOLTAGE METER.
(f)	Return "READ-STANDBY" Switch to "STANDBY".	NONE
(g)	Set all Power Supply potentiometer knobs to extreme COUNTER-CLOCKWISE position.	Minimum Voltage

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5.5 (Continued)

(h)	Power Switch (on power supply)	"POWER"
(i)	150 Volt Switch	"-150 VOLTS"
(j)	300-450 Volt Switch	"300-450 VOLTS"

NOTE: Allow suitable warm-up for the Power Supply.

(k)	Adjust 0-10 V AC, 10 A Knob	"6.3 VOLTS" (Small Center Meter.)
(l)	Voltmeter Selector Knob to -150 volts and; 0-300 volt Potentiometer Knob to required adjustment.	"300 VOLTS" (Power Supply Voltmeter.)
(m)	Set 450 Volt Output	"450 VOLTS" (Power Supply Voltmeter.)

(6) PROCEDURE OF OPERATION

(a) Tape Loading

Load and Route an eight (8) inch roll of blank paper tape into the tape dispenser assembly as shown in Figure 11.

i.e., Under the Guide,
Over the tension arm,
Under the runout arm, plastic chip guide, punch holddown arm, (which swings out to permit the tape to be properly aligned on the sprocket drive wheel), and around the punch take-up wheel.

NOTE: When loading a PRE-PUNCHED TAPE which is to be read, it must be wound onto the READER FEED REEL. It is IMPORTANT to MARK CLEARLY the BEGINNING and END of the tape so as to wind it correctly on the Reader Feed Reel. The tape is then fed over the top of the READER, and under the Reader Holddown Arm (which is raised to permit tape alignment).

(b) Tape Punching

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5.5 (Continued)

	OPERATE	OBSERVE
	Reader-Punch Control Motor Switch	"ON"
(c)	Reader-Punch Control Mode Switch	"MANUAL-PUNCH TAPE"
(d)	Make desired program selections with any combination of selector switches described in Sections 2.3.3.2 and 2.3.3.2. When the last selection is made, the test may begin.	

NOTE: ALWAYS make selections from LEFT to RIGHT.

(e) Tape Reading

With punched tape on READER FEED REEL (load punched tape on READER FEED REEL and under READER HOLDDOWN ARM as shown in Figure 10), make certain that blank tape is ALSO threaded in Punch as the system is arranged to punch a DUPLICATE of the tape being read.

OPERATE	OBSERVE
Reader-Punch Control Motor	"ON"
Reader-Punch Control Mode Selector	"AUTO-READ TAPE"
Reader-Punch Control Reader-Remote-Local Switch	"LOCAL" (If "ON-OFF" switch is to control start of test program, or "REMOTE" if Booster Ignition Start Signal is to control start of test program.)

CAUTION: If the tape breaks, binds, or runs out, when the REMOTE-LOCAL switch is in "REMOTE" position, the programmer outputs will be automatically cut off and the reader clutch disengaged. The program in effect at the time will hold; therefore, the programmer should be CLEARED by setting the Mode Switch

5.5 (Continued)

to a "MANUAL" position and operating the CLEAR switches involved.

NOTE: MASS CLEARING of the program in effect may be accomplished at any time by turning power "OFF". If the tape breaks, binds, or runs-out with the Remote Local Switch on "LOCAL", the reader clutch will disengage.

(7) LIMITATIONS

(a) Multiple Selections

Outside of channel selections, multiple selections are meaningless. ATP will send out the vector sum of multiple signals chosen.

(b) Clearing

It is important to clear a function. Otherwise, the unit will hold the program INDEFINITELY or until power is turned "OFF".

(c) Program Time Limit

The outputs of the SIGNAL GENERATOR concerned with SWEEP frequency and RAMP functions are produced by Precision Potentiometers, therefore, the functions end when the limit of potentiometer travel is reached. These signals will not repeat indefinitely.

(d) Ramp

The total Ramp starts at ZERO, progresses to maximum, reverses to an equal, opposite polarity (phase) maximum, and returns to ZERO. The time given on the Autopilot Test Programmer Control Panel is that to reach the first peak or maximum. The total ramp will return to ZERO in four (4) times this duration and will remain thereuntil cleared.

(e) Sweep

The Autopilot Test Programmer Control Panel indicates the total time to SWEEP from 0.3 cps to 20 cps by specifying the total number of cycles produced in this period. When the HIGH END of the SWEEP (22 cps) is reached, the Frequency Generator will continue to put out 22cps until the function is cleared.