STUDENT WORKBOOK

AIR TRAINING COMMAND

MISSILE LAUNCH/MISSILE OFFICER

BLOCK III
(1-13)

OBR1821/3121-3
Technical Training

FOR INSTRUCTIONAL PURPOSES ONLY

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Missile Launch/Missile Officer
Missile Fundamentals Branch
Department of Missile Training
Sheppard Air Force Base, Texas

OBR1821B/3121-3-III-1-P1
Student Workbook
12 January 1962

DAY 39

AIRFRAME SECTIONS AND MAJOR COMPONENTS

OBJECTIVE

To familiarize you with missile sections, major components and types of airframes.

PROCEDURE

1. Answer the following questions:

   a. Define "Mass Ratio". WT OF MISSILE AT LAUNCH / EMPTY WEIGHT

   b. How can the Mass Ratio be improved?

   (1) DECREASE EMPTY WEIGHT

   (2) INCREASE DENSITY OF PROPELLANT

   c. How is the Mass Ratio related to range? PROP TO LOG OF MASS RATIO

   d. Define "Burnout Ratio". WT LOADED / WT AT BURNOUT

   e. How does staging effect the Burnout Ratio and why?
   INCREASES - BECAUSE BY STAGING YOU LIFTING LESS WITH MORE THRUST

f. What is the big disadvantage to the staging of a missile?

DROP IN RELIABLITY

g. What is the advantage of milling?

DECREASE WEIGHT OF MISSILE
INCREASE LONG STRENGTH

h. What are two methods of milling?

(1) MECHANICAL

(2) CHEMICAL

i. Why is integral tank construction an advantage in missile construction?

DECREASE WT.

j. What

j. What is monocoque construction?

NO INTERNAL SUPPORT IS NECESSARY

k. How does semi-monocoque construction differ from pure monocoque construction? STRESSED BY FORMERS + STRINGERS

l. Why is the missile launched vertically?

(1) GET OUT OF ATMOSPHERE QUICKLY

(2) REDUCE LATERIAL STRESS

m. What is the significance of orientating missile fuel and liquid oxygen tanks? CENTER OF GRAVITY

n. What is the advantage of separating the re-entry vehicle?

REDUCES THE RE-ENTRY PROBLEM

2. **Identify and label the missile sections shown in Figure 1.**

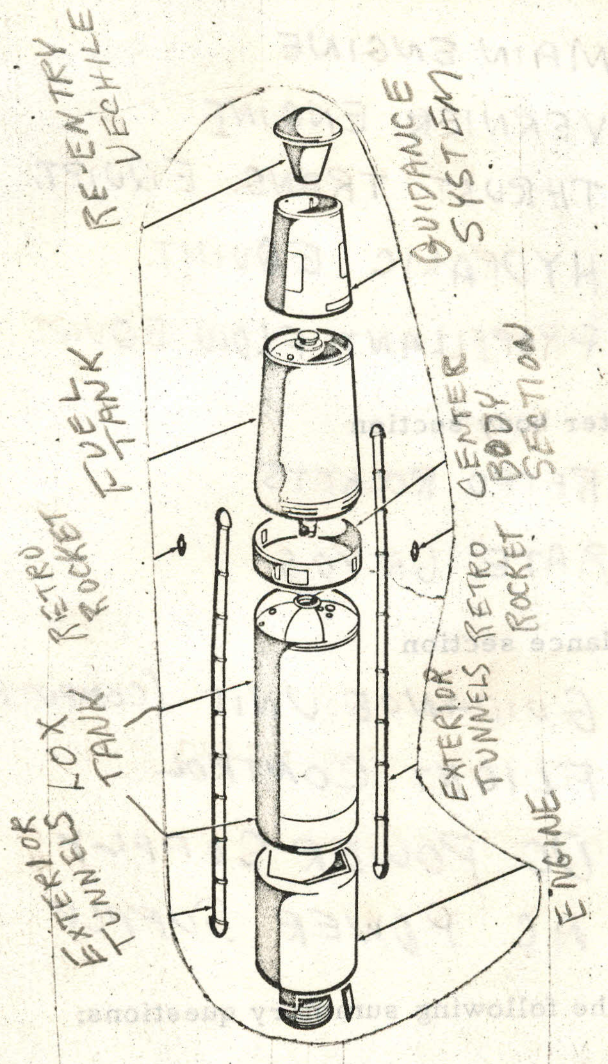


Figure 1 - Missile Section

3. List the major components of the following missile sections.

a. Engine accessories section.

(1) MAIN ENGINE

(2) VERNIER ENGINE

(3) THRUST TRANS. EQUIPT.

(4) HYDRALIC EQUIPT.

(5) PROPELLANT FLOW EQUIPT.

b. Center body section

(1) RETRO ROCKETS

(2) RATE GRYOS

c. Guidance section

(1) GUIDANCE UNIT (COMPUTER, STABLE PLATFORM

(2) FLIGHT CONTROL

(3) DC POWER SUPPLY

(4) AC POWER SUPPLY

4. Answer the following summary questions:

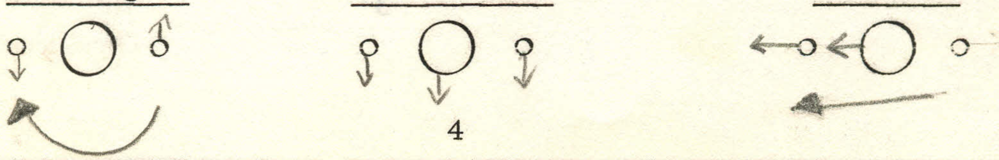
a. What is the purpose of the thrust beams in the engine accessories section? TRANSFER THRUST FROM ENGINE TO THE MISSILE

b. The three axis of a missile are: PITCH, ROLL

YAW.

Shown below are three representations of main and vernier engine orientations. With arrows show how the engines can be gimbaled to provide missile steering as indicated.

Roll Right | Pitch ~~Over~~ DOWN | Yaw Left



c. Why are the rate gyros located in the center body section?
SO THEY WONT EXAGERATE INFO

d. Why are retro-rockets used on missiles?
SLOW DOWN TO ALLOW SEPARATION OF RENTRY VECHILE

e. What is the purpose of missile airframe access doors and openings? FOR MAINTENANCE + INSPECTION

f. What is the purpose of including exterior tunnels on the missile airframe? ROUTE CABLES

g. Why are re-entry vehicle latches used?
HOLD TO MISSILE

h. How are these latches activated?
EXPLOSIVE SQUIB

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PROPELLANT LOADING

OBJECTIVE

To become familiar with system concepts and equipment functions.

PROCEDURES

1. Answer the following questions:

a. Why is a rupture disc generally installed on a pressure vessel?
SAFETY DEVICE FOR BACKUP

b. What is the advantage of a pneumatic system over a mechanical system in propellant transfer?
SIMPLE AND FAST

c. Why is vacuum used as insulation for LOX storage tanks?
BECAUSE IT IS THE BEST INSULATER

d. Why are the filters usually located near the missile in a propellant transfer system? TO FILTER MAX

e. How is contraction compensated for in the cryogenic fluid transfer lines? EXPANSION JOINTS

f. How is the amount of propellant in the missile determined?

(1) Oxidizer SENSORS

(2) Fuel FLOW METERS

g. What is the purpose of the filtering and dewatering unit?

REMOVE WATER
REMOVE FORIEGN MATTER

DAY 42

MISSILE PROPULSION SYSTEM FAMILIARIZATION

OBJECTIVE

To familiarize the student with typical system components needed in solid and liquid rockets.

PROCEDURES

1. Label Figure 1 to include the following:

   a. Nozzle
   b. Combustion chamber
   c. Pump
   d. Turbine
   e. Gas generator
   f. Exhaust
   g. Propellant tanks
   h. Propellant valves

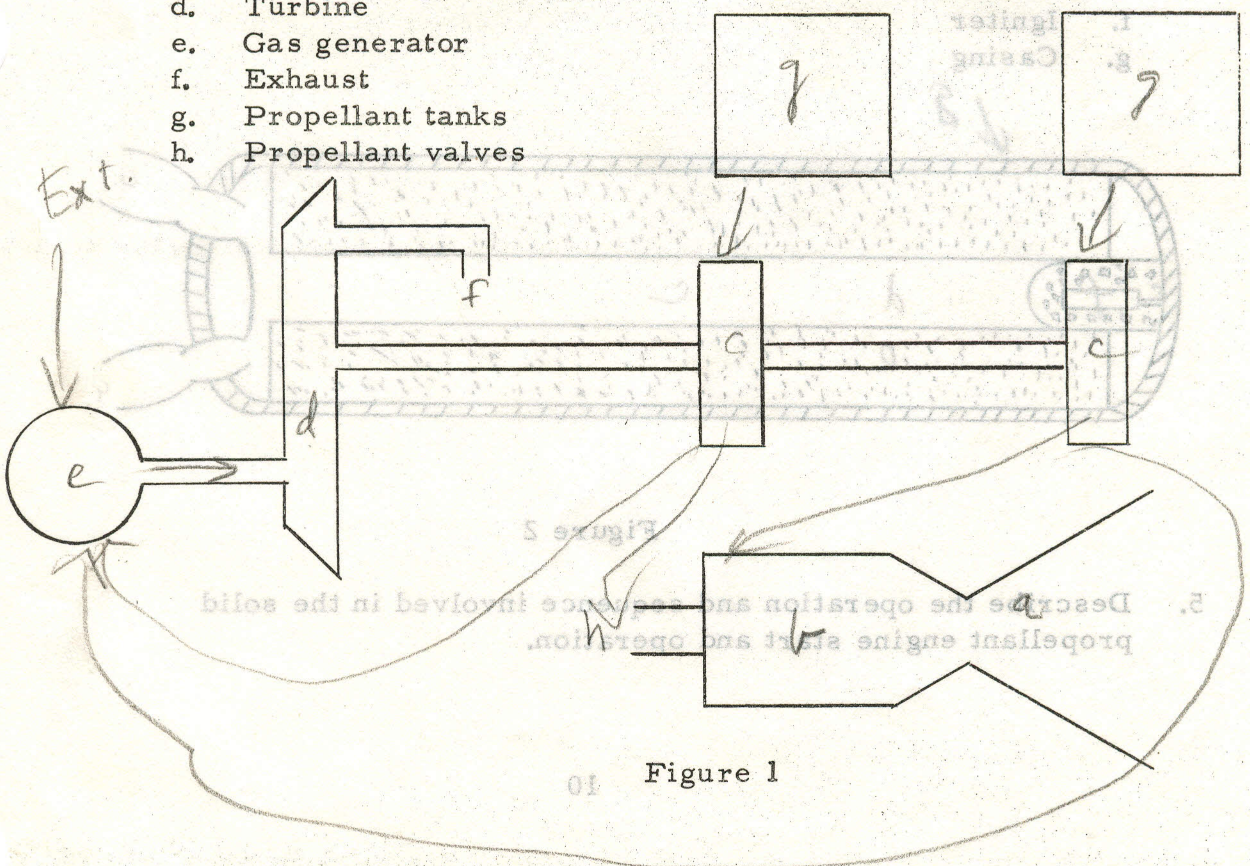

Figure 1

2. Use Figure 1 and draw the propellant flow in red and the hot gas flow in blue. Include a labeled bootstrap system on the diagram.

3. Explain the operation of the system shown in Figure 1 to include a start system.

4. Label the Figure 2 to include the following:

   a. Nozzle
   b. Bosses
   c. Combustion chamber
   d. Port area
   e. Grain
   f. Igniter
   g. Casing

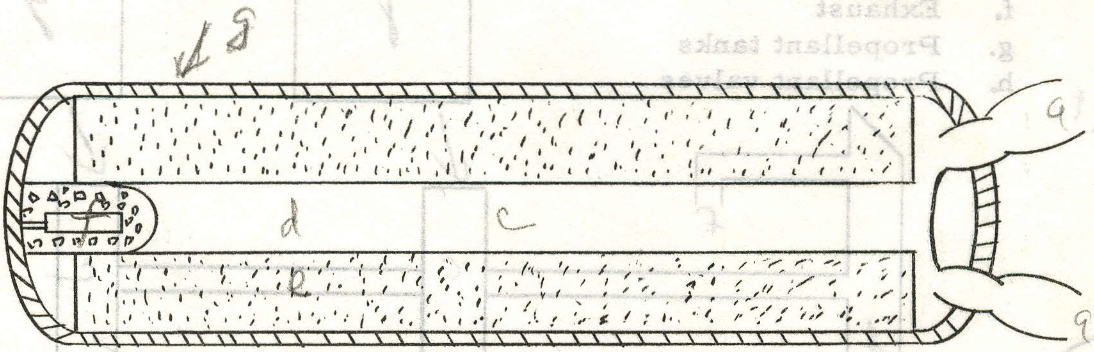

Figure 2

5. Describe the operation and sequence involved in the solid propellant engine start and operation.

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(Supplementary Problems)
12 January 1962

MISSILE ROCKET PROPULSION PROBLEMS

OBJECTIVE

To familiarize the student with the theory of propulsion involving the parameters of engine operation.

PROCEDURE

1. Work the following problems.

GIVEN	DETERMINE
a. A large liquid rocket operates as follows:	
(1) Theorectical exhaust velocity 6000 FT/SEC	(1) The thrust when the engine is fired on the test stand? 84,000 lbs
Exit pressure - 6.7 PSIA	The ambient pressure at design altitude? 6.7 psiA
Exit area - 700 SQ IN	The thrust at design altitude? 90,000 lbs
Mass flow rate - 15 slugs/SEC	The effective exhaust velocity at sea level? 5,627 ft/sec
Test stand ambient Pressure 14.7 PSIA	The effective exhaust velocity at design altitude? 6,000 ft/sec
	The specific impulse at sea level? 174 sec
	The specific impulse at design altitude? 188 sec

GIVEN	DETERMINE
(2) The ambient pressure is 1.7 PSIA at 50,000 feet.	(2) What is the thrust at this altitude? N/A LOWER THAN 90,000 Is the engine operating under conditions of over, under or optimum expansion at this altitude? under expansion
(3) The throat area is 70 SQ IN	(3) What is the expansion ratio? 700/70 = 10:1

b. The following data apply to a rocket system:

GIVEN	DETERMINE
(1) At sea level, ambient pressure 14.7 PSIA	(1) a The theoretical exhaust velocity and the exit pressure? 8,000 lbs 5.2 PSIA
At design altitude, ambient pressure - 5.2 PSIA	b The test stand (sea level) thrust? 86,424 lbs
At design altitude, effective exhaust velocity - 8000 FT/SEC	c The thrust at design altitude? 96,000 lbs
At 40,000 feet, ambient pressure 2.7 PSIA	d The effective exhaust velocity at sea level? 7,202 ft/sec
A_e - 7 SQ FT	e The amount of propellant used in the 50 second run. 600 slugs 19,320 lbs
M-12 slugs/SEC	
t_b - 50 seconds	

c. A rocket engine is designed for a specific impulse of 270 seconds average at design altitude. When fired on a test stand at sea level (P_a = 14.7 PSIA), it develops a thrust of 42 tons. The exit pressure is 6.4 PSIA and the exit area of 8 SQ FT.

c. How long will the engine operate with 40,000 LB of propellant?

116 sec

SUMMARY

1. In the operation of a rocket engine, what relationship must exist between exit pressure and ambient pressure in order to achieve over expansion, optimum expansion, and under expansion?

$P_a > P_e$ over
$P_a = P_e$ opt
$P_a < P_e$ under

2. What is meant by the "design altitude" of a rocket engine?

thrust max

3. Explain the "second" as a unit of measure of specific impulse.

The result of math manipulation

4. On high design altitude engines (sustainer type) the throat area is usually smaller than a comparable booster engine. Why is this true and what effect does it have on the fundamental thrust equation?

To increase the expansion ratio

5. Using the parameters in the fundamental thrust equation, explain some methods we can increase the thrust in a solid motor.

~~Increase Temp~~
~~Increase Pressure~~
Increase Burning rate
Increase size of nozzle

DAY 42

MISSILE PROPULSION SYSTEM

OBJECTIVE

To familiarize you with the Missile Engine Start System.

PROCEDURES

1. Sketch an engine system for a typical rocket to include the following components:

    a. Engines
    b. Turbopump
    c. Tanks
    d. Gas generator
    e. Start system either liquid or solid
    f. Main propellant valves
    g. Secondary propellant system for operation of gas generator
    h. Propellant, pneumatic and electrical lines

2. Use a basic system which includes all components necessary for operation and set up a sequence of engine operation to include engine start and shutdown.

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Missile Fundamentals Branch
Department of Missile Training
Sheppard Air Force Base, Texas

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12 January 1962

DAY 42

MISSILE PROPULSION SYSTEM IDENTIFICATION

OBJECTIVE

To familiarize you with engine components.

PROCEDURE

1. Identify each lettered unit in Figure 1 and give the purpose of each.

ITEM	NOMENCLATURE	PURPOSE
A	FUEL INLET LINE	
B	TURBO PUMP	
C	FUEL START VALVE	
D	PYROPHORIC INGNITER	
E	FUEL VALVE	
F	INJECTION PLATE	
G	SKIRT	
H	OXIDZER INLET	
I	GAS GENERATOR	
J	SOLID PROPELLANT SLUG	START TURBINE
K	OXIDZE START VALVE	
L	TURBINE EXHAUST	

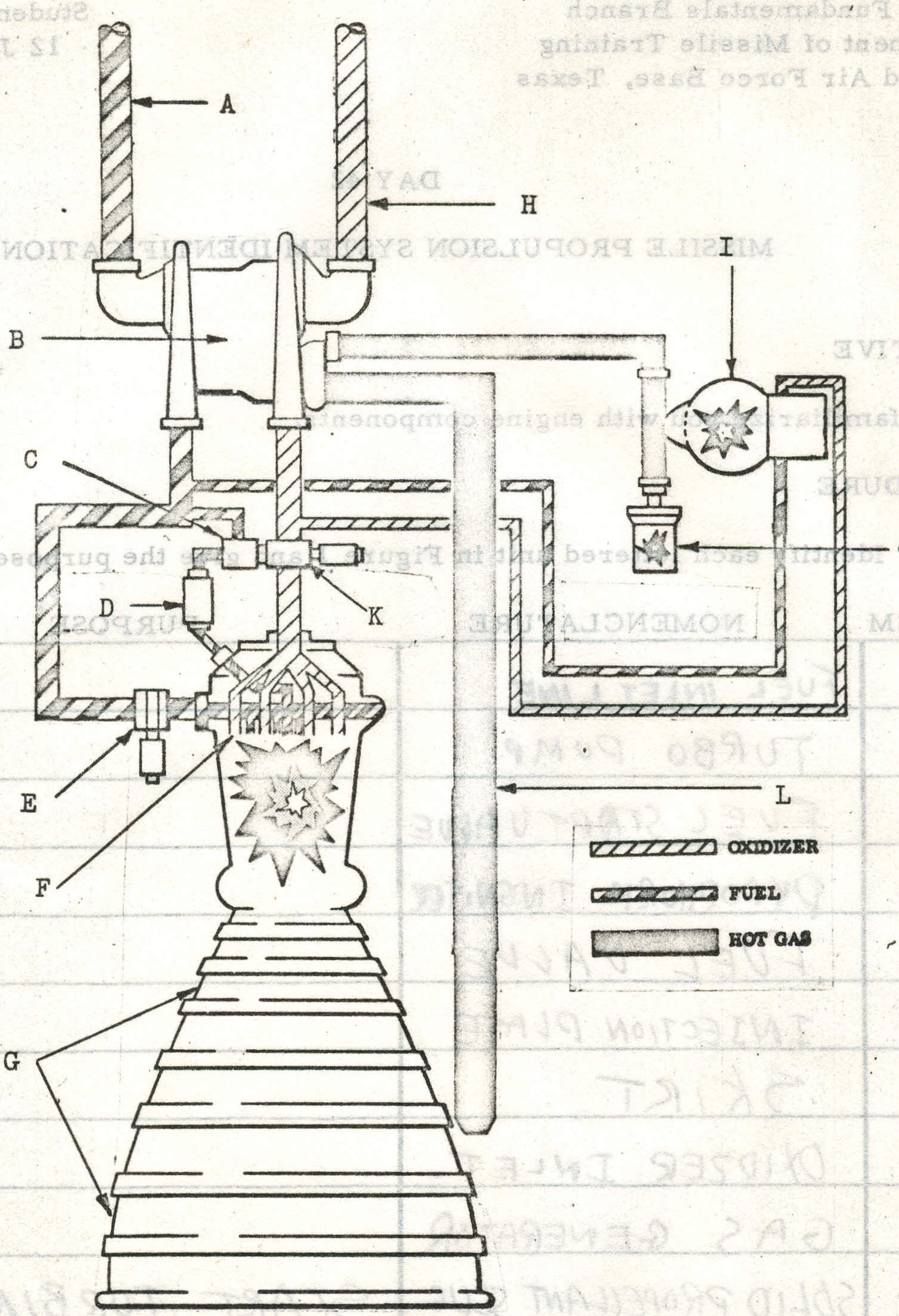

Figure 1

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Sheppard Air Force Base, Texas

OBR1821B/3121-3-III-5-P1
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12 January 1962

DAY 43A

PRINCIPLES OF TRAJECTORIES

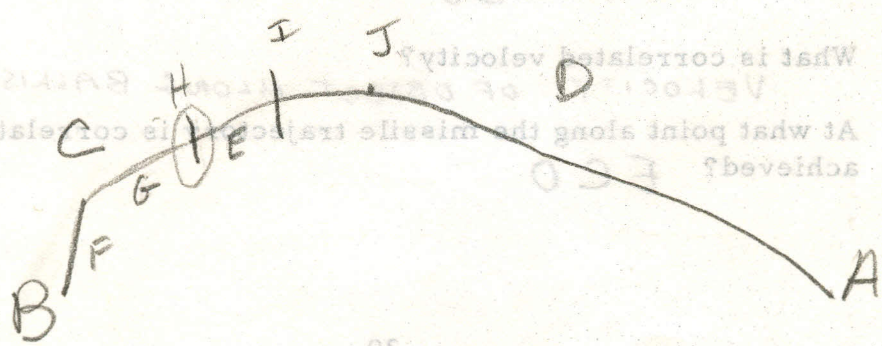
OBJECTIVE

To familiarize you with trajectory problems and variables.

PROCEDURE

1. Draw a typical missile trajectory for a single stage missile to include the following:

a. Target
b. Launch Point
c. Powered portion
d. Ballistic portion
e. Guided portion
f. Roll programmed portion
g. Pitch programmed portion
h. Barrel in the sky
i. Separation point
j. Apogee



2. Answer the following summary questions.

a. What is the purpose of roll programming a missile?
ALINE MISSILE IN AZIMUTH

b. How could this purpose be accomplished prior to lift off?
ROTATE MISSILE

c. Explain how fuel is conserved by the use of a roll program.
SAVES TIME - SHORTER DISTANCE

d. What is the purpose of the pitch program?
HEAD DOWN RANGE

e. Why is the first portion of the missile flight programmed?
SIMPLER GUIDANCE

f. Why is it impossible to program the entire powered portion of flight? TOO MANY UNPEDICTABLES

g. When does the guidance system assume control of a missile?
AT END OF PROGRAMED PORTION

h. What is the advantage of the application of a ballistic trajectory to a missile flight? MUCH LESS FUEL REQUIRED

i. What commands does the guidance system originate?
CORRECTIONS IN COURSE AND ENINE CUT OFF AND PREARM

j. Why does the guidance system not originate roll steering signals? NO NEED FOR IT

k. How does the guidance system control the direction of missile velocity? STEERING

l. How does the guidance system control the magnitude of missile velocity? ECO

m. What is correlated velocity?
VELOCITY OF OBJECT ALONG BALLISTIC TRAJECTORY

n. At what point along the missile trajectory is correlated velocity achieved? ECO

o. How is the magnitude of correlated velocity related to:

(1) Range

(2) Altitude

DIRECTLY PROPORTIONAL

p. Why does the guidance system choose a new trajectory rather than correcting to an ideal (pre-planned) trajectory?

SAVE FUEL + TIME AND STRESS

q. Why is throwout velocity the greatest at the equator?

BECAUSE THE DIAMETERS ALONG ROTATION LARGEST

PREDICTABLES

r. State how Coriolis force is affected by:

(1) Missile velocity DIRECTLY PROP

(2) Latitude INCREASES

(3) Longitude NO EFFECT

s. Define target's predicted position: THE POSITION THE TARGET AT END OF FLIGHT

t. What two variables affect the target's predicted position?

1 LAT.

2. TIME OF FLIGHT

u. Name three missile flight variables that cannot be accurately predicted.

(1) WEATHER AT LAUNCH

(2) THRUST VARRIATIONS

(3) INDIVIDUAL THRUST CHARATUPISTICS

v. Why isn't the missile aligned to the immediate target position during the roll program (Phase) ?

EARTH'S ROTATION

DAY 43 B

POSITION AND RATE SENSORS

OBJECTIVE

To become familiar with gyro components and operation.

PROCEDURES

1. Locate and identify the components shown in the gyro diagram of Figure 1. Record the name of the components on the diagram.

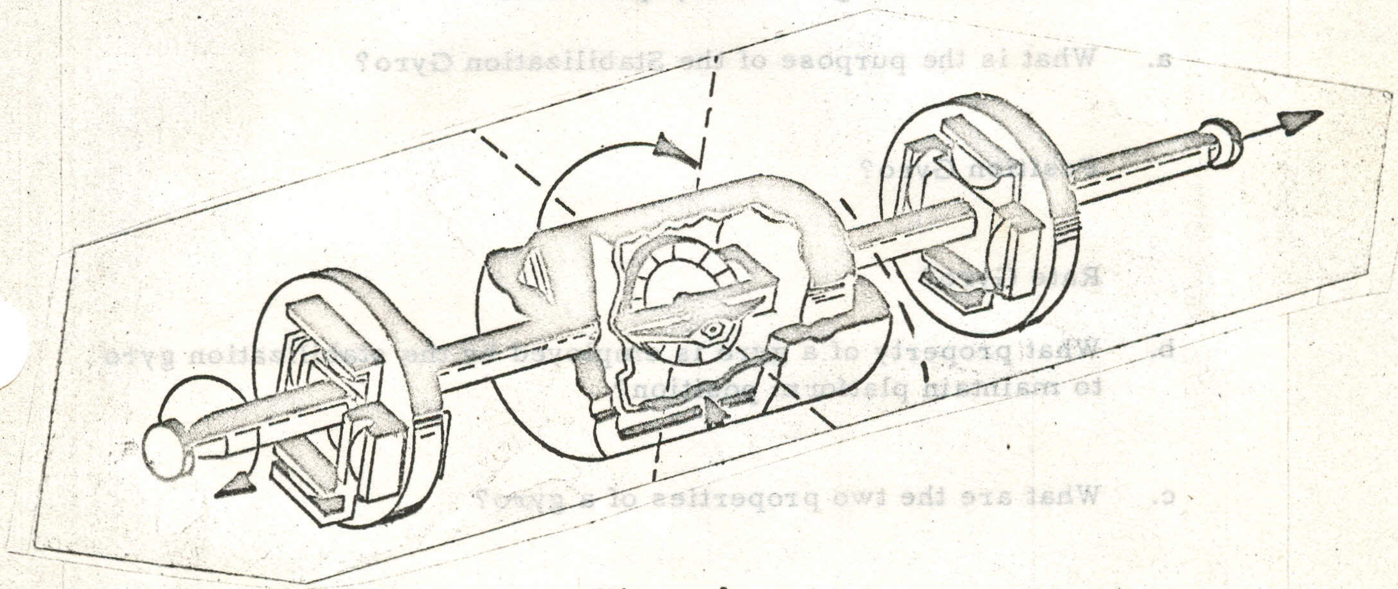


Figure 1

2. Label the INPUT, OUTPUT, and SPIN axes of the gyro in the diagram.

3. Give the purpose of the following gyro components:

   a. Gyro Wheel ______________________________

   ____

   b. Inner Gimbal or Float ______________________________

   ____

c. Outer Gimbal or Housing ______________________________

____

d. Torque Microsyn ______________________________

____

e. Signal Microsyn ______________________________

____

4. Answer the following summary questions:

a. What is the purpose of the Stabilization Gyro?

Position Gyro?

Rate Gyro?

b. What property of a gyro is employed by the stabilization gyro to maintain platform position?

c. What are the two properties of a gyro?

d. What method is used to compensate for drift?

e. Define "degree of freedom".

f. How does the operation of an attitude gyro differ from that of a stabilization gyro?

g. What are the different approaches to gyro gimbaling?

h. Explain how the rate gyros detect rate of movement.

i. How are the rate gyros "nulled" or "erected"?

j. What is the purpose of the rate gyros in a missile?

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Sheppard Air Force Base, Texas

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DAY 44 AND 45

THE FLIGHT CONTROL SYSTEM

OBJECTIVE

1. To acquaint you with the nomenclature, location and function of various flight control system components.

2. To familiarize you with location and operation of the electrical subsystem components.

3. To become familiar with the operation and construction of the hydraulic subsystem.

PROCEDURE

1. Use Figure 1

   a. Identify all components.

   b. Properly connect the electrical subsystem components with lines for DC by using a blue pencil and AC by using a red pencil. Simulate actual air placement and current flow by using arrows.

   c. Show all DC SIGNALS by blue dashes with arrows for direction.

   d. Show all AC SIGNALS by red dashes with arrows for directions.

2. Use Figure 2

   a. Identify all components.

   b. Trace a programmed roll command signal by using a red pencil to indicate signal path.

c. Trace a programmed pitch command signal by using a blue pencil to indicate signal path.

d. Trace a pitch error signal by using a green pencil to indicate signal path.

e. Trace a guidance enable signal by using a pink pencil to indicate signal path.

f. Trace a guidance pitch command signal by using a brown pencil to indicate signal path.

g. Trace a guidance yaw command signal by using an orange pencil to indicate signal path.

3. Figure 3

a. Identify components

b. Color all 3000 PSI hydraulic areas red.

c. Color all 1500 PSI hydraulic areas yellow.

d. Color all hydraulic return areas blue.

4. Figure 4

a. Identify components

b. Color all hydraulic pressure areas of 3000 PSI red.

c. Color all hydraulic return areas blue.

d. Color all pneumatic pressure areas orange.

5. Use Figure 5

a. At direction of instructor trace signal flow through the differential bridge network.

6. Answer the following questions after observing the operation of the flight control system.

a. The DC signal from the flight controller goes to what unit?
SERVO VALVE

b. What is the purpose of the differential bridge network?
DIF PITCH + ROLL SIGNALS TO VE

c. What effect will the differential bridge have on the main engine movement? NONE

d. What does the liftoff switch energize?
PROGRAMMER

e. Explain the nose cone release sequence.
1. PREARM ENABLE
2 M E C O
3 SQUIBS 15 sec
4 RETROS - 1 sec

f. Where is the programmer located?
FLIGHT CONTROL

g. What signals does the programmer allow?
1. ROLL + PITCH PRO
2. GAIN CHANGE
3. GUIDANCE ENABLE
4. PROGRAM ENABLE

h. How are programmer command signals terminated?
Activate unlatch relay - Break holding ground.

i. What determines the magnitude of the pitch program current?
RESISTOR

j. What happens to the guidance signals while the programmer is controlling missile flight? STORED IN COMPUTER

k. What is the purpose or function of the microsyn signal generator? MECH MOVE ELE SIGNAL
DETECT AMOUNT + DIRECTION OF GRYO PRECESSION

l. What is the purpose of the spring restrainer in the rate gyro?
DAMPEN GRYO PRESSION
BRING BACK TO ZERO

m. Do the position (~~HIG~~) gyros have a critical temperature for operation? Why? YES - FLOORILUBE

n. What is the function of the microsyn torque generator? CONTROL SIGNAL TO GRYO

o. How many AC amplifiers are in the flight control circuitry? 6

p. The output signal of the demodulator feeds into what part of the flight control system? SUM + SHAPE NET

q. What is the purpose of the engine feedback potentiometers?
1. PERMIT ENGINE TO STOP AT INTERMEDIATE POSITION
2. RETURN ENGINE TO ZERO

r. Why is the hydraulic powerpack sealed?
LOX

s. What is the purpose of the feedback beam in the servo valve?
CENTER IT

t. Where is hydraulic pressure obtained after main engine cutoff?
ACCUMULATOR

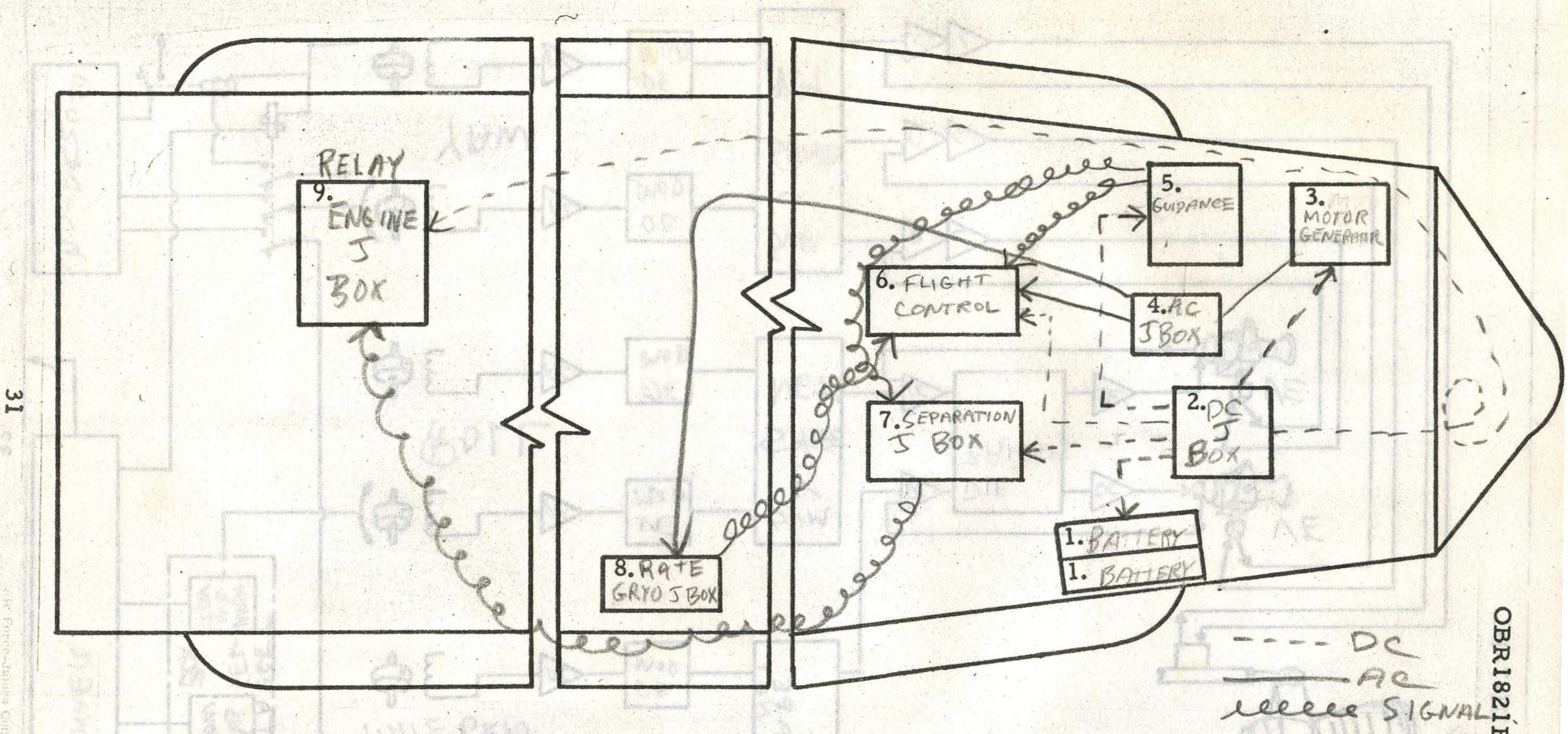


Figure 1 Missile Electrical System Block Diagram

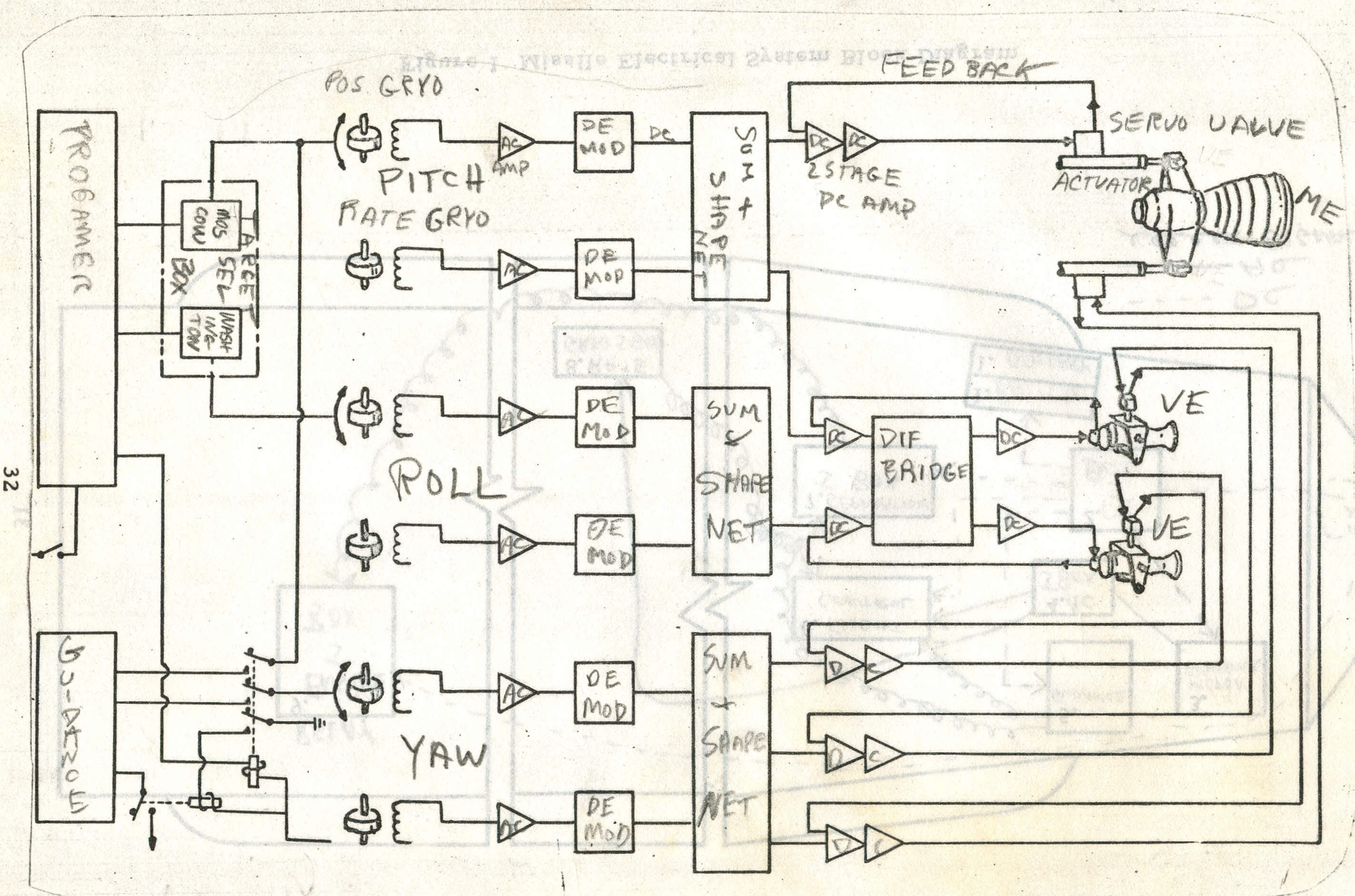


Figure 2 Flight Control System Schematic Diagram

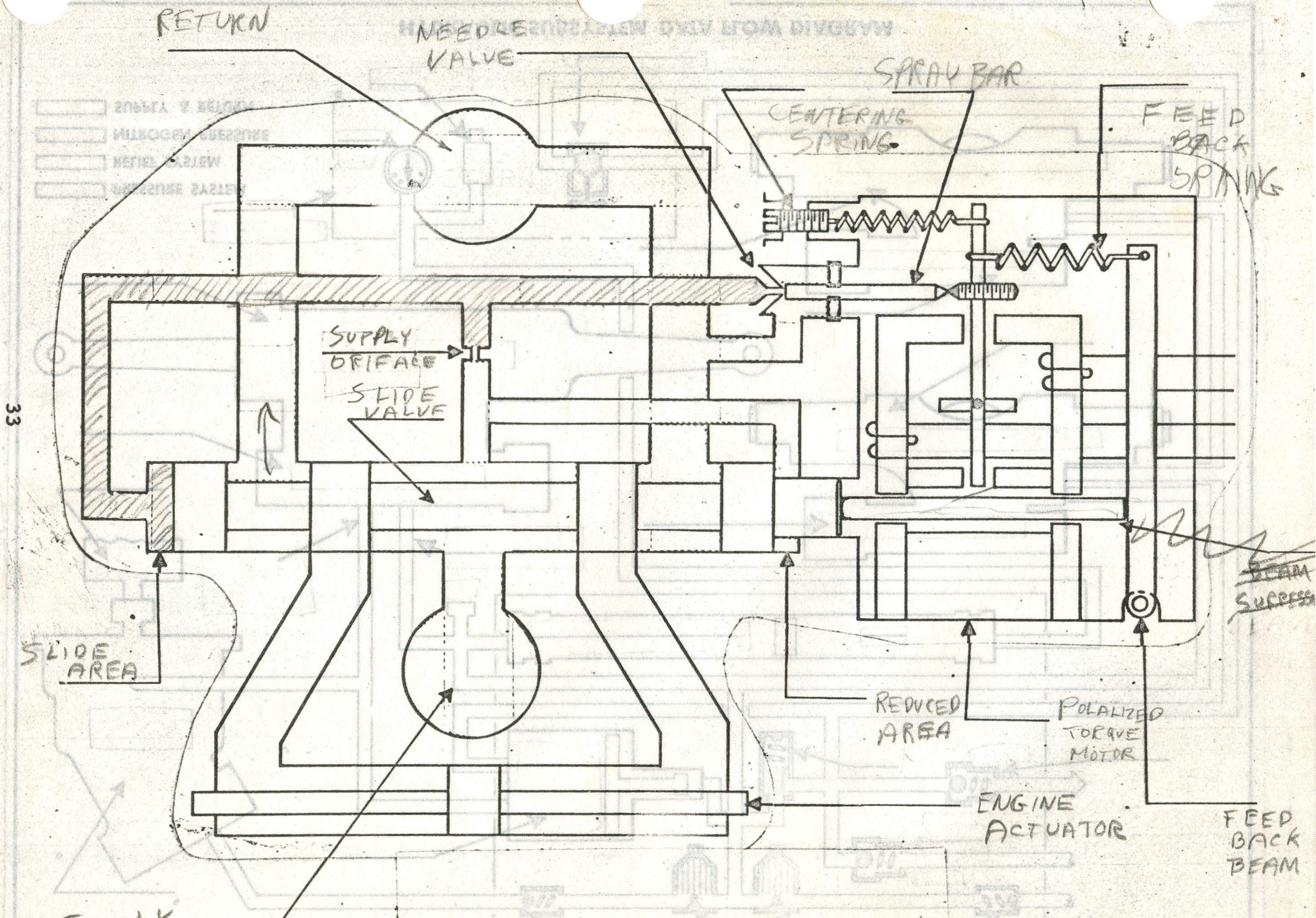
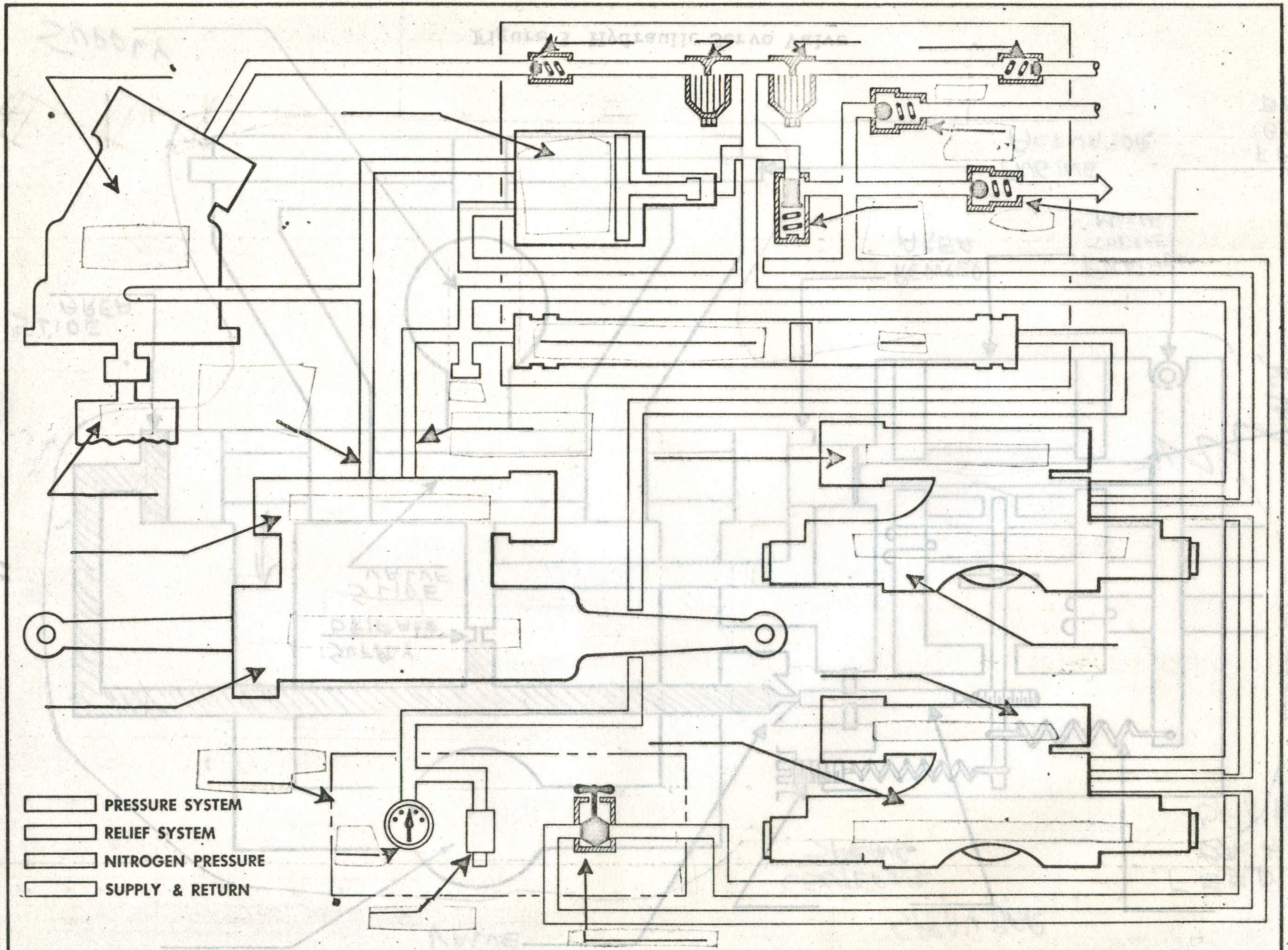


Figure 3 Hydraulic Servo Valve



HYDRAULIC SUBSYSTEM DATA FLOW DIAGRAM

...ure 4

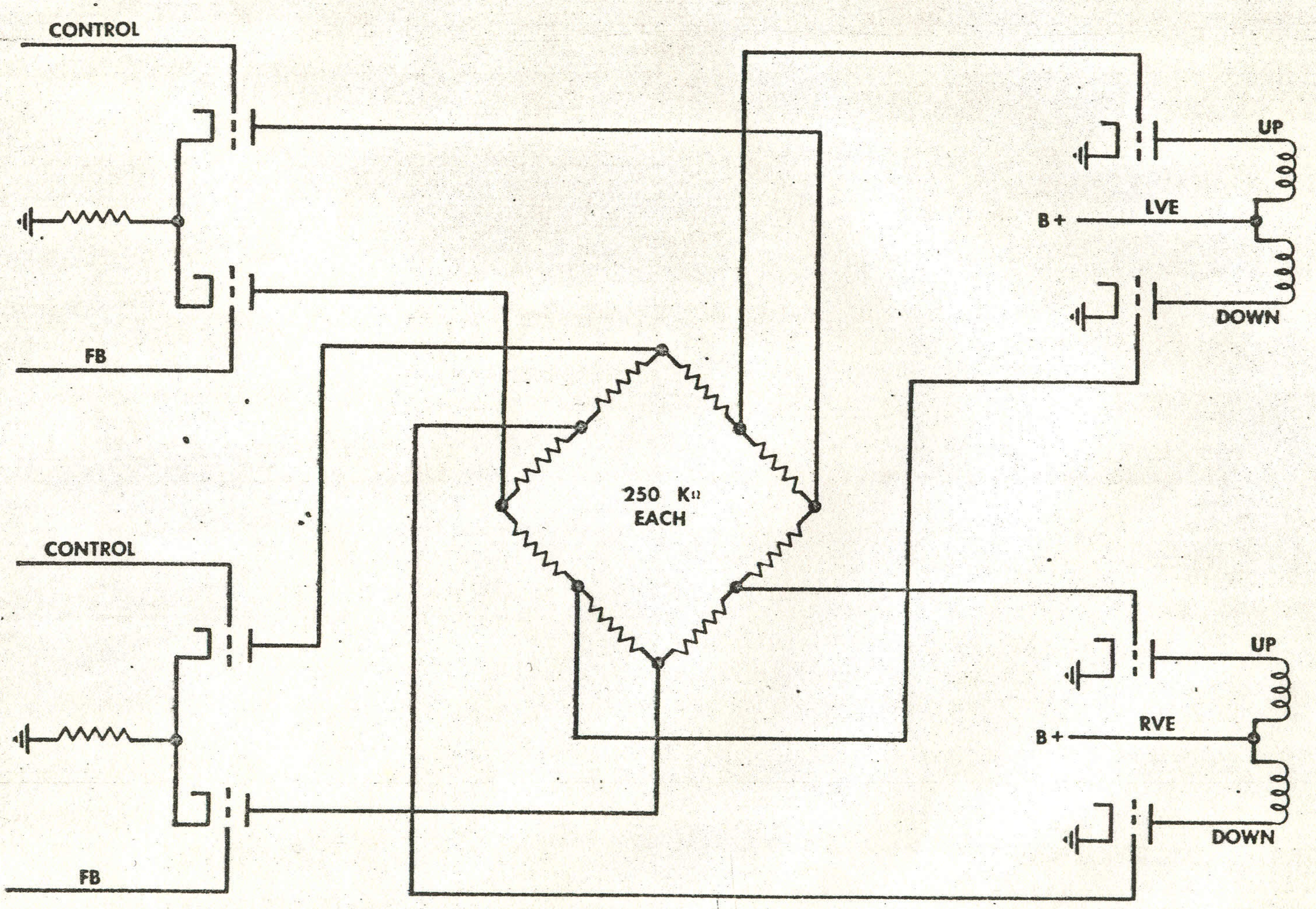


Figure 5 Differential Bridge

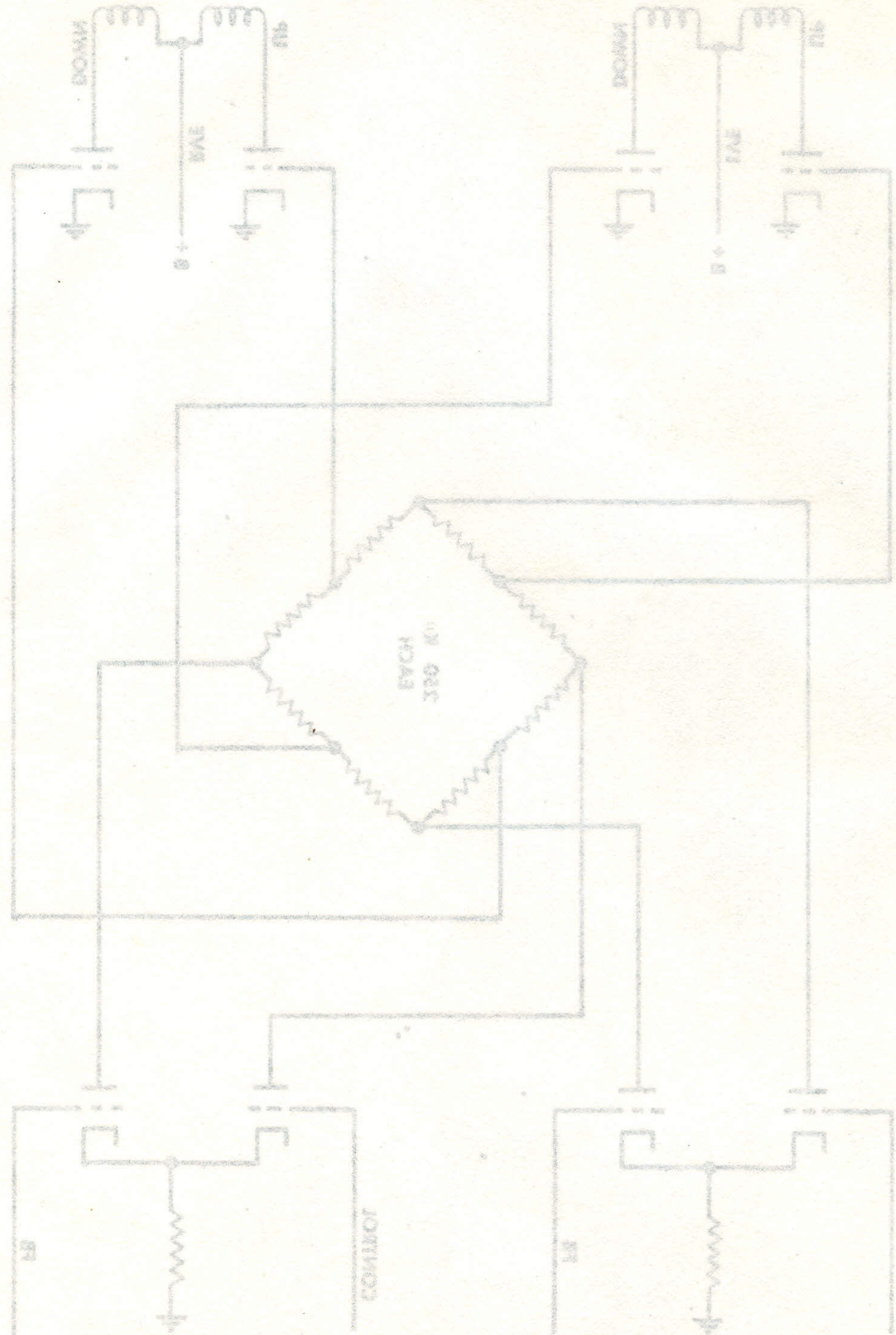


Figure 5 Differential Bridge

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Sheppard Air Force Base, Texas

DAY 45

FLIGHT CONTROL CHECKOUT

OBJECTIVE

To familiarize you with the principles of flight control checkout (data flow).

PROCEDURE

The checkout procedures contained in this workbook permits a detailed test of the flight control system, at the launch emplacement or in the RIM building to determine that it is in a ready condition.

1. Prepare the equipment for use.

   a. Insure that all switches on the power control, gimbal control, and programmer panels in the missile checkout station are in the down position.

   b. The HIG gyro input switch on the gimbal control panel must be in the Cage position.

   c. The Guidance External Power switch must remain in the enable position at all times.

   CAUTION

   The missile igniters must be disconnected and/or removed before cables to and from the missile and the missile checkout station are connected. Failure to observe this warning may result in injury or death to personnel.

   d. Insure that all electrical connections to the missile igniters have been removed.

   e. Remove the signal isolation unit test adapter and all cables from their storage position.

f. Mount the test adapter on the missile.

For the purposes of this exercise all power cables and circuit breakers will be pre-positioned in their proper positions.

g. Place the autopilot gyro heaters switch on the power control system relay chassis, in the high and low heat position.

h. If during checkout the proper response to any test is not obtained, return the controls to their previous positions, discontinue the checkout, and proceed in accordance with troubleshooting instructions.

CAUTION

Power to the gyro heater circuits of the inertial guidance system must not be shut off for periods in excess of five (5) minutes. Serious damage to delicate gyro parts may result if this caution is not strictly observed.

i. Make certain that all personnel are clear of the missile engines before applying hydraulic power to the flight control system. Serious injury may result if personnel are struck by a deflecting engine.

2. Complete Power Supply Checks by using the Power Control and Power Checkout Panels.

Make certain that all circuitt breakers in the missile checkout station and the launching countdown group or missile launching simulator are in the ON position before proceeding with the checkout.

OPERATION	INDICATION
a. Place the POWER TRAILER switch in the ON position.	a. POWER TRAILER light ______
b. Place the POWER CONTROL switch in the MANUAL position.	b. POWER CONTROL Light ______
c. Press the 115 Volt, 60ØA pushbutton.	c. The NULLMETER indicates ______
d. Press the 115 Volt, 60ØB pushbutton.	d. The NULLMETER indicates ______
e. Press the 115 Volt, 60 ØC pushbutton.	e. The NULLMETER indicates ______
f. Observe the 60 CPS PHASE SEQUENCE lamps.	f. They are illuminated BRIGHT and DIM as placarded. Neither lamp light is out.
g. Press the 28 Volt DC MISSILE pushbutton.	g. The NULLMETER indicates ______
h. Press the 28 Volt DC INVERTER pushbutton.	h. The NULLMETER indicates ______
i. Press the EXTERNAL 115 Volt ØA pushbutton.	i. The volts, AC, RMS meter indicates between 113.3 and 116.7 volts. The FREQUENCY CYCLES PER SECOND meter indicates ______
j. Press the 28 Volt DC GUIDANCE pushbutton.	j. The NULLMETER indicates ______

OPERATION	INDICATION
k. Press the EXTERNAL 115 Volt ØB pushbutton.	k. The volts AC, RMS meter indicates ________ volts. The FREQUENCY CYCLES PER SECOND meter indicates ________.
l. Press the EXTERNAL 115 Volt ØC pushbutton.	l. The volts AC, RMS meter indicates ________ volts. The FREQUENCY CYCLES PER SECOND meter indicates ________.
m. Observe the 400 CPS PHASE SEQUENCE lights.	m. They glow BRIGHT AND DIM according to placarding. Neither light is out.

CAUTION

The plates and spin-motor circuits within the flight controller (CEA) must not be continuously energized for periods greater than 90 minutes. Each operating period must be followed by a cooling off interval equal to at least one-half the operating time, before the circuits are re-energized.

n. Place the CEA FILAMENTS and HEATERS switch in the ON position.	n. HIGH heat ON light comes on and remains on for the high heat cycle, then automatically goes out. LOW heat lights (YAW, PITCH and ROLL) go initially with the HIGH heat light, then continue to recycle.

NOTE

Allow LOW heat lights to cycle twice before proceeding with checkout.

o. Observe the START POSITION lights on the PROGRAMMER panel.	o. Light ________
p. Place the CONTROL ELECTRONICS ASSEMBLY POWER switch in the ON position.	p. CONTROL ELECTRONICS ASSEMBLY POWER light ________

3. Complete the voltage check with the Power Checkout Panel.

OPERATION	INDICATION
a. Press the EXTERNAL 115 Volt ØA pushbutton.	a. Refer back to steps 2i, 2k, and 2l under POWER SUPPLY CHECKS for proper readings.
b. Press the EXTERNAL 115 Volt ØB pushbutton.	b. As above.
c. Press the EXTERNAL 115 Volt ØC pushbutton.	c. As above.
d. Press the 115 volt REF pushbutton.	d. Same as ØA (step a. this procedure)
e. Press the NULL REF CHECK pushbutton.	e. The NULLMETER indicates ________
f. Press the RATE 27 Volt pushbutton.	f. The NULLMETER indicates ________

g. Press HIG 5 Volt pushbutton. | g. The NULLMETER indicates ______

h. Press the DC AMPLIFIER 330 Volt pushbutton. | h. The NULLMETER indicates ______

i. Press the DC AMPLIFIER 165 Volt pushbutton. | i. The NULLMETER indicates ______

j. Press the POT 50 Volt pushbutton. | j. The NULLMETER indicates ______

k. Press the POWER SUPPLY BALANCE pushbutton. | k. The NULLMETER indicates ______

l. Press the DEMODULATOR REF 80 Volt pushbutton. | l. The NULLMETER indicates ______

4. Complete the buzz voltage check by using the Signal Monitor Panel.

WARNING

Make certain that all personnel are clear of the missile engines before applying hydraulic power to the flight control system. Serious injury may result to personnel struck by a gimbaling engine.

OPERATION	INDICATION
a. Place the HYDRAULICS switch on the power control panel in the ON position.	a. The HYDRAULICS ______
b. Observe the GIMBAL CHECK lights on the gimbal control panel.	b. In approximately 30 seconds, they light in the sequence: ______
c. Observe the SYSTEM PRESSURE.	c. The gauge indicates ______ ______

OPERATION	INDICATION
d. Observe the LEFT VERNIER PITCH/ROLL and RIGHT VERNIER PITCH/ROLL BUZZ meters.	d. They indicate __________ when the CONTROL ELECTRONICS ASSEMBLY POWER switch is placed in the ON position.
e. Press the BUZZ MAIN YAW pushbutton.	e. Meter indicates __________
f. Press the MAIN PITCH BUZZ pushbutton.	f. Meter indicates __________
g. Press the BUZZ YAW VERNIER LEFT pushbutton.	g. Meter indicates __________
h. Press the BUZZ YAW VERNIER RIGHT pushbutton.	h. Meter indicates __________

5. Complete the engine electrical centering with the Gimbal Control Panel.

NOTE

The Trim Pots, located with the Buzz Pots behind the access plate on the flight controller, are utilized to cause the uncaged engine position to coincide with the center of thrust positions. The left vernier pitch zero pot adjusts the vernier engines together in pitch. The Right Vernier Pitch Zero Pot adjusts the vernier engines differentially in roll. All adjustments are made immediately after the HIG Gyro Input switch is placed in the Slew position to prevent errors in adjustment due to gyro drift.

OPERATION	INDICATION
a. Place the HIG GYRO INPUT switch in the SLEW position for approximately three (3) seconds while observing the MAIN PITCH gimbal position meter.	a. Meter needle indicates ______
b. Return HIG GYRO INPUT switch to the CAGE position.	
c. Repeat step 5a, observing the MAIN YAW gimbal position meter and RECENTER lamp.	c. Meter needle ______ Recenter lamp ______
d. Step 5c repeated for left and right vernier yaw gimbal.	d. Indications same as for main yaw gimbal in step 5c.

6. Complete the flight controller checkout by using the Gimbal Control Panel and Signal Monitor Panel.

INFORMATION

The control field meters give indications for approximately eight (8) seconds, then revert back to their normal positions. If the affected control field meter returns to zero before any one of the following into slew tests are completed, return the HIG Gyro Input switch to the cage position, then back to slew after approximately 30 seconds. This is to insure that all meters return to their neutral positions. Press the auto slew pushbutton previously designated and complete the remaining portion of the test.

YAW SLEW RIGHT TEST

Place the HIG gyro input switch in the slew position, then press the yaw auto slew right pushbutton on the gimbal control panel.

OPERATION	INDICATION
a. Observe the YAW CONTROL FIELD meter.	a. Needle deflects ______ ______
b. Observe the PITCH CONTROL FIELD meter.	b. Meter indicates ______
c. Observe the ROLL CONTROL FIELD meter.	c. Meter indicates ______
d. Observe the YAW LEFT VERNIER meter.	d. Meter indicates ______
e. Observe the YAW RIGHT VERNIER meter.	e. Meter needle deflects ______
f. Observe the YAW MAIN meter.	f. Meter needle deflects ______
g. Observe the PITCH/ROLL LEFT VERNIER meter.	g. Meter indicates ______ ______
h. Observe the PITCH/ROLL RIGHT VERNIER meter.	h. Meter indicates ______ ______
i. Observe the PITCH MAIN meter.	i. Meter indicates ______
j. Press the YAW HIG SIGNAL GENERATOR pushbutton on the signal monitor panel, and observe the GYRO meter.	j. Meter needle deflects ______
k. Press the YAW HIG DEMODULATOR pushbutton and observe GYRO meter.	k. Meter needle deflects ______ ______
l. Observe the main and vernier engines.	l. The main and right vernier are gimbaled ______ The left vernier engine is gimbaled ______

m. Place the HIG GYRO INPUT switch in the CAGE position and return to SLEW after approximately 30 seconds. This is to insure that all the meters return to their neutral positions.

m. The meter positions are ____

YAW SLEW LEFT TEST

This test is accomplished in the same manner as the YAW Slew Right test. The only difference being that the reading and engine movement will be opposite. At this time continue with the pitch slew up test.

NOTE: Pitch and roll slew tests are similar to yaw slew tests, and will be omitted.

NOTE

Replace the HIG Gyro Input switch to the CAGE position.

7. Complete the programmer check by using the Programmer Panel

OPERATION	INDICATION
a. Observe the START POSITION light.	a. Light ____
b. Press the TARGET 1 pushbutton. Place the TARGET DESIGNATE switch in the ON position and release it. Observe the TARGET 1 and the RANGE lights.	b. The TARGET 1 ____ Either the LONG or SHORT RANGE ____ Normally the LONG RANGE is set on target 1.

c. Press the FORWARD DRIVE MOTOR pushbutton. Check that the indications presented by the CONTROL FIELD and GIMBAL POSITION Meters correspond as required with the position in elapsed time of the programmer film strip as indicated by the programmer position seconds counter.

c. Refer to the chart presented below.

EVENT	TIME IN SECONDS	ROLL	PITCH
Roll program start	2	See note following step b.	
Roll program end	10	Centered	
First Pitch Program	11		________ ________
Second Pitch Program	30		________ ________ ________
Third Pitch Program	60		________ ________ ________
Fourth Pitch Program	83		________ ________ ________
Pitch Program End	100		________ ________
Reverse (Programmer time reverses).	180		
Stop (Programmer time stops. 360 seconds total elapsed time.)	0		

OPERATION	INDICATION
d. Steps 7b and 7c repeated for programmer check, target 2.	d. Indications same as in steps 7b and 7c except indications are for target 2.

8. Complete the sensing test of the Flight Controller

OPERATION	INDICATION
a. Place the HYDRAULICS switch in the OFF position.	a. HYDRAULICS ON light __________

CAUTION

Do not perform step "8b" below until the engines have dropped to their normal positions. (Approximately 30 to 40 seconds).

OPERATION	INDICATION
b. Place the CONTROL ELECTRONICS ASSEMBLY POWER switch in the OFF position.	b. CONTROL ELECTRONICS ASSEMBLY POWER light __________
c. Place the CONTROL ELECTRONICS ASSEMBLY switch in the ON position.	c. CONTROL ELECTRONICS/ ASSEMBLY POWER light __________

NOTE

In addition to the operator in the missile checkout station, the sensing test also requires a technician at the missile guidance section to manually move the flight controller. These men must have suitable means of communication with each other. The technician at the guidance section grasps both ends of the flight controller so that the moveable mounts are up and the cables are to his right. He moves the flight controller in the axis and direction requested by the operator.

d. The operator places the HIG GYRO INPUT switch in the SLEW position, presses the YAW HIG DEMODULATOR pushbutton, requests YAW RIGHT, and observes the GYRO meter. The technician slowly turns the flight controller approximately 3 degrees to the right.

d. The GYRO meter needle ______________________

e. The operator places the HIG GYRO INPUT switch in the CAGE position and allows approximately 30 seconds for the gyros to cage. This is to insure that the GYRO meter returns to its neutral position.

f. Steps 8d and 8e repeated for pitch and roll right.

f. Indications same as in step 8d except indications are for pitch and roll.

g. Place the CONTROL ELECTRONICS ASSEMBLY POWER switch in the OFF position.

NOTE: The sensing test of the Rate Gyros is similar to Flight Controller Sensing test and therefore will not be completed in this project.

SUMMARY

1. What electrical power is required for flight control system operation?

2. How are the flight control position GYROS checked?

3. How could you determine if the roll program event was initiated by the programmer during checkout?

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Student Workbook
(Supplementary Questions)
12 January 1962

INERTIAL GUIDANCE STABILIZATION

OBJECTIVE

To become familiar with inertial guidance system components.

PROCEDURE

1. Answer the following questions:

   a. Explain how the stable platform maintains its orientation when there is a missile movement. MOTORS GIMBLE

   b. Why are gyros used as sensing devices rather than using their property of rigidity to maintain the platform orientation?
   SIZE + WEIGHT

   c. What would result if the platform failed to maintain its orientation for a short duration of flight?
   NO PREARM SIGNAL + MISS TARGET

   d. What effect does missile movement have on the computational axis orientation? NONE

   e. How many gimbals must be used to mount a stable platform?
   THREE

   f. What is the minimum number of two degree of freedom gyros necessary for platform stabilization?
   TWO

   g. What three points determine the reference plane?
   A.P. L.P. C.o.E

h. What is the horizontal plane?
TANGET AT L.P.

i. What is the purpose of the horizontal and reference planes?
PROVIDE AXIS FOR ELE + AZMUTH REF

j. When does the missile leave the reference plane?
AT LAUNCH

k. How is the reference plane determined?
ELETRO THEODOLITE

l. How is the horizontal plane determined?
VERT SENSING DEVICE

m. Why are the reference and horizontal planes earth oriented prior to launch? EASIER (ON EARTH)

n. How many axis of freedom does the vertical sensing element have? TWO

o. What condition exists when the vertical sensing element is not at a null position?
1. NOT VERT
2. PLATFORM ISN'T LEVEL

p. Why must apparent precession be compensated for prior to launch? LOSS OF ORIENTATION
(*) NULL POSITIONS LOST

2. Use Figure 1

a. At the direction of the instructor trace signal flow throughout stabilization loops.

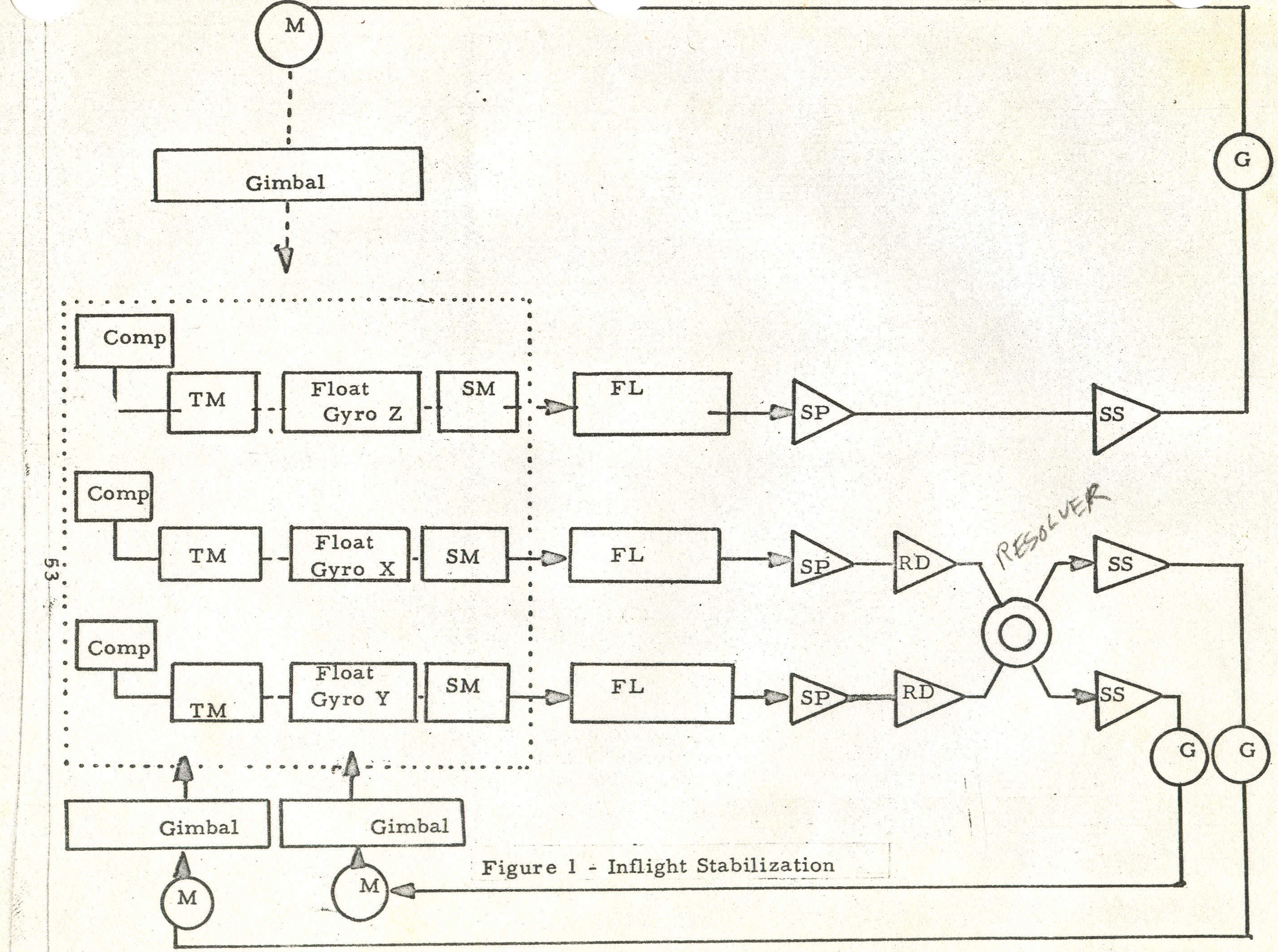

Figure 1 - Inflight Stabilization

OBR1821B/3121-3-8-P1A

DAY 48

RADIO GUIDANCE SYSTEM

OBJECTIVE

To familiarize you with radio guidance system operation and system components.

PROCEDURE

1. Answer the following questions by using Figures 1 and 2, and the notes taken in class.

    a. What information is obtained from the position antenna?

    b. How are antenna position errors corrected?

    c. Where do discrete signals originate?

    d. What is the main disadvantage to a command guidance system?

    e. Why is a transponder used in the missile?

    f. Where do steering signals originate?

g. What is the purpose of the rate antenna in a system utilizing the principle of Doppler shift?

h. How is missile velocity obtained with a single antenna system?

i. Why is a reflected radar signal not used to obtain missile velocity?

j. How is missile velocity obtained in a Doppler system?

k. What is the function of the last pulse in the addressed code?

2. Sketch a block diagram of a radio inertial guidance system.

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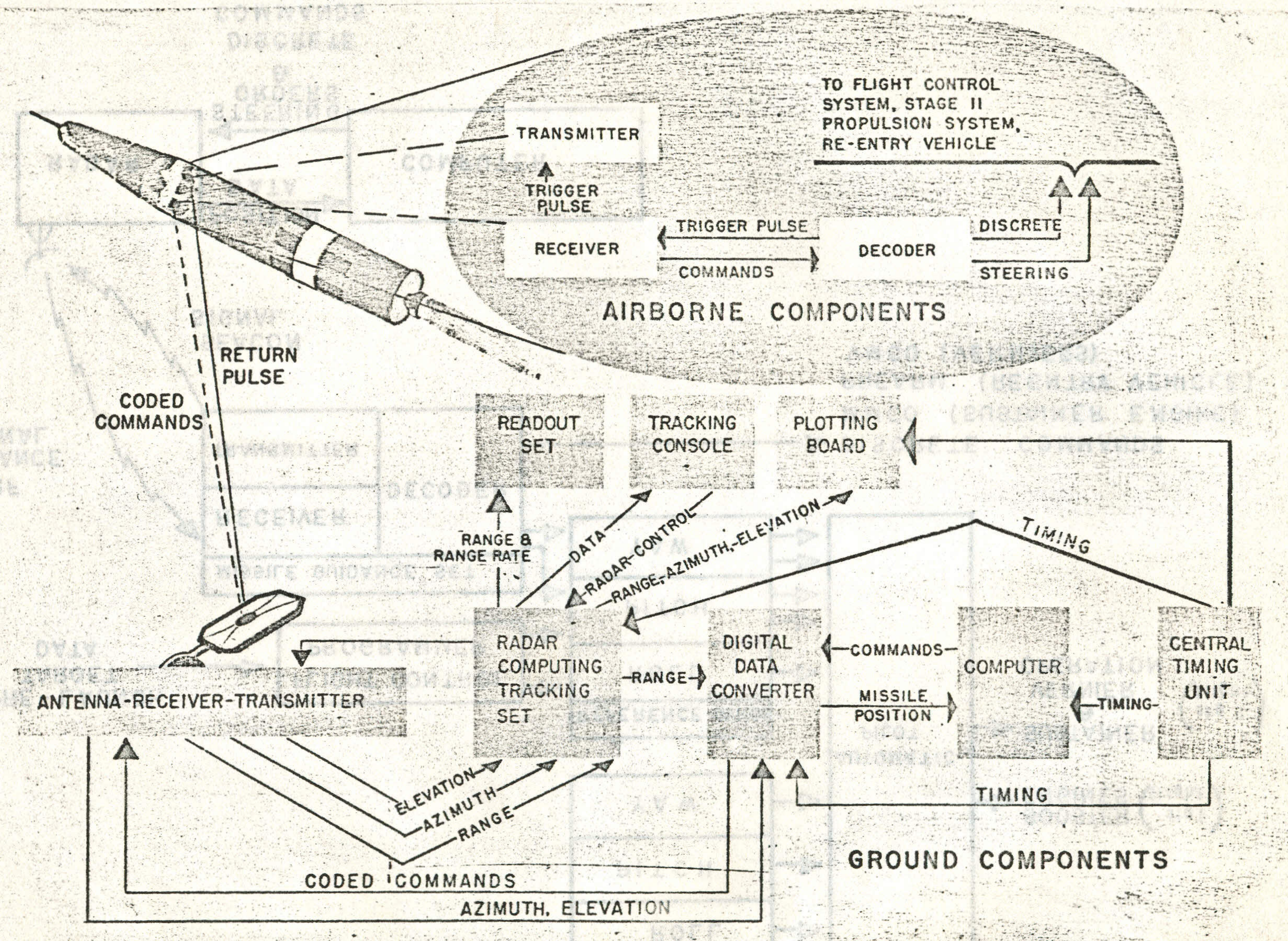
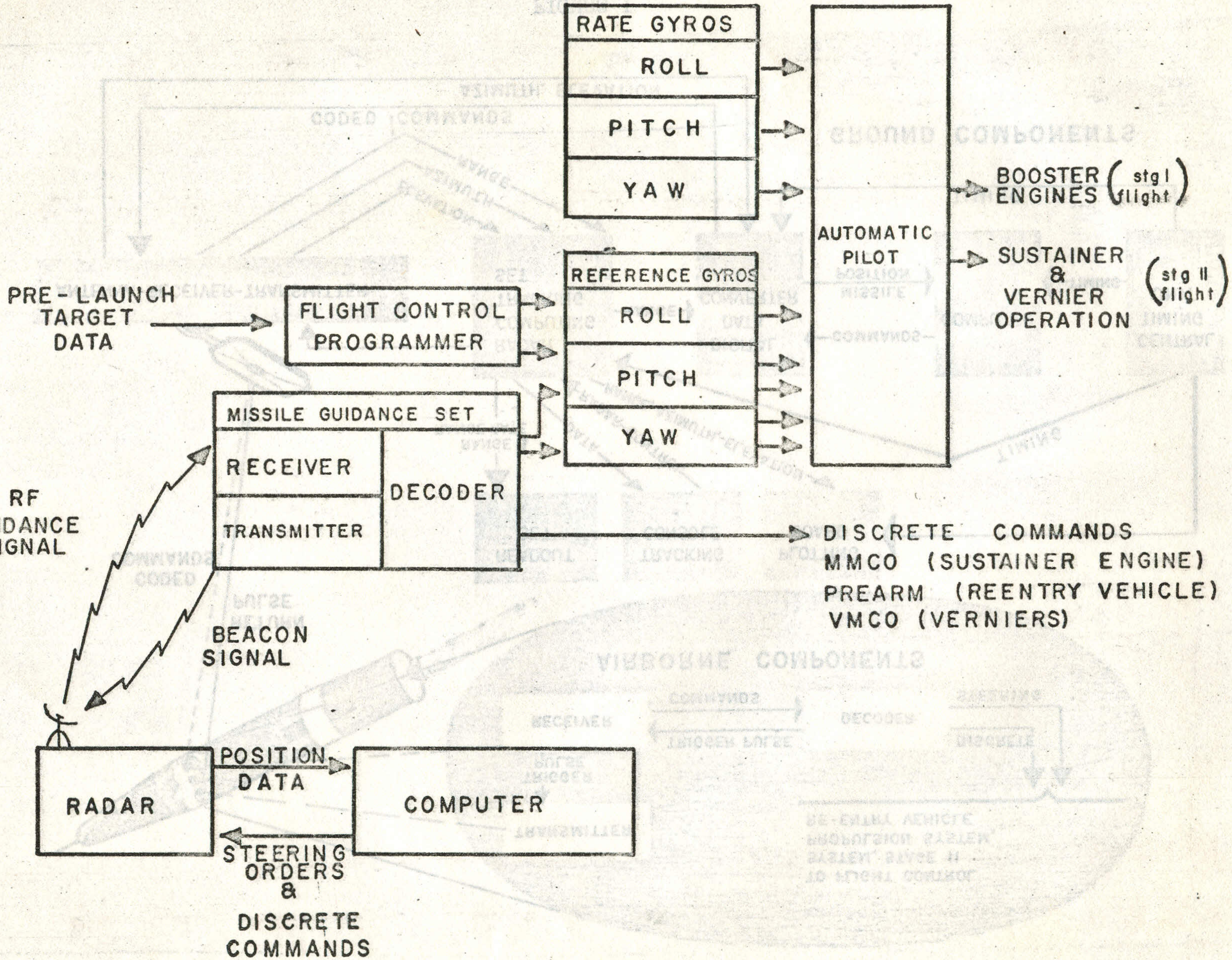


FIGURE I

RADIO GUIDANCE DATA FLOW

OBR1821B/3121-3-III-9-P1



Figur[illegible] Guidance-Flight Control

DAY 49

POWER GENERATION AND DISTRIBUTION

OBJECTIVE

To familiarize the student with power generation and distribution including power outputs, distribution units and locations.

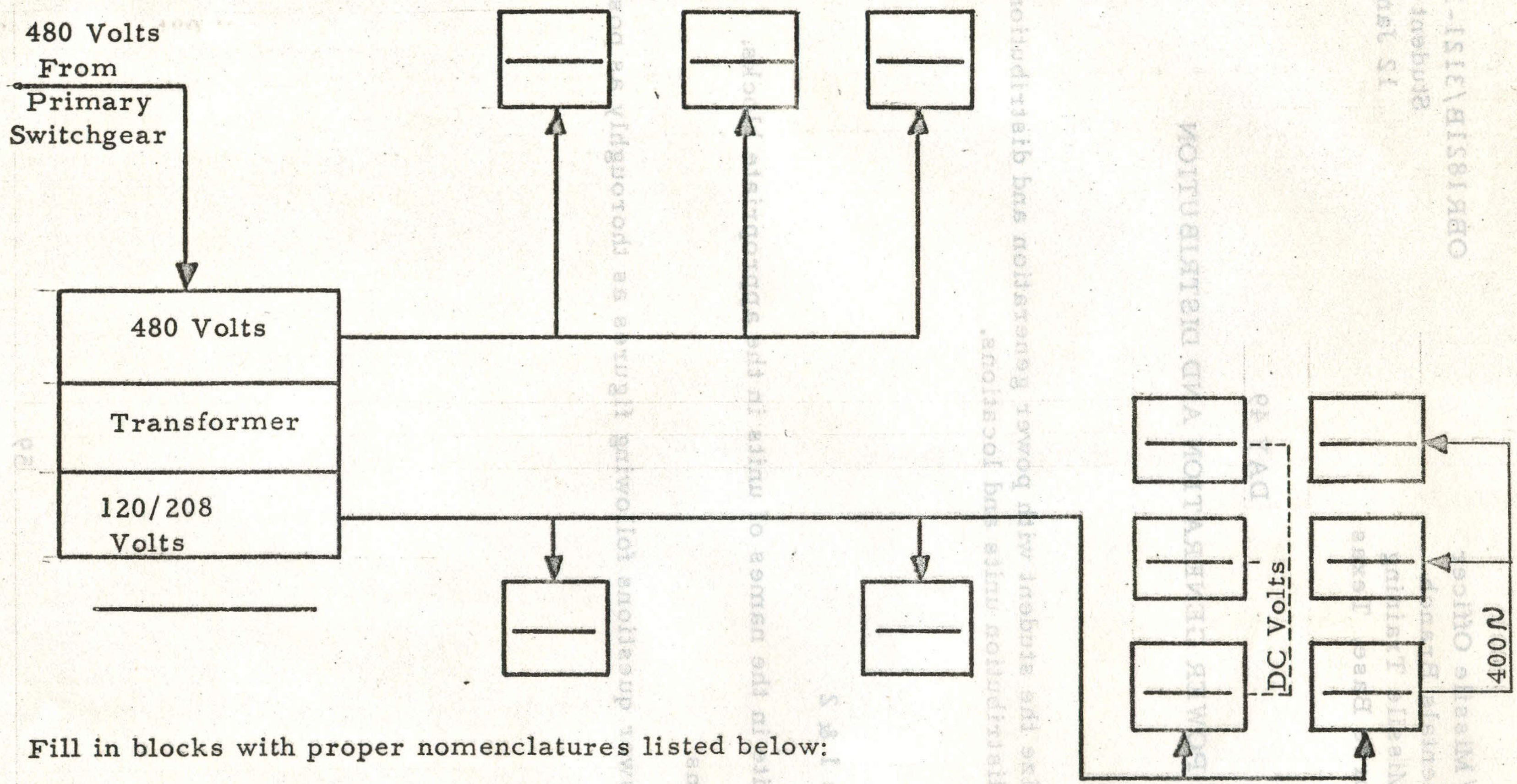
PROCEDURE

1. Figures 1 & 2

    a. Write in the names of units in the appropriate blocks.

2. Questions

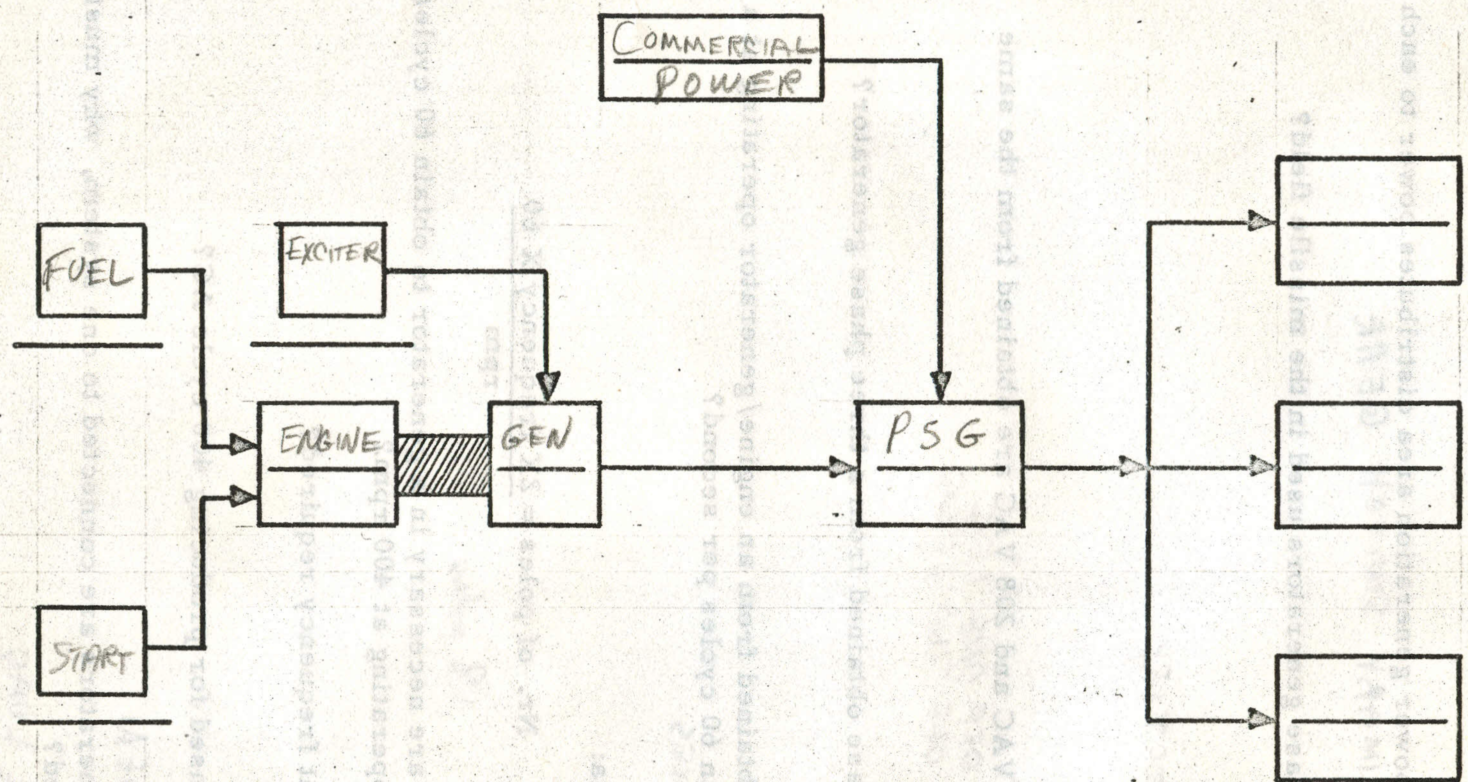
    a. Answer questions following figures as thoroughly as possible.



Fill in blocks with proper nomenclatures listed below:

Logics	Control Circuitry	Checkout
Elevating/Erecting	Sequencing	Signal Responders
Transformer/Rectifier	Secondary Switchgear	Motor Generator
Air Conditioning	Hydraulics	Relays, Warning Lites

Figure 1 - Theoretical Missile Emplacement Power Distribution



Primary Switchgear
Exciter
Fuel
Secondary Switchgear

Diesel Engine
Commercial Power
Generator or Alternator
Start System

Fill in blanks with nomenclatures listed

Figure 2 - Theoretical Power Generation System

QUESTIONS:

a. What unit in the power generation area distributes power to each launch pad? PRIMARY SWITCH GEAR

b. Why are three phase generators used in the missile field?

(1) LIGHTER

(2) EASY TO RECTIFY

(3) EFFICIENT

c. Explain how 120 VAC and 208 VAC are obtained from the same source. TAKE OFF ONE LEG
TAKE OFF TWO LEGS

d. How is single phase obtained from a three phase generator?

e. How is 60 CPS obtained from an engine/generator operating at a slower speed than 60 cycles per second?
INCREASE NUMBER OF POLES

f. Using the formula:

$$\text{Nr. of poles} = \frac{2X \text{ frequency } X\ 60}{\text{rpm}}$$

18 poles

How many poles are necessary in a generator to obtain 60 cycles with the engine operating at 400 rpm.?

g. Why is a constant frequency required?
TIME
GRYOS

h. What method is used for producing 400 cycle AC?
MOTOR GEN

i. When two AC generators are connected to one system, why must they be paralleled?
EQUALIZE LOAD

j. What are three ways to change the voltage output of a generator?

(1) RPM

(2) FIELD STRENGTH

(3) POLES

k. Why are high voltages used to carry electricity over long distances?

LESS POWER LOSS

Missile Launch/Missile Officer
Missile Fundamental Branch
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Sheppard Air Force Base, Texas

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Student Workbook
12 January 1962

DAYS 52 AND 53

LAUNCH CONTROL AND COUNTDOWN

OBJECTIVE

To familiarize you with a missile countdown and launch control.

PROCEDURE

1. Listed below are the phases of an SM-65D countdown. Fill in information regarding time of starting each phase, and list the main events that occur during each phase.

   a. Erection, Hold-down and Release

   b. Engines and APS

   c. Liquid Nitrogen and Helium

d. Hydraulics

e. Flight Control and Re-entry Vehicle

f. Fuel

g. Liquid Oxygen

h. Commit

2. Answer the following questions:

a. When does the LCO take control of the countdown?

b. When during the countdown does the LCO verify target information?

c. What is the function of the liquid nitrogen supply?

d. How is the rate of fuel and oxidizer transfer varied for line filling, tank filling, etc?

e. What is the purpose of the malfunction panel?

f. Who is responsible for establishing the "ready condition"?

g. Define the "ready condition".

h. How do we monitor the weapon system in the ready condition?

i. Generally, what determines the start of the "commit" phase or sequence?

j. What is the purpose of the continuous status panel?

k. What is the primary purpose of the Launch Control Officers console?

l. What is the purpose of the Launch Sequencer?