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Troubleshooting APQ-122 Radar
The Amazing Hercules

SERVICE NEWS

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Cover: The subject of our special cover spread is the 1500th Hercules, which was delivered to the Government of Sudan. The main picture shows it under construction, and the top photo on the back cover shows the same airplane on its maiden flight.

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Troubleshooting APQ-122 radar

by Ralph A. Romanis, *Electronics Engineer, Senior*

In the Oct.-Dec 1977 issue of the Service News (Vol. 4, No. 4), we presented a general, introductory article on the APQ-122(V)5 radar system. In this issue we are presenting some troubleshooting procedures for the APQ-122 which we have found helpful on the Lockheed-Georgia flight line.

These troubleshooting techniques are presented only for informational purposes, and are not intended to replace or circumvent procedures or safety precautions that may be presently in use by your organization.

These procedures should assist in reducing the time required to locate a failed component or system wiring fault.



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Above: The navigator's indicator being set up for checkout in the lab. Left: Lab testing of the receiver-transmitter. Below: Flight station radar components.



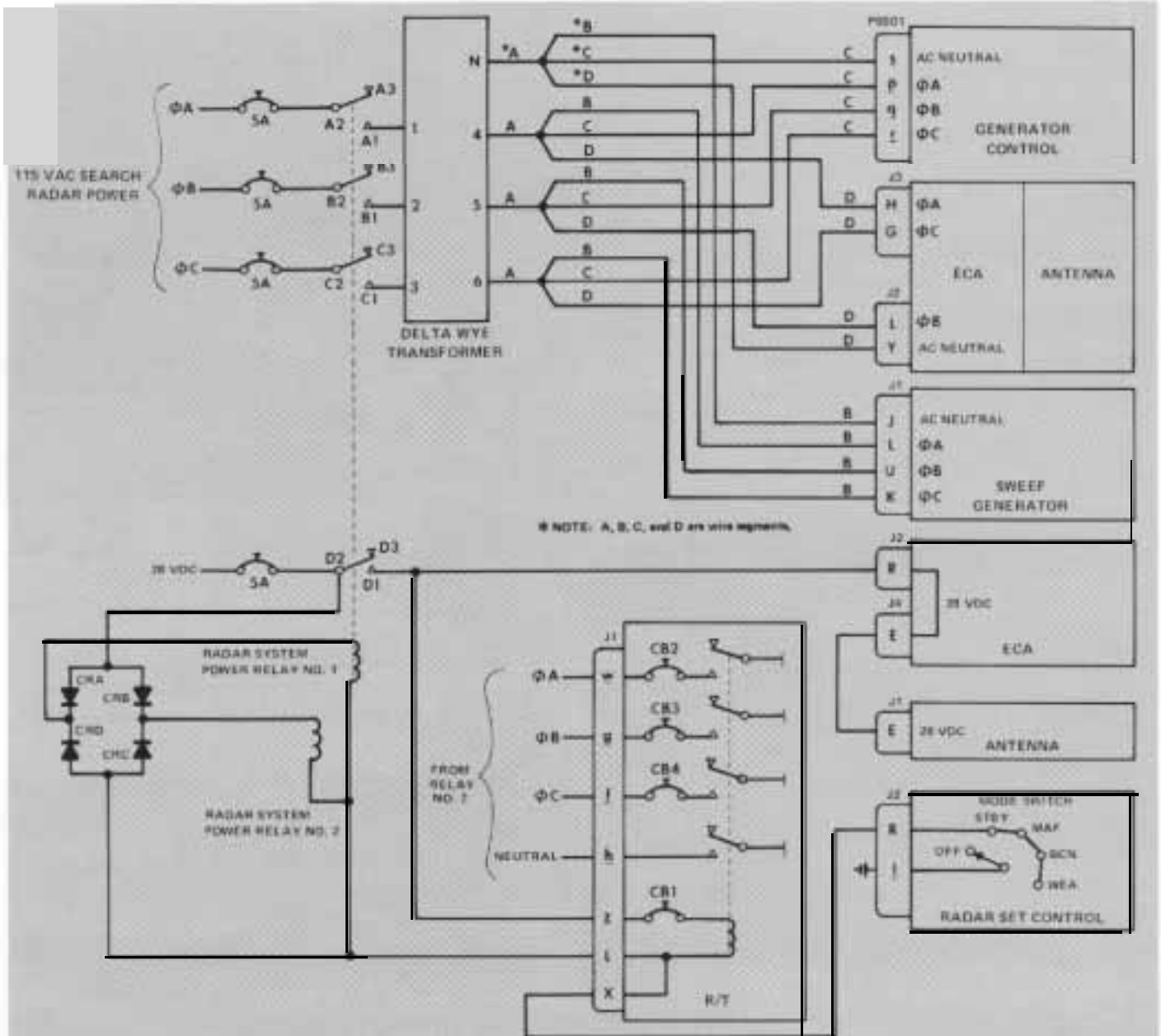
This will enable maintenance personnel to identify and return for repair only those components which have failed.

We will discuss the following four main areas for troubleshooting:

- Prime Power Failures
- Antenna System Failures
- Receiver/Transmitter Failures
- Navigator and Pilot Display System Failures

The components of the APQ-122(V)5 system have the following line replaceable unit (LRU) identifications:

LRU	Number
Antenna	1
ECA	4
Antenna control	5
Receiver/transmitter	7
Radar set control	11
Sweep generator	15
Pilot's indicator	16
Navigator's indicator	17
Cursor control	18
Receiver/transmitter blower	25



APQ-122 PRIME POWER - PART 1

PRIME POWER FAILURES

Aircraft electrical power for the radar system is applied through circuit breakers on the pilot's side circuit breaker panel, which is located to the left and aft of the pilot's seat. On this panel, under the ESS AC BUS/ISOLATED DC BUS placard, there are two banks of circuit breakers for the 3-phase, 115 VAC power. Under the title RADAR, one bank is labeled SEARCH and the other bank BLOWER. Below the ESS AC BUS portion of the panel is an ESS DC BUS section. A 28 VDC circuit breaker, identified as RADAR, protects the DC power circuit in the system.

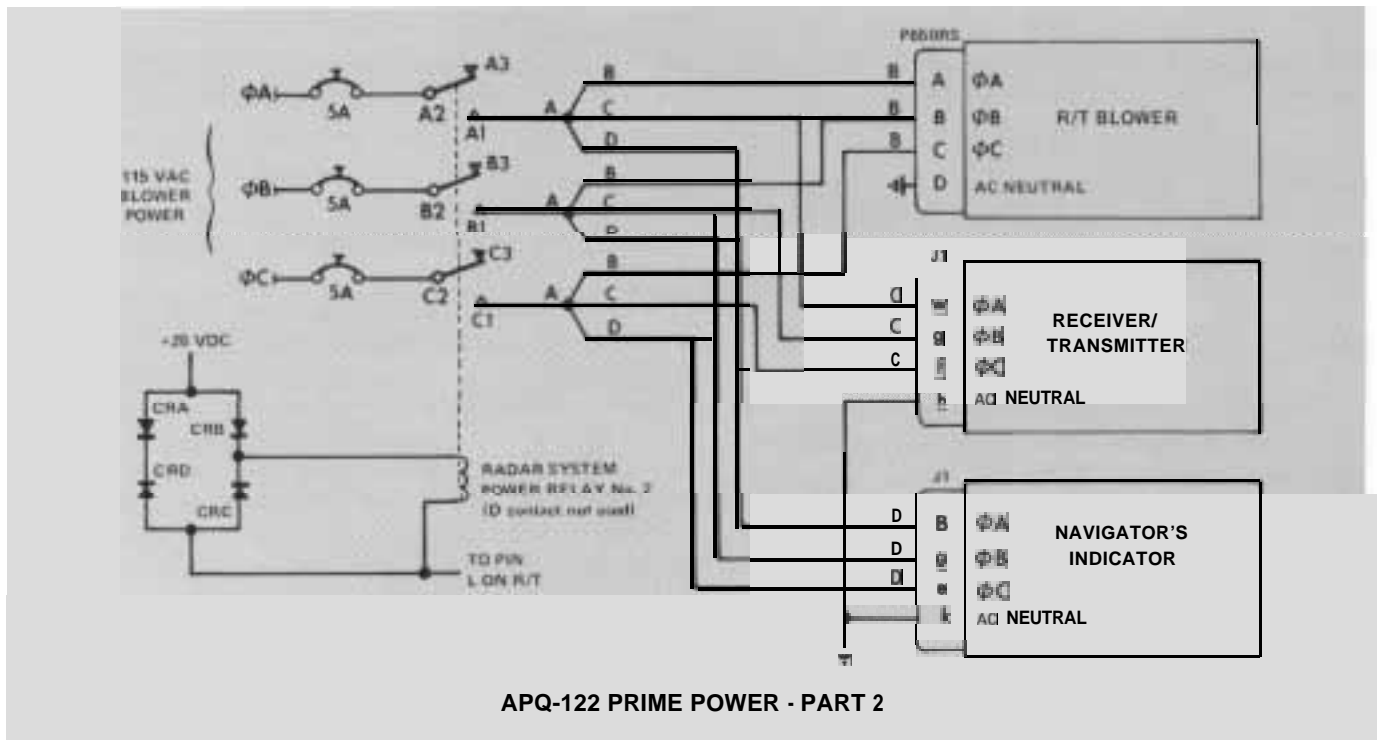
The 3-phase power for the search portion of the system is supplied through the A, B, and C contacts of the radar system power relay No. 1. The D contacts of this relay carry aircraft +28 VDC power. Contacts A1, B1, and C1 are connected to pins 1, 2, and 3 of a delta wye transformer which is used to provide power to the generator control, the electronic control amplifier (ECA), the antenna, and the sweep generator. The delta wye transformer is required to align the reference phase of the aircraft gyros.

The radar system is designed to use radar phase B as a reference, and the other aircraft systems use aircraft phase A. To make the two systems compatible, the delta wye transformer rotates the phase of the incoming 115 VAC, 400 HZ power such that the inputs are: $\phi A' = \phi A/30^\circ$ or $\phi C/-90^\circ$, $\phi B' = \phi B/30^\circ$ or $\phi A/-90^\circ$, $\phi C' = \phi C/30^\circ$ or $\phi B/-90^\circ$. Therefore, by using $\phi B'/90^\circ$ as the antenna reference phase, the antenna will be in phase with the



Circuit breakers for the APQ-122 radar.

applied aircraft ϕA . The two radar system power relays and the delta wye transformer are located in the navigator's junction box, below and behind the navigator's table.



APQ-122 PRIME POWER - PART 2

Power not related to stabilization (blower power) is switched from the aircraft power buses, through the circuit breakers to contacts A2, B2, and C2 of the radar system power relay No. 2, and then from contacts A1, B1, and C1 to the receiver/transmitter (R/T), the R/T blower, and the navigator's indicator. The D contacts of radar system power relay No. 2 are not used because 28 VDC power is applied through the radar DC circuit breaker to contact D2 of radar system power relay No. 1, and then through diode CRA to the high side of the radar system No. 1 power relay coil. Twenty-eight VDC is also applied from contact D2, relay No. 1, through diode CRB, to the high sides of the radar system power relay coil No. 2. The low sides of both relay coils are connected to pin L of connector J1 at the R/T unit. Diodes CRA and CRB are used as isolation diodes, and diodes CRC and CRD are used as spike suppression diodes across the relay coils.

Pi L and pin X on connector J1 at the R/T unit are jumpered together, and pin X is wired to pin R on connector J2 at the radar set control. When the mode switch on the radar set control is switched from OFF to STBY-MAP-BCN or WEA, a ground from pin L on connector J2 at the radar set control is applied to pin R, providing a path for the 28 VDC aircraft power to go to ground through the diodes CRA and CRB and the relay coils.

- 6 This action closes the power relays, applying 3-phase power through the delta wye transformer to the generator control, the ECA, the antenna, the sweep generator, and directly to the R/T, the R/T blower and the navigator's indicator. Twenty-eight VDC is switched through contact D1 of radar system power relay No. 1 to the R/T where it is used to close the power relays which switch the 115V 3-phase power into the unit to generate the necessary power unit supplied voltages. Twenty-eight VDC is also switched to the antenna through the ECA.

A convenient method of troubleshooting failures in this system is by the use of "go/no-go" flow charts. They can be very helpful in determining specific problems and corrective actions.

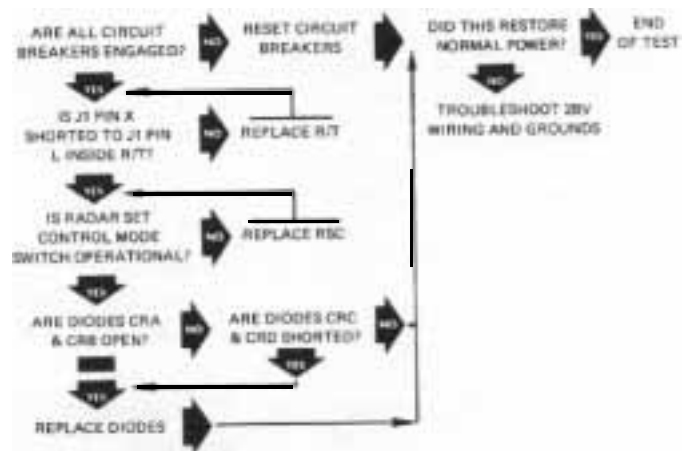
Notes

1. When troubleshooting power failures, first check the affected line replaceable unit (LRU) circuit breakers and ensure that they are set.
2. When using Chart 2 to troubleshoot, always patch in an ECA before changing the antenna.
3. Troubleshooting Chart 2 can also be used to check prime power failures to the sweep generator. The sweep generator fail light will illuminate and there will be no

pilot's display. When using Chart 2 for this purpose, wherever the chart advises "change the ECA" read it as "change the sweep generator" and continue checking through the test by the wiring from the delta wye transformer to the sweep generator.

4. If the NAV indicator has prime power and the R/T or R/T blower does not, (indicated by illumination of an R/T fail light on the radar set control, but fan noise at the navigator's station) the wiring failure will be from the splices after the relay to the affected unit. To check this condition, use Troubleshooting Chart 3 and where the directions advise "check wiring from relay to NAV indicator", change this to read "check wiring from relay to R/T and R/T blower". Troubleshooting Chart 3 covers the condition of all 3 units lacking prime power.

Problem: No power to system with mode switch in STBY.



TROUBLESHOOTING CHART 1

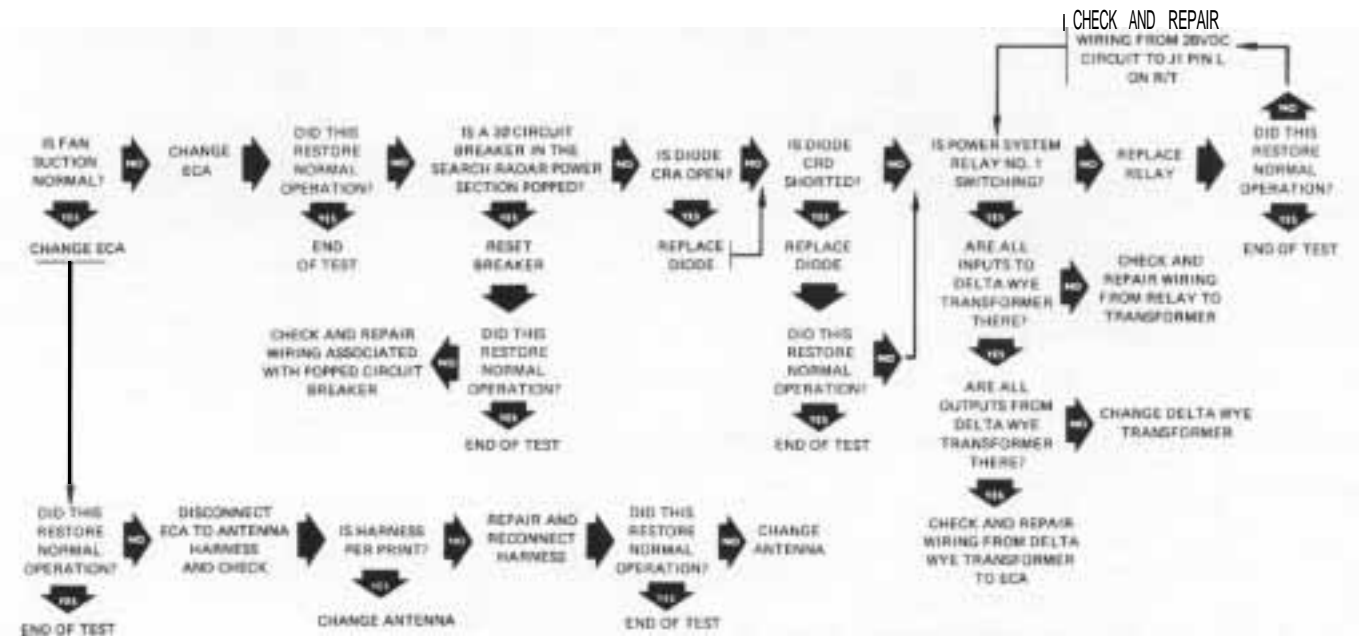
ANTENNA SYSTEM FAILURES

Failures of the antenna, electronic control amplifier (ECA), associated wiring, and control LRU's are indicated by an ANT FAIL light on the radar set control. On observing an ANT FAIL light on the radar set control, raise the radome and check whether the ANT, ECA, or SDG fail light is illuminated on the ECA. If the SDC fail light is illuminated, it is because the wire that shorts pins F and R on the aircraft harness plug which mates with plug 4J5 on the ECA has become open-circuited.

If either the ECA or the ANT fail light is illuminated, the following troubleshooting steps should be initiated, using Troubleshooting Charts 4 through 10.

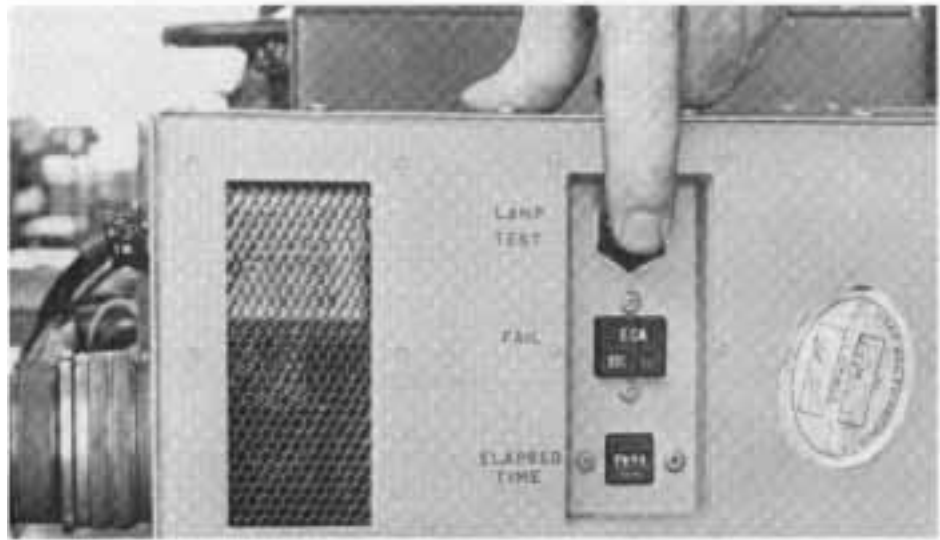
Problem: Antenna light comes on after a 3-minute delay.

This can indicate a loss of phase to the ECA. Make initial check by holding hand at rear of ECA to feel for fan suction.

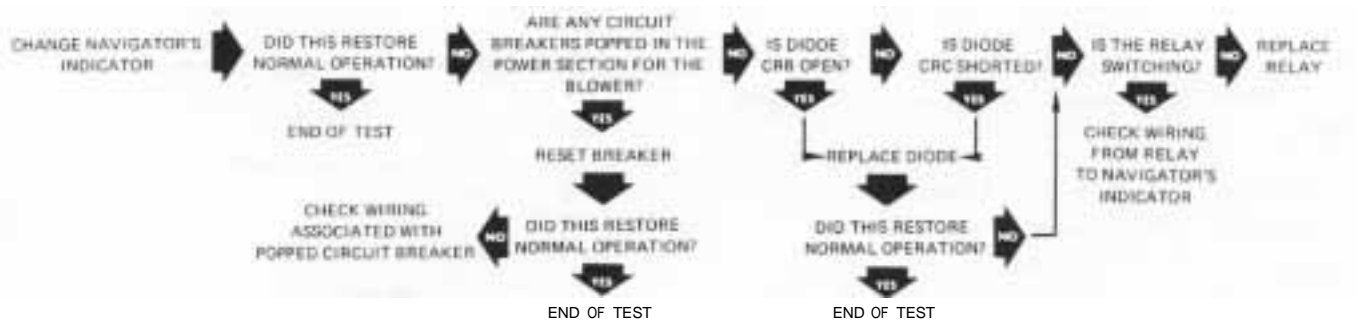


TROUBLESHOOTING CHART 2

Checking the fail lights and circuit with the LAMP TEST switch.

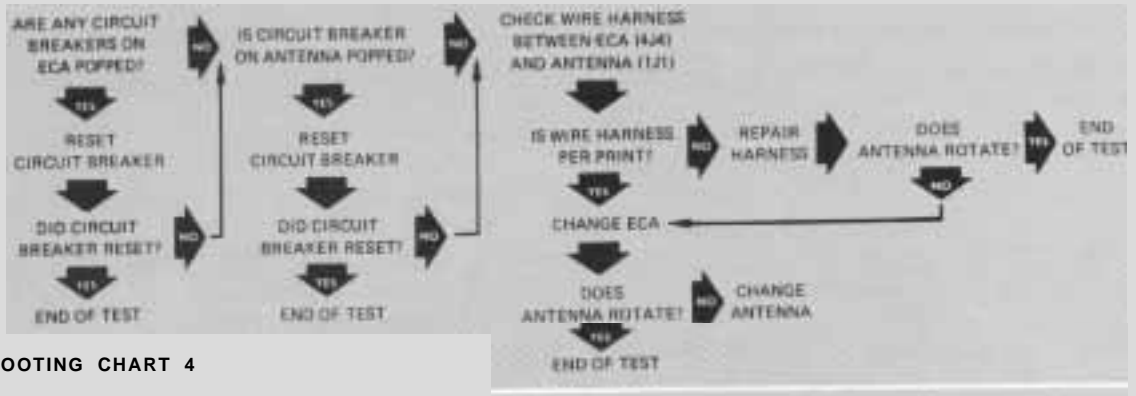


Problem: No power to navigator's indicator, indicated by lack of fan noise at navigator's station.



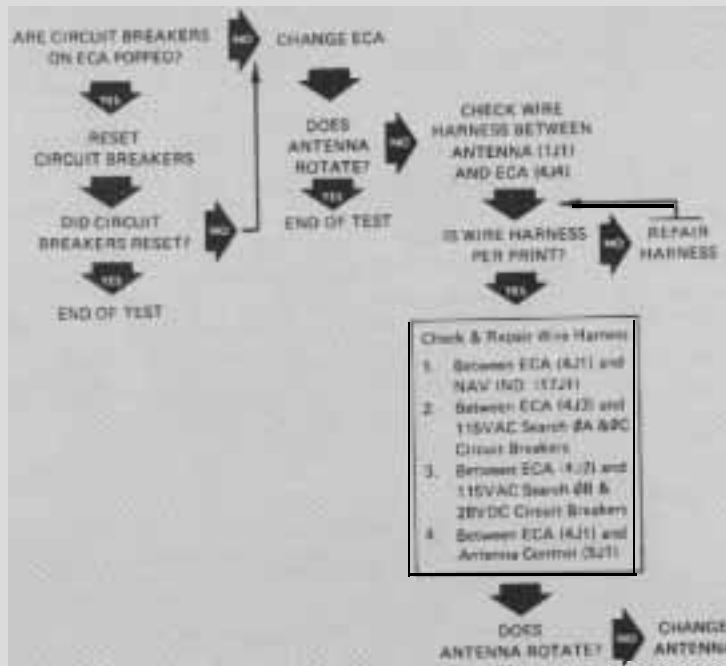
TROUBLESHOOTING CHART 3

Problem: Antenna fail light illuminates and antenna is not rotating.



TROUBLESHOOTING CHART 4

Problem: ECA fail light illuminates and antenna is not rotating.

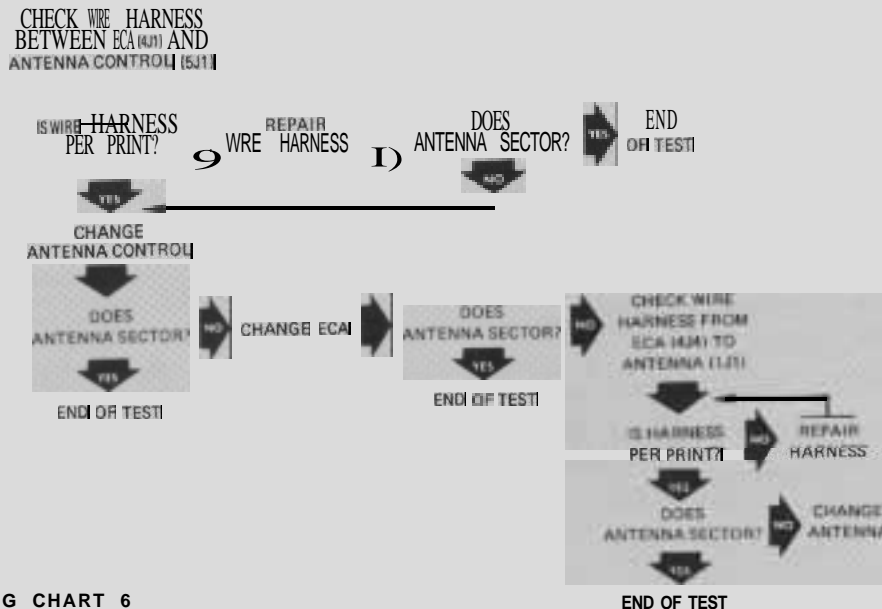


TROUBLESHOOTING CHART 5

END OF TEST

Problem: Antenna does not stop rotating when scan is switched off at the radar set control, and it will not sector.

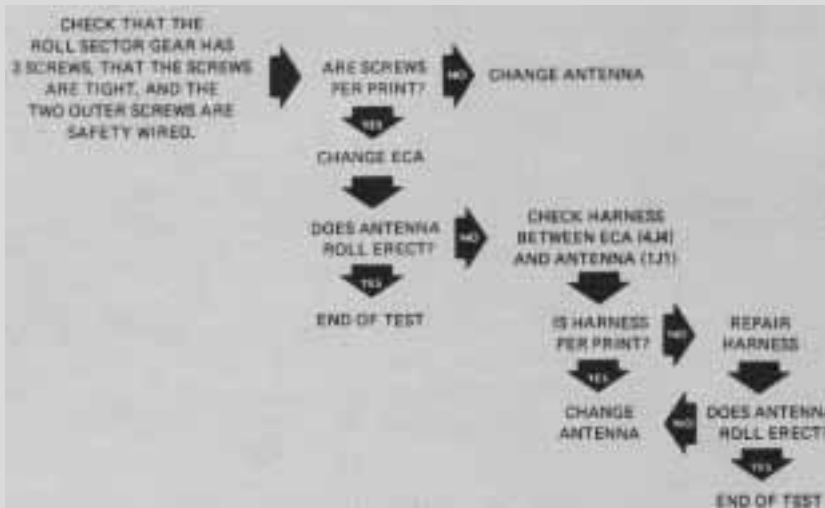
Check that the AZ STAB switch on the radar set control is in NORTH or HDG, and not in TRK.



TROUBLESHOOTING CHART 6

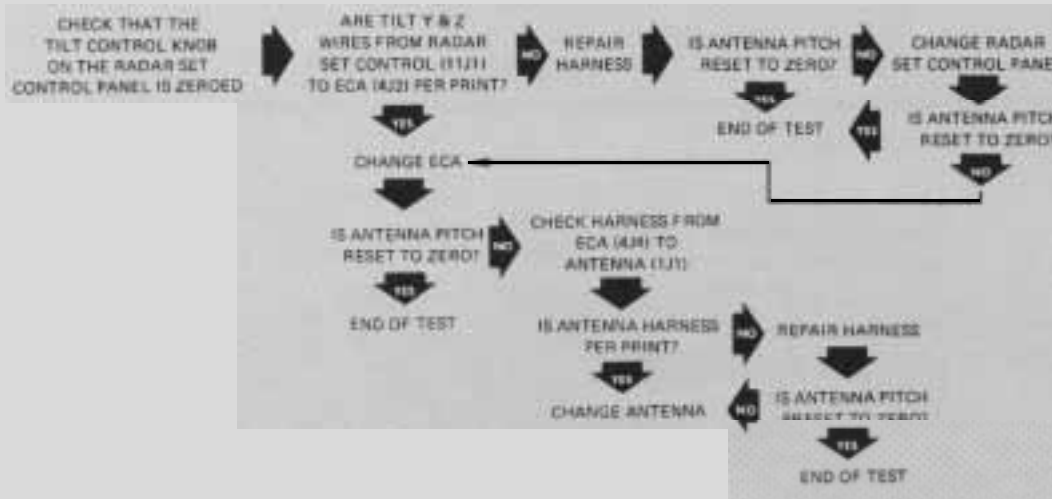
END OF TEST

Problem: Antenna is not level in the roll axis throughout all positions of the radar stabilization switch,



TROUBLESHOOTING CHART 7

Problem: Antenna is inoperable in the tilt axis throughout all positions of the radar stabilization switch.



TROUBLESHOOTING CHART 8

Problem: Antenna operates properly in the roll and pitch modes while in the STAB OUT position of the radar stabilization switch, but is inoperable in the GYRO 1 and/or GYRO 2 positions of the switch.

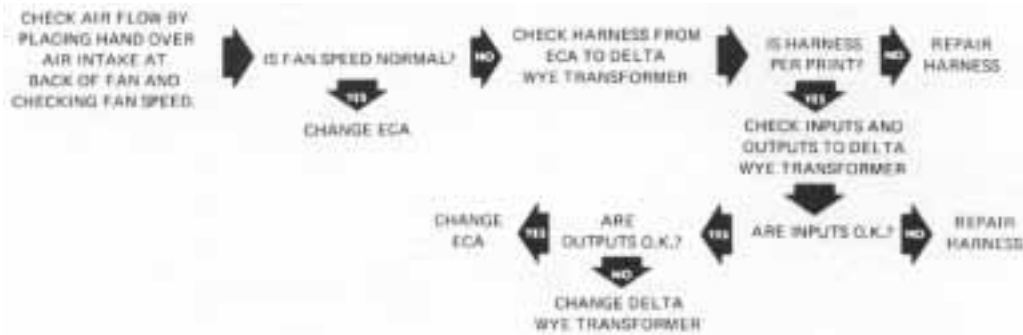


TROUBLESHOOTING CHART 9

Problem: Antenna **does not zero in** the roll or pitch modes while operating in the STAB OUT position of the radar stabilization switch, but the antenna does stabilize while in the GYRO 1 and GYRO 2 positions of the switch.

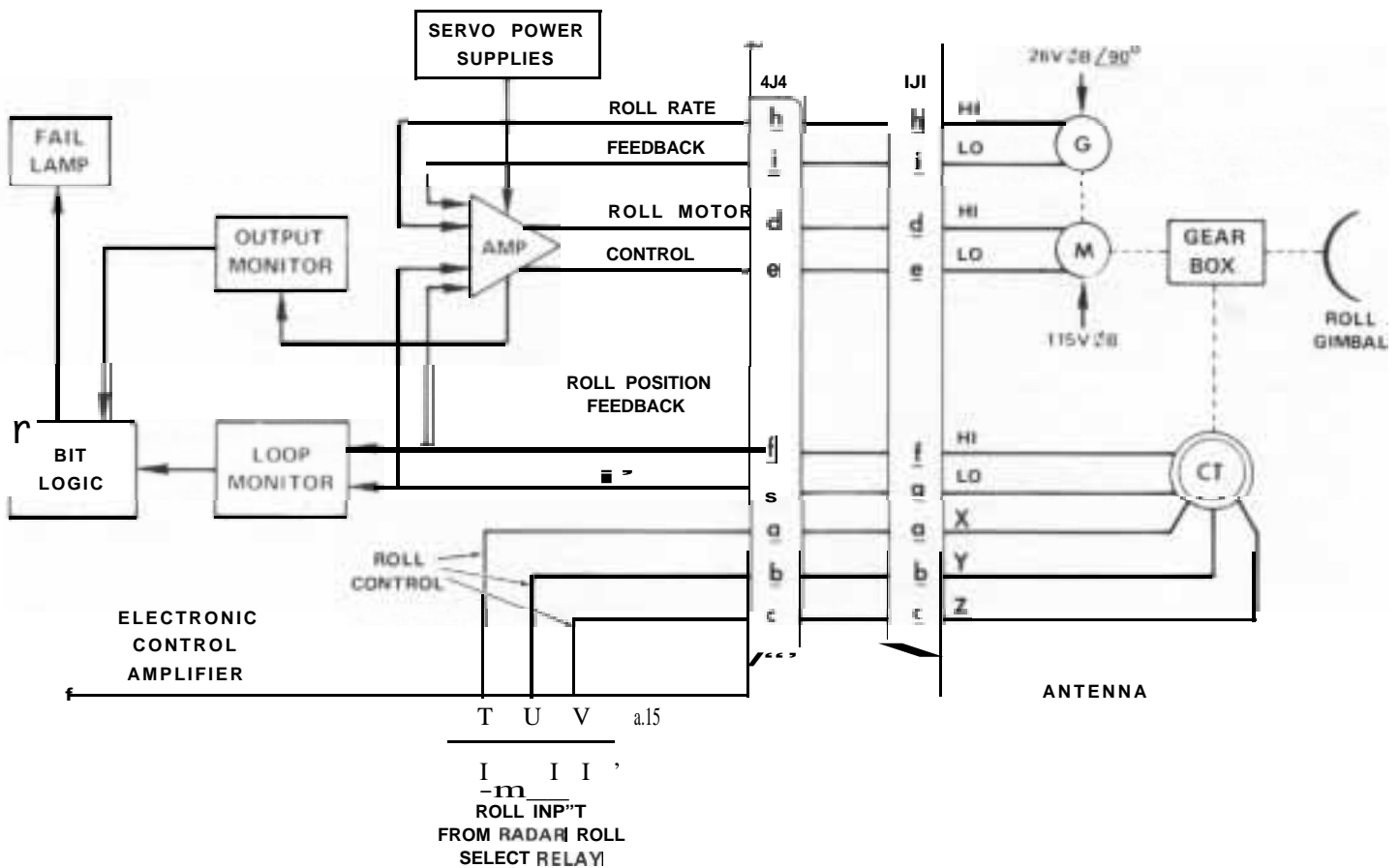
Change ECA.

Problem: The antenna fail light on the radar set control panel and the ECA fail light on the ECA illuminate but antenna operation is normal.

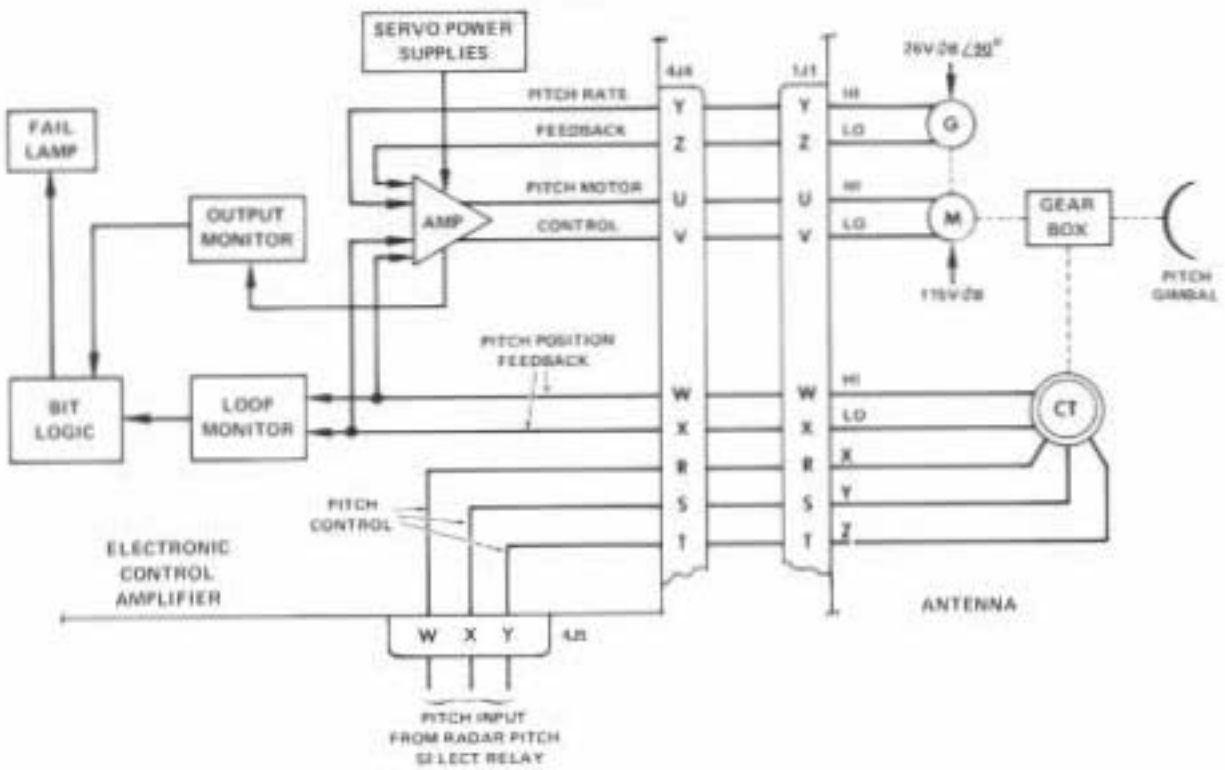


TROUBLESHOOTING CHART 10

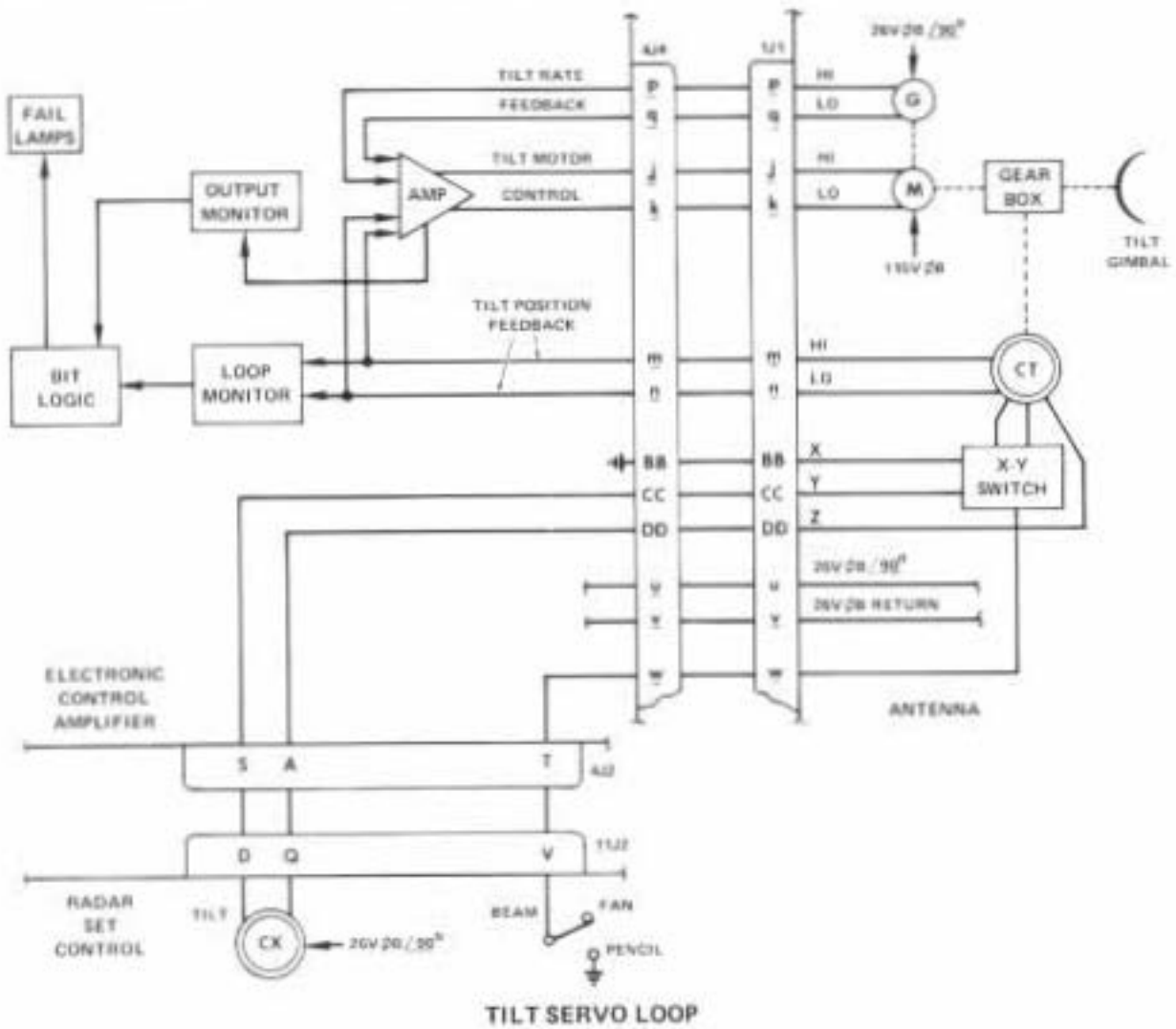
10



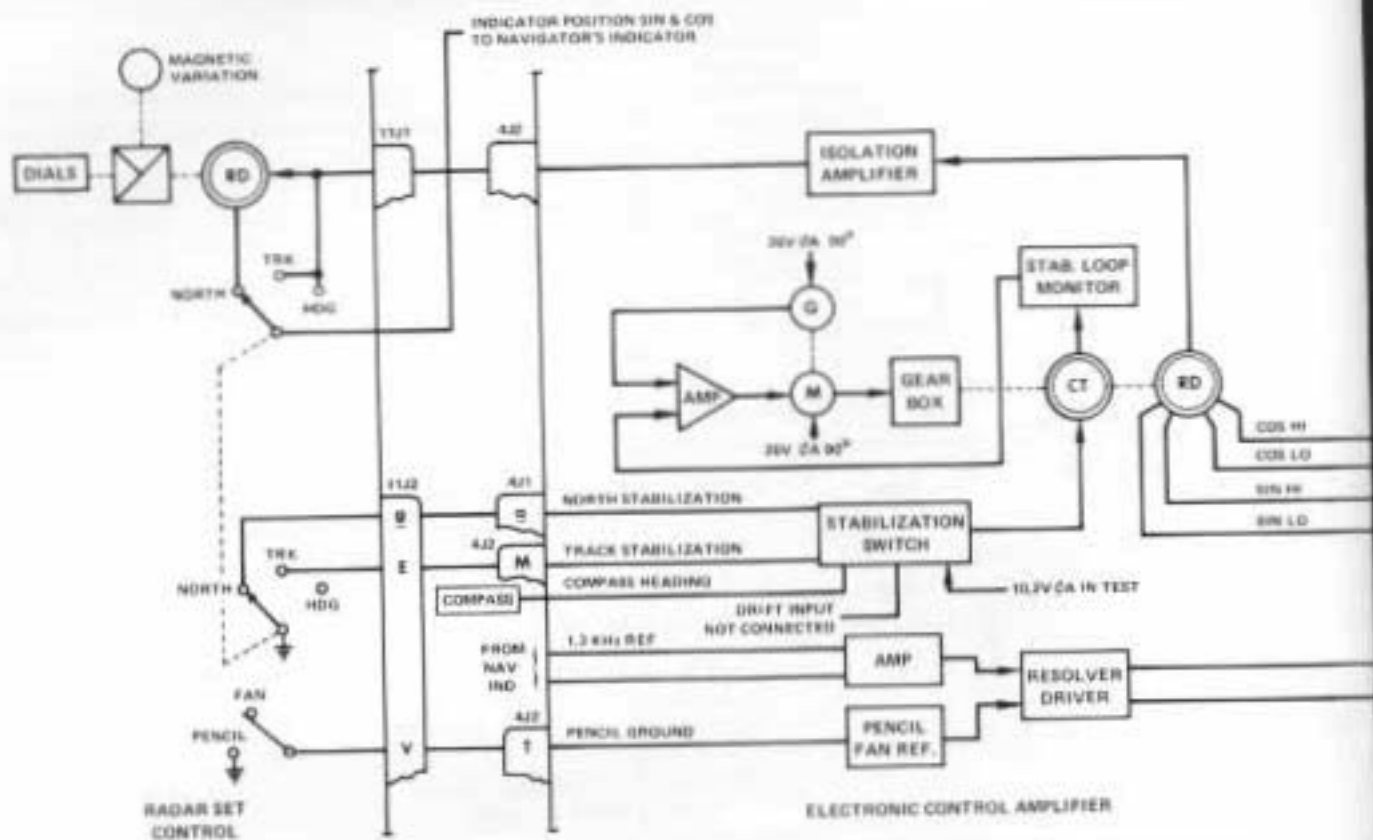
ROLL SERVO LOOP



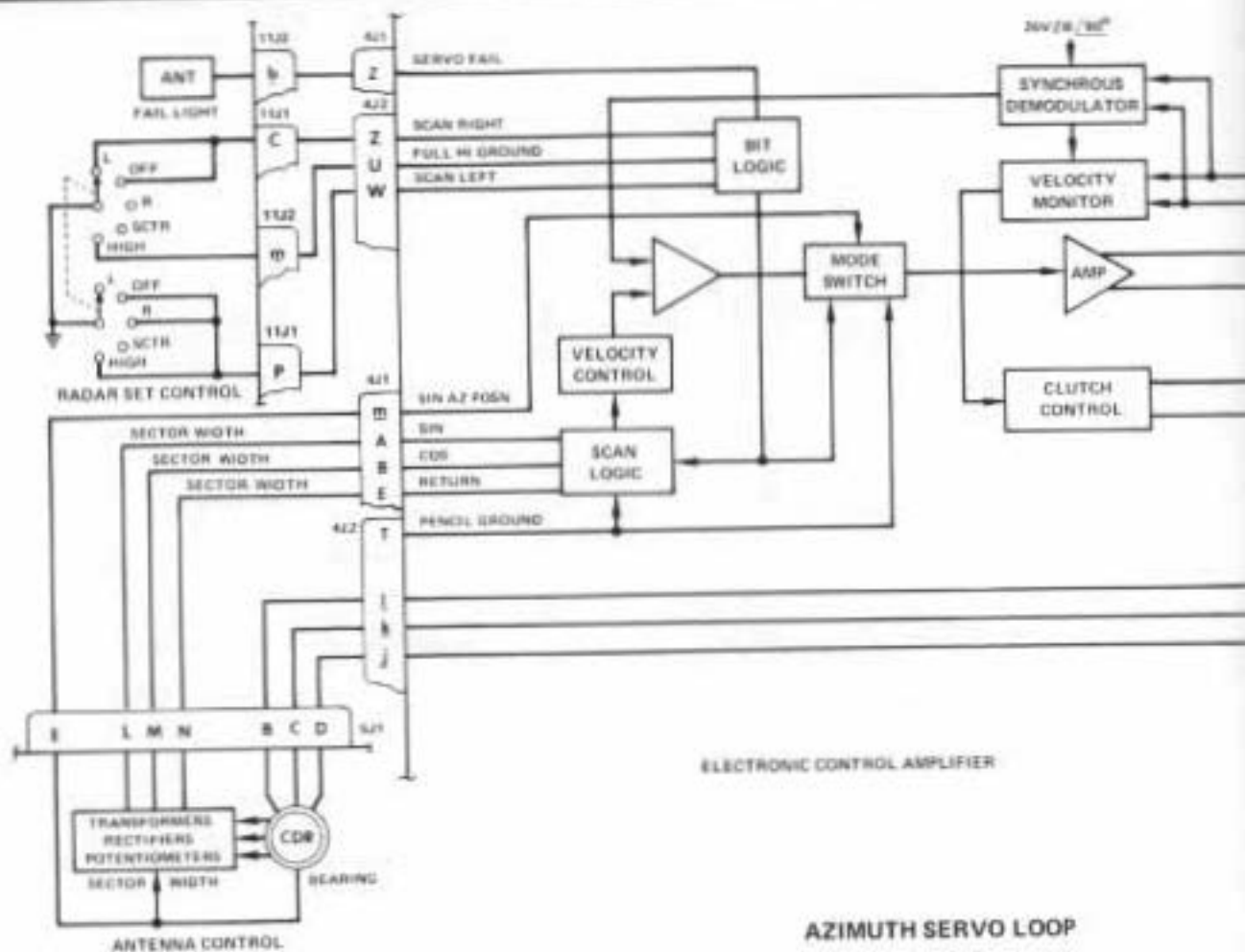
PITCH SERVO LOOP



TILT SERVO LOOP



AZIMUTH STABILIZATION LOOP



AZIMUTH SERVO LOOP

RECEIVER/TRANSMITTER FAILURES

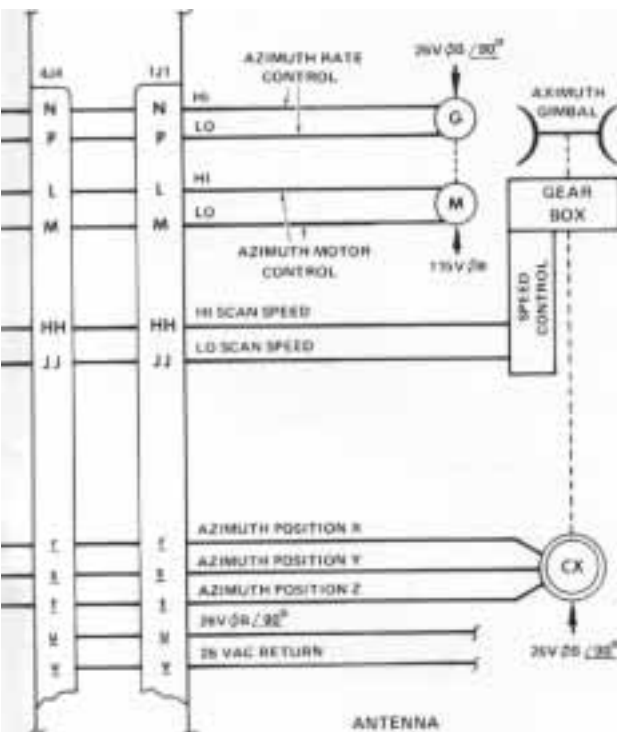
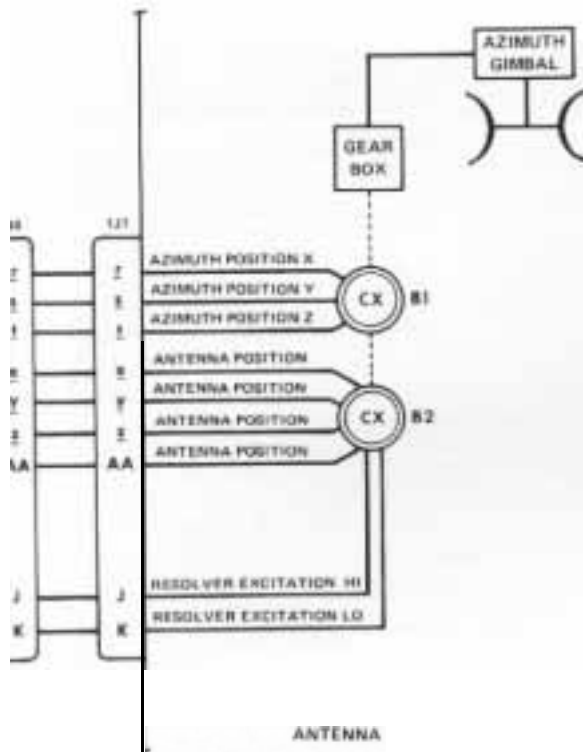
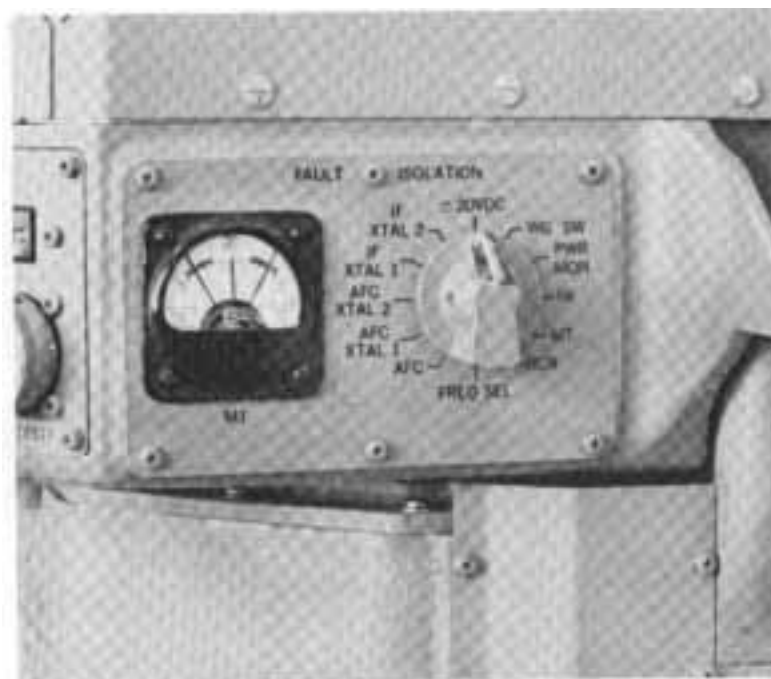
An R/T fail light is located below the antenna fail light on the radar set control panel. Should the R/T fail, the lamp will illuminate and the following procedure should be used to clear the malfunction:

1. Return the MODE switch to STBY and back to MAP several times. Perform this same procedure with BCN and WEA.
2. Switch the frequency selector from position 5 to position 9, pausing at each step.
3. Select FAN and PENCIL position several times on the BEAM switch.
4. Switch several times between the ANT and LOAD settings on the RF PWR switch.
5. Should none of the above steps cause the fail light to extinguish, switch the MODE switch to OFF and back to MAP to see if the system will activate after the three-minute waiting period.






If the R/T fail light on the radar set control cannot be extinguished by any of the above steps, go into the nose wheel well and, with the system still in the mode in which the failure occurred, rotate the FAULT ISOLATION test switch and observe in which of the 12 test positions a failure is indicated on the test meter.

13

The fault isolation *switch* and indicator are located on the R/T *unit* in the nose *wheel well*.



FAULT ISOLATION TESTS

Position	Indication	Remarks
AFC 	Meter needle centered.	AFC has failed. Change the R T.
AFC XTAL 1 	Out of the green band.	Change R T.
AFC XTAL 2 	Out of the green band.	Change R T.
IF XTAL 1 	Out of the green band.	Change R T.
IF XTAL 2 	Out of the green band.	Change R T.
20 VDC	Meter needle centered.	Check prime power 115 VAC, 400 Hertz, to the R T. If the check is OK, change the R T.
WG SW	Meter needle centered.	Change R T.
PWR MON	Meter needle centered.	If the PWR MON position is the only position in which a failure is indicated on the meter, change the R T. The mode switch must be in the MAP, BCN, or WBA position. This is a normal meter indication when the mode switch is in the STBY position. If the MODE switch is in the STBY position, the magnetron will not fire and no fault indication will be observed.
NF	Meter needle centered.	Change R T.
MT	Meter needle centered.	Check the wire harness between the radar set control and the R T. If the harness is per the print, change the radar set control. If the master trigger is still indicating a failed condition, change the R T.
BCN	Meter needle centered.	If a fail indication is noted when the MODE switch is in MAP or WX, change the R T. If a fail indication is noted when BCN is selected, check the harness from the radar set control to the R/T. If the harness is per the print, change the radar set control. If the failure persists, change the R/T.
FREQ SEL	Meter needle centered.	Check continuity from R/T 7JI Pin W to radar set control 1 1J2-Pin F. If harness is per print, change radar set control. If FREQ SEL still indicates failed, change the R/T.

Note:



In this condition the four crystal currents, AFC 1 and 2 and IF 1 and 2 will sweep continuously.



If XTAL meter indication is sweeping, the AFC is not locked on and a failure will be evidenced in another test position.

NAVIGATOR AND PILOT DISPLAY SYSTEM FAILURES

The two viewing stations are provided with similar information presented in different formats; the pilot's station has a 5-inch direct view storage tube (DVST) and the navigator's station has a 7-inch cathode ray tube (CRT). The navigator's indicator has functions which permit the operator to use cursors for both azimuth and range to highlight a target. The pilot's indicator can repeat the navigator's display but has no cursor capability. Video is sent from the R/T to the navigator's indicator where it is branched off inside the navigator's indicator to the sweep generator, which processes the video signal and passes it to the pilot's indicator. The sweep generator and the navigator's indicator have common circuit functions; the sweep generator and the pilot's indicator are the display processing equivalent of the navigator's indicator.

Loss of sweep or video at one or both of the stations can be due to many causes. The following troubleshooting methods are set up to minimize the effort required to locate the failed component. However, prior to performing these tests, ensure that (1) the RNG-DLY switch on the navigator's indicator is in the OFF position, and that (2) the AZ STAB switch on the pilot's indicator is in HDG. If these functions are set as noted and the problem still exists, proceed with the checks.

Section A. Failure at Pilot's Station Only

Section B. Failure at Navigator's Station Only

Section C. Failure at Pilot's and Navigator's Stations

Note: To further facilitate the use of the display systems on the aircraft, alignment procedures which can be performed on the aircraft are also described in this section.

Section D. Pilot's Indicator Alignment

Section E. Navigator's Indicator Alignment

Note: When the navigator's indicator, the pilot's indicator, or the sweep generator is changed, it may be necessary to go to the appropriate alignment section and match the changed components to the system as installed on the aircraft.

Problem: Failure of the range annunciator lamps.

The range annunciator lamps on the pilot's and navigator's indicators have a three-position switch marked TEST, DIM, and BRT. When the switch is in the bright (BRT) position, the selected range (selected on the radar set control panel) will be brightly illuminated. If range delay is selected, it will also be brightly illuminated. When the switch is in the DIM position, the applied

annunciator voltage is cut in half, thus effectively reducing the resultant lamp brightness by one-half. In the TEST position, the lamp bright voltage is applied to all the lights; however, only the selected range annunciator will be brightly illuminated. The other annunciators will be illuminated dimly. Failure of all the annunciators requires that the 5 VDC unregulated power and return wires from the sweep generator plug 15J2-C and 15J2-B to the pilot's indicator plug 16PI-C and 16PI-B be checked. If the wiring is correct, check the bulbs in the lamps. If the bulbs are good, change the pilot's indicator.

Problem: Failure of the bezel and/or panel illumination intensity.

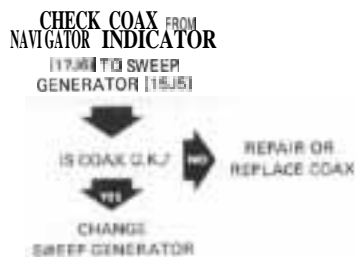
Failure of either the bezel or the panel illumination intensity is normally due to a failure of the edge-lit pilot's indicator panel, and requires that the pilot's indicator be changed. However, the sweep generator supplies the 5 VDC unregulated power and return excitation for the panel, so it is necessary to check the circuit from the sweep generator plugs, 15J2-C and 15J2-B, to the 16JI-C and 16JI-B plugs on the pilot's indicator before changing the indicator. Should this not correct the lighting problem, change the sweep generator.

SECTION A

Failure at Pilot's Station Only

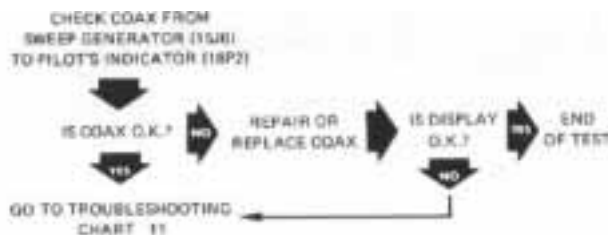
15

Problem: No video on the pilot's indicator. Sweep and range marks are normal.



TROUBLESHOOTING CHART 11

Problem: No video or range marks on the pilot's indicator. Sweep is normal.

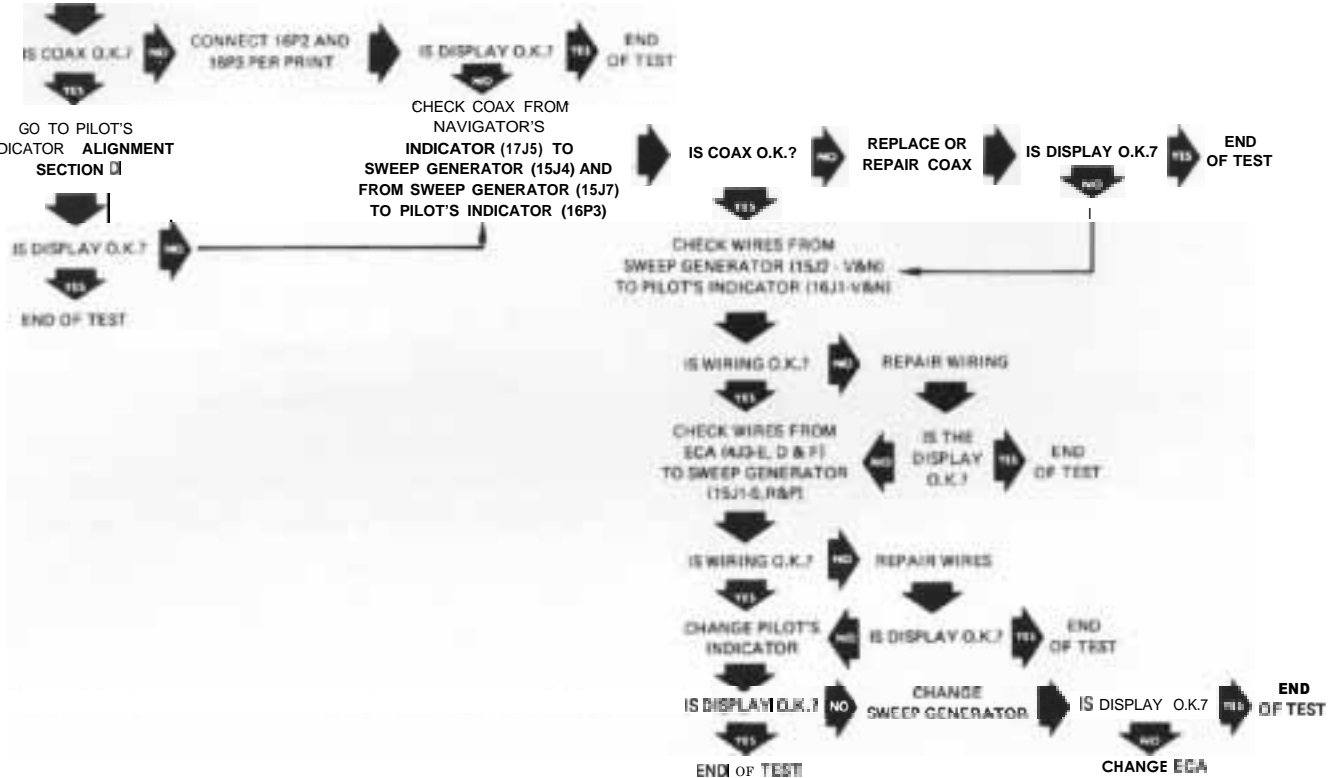


TROUBLESHOOTING CHART 12

Problem: No evidence of sweep but indicator has collimated.

First switch the AZ STAB switch back and forth. If sweep appears in one of the positions, go to Troubleshooting Chart 18. If no sweep appears, check that the AZ STAB switch is in the HDG position, and that the RNG DLY switch on the navigator's indicator is OFF. Then **continue** with this procedure.

CHECK COAX CONNECTOR
16P2 AND 16P3 ARE
INSTALLED PER PRINT
I.e., Not Crossed)

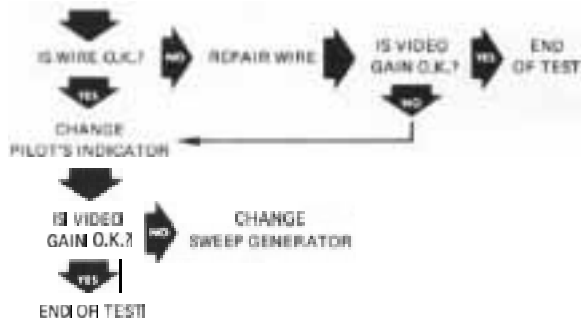


TROUBLESHOOTING CHART 13

16

Problem: Pilot has no control of video gain.

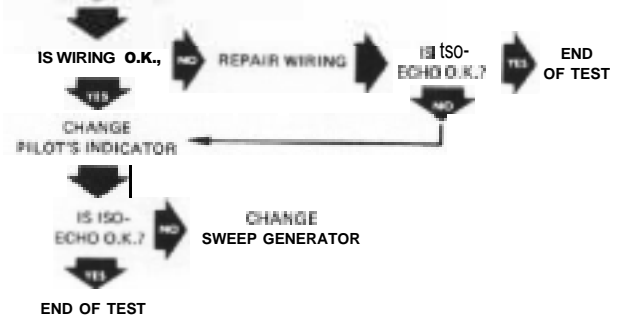
CHECK VIDEO GAIN
WIRE FROM SWEEP
GENERATOR (15J2-Z1)
TO PILOT'S INDICATOR
-1W1-Z1



TROUBLESHOOTING CHART 14

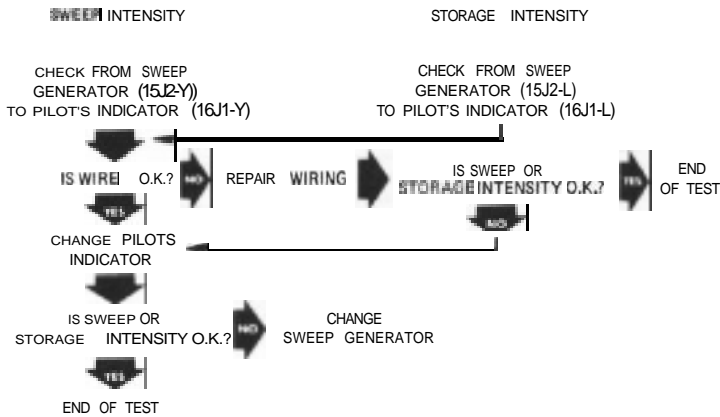
Problem: Pilot has no control of iso-echo.

CHECK WIRES FROM
SWEEP GENERATOR
(15J2-5 AND 7)
TO PILOT'S INDICATOR
(18P1-5 AND 7)



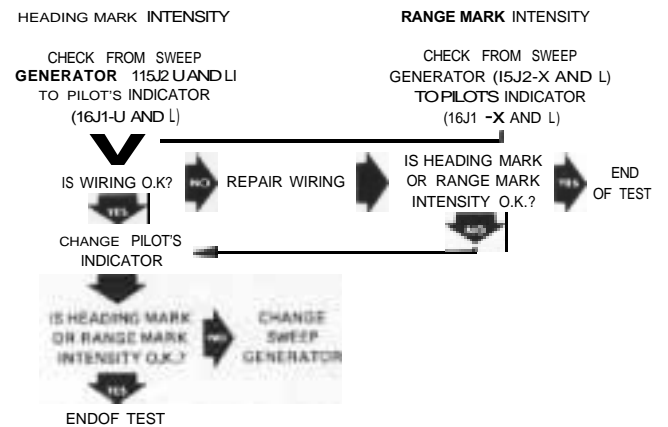
TROUBLESHOOTING CHART 15

Problem: Sweep and storage intensity adjustments.



TROUBLESHOOTING CHART 16

Problem: Heading mark and range mark intensity adjustments.

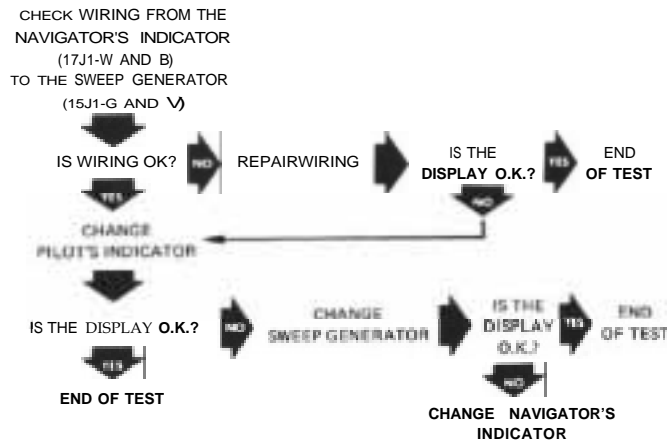


TROUBLESHOOTING CHART 17

Problem: No sweeps are evident in either the SLV or the HDG position of the AZ STAB switch on the pilot's indicator.

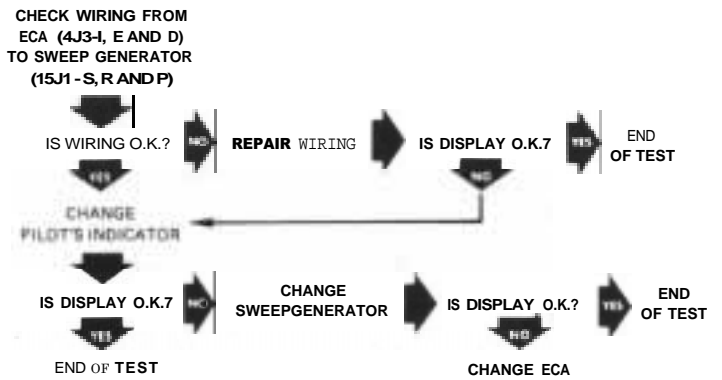
Go to Troubleshooting Chart 13. If there is no sweep in one position only of the switch, continue with Chart 18 or 19 procedure. In either of the preceding conditions, note that the navigator's indicator does have sweep.

Condition (a): AZ STAB switch is in the SLV position. There is no sweep on the pilot's indicator but the navigator's indicator does have sweep.



TROUBLESHOOTING CHART 18

Condition (b): AZ STAB switch is in HDG position. There is no sweep on the pilot's indicator, but the navigator's indicator does have sweep.



TROUBLESHOOTING CHART 19

SECTION B

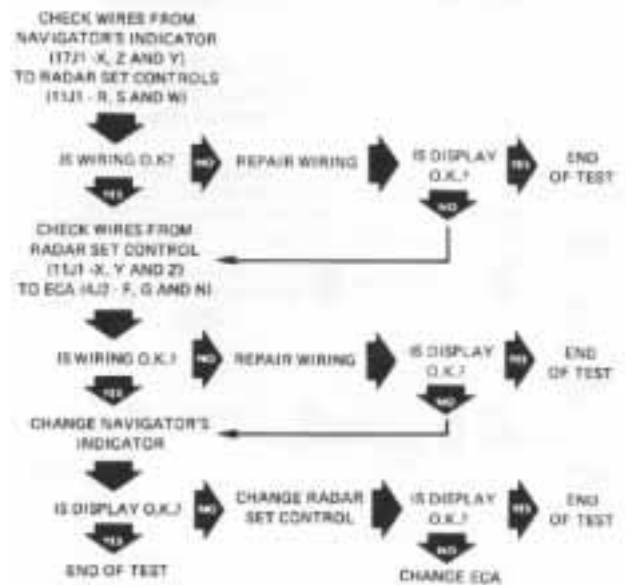
Failure at Navigator's Station Only

Problem: Loss of video on the navigator's indicator.

If the pilot's indicator has video, change the navigator's indicator. If the sweep on the navigator's indicator does not appear to brighten when the video gain control is rotated, proceed to the navigator's indicator alignment procedure, Section E.

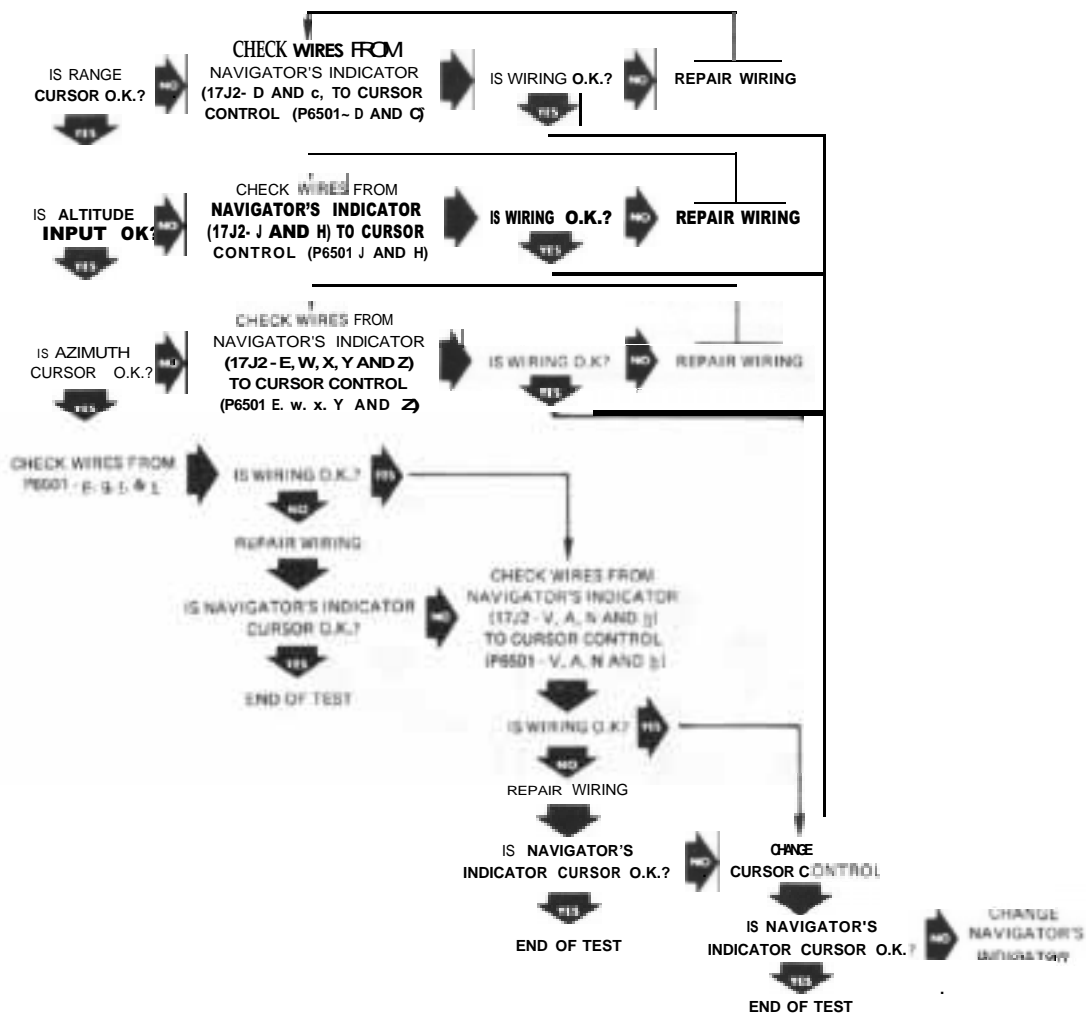
Problem: Loss of sweep on the navigator's indicator only.

Check if the RNG DLY switch is OFF. If the switch is ON, then check that the range cursor is within the displayed range. If sweeps do not appear, continue with this test.



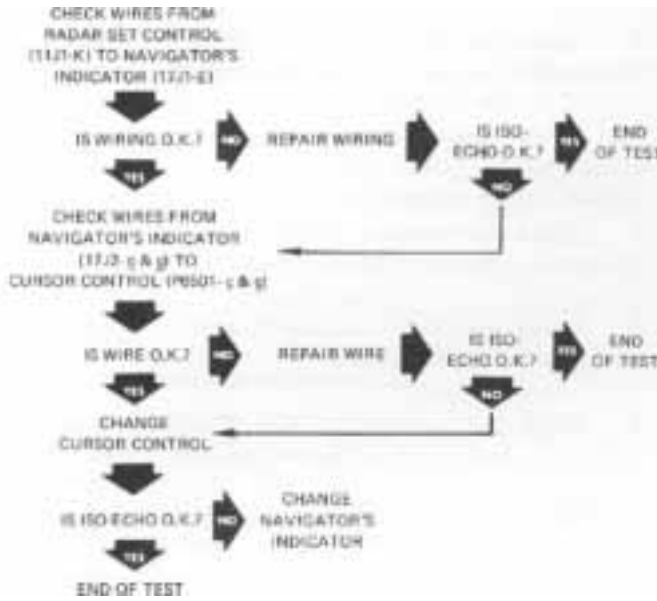
TROUBLESHOOTING CHART 20

Problem: Failure in the cursor mode.



TROUBLESHOOTING CHART 21

Problem: No iso-echo control while operating in the weather mode.



TROUBLESHOOTING CHART 22

Problem: Failure of Navigator's Indicator Control

1. Range Delay – If the navigator's indicator will not switch to the delayed range, check that the range cursor is within the selected range and greater than 45 NM. If the selected range is correct, change the navigator's indicator. If the problem persists, change the cursor control.

2. Range Lights and Lamp Test Switch – For failure of individual range annunciators, change bulbs and recheck. If the lights still do not function and the indicator is correctly displaying the selected range, it will be necessary to change the navigator's indicator.

3. Panel and Bezel Illumination Intensity Adjustment – Failure of either of these controls requires that the navigator's indicator be changed.

4. Focus Adjustment ~ If the indicator cannot be focused or defocused, change the indicator.

5. Cursor Intensity Adjustment – If the cursor intensity cannot be adjusted, see the navigator's indicator alignment section of this article. If the intensity cannot be aligned, change the indicator.

6. Heading Mark Intensity and Range Mark Intensity Adjustments – If either of these controls fail, the navigator's indicator should be changed.

7. Reticle Adjustment and Engraved Cursor Rotation – These are mechanical drives, and if they fail, the indicator must be replaced.

8. Sweep Intensity Adjustment – If the sweep intensity adjustment fails, it is necessary to realign the indicator on a test bench; thus, the indicator should be changed.

9. Video Gain Adjustment – If the video gain cannot be adjusted, go to the appropriate alignment section of this article. If the gain adjustment cannot be aligned, replace the navigator's indicator.

10. Variable Range Adjustment – If the range cannot be varied, change the indicator. If the range adjust is out of alignment, refer to the appropriate alignment section of this article.

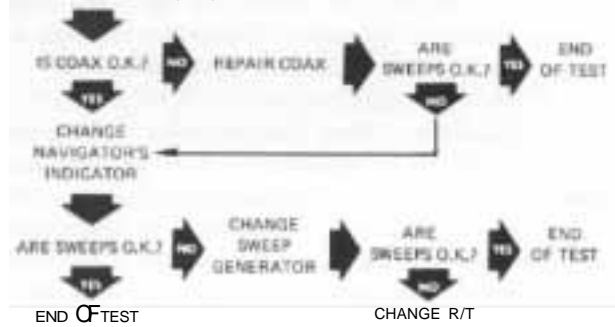
11. Cursor Adjustment – This control is not operative when the cursor control panel is connected to the navigator's indicator.

SECTION C

Failure at Pilot's and Navigator's Stations

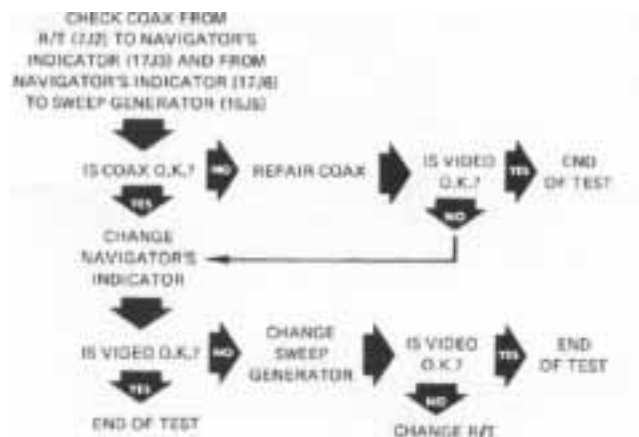
Problem: LOSS of sweep on both indicators.

CHECK COAX FROM R/T (7J31 TO NAVIGATOR'S INDICATOR (17J4) AND FROM NAVIGATOR'S INDICATOR (17J5) TO SWEEP GENERATOR (15J4)



TROUBLESHOOTING CHART 23

Problem: No video on either indicator.



TROUBLESHOOTING CHART 24

Problem: Video at vertex only on both indicators.

CHECK RECEIVER GAIN
WIRE FROM RADAR SET
CONTROL (11J2-j) TO RT (7J1-j)



TROUBLESHOOTING CHART 25

Problem; Sweep present but not rotating.

Check the stabilization portion of the antenna troubleshooting procedure.

SECTION D

Pilot's Indicator Alignment

The following alignments may be performed with the radar installed on the aircraft. To align the pilot's indicator, it is necessary to remove the right side plate as viewed facing the indicator. Ensure that the radar is off when removing and replacing the cover plate.

Gain Adjustment - When changing either the pilot's indicator or the sweep generator, it may be necessary to match the two units by adjusting potentiometer A3R18 (Figure 1). To make this adjustment, turn the sweep intensity control on the front panel of the pilot's indicator fully clockwise and the video gain control fully counterclockwise. Adjust potentiometer A3R18 until the sweep is just visible, then readjust until the sweep barely disappears. If this adjustment is not successful, change the indicator.

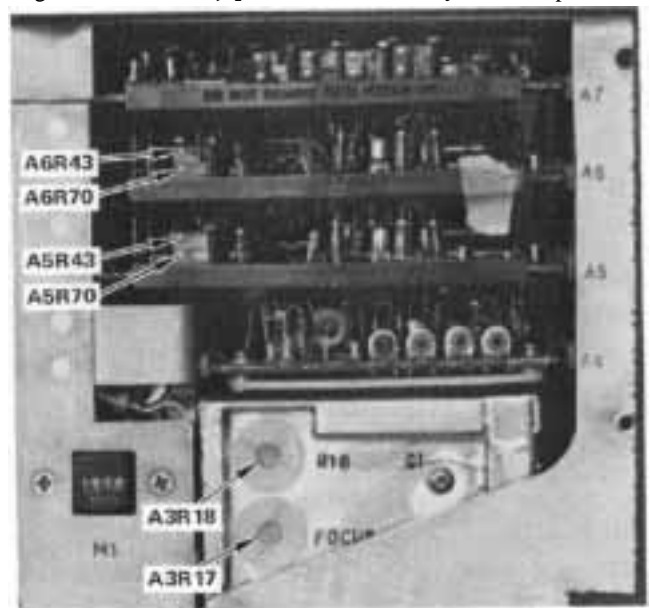
Focus Adjustment - Set the range marks for optimum viewing, then adjust potentiometer A3R17 (Figure 1) for the required focus on the face of the display. If the focus does not optimize, change the indicator.

Sweep Alignment - To adjust the center and the length of the sweep, (when not in variable range), the following steps may be performed while the equipment is installed on the aircraft:

1. Set the range control selector on the radar set control to 50/10.
2. Set the SCAN switch on the radar set control panel to OFF.

3. Set the relative bearing control on the antenna control panel to zero.
4. Adjust potentiometer A5R43 (Figure 1) to position the vertex at the center of the display (cosine adjust).
5. Rotate the relative bearing control on the antenna control panel to 90°.
6. Adjust potentiometer A6R43 (Figure 1) to position the vertex at the center of the display (sine adjust).
7. Rotate the relative bearing control on the antenna control panel to zero degrees.
8. Adjust potentiometer A5R70 (Figure 1) until the entire fifth range mark appears at the edge of the display.
9. Rotate the relative bearing control of the antenna control panel to 180° and check that the fifth range mark appears at the same relative position at the bottom of the sweep. Slight adjustments of potentiometers A5R70 and A5R43 may be required to fine-adjust sweep in the vertical plane.
10. Rotate the relative bearing control on the antenna control panel to 90°.
11. Adjust potentiometer A6R70 (Figure 1) until the entire fifth range mark appears at the edge of the display.
12. Rotate the relative bearing control on the antenna control panel to 270° and check that the fifth range mark appears at the same relative position on the left side of the

Figure 1. Location of pilot's indicator adjustment points.



display. Slight adjustment of potentiometer A6R70 and A6R43 may be required to fine-adjust the sweep in the horizontal plane.

13. Set the range control on the radar set control panel to 3-30/1, 3-30/5, 100/20, and 240/30 and set the scan switch to R to be sure that the last range mark in each range does not go out of view in any of the selected ranges. If this check cannot be satisfied, change the indicator.

SECTION E

Navigator's Indicator Alignment

With the exception of cursor alignment on the dash 3 indicator, the following alignments may be performed with the unit installed on the aircraft. To align the navigator's indicator, it is necessary to remove the top cover. Be sure that the radar is switched off when removing or replacing the cover.

Cursor Alignment (for generator control, P/N C3939 or cursor control, P/N 799046-1, and navigator's indicator, P/N's 692762-1 or -2).

1. On the radar set control panel, set the MODE switch to STBY, the SCAN switch to OFF, the RANGE (NM) selector to 240/30, and the AZ STAB switch to HDG.
2. On the cursor control panel, set the azimuth to zero degrees and the range to 220 NM.
3. Adjust the relative bearing control on the antenna control panel until the sweep is adjacent to, but not over, the azimuth cursor.
4. Adjust display intensity and cursor intensity on the navigator's indicator until the range cursor on the azimuth cursor and the range cursor on the sweep can barely be seen.
5. Adjust potentiometer A3R65 (Figure 2) until the range cursor on the azimuth cursor is coincident with the range cursor on the displayed sweep.

Sweep Alignment – To adjust the center and length of sweep when not in variable range, the following steps may be performed while the equipment is installed on the aircraft:

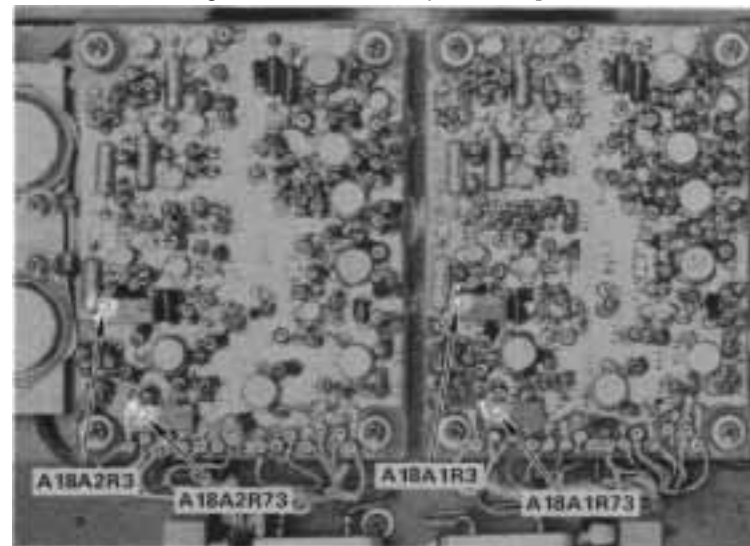
1. On the radar set control panel, set the MODE switch to STBY, the AZ STAB switch to HDG, the SCAN switch to OFF, and the RANGE (NM) selector to 50/10.
2. Adjust the intensity, focus, and range marker controls on the navigator's indicator to optimize the display.

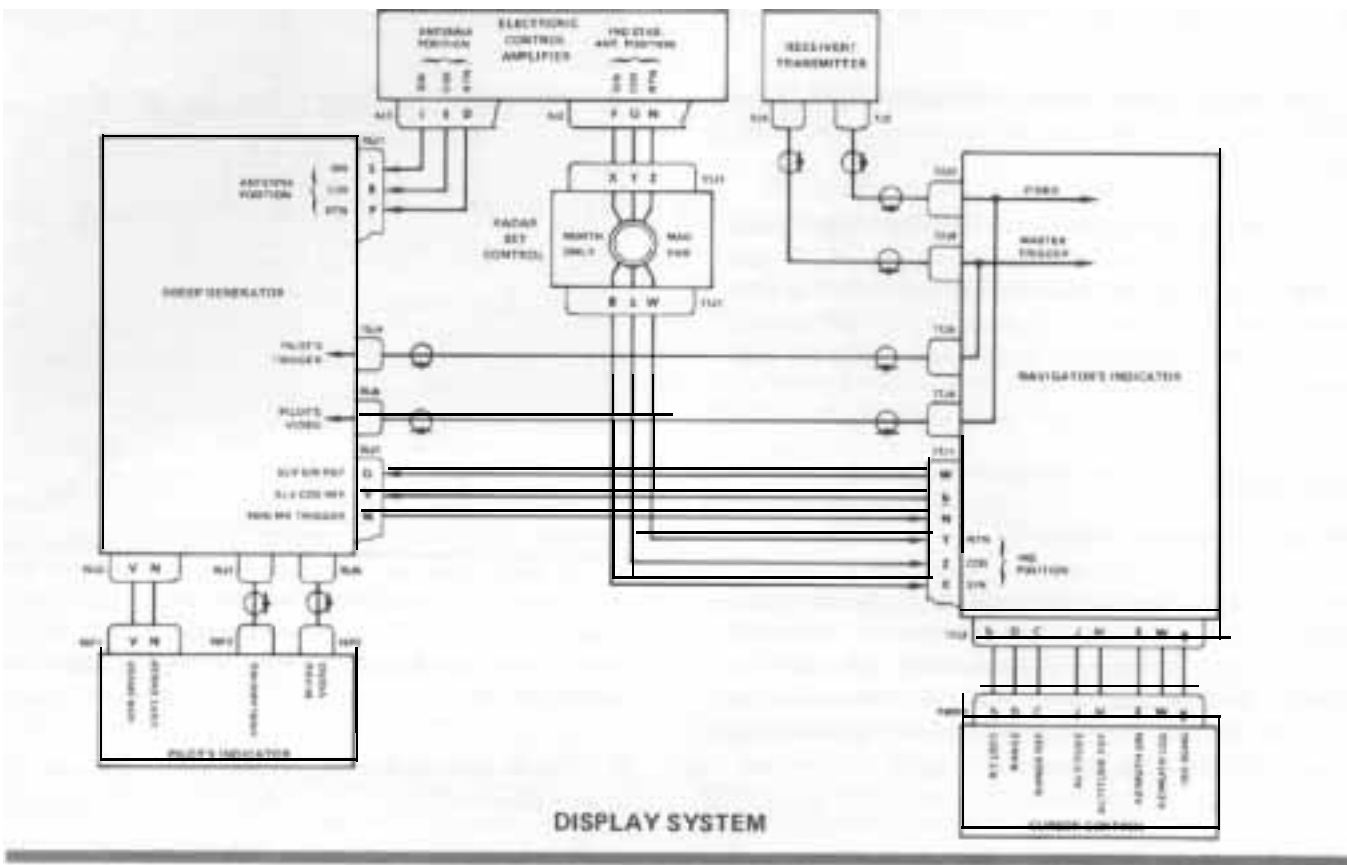


Figure 2. A dash 3 navigator's indicator with cover removed for access to adjustment points. NOTE: Cursor alignment for the dash 3 indicator must be accomplished on the bench while the dash 1 and dash 2 indicators can be adjusted on the airplane. On the dash 1 and dash 2 indicators there will be a potentiometer, A3R65, in the position noted on the photo, which is used to adjust for cursor position.

3. Adjust the relative bearing control on the antenna control panel to 0°.
4. Adjust potentiometer A1 8A1 R3 (Figure 3) to center the vertex of the vertical sweep (cosine adjustment).
5. On the antenna control panel rotate the relative bearing control to 90°.
6. Adjust potentiometer A1 8A2R3 (Figure 3) to center the vertex of the horizontal sweep (sine adjustment).
7. On the antenna control panel rotate the relative bearing control to 0°, and adjust potentiometer A18A1R73 (Figure 3) until the entire fifth range mark appears at the edge of the display.

Figure 3. Location of navigator's indicator adjustment points.





8. Rotate the relative bearing control on the antenna control panel to 180', and check that the fifth range mark appears at the same relative position at the bottom of the display. It may be necessary to adjust potentiometers A18A1R3 and A18A1R73 (Figure 3) to fine adjust the sweep in the vertical plane.

9. On the antenna control panel, rotate the relative bearing control to 90', and adjust potentiometer A18A2R73 (Figure 3) until the entire fifth range mark appears at the edge of the display.

10. On the antenna control panel, rotate the relative bearing control to 180', and check that the fifth range mark appears at the same relative position on the left edge of the display. It may be necessary to adjust potentiometers A18A2R3 and A18A2R73 (Figure 3) to fine-adjust the sweep in the horizontal plane.

11. Set the SCAN switch on the radar set control panel to R and the RANGE (NM) selector to 3-30/1, 3-30/5, 100/20, and 240/30 and ascertain that the outer range mark in each range does not go out of view during sweep rotation in any of the selected ranges. If this check cannot be satisfied, change the navigator's indicator.

Washed-Out Targets - If the indicator has faint targets at short range with the video gain full clockwise, the following steps may be performed.

1. Set the radar range to 3-30/5 and vary the range to display approximately 15 NM, i.e., 3 range marks.

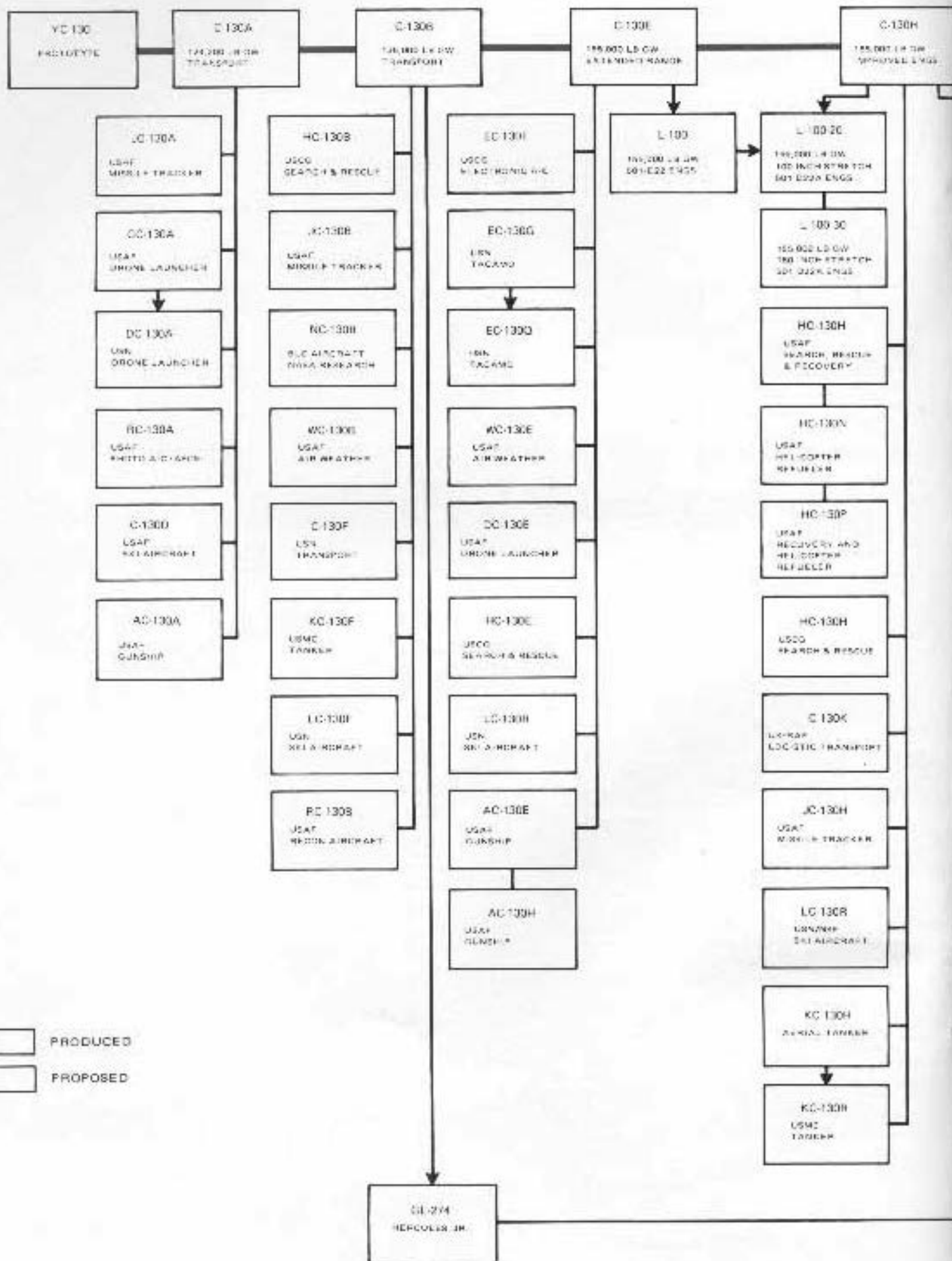
2. Select a known target at approximately 10 to 12NM.
3. Set the RCVR GAIN control on the radar set control panel at one-third (one-third of the total clockwise rotation).
4. Reduce the video gain on the navigator's indicator to one-half (one-half of the total clockwise rotation).
5. Adjust potentiometer A6R18 (Figure 2) until the target is just appearing, then adjust potentiometer A6R18 one full turn clockwise.
6. If the target cannot be seen with the foregoing settings and adjustments, replace the indicator. If the video is still washed out, go to R/T troubleshooting procedures.

As we reach the conclusion of the troubleshooting portion of our two-part discussion of the AF'Q-122 radar, (also see *Service News*, Vol. 4, No. 4) please note once again that the procedures described in this article are not intended to supplant or modify any of the procedures that may currently be approved for use in your organization. It is our **hope**, however, that these simplified checks will prove helpful to you in your effort to maintain the radar system of your Hercules aircraft at peak operating efficiency.

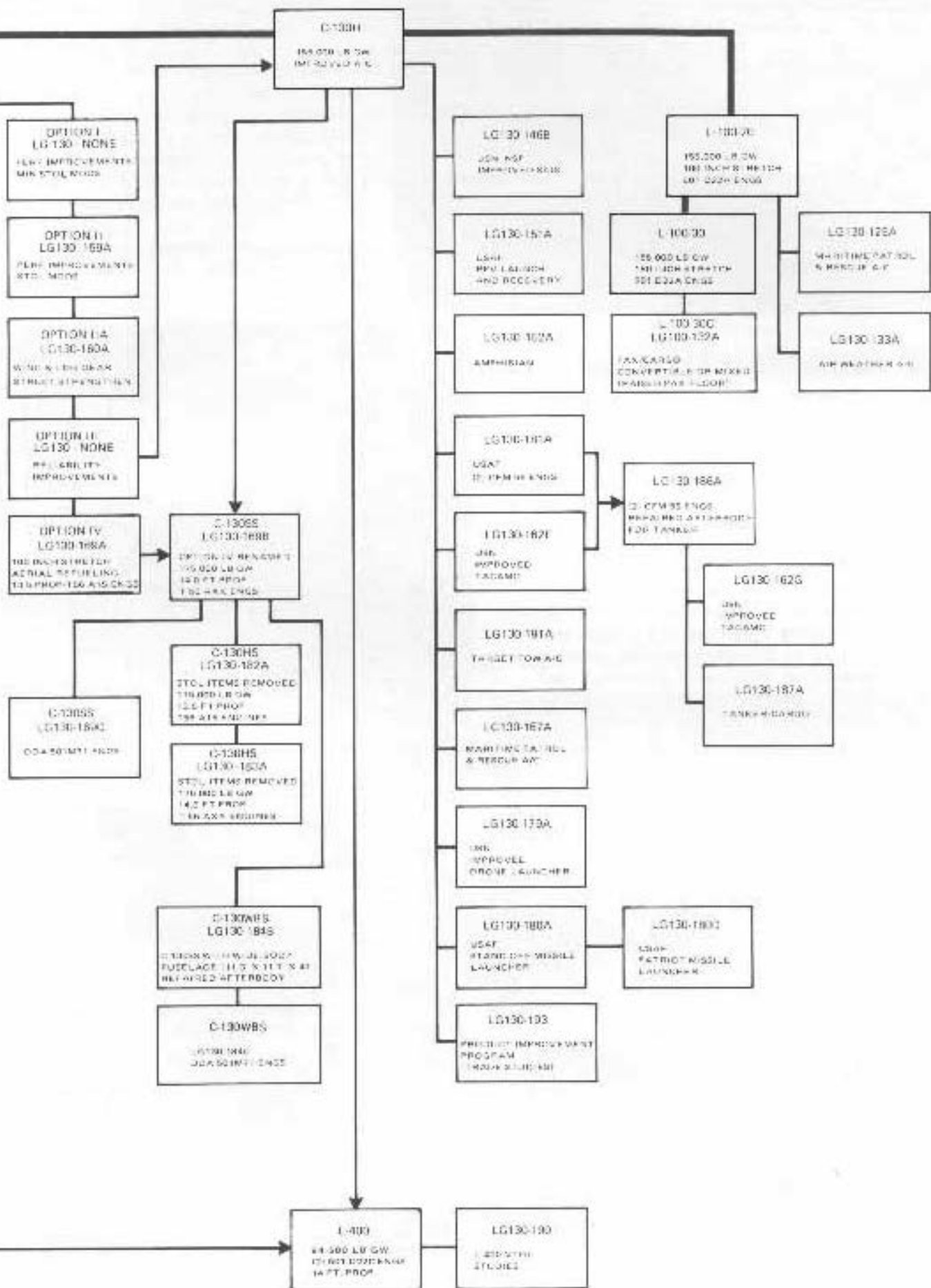


The amazing Hercules

**— airlifter for today
and tomorrow.**



Derivatives





Left and below: The Hercules on the production floor.

The amazing Hercules

by Joseph T. Hein, *Airline Sales Representative*

Many magazine articles, news stories, brochures, pamphlets, and even some books have gone into circulation with fascinating facts about the C-130 Hercules. This Lockheed-built aircraft has almost become a legend over the past quarter of a century. And yet, the question remains: Why the Hercules? If you ask why the name Hercules was selected, it is a relatively easy question to answer. The name was chosen to carry on Lockheed's stellar theme - Hercules is the name of a northern constellation. Some also would relate the Hercules aircraft to the Greek mythological hero known for strength and courage. But if you ask why the Hercules has existed, succeeded, and excelled over the past two decades, then these are much more complex questions to answer.

Why has the Hercules lasted so long? How has it been able to prove itself under so many diverse conditions; and how has it become the leader in modern airlift transportation? In simple terms, there are three answers for these questions: dependability, versatility, and adaptability. Dependability involves such factors as economy, payload, range, safety, and faultless operation in many previously unreachable locations throughout the world. Versatility refers to the myriad ways in which the Hercules has been put to use around the globe. Adaptability relates closely to versatility, but also includes the ways in which the basic Hercules has been altered, equipped, or redesigned to fit the needs of the many people and nations using the aircraft.

This article will examine these three factors - dependability, versatility, and adaptability - in regard to the past, present, and future of the C-130 to illustrate the position that this transport enjoys in modern aviation history. In order to fully understand the why and how of the Hercules it is necessary to consider its past as well as its present and its projected future.



PAST

This section of the article includes both historical facts describing how the Hercules came into existence, and facts demonstrating its dependability, versatility and adaptability.

Early in 1951, the Tactical Air Command (TAC) of the United States Air Force (USAF) issued a specification to the aircraft manufacturing industry for a new medium cargo transport having capabilities beyond those of any plane in service at that time. The requirements called for a short take-off and landing type vehicle with substantial load carrying capability, adequate range, and ability to function in undeveloped areas.

By the middle of 1951, Lockheed's basic design was approved and a contract was signed to move ahead with the proposed Model 182. Lockheed's winning design was radical for the times. It was for a high wing monoplane equipped with four turbo-prop engines; the piston engine had about reached the end of its technical development. The selected engine, the Allison T-56, has since

matched the fine record of performance and development of the Hercules' airframe.

Other distinctive features of this new type of transport were: The broad, roomy fuselage; a blunt nose for good crew visibility; a relatively high aspect ratio wing; compact engine nacelles; a sharply upswept rear fuselage; and a prominent empennage. In its original transport role, the Hercules carried a crew of four - two pilots, a flight mechanic/technician and a navigator.

Access to the cavernous cargo compartment was provided by two cargo doors: One, a 7-foot, 3-inch by 6-foot door in the forward port side of the fuselage; and the other, a two-section rear door which opened up to expose the full cross-section of the cargo hold. The lower portion of the door formed part of the lower fuselage and dropped down to form a loading ramp at a convenient truck-bed height. The other portion was hinged at its aft end and could be raised up within the fuselage for access to a cargo compartment 10 feet, 3 inches wide at floor level, by 9 feet, 1 inch in height, with an unobstructed length of 40 feet, 5 inches. These basic loading arrangements became the standard for the production Hercules. The side cargo door was later eliminated.

To give the Hercules this unobstructed cargo hold and to keep the undercarriage short and robust, the main landing gear retracted into external fairings on each side of the fuselage. The floor of the cargo hold was only 41 inches from the ground so that cargo being transferred from trucks did not have to be hoisted or lowered.

For this new project there were to be several improvements over past transports: Increased payload/range, engine-out capabilities leading to a four-engine configuration, and exceptional field performance. As for all transports of this general type, performance could not be allowed to compromise the design philosophies of simplicity, reliability and rugged construction, or those of economy of maintenance, operation and manufacture. This early design for the configuration of the Hercules has, in fact, become the accepted norm for freight carriers; and many military transports, large and small, have subsequently been designed along similar lines.

On September 19, 1952, Lockheed was awarded a second contract for the manufacture of two Hercules prototypes for evaluation. In the summer of 1954, the first Hercules (designated as YC-130 by the USAF) rolled out in Burbank, California. The second prototype also was

Taking off *from the Burbank airport,*
the first Hercules (YC-130 prototype) makes its maiden flight.



produced by the California plant, but subsequent production was transferred to the Lockheed plant at Marietta, Georgia, where the Hercules continues in production at the present time.

The initial flight of the Hercules prototype took place on August 23, 1954: and lasted 61 minutes. It took the aircraft from the Lockheed Air Terminal at Burbank to Edwards Air Force Base, where the airplane was to be evaluated by the IISAF.

Early trials were more than encouraging. On almost all points the Hercules exceeded the original requirements. In addition, it was easy to handle due to the very light control forces provided by the hydraulic power-boost systems.

Only minor changes were made as the initial prototypes were developed and tested. The propeller was exchanged for a more satisfactory model and the design of the vertical stabilizer and rear fuselage structure were modified.

Completion of further C-130s and test and evaluation work proceeded rapidly. It soon became obvious that, with its four advanced turbo-props, the Hercules' performance exceeded that of any transports then available. The third production Hercules C-130A demonstrated a remarkable ability to take-off with a ground roll of only 900 feet and land in a distance of just 600 feet at maximum landing weight with a payload in excess of 16,000 pounds. Another important feature was rapid convertibility between contrasting types of loads demanding speedy on/off loading and ease of change from one configuration to another. Equally remarkable was the ability of the Hercules to operate all over the world from surfaces



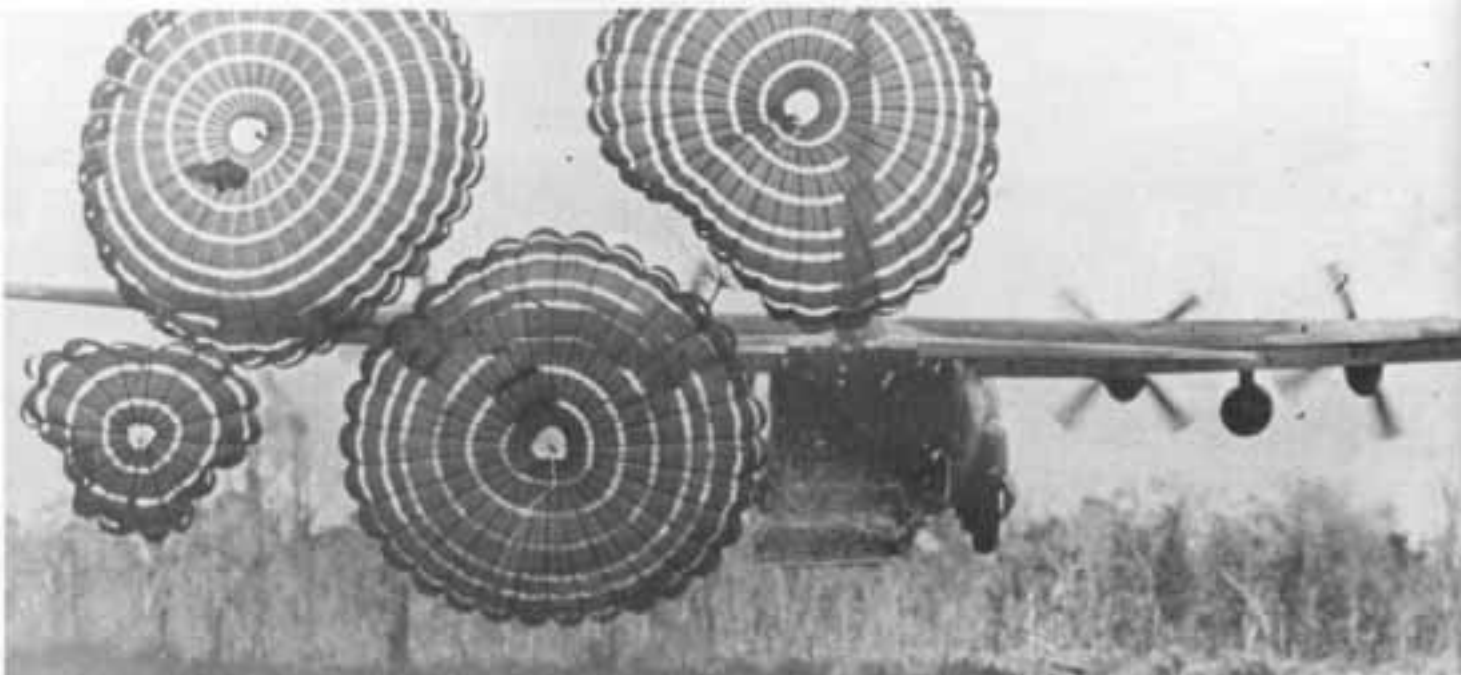
An early B model Hercules.

including sandy loam, gravel, dirt, bare soil, sod, grass, and pierced steel plank, as well as macadam, concrete, and the polar ice caps.

Even from its earliest days, the Hercules demonstrated an impressive capability for dropping exceptionally large and heavy loads from the air. But a new technique, developed in the mid-1960s was the low level extraction method whereby heavy loads could be jettisoned from a flying aircraft without the risks or imprecision of parachute dropping at altitude. In one system, a hook attached by cable to a palletized load was trailed out to catch a steel cable on the ground. The second system employs 22-foot diameter ribbon parachutes to drag the pallet out of the cargo compartment.

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Precision low-level cargo delivery is made possible by utilizing the low altitude parachute extraction system (LAPES).





U.S. Marine Corps KC-130F refueling two F4Hs.

Also in relation to cargo, other equipment developments were made to enhance the value of the Hercules. One of these was a cargo handling system made up of seven track-like sections stowed inside the aircraft which could be deployed by two men 30 seconds after landing. With the help of special tracks and roller guides in the aircraft floor, palletized cargo could be moved out of the aircraft at a rate of 12 feet per second. Thus, the entire operation of unloading 40,000 pounds of cargo could be completed in five minutes.

Following the C-130A, the next major Hercules development was the C-130B, which featured greater power, higher weights, and more fuel to improve payload/range performance. In addition, the B model had a strengthened landing gear and modifications in the hydraulic and electrical systems. The C-130B entered service on June 12, 1959.

In short order, the C-130E appeared on the scene - essentially an extended range version of the C-130B. This range improvement could also be traded for extra payload on short flights to maximize flexibility. The first flight of the first C-130E took place on August 25, 1961, with deliveries beginning the following year. This model was built in greater numbers than any other Hercules variant so far.

The latest version of the Hercules, the C-130H, is basically a C-130E with more powerful engines and an improved braking system. This model was introduced in 1963-64 first as the HC-130H, the search and rescue version; and then as the C-130H, the tactical transport version, which retained the more powerful T56-A-1 S engines. This is the basic version in production today. Even though the C-130E remains the model produced in greatest numbers, the C-130H is rapidly approaching this total, and may eventually surpass it.

The C-130A, C-130B, C-130E, and the C-130H plus the L-100, the commercial cousin of the C-130, are the basic versions of the Hercules. However, within the basic model variations, there have been over forty derivatives or adaptations to suit special needs. A discussion of some of the major derivatives follows.

The first special role of the C-130 was that of aerial survey. Equipment added to these aircraft were aerial electronic geodetic surveying apparatus, and cameras for photo mapping. Other early model C-130s were converted for use as missile and spacecraft tracking aircraft in support of operations at Cape Canaveral.

Early Hercules were also fitted with ski installations for use in the Arctic and Antarctic. This version, with a combination wheel/ski undercarriage, appeared for the first time in January, 1959. It was to remain one of the major derivatives which provided service to a whole new

The Hercules in a photomapping configuration.





An Air Rescue Service Hercules demonstrates *an* inflight pickup of personnel *from the* surface.

area of the globe. The Hercules is the largest aircraft ever to be fitted with skis. This is a tribute to the exceptional ruggedness of the basic design.

It was the U. S. Marine Corps that first tested the C-130A for in-flight refueling and later ordered and received specially equipped C-130Bs (first designated as GV-1s, later changed to KC-130Fs).

Other uses of the Hercules during this era included reconnaissance work and a conversion which added equipment for the launching, tracking and control of drones. The Coast Guard then became interested in the Hercules and obtained specially equipped C-130s for search and rescue missions.

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Further derivatives continued to appear at a prolific rate throughout the 1960s as new tasks were found for this versatile transport. A specialized Hercules, the HC-130H, was built for the Air Rescue Service to include astronaut recovery from land or sea. A notable feature of this recovery variation was the elaborate nose-mounted Fulton recovery system, enabling men or objects up to a total weight of 500 pounds (including recovery gear) to be picked up safely from land or water with the aircraft in flight. Standard equipment aboard this specialized search and rescue aircraft included four 6-man rafts, two casualty litters, bunks, recovery winches, 10 flare launchers and a wide range of other rescue equipment. Any of this equipment could be precision-dropped with the aid of an intervalometer and special overhead rails provided specifically for this purpose.

Twenty of the HC-130Hs were converted to HC-130Ps (helicopter refuelers) with a refueling pod under each wing (similar to the refueling system already developed by Lockheed for the U.S. Marine Corps). The HC-130P was also equipped for mid-air retrieval of parachute-borne loads.

Additionally, the Hercules was converted for weather reconnaissance work and made significant contributions in this area. As such, the WC-130 was equipped with special weather instrumentation to gather temperature, wind-speed and direction, barometric pressure, humidity,

dewpoint, and sea surface condition information to help predict world-wide weather. Most popular were the "Hurricane Hunters"; these aircraft could provide warning of the approach of tropical storms and have saved countless lives and millions of dollars worth of property. At other times, they could detect and track potentially crippling winter storms, and seed clouds with silver iodide crystals over drought-stricken areas.

An Air Rescue and Recovery Service HC-130P refuels a helicopter. Below: Installation of a modular airborne fire fighting system converts the Hercules into a water bomber.



The Hercules has also been converted into an aerial fire truck, spraying 3000 gallons of fire retardant in a 150-foot wide by 2000-foot long path in less than six seconds. Again, it is obvious that the Hercules derivatives have **been** used in many wide-range and valuable services.

From the early days of the program, a considerable commercial market (completely separate from military uses) was foreseen for the Hercules by Lockheed. Therefore, the Hercules finally went commercial in 1964, and it received an FAA Type Certificate in 1965.

To give the Hercules even better operating economics in the civil role, Lockheed embarked on a stretched version during 1967: the L-100-20. Extra fuselage sections were added ahead of and behind the wing, increasing the fuselage length by 8 feet, 4 inches. This expanded the L100 to the point where seven pallets could be accommodated. One of the major applications of the L-100 at this time came as a result of the oil exploration activities on the Alaskan North Slope. Here the Hercules proved ideal because of its ruggedness, its ability to operate from rough terrain and small areas, and its capacious cargo hold. Further stretching resulted in the L-100-30 which would accommodate eight pallets or more, and longer outsize loads.

It is evident that there were very few activities other than that of revenue passenger carrying, to which the Hercules was not being, or had not been, applied. Low costs, ruggedness and ease of operation under difficult conditions have enabled its high performance and carrying capacity to be involved with a remarkable range of tasks otherwise beyond the scope of an aircraft of this specification. Thus, the Hercules comes into the present era with an outstanding track record in terms of dependability, versatility and adaptability.



Above: The Hercules delivering *heavy* equipment to the North Slope in Alaska. Below: The L-100-30 stretch model of the Hercules.



Today, some twenty-three years after the C-130 Hercules first became operational, it is famous all over the world. It is well known not only for its numerous achievements as a military transport plane, but also for its many mercy missions to countries wracked by natural disasters or man-made troubles. In fact, this present stage of the Hercules story is most notably marked with the "Angel of Mercy" image. The Hercules has spearheaded the rescue effort in almost every known kind of disaster in recent years, bringing food, machinery, people, supplies. And to its military and humanitarian operations it has added a second distinguished career in commercial aviation as the L-100.

Four basic versions have now been built, covering no fewer than forty-five operational tasks - some of them experimental, some subsequently discontinued. When the Hercules first went into production a run of about 300 was considered likely. Including civil versions, more than 1,500 have now been built and orders are still coming in to the Lockheed-Georgia Company in Marietta. The majority have gone to the United States Air Force, but other customers have been the U. S. Navy, the U.S. Marine Corps, the U. S. Coast Guard, and the governments of 43 foreign countries, plus a variety of commercial customers.

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Loads regularly flown by the Hercules include such weighty and bulky items as bulldozers, road graders, trucks, aircraft engines, and road tankers filled with fuel. Other cargo has included livestock, airplanes with wings stowed separately, helicopters with rotors removed, jeeps, tanks, a mobile dispensary and clinic, fuel drums, sacks of grain, water purification equipment, and cargo pallets.

The Hercules cargo compartment can accommodate a variety of cargo.



The Hercules in trial operations from the deck of the U.S.S. Forrestal.

Speaking of record books, perhaps this is the place to set down the Hercules' records to date. As mentioned earlier, the Hercules was the largest aircraft ever to land on, or take off from, an aircraft carrier. A USMC KC-130F set the record in 1963 making 29 touch-and-go landings and 21 unarrested, full stop landings and takeoffs on the U.S.S. *Forrestal*. The Hercules is also the largest operational ski-and-wheel equipped aircraft. As such, it holds all the skilift records for transports. For example, it is the largest plane ever to operate from the 10,000-foot high runway at the South Pole. The ski equipment has also allowed it to venture to places which were previously unreachable by air.

The Hercules also holds the record for the world's heaviest low-altitude cargo extraction. Twenty-five tons were extracted by parachute from a C-130 skimming 10 feet above the ground at El Centro, California. Nine U. S. Marine parachutists jumped from a C-130 flying at an altitude of 44,100 feet. And in 1972, an Air Force HC-130 set a new long-distance flight record for a turbo-prop aircraft. **It flew 8,790 miles** from Taiwan to Scott

AFB in Illinois, landing with 4,500 pounds of fuel in reserve. This non-stop, non-refueled flight broke a record of 6,842 miles previously held by another Lockheed product, the P-3 Orion. The commercial derivative, the L-100 Hercules, also holds a record. It had the longest first flight ever made by a commercial aircraft. The maiden flight lasted 25 hours, 1 minute whereas most first flights usually last 30 to 40 minutes.

Over the years, the Hercules has gained a reputation for safety far above the common level in both military and civil work. Typical figures are those of a U. S. Marine Corps group which flew 12 Hercules KC-130Fs over a period of 14 years without an accident and logged 160,000 hours; or those of the Third Aerospace Rescue and Recovery Group, which flew 125,000 accident-free hours in 30 months in Vietnam; and those of a Royal Australian Air Force Squadron which flew its 12 Hercules for 100,000 hours without accident.

The Hercules itself is ageless. One delivered today does not differ much in appearance from ship number one at rollout. So successful, so functional has been the Hercules in more than 20 years of service that, in response to continually more demanding user requirements, Lockheed has retained the working airframe and efficient propjet design, and concentrated on new and important improvements to its internal systems, power and performance. Virtually every part of every system has been strengthened, modernized, and otherwise improved. Fuselage skin, wing panels, wing structure, landing gear, engines, propellers, hydraulic systems, electrical systems, fuel system, radios, instruments, environmental systems, and other components have been systematically updated to make today's C-130H one of the best tactical airlifters the world has ever known.

The versatility and adaptability of the Hercules have been demonstrated anew with almost routine regularity since the first was delivered to the USAF at Ardmore AFB,

Oklahoma, on December 9, 1956. But the end result is that the Hercules of today, although similar in outward appearance to the hundreds produced at Marietta, Georgia, is a vastly improved, essentially all-new cargo carrier ready to undertake new tasks and establish new safety and endurance records. As such, it is an aircraft which looks toward the future.

FUTURE

The future of the C-130 Hercules looks almost as good as its past. There are perhaps fewer milestones to reach and fewer records to set, but the Hercules will undoubtedly continue to serve well in every respect. Lockheed engineers are working on updated and advanced versions which should carry the Hercules production string well into the 1980s; and those future production models, as well as many flying today, will probably be in service into the year 2000 and beyond.

During the 23 years the Hercules has been in production, it has been the subject of various developments and daring experiments. However, not all of the projected improvements and variations have seen the light of day. From time to time Lockheed proposals for Hercules variants have remained on the drawing boards. Many have never even emerged through the project office doors or beyond an engineer's brainstorm.

However, since they may still be in line for future development, some of the versions which have not yet taken concrete form should be discussed here. Several STOL (short takeoff and landing) versions have been proposed at different times. The latest one is the C-130SS, the stretch/STOL. The SS features an elongated fuselage (8.3 feet longer), greater payload, and modifications giving it true STOL capabilities. Research, design and wind tunnel evaluations have shown that the stretch/STOL Hercules would be the most cost-effective replacement for the C-130 now in service.

The skibird version of the Hercules taking off with JATO assistance.





*A proposed Hercules version, the C-1 30SS (stretch/STOL).
Below: The L-400; a two-engine derivative of the Hercules.*

Lockheed has also completed preliminary design work and economic studies on a convertible passenger version of the L-100-30 commercial Hercules airfreighter. This unique configuration, designated as the L-100-30C, features comfortable, wide body airliner-type seat accommodations for 106 passengers. Removal of the palletized seats, galley, and lavatories returns the "Dash 30C" to an all-cargo configuration.

Still another future Hercules derivative is called the "Twin Hercules". This aircraft, designated the L-400, would have the same fuselage structure and ruggedness of the C-130 and the L-100. It would serve as a short haul companion to Hercules fleets now in operation, carrying a 22,500 pound payload with a 550-mile range. The two-engine configuration would make it ideal as a light-weight, in-country airlifter.

Perhaps the most unusual of all the Hercules projects is an amphibian version first studied in 1968 under U. S. Navy contract. This project proposed a molded fiberglass hull fitted over the existing fuselage structure, with the standard landing gear retained and a retractable hydro-ski in

the hull for water takeoffs and landings. Lockheed has proposed 70- to 100-seat commercial versions, using the L-100-30 for the latter.

Lockheed expects some of these proposals to be fully developed and fly, and for new versions of the Hercules to appear on the drawing boards. Certainly in today's economic climate there is adequate reason to develop existing airplane types to the absolute maximum before investing in entirely new aircraft.

The circuit has now been completed. We have presented the Hercules of the past, the Hercules of the present, and the Hercules of the future. After reading these pages, it is obvious that the real answers to the why and how of the Hercules are amazingly complex. It goes beyond dependability, versatility and adaptability to include proven ability, superior workmanship, unexcelled engineering and design, tremendous backup and support, and simplicity. The Hercules is unequalled in aviation annals and will remain so for some time to come.

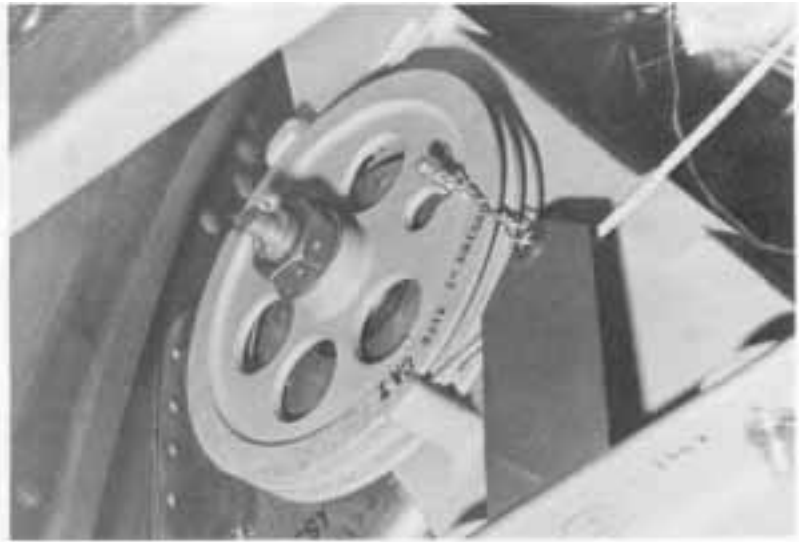
SERVICE NEWS



More About Rig Pins

The "Power Plant Rigging" article in the Vol. 5, No. 1, January-March 1978 issue of *Service News* called for the use of a 1/8-inch diameter rig pin in the control cable pulleys at the engine fire seal. Although the use of this size pin will produce satisfactory results, the holes in the pulley and bracket will accommodate a 3/16-inch rig pin, which may be used to obtain closer tolerances.

SERVICE NEWS



Correction

In "Power Plant Rigging", Vol. 5, No. 1, a line was omitted at the end of the first paragraph, right column, on page 16. The last two sentences should read:

"If the indexing lever tends to rotate past the feather slot of the index bracket, loosen a jamnut and turn the rod end 1/2 turn to shorten it. If the indexing lever does not rotate far enough, turn the rod end 1/2 turn to lengthen it."

StarTip

AI RCRAFT STATUS DESIGNATIONS

Recently the U.S. military services have adopted some new terminology that may be of interest to you. Many non-military operators of the Hercules are familiar with the NORM and NORS designations used to denote aircraft status. The old acronyms have been superseded as follows:

OLD DESIGNATIONS

OR	Operationally Ready
NORM-G	Not Operationally Ready Maintenance-Grounded
NORS-G	Not Operationally Ready Supply-Grounded
NORM-F	Not Operationally Ready Maintenance-Flyable
NORS-F	Not Operationally Ready Supply-Flyable

NEW DESIGNATIONS

FMC	Fully Mission Capable
NMCM	Not Mission Capable Maintenance
NMCS	Not Mission Capable Supply
PMCM	Partial Mission Capable Maintenance
PMCS	Partial Mission Capable Supply

Two new status codes have also been added. The new codes are to be used when a required part is not available but maintenance is still working on the aircraft.

NMCB	Not Mission Capable Maintenance & SUPPLY
PMCB	Partial Mission Capable Maintenance & SUPPLY

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