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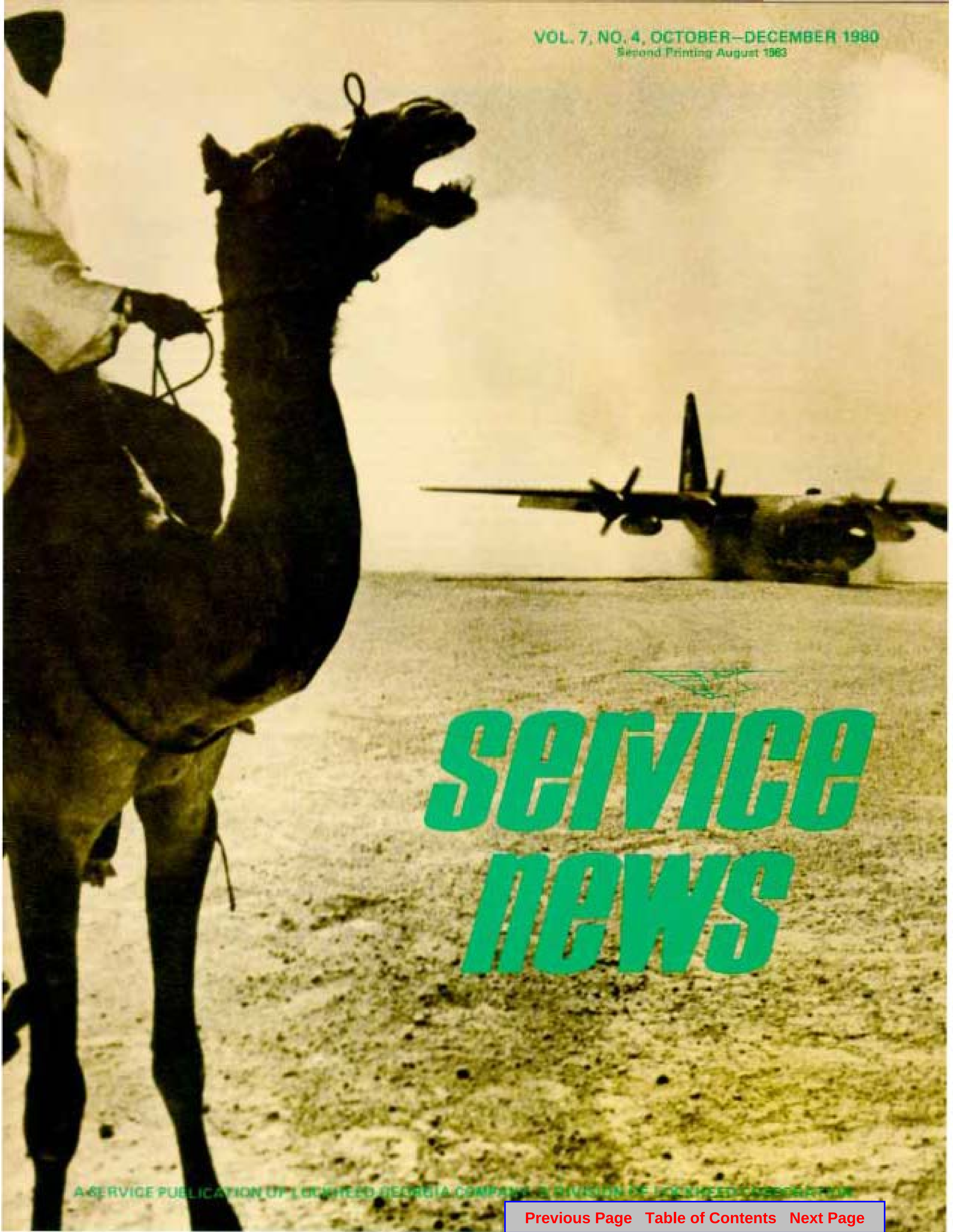

# service news

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Cover: **An ancient form of desert transportation** bears witness to the desert operations capabilities of the **Hercules** aircraft.



# Focal&pint

Walter E. Hensleigh

Lockheed-Georgia's Flying Operations people have as their primary purpose service to our company and to our customer. We serve Manufacturing by performing the final "proof of the pudding" functional check on new and modifird airplanes. We support Engineering with engineering test crews as design advisors, and wc also provide flight crews to perform experimental and engineering tests on test airplanes and simulators. We support our customers by offering flight crew qualification training, operational support, acceptance flight assistance, delivery flight service, flight planning support, and technical assistance. We operate all company transportation and flight demonstration airplanes, which on occasion arc used to support our customers and to help them evaluate our products. Assistance to all flight crews using or visiting our facility is provided by our control tower and flight equipment service.

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Sincerely,

Walter E. Hensleigh

Walter E. Hensleigh
Director of Flying Operations

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***by*** H. B. Armitage, ***Engineering Test Pilot***
***R.*** M. Holdernan, ***Engineering Specialist***

# Desert Operations

Climate and the special problems imposed by environmental extremes are major factors which must be fully evaluated before any type of mechanical equipment can be operated successfully at a given location. There is usually a close relationship between the degree to which machinery can be protected from the adverse effects of an unfavorable climate and the length of its service life.

In no situation is this principle more readily applicable than in the case of airplanes which are operated in desert regions. Of all possible climatic extremes, no terrestrial environment is potentially more rapidly destructive to key aircraft components than that of the arid and semi-arid regions of the world. Every modern, turbine-powered aircraft, regardless of make or type, can be seriously affected by desert operations. It follows that operational and maintenance techniques which serve to counter the effects of desert conditions will pay substantial dividends in terms of improved aircraft reliability, lower operating costs, and extended service life.

The reason that desert conditions often have such deleterious effects on aircraft can be found in an examination of the desert air itself. The air in desert regions often contains a heavy burden of sand and dust particles that have been picked up from dry surface soils and carried aloft by the wind. These particles are quite small in size and, in the absence of sufficient rainfall to return them to the ground, tend to become more or less permanent components of the atmosphere.

Although dry desert air has long been recommended as beneficial to human sufferers of allergies and certain lung diseases, the effects of an arid climate on precision machinery are less benign. Mechanical equipment is much more vulnerable to damage from airborne sand and dust than are living organisms. An important reason for this is that most living creatures have effective internal systems which help them eliminate any potentially harmful ingested particles. Machines, on the other hand, generally must be protected from solid contaminants in the environment by external devices such as covers, screens, and filters. Even when superbly designed, this type of protection is seldom completely foolproof; nor is it practical for all types of equipment. The unhappy fact of the matter is that in sandy or dusty climates, it is next to impossible to prevent at least some particulate matter from reaching internal parts where critical working tolerances can be affected.

With aircraft, the problems posed by sand and dust contamination are particularly difficult to control. It happens that airplanes are often used and stored in such a way that they are exposed to the very worst environmental conditions any locale has to offer. In the desert, this means plenty of heat, wind, and dust. The suspended contaminants in the air, together with the larger particles stirred up from runways and taxiways by propellers and jet exhaust, can penetrate to the interior of even the most carefully protected aircraft components. Once inside, the particulate matter is likely to remain there and cause trouble, clogging passages, eroding surfaces, and converting lubricants into abrasive slurries.

Solid particles carried by the air are clearly the fundamental cause of many of the most serious operational and maintenance problems commonly encountered in desert localities, but this is by no means the only problem area. Another source of trouble is heat. The high ambient temperatures typical of many arid regions not only contribute to the dryness, but subject aircraft components and systems to stresses specifically related to excessive heat. This tends to complicate an already rather challenging maintenance situation.

In the case of turbine-powered aircraft, undoubtedly the single most troublesome problem attributable to desert operations is compressor erosion. Each siliceous particle that is ingested by an engine invariably strikes a compressor blade, vane, or seal; usually at high velocity, and often under conditions of elevated temperature and pressure. It is, quite simply, a form of sand blasting. Over a period of time, even the most resistant of surfaces will wear away under this kind of assault.



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## What is a Desert?

The dictionary defines a desert as an area in which the prevailing conditions include generally high daytime temperatures, little rainfall (less than 10 inches annually), persistent winds, and dusty or sandy soils. But as far as the operation of a modern airplane is concerned, anyplace where high temperatures, dry conditions, and blowing sand or dust are present – even if only temporarily – qualifies as a "desert."

Almost every aircraft operator encounters such conditions from time to time, and that is why this article is important. No matter where your home base is located, the information in "Desert Operations" can make a real contribution towards ensuring that you will get the best possible service from your Hercules aircraft.

It does not necessarily even take very much time. Compressor damage due to sand ingestion can show up quite rapidly if the air quality is poor. Remember that when an Allison T56-A-15/501-D22A power plant is on speed, over 26,000 cubic feet of air is passing through its compressor every minute. With such a large volume involved, the presence of even a relatively modest amount of sand or dust in the atmosphere can make a measurable difference in engine service life.

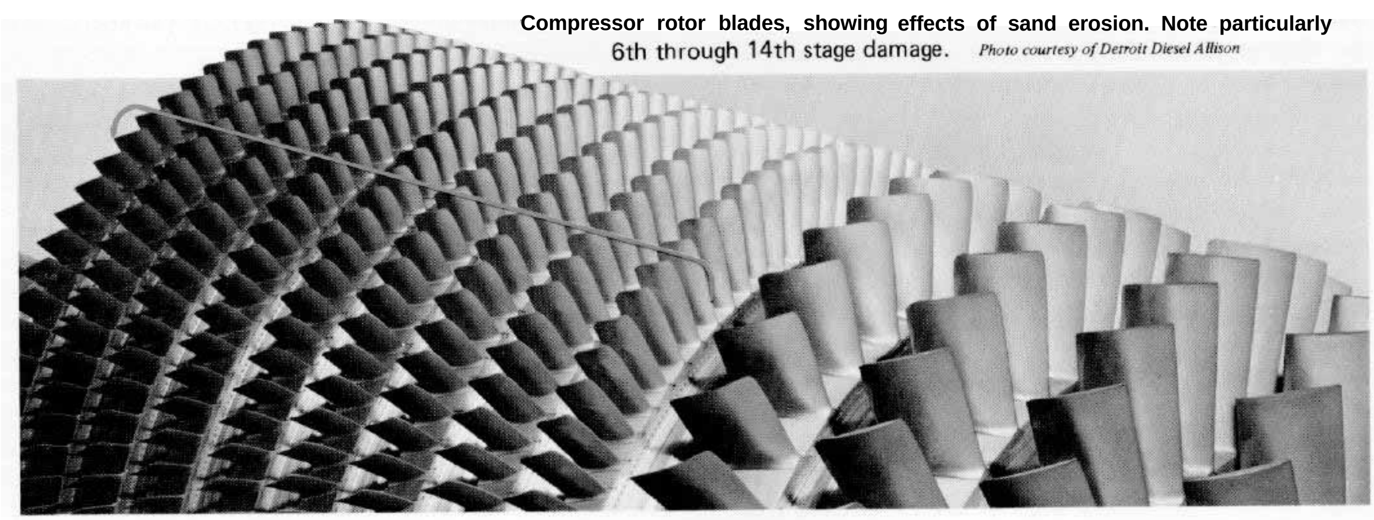
The principal effect of sand and dust erosion on compressor performance is a gradual reduction in discharge pressure and volume. This is accompanied by a decline in efficiency and an increase in the incidence of such problems as hung starts, compressor stalls, and engine "bog-down" – a condition in which the engine supplies less power than is required to support propeller operation at a given throttle setting.

Unfortunately, power plant damage from ingested sand and dust is not limited to compressor erosion. Among other things, dust-laden air can lead to plugged fuel control compensator probes, abnormal flame patterns in the combustion liners due to dirty fuel injectors, clogged engine anti-icing passages, sluggish bleed air manifold valves, and a general shortening of the service life of many other engine and propeller components because of oil contamination.

Nor are aircraft systems beyond the engines immune from environmentally-caused damage in the desert. Every moving part, every valve, switch, or cam; every duct, passage, or seal may have its function impaired by airborne sand and dust or be degraded by long exposure to excessive heat.

Experience is at the heart of most of the principles and practices that have become established over the years in connection with aircraft operation. So it is with those special techniques which have been found useful in protecting aircraft used for desert operations. No particularly sophisticated or unusually elaborate procedures are involved. What is involved is the consistent application of proven, "desert wise" practices in all situations where the aircraft and the environment interface.

The list of operating and servicing limits presented here does not by any means exhaust all possible ideas that could help protect your aircraft from harsh climatic conditions, but it does provide a proven data base from which to start. It is not possible to protect an aircraft from all of the rigors of the desert, but the use of these techniques and procedures will make a real contribution toward minimizing the amount of punishment that your Hercules aircraft will have to absorb when it is operated and maintained in the arid regions of the world.



**Compressor rotor blades, showing effects of sand erosion. Note particularly 6th through 14th stage damage.** *Photo courtesy of Detroit Diesel Allison*



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OPERATIONAL RECOMMENDATIONS

1. Taxi with all engines in low speed ground idle (LSGI) whenever possible. This practice will greatly reduce the amount of sand and dust being drawn into the intakes and it will also aid in cooling engine oil since less engine heat is developed in LSGI.

2. If it is necessary to use high speed ground idle (HSGI) during ground maneuvering at speeds below 40 knots, avoid moving the throttles below the ground idle detent. Below ground idle, blade action is reversed and blows debris forward where it may be subjected to ingestion by the engines.

3. During sharp turns on the ground (180' on the runway, etc.), use minimum speed and use LSGI on the engines inside the turn to help reduce the possibility that debris will be drawn into the engines.

4. If it is necessary to move the aircraft backwards by using reverse thrust, first stop the aircraft and, while holding the brakes, position the throttles above flight idle to blow the sand and dust aft. Then move the aircraft backwards, utilizing the minimum reverse power on all four engines.

5. The flaps should be retracted during all taxi operations and should be lowered just prior to takeoff. Extended flaps deflect prop blast to the ground during taxi, stirring up debris and thus increasing the possibility of these particles being ingested by the engines, APU, and air conditioning units.

6. Minimize the operation of the air conditioning systems during landings and while on the ground to reduce sand and dust contamination of the heat exchanger. Turn off the cargo air conditioning system to aid in this effort whenever possible. The flight station air conditioning may be left on, since its intake is located far enough forward on the fuselage to preclude ingestion of debris thrown up by prop blast.

7. Operate the APU or GTC/ATM only when required for electrical or pneumatic power. This will minimize the ingestion of sand and dust by the equipment.



8. Make the reverse thrust check (prior to takeoff) after the engine run-up. The sand and dust will be blown aft during the engine run-up; hence, less will be ingested during the reverse check.

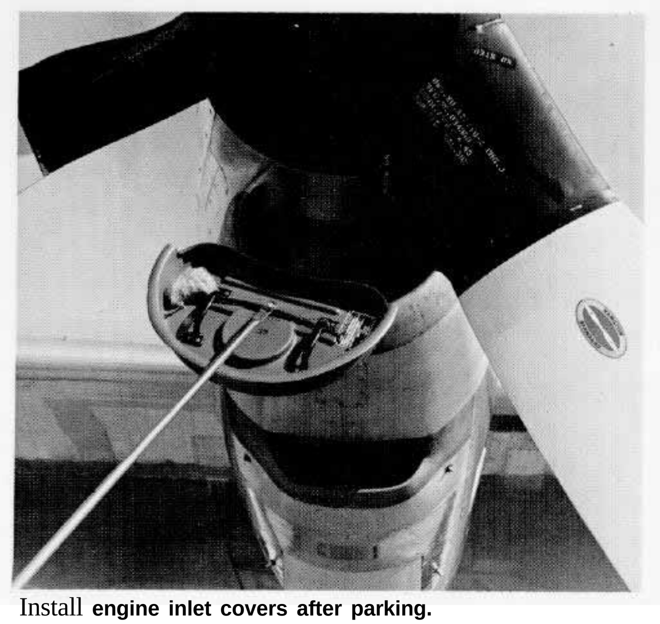
9. Minimize flight time in blowing sand or when there is sand and dust in the atmosphere by climbing and descending as rapidly as practical.

10. Cycle the wing, empennage, and engine anti-icing systems during each flight to prevent dust and sand contamination from causing the anti-icing valves to stick.

11. During landings, move the throttles from FLIGHT IDLE to GROUND IDLE to MAXIMUM REVERSE as soon as practical; then return to GROUND IDLE before ground speed reaches 40 knots. Below 40 knots, the propellers move dust and sand forward of the airplane where these particles are ingested by the engines.

12. If blowing sand or dust is present, install the inlet plugs after parking, even during turnaround stops. Install exhaust plugs as soon as the tail pipes cool. Also close the oil cooler flaps.

13. During hot weather operation, avoid sudden power changes. Normal engine acceleration should be experi-



Install **engine inlet covers after parking.**

enced; however, engine bog-down is more likely under high-temperature conditions. If engine bog-down is experienced, notify maintenance.

14. Minimize the use of the wheel brakes, since they will heat rapidly and not cool at the normal rate under high ambient temperatures.

15. To produce the coolest oil temperatures for reversing, taxi, and ground maneuvering in extremely hot climates, manually open the oil cooler flaps and position the switch to OPEN and FIXED below 15,000 feet. Remember that oil temperatures above 85'C are detrimental to engine components.

16. Perform NTS checks frequently while operating in these conditions to ensure proper operation of the negative torque system.

17. Park the aircraft facing into the wind whenever practical. Tailwind starts in high ambient temperatures increase the possibility of "stall starts", overtemperature conditions, and turbine damage. A stall start occurs during an engine start attempt and appears as stagnated rpm at approximately 35 to 55% rpm, with TIT continuing to rise uncontrollably beyond start limit.

MAINTENANCE RECOMMENDATIONS

The following recommended maintenance procedures, practices, and techniques are intended to complement established maintenance practices. The use of these recommendations will result in increased service life of components by reducing sand and dust contamination of aircraft components. These procedures will also help to minimize the adverse effect of high ambient temperatures on aircraft systems.

Please note that the recommended time spans between performance of certain maintenance checks are "best judgment" averages based on studies of Hercules aircraft operations under desert conditions. These time spans may be adjusted by individual operators according to the severity of the local climate.

1. Remove, clean with approved solvent, and reinstall engine starter control valve filters every 25 engine starts. This will reduce the possibility of the valve sticking or failing to regulate the air pressure to the starter. Failure to regulate air pressure correctly results in extremely rapid

Blow **sand and dust aft before backing aircraft with reverse thrust.**



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starter degradation. For Bendix starter valves, refer to the applicable Bendix publication for filter location.

2. Check for proper operation of the engine starter valves every 50 hours. When using bleed air from an engine operating in HSGI, the starter control valve should regulate the pressure to the starter scroll of the engine being started at between 36 and 42 psi during engine rotation. It should also drop to 0 psi within five seconds after the flight station starter switch is deactivated. Failure of the valve to function in this manner can cause serious damage to the starter and engine gearbox by generating high impact loads, excessive torque, and excessive rpm after switch deactivation. If the regulated pressure is low, long, hot starts and reduced turbine life will result. To check the operation of Bendix starter valves, Bendix suggests that operators tee in a direct reading gage and measure the starter control valve pressure at the "B" check (200 hours of aircraft time), especially if starter problems have been experienced. The tee should be installed at the pressure sensing line port of the starter scroll so that accurate readings of actual starter operating pressures may be obtained. When the gage is installed, use bleed air from an engine operating in HSGI. Start the engine being checked, observing the pressure gage. If the valve does not operate within the above limits, replace the valve.

3. Use a rag to wipe out the engine inlets when the inlet plugs are removed. Some blowing sand can bypass the inlet plugs and be ingested during engine starting.

4. Maintain between 11 and 12 gallons of engine oil in the tank. This provides the maximum oil quantity possible to absorb engine-generated heat and assists in preventing high oil temperatures during ground operations. However, do not service the oil tank with over 11 gallons when the oil is cold since this will result in overfilling.

5. Be sure that the engine throttle-to-coordinator-to-fuel control rigging is maintained to specified tolerances. This will ensure optimum engine response to throttle position. Check every 50 hours in accordance with the instructions contained in the applicable maintenance documents.

6. Maintain the engine coordinator to propeller linkage within the specified tolerances. This will ensure the proper relationship of propeller blade angle to throttle and fuel control position. Check every 50 hours.

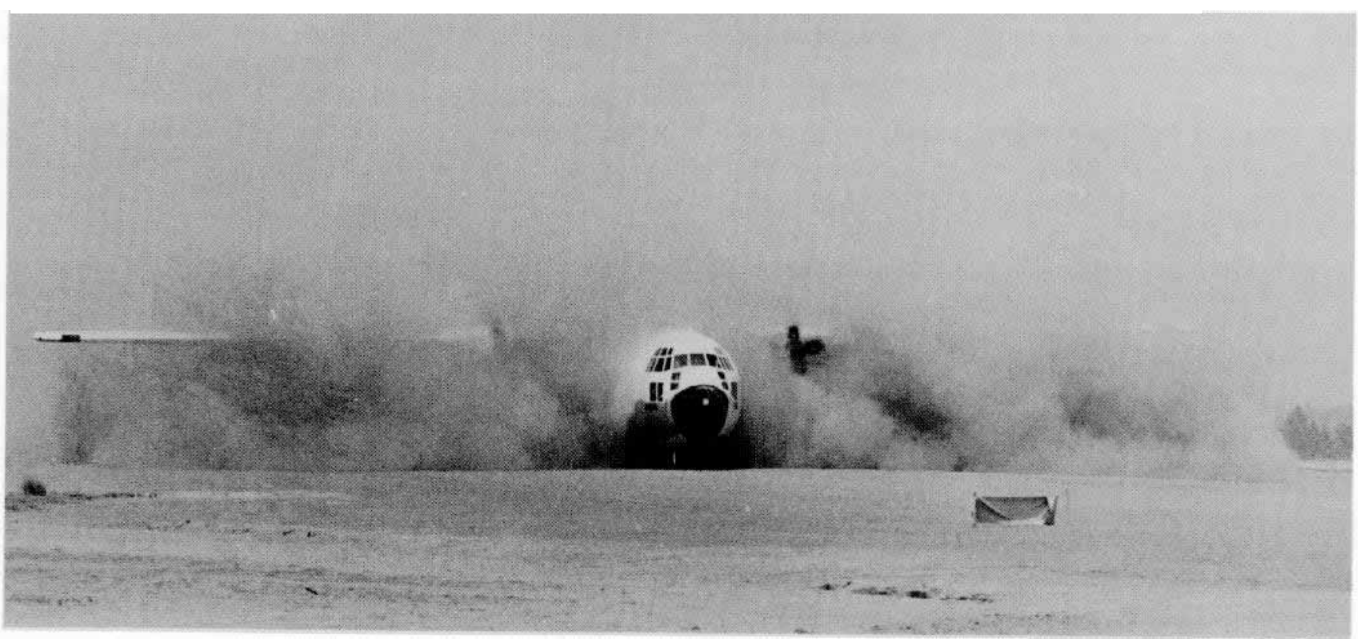
7. When maintenance actions require ground operation of an engine, move the throttles slowly, utilizing approximately twice the normal time required. During high ambient temperatures, the engine power change response rate is slower than the propeller response rate. Slow throttle movements minimize the possibility of the propeller "getting ahead" of the engine and causing some degree of engine overload and degradation of compressor or turbine.

8. Remove, clean with approved solvent, and reinstall the engine 14th stage bleed air filter every 25 hours to reduce contamination of the speed sensing valve. Malfunction of the speed sensing valve can result in the compressor's 5th and 10th stage bleed valves not closing completely, causing power loss and, under extreme conditions, engine bog-down. Refer to the appropriate engine maintenance manual for removal and reinstallation instructions.

9. Remove, clean with approved solvent, and reinstall the 5th and 10th stage engine compressor bleed valves



**Dust cloud stirred up by reversed propellers during landing can be limited by appropriate throttle management.**



every 100 hours. Contamination with dust, sand, or oil will cause the valves to operate sluggishly or not close properly. Such a condition results in power loss and can cause an unscheduled engine rundown. Just one of the four 5th~stage bleed valves remaining open at takeoff power results in a loss of approximately 130 horsepower, and one of the four 10th~stage bleed valves remaining open at takeoff power results in a loss of approximately 270 horsepower.

10. Clean the engine pressure probe every 50 hours according to the following procedure:

a. Disconnect the compressor inlet pressure sensing line at the fuel control connection. Note: Refer to Allison Publication 4RC2, Subject No. 75-11-0, Figure 1, Item 11. for connection location.

b. Using an air pressure cleaning gun at the disconnected end of the pressure sensing line, flush cleaning solvent through the line and out the sensing tip until the solvent is dirt-free. Note: Refer to Allison Publication 4RC2, Subject No. 75-l l-0, Figure 1, for sensing tip location.

c. After completion of Step (b), blow dry air through the line and out the tip to remove any loose dirt and to dry out the line.



CAUTION

Do not apply shop air pressure or introduce solvent into the fuel control.

d. Remove the bellows housing overboard drain plug from the fuel control and apply a maximum of 5 psi air pressure to the overboard drain opening in the fuel control.

e. Reinstall the pressure sensing line disconnected in Step (a) above and plug removed in Step (b) above. Replace safety wire as required.

The procedure just discussed will prevent the pressure sensing system of the fuel control from becoming contaminated, which results in an extremely lean fuel flow schedule. It is possible for an extremely lean fuel schedule to cause engine bog-down, especially when the throttles are below crossover.

11. Make sure that LSGI is maintained at between 69.0 and 75.6% rpm. Refer to the appropriate engine maintenance manual for the adjustment procedure.

12. Keep the temperature datum valve null orifice adjusted to admit as much fuel as possible without start TIT limits being exceeded. This provides the maximum fuel flow below crossover and reduces the possibility of engine bog-down.

13. Make sure that the temperature datum amplifier start limit is set correctly. Check every 50 hours and anytime there is a reported high start TIT. This will prevent turbine damage from excessive starting temperature.

14. During overhaul of the engine speed sensing control (P/N 7854687), specify that switch No. 1 be set to actuate at the minimum rpm allowed in Allison Publication No. 4RC3, Subject No. 73-12-0, Table III. During in-service time, replace any control unit that consistently does not provide fuel flow and ignition between 16% and 20% rpm during the engine start cycle. This will provide the earliest possible light-offs, and allow for maximum turbine assistance to accelerate the engine to an on-speed condition. The possibility of long or “hung” starts is thus much reduced.

1.5. Visually and electrically check engine thermocouples every 100 hours, in accordance with the procedures described in the applicable maintenance manuals. This will assist in preventing engine turbine damage.

16. Check the operation of the engine anti-icing valves every 50 hours. At 100% rpm, there should be approximately 900 inch-pounds of torque reduction when engine anti-ice is turned on. These valves are “fail-safe” in the open position; in the event of a bleed system failure, the valves automatically open. Therefore a malfunction can cause a loss of approximately 170 horsepower per engine, possibly causing an engine bog-down.

17. Instruct your fuel control overhaul facility to take advantage of all tolerances given in Allison Publication No. 4RC3, Subject No. 73-3-1, Figure 710, to provide the highest allowable fuel flow with the temperature probe in the **+1** 10 degree F bath. This will help make certain that at extremely high ambient temperatures, the engine is not running lean enough to be subject to “lean blowout.” Lean blowout occurs during a rapid retardation of the throttle, or during flight when descending from altitude. It can also happen when shifting to LSGI. The symptoms are that the engine behaves just as though fuel were intentionally cut off, with rapid deterioration of rpm and TIT.

18. When maintenance action requires engine operation, if possible select times when there is little or no blowing sand. If you are in an area where there is sand on the ramp or on an adjacent area, water down a circle approximately 30 feet in diameter under each propeller. This will reduce sand ingestion by the engines.

19. Wash down the engines frequently. Do not allow the inside of the nacelle to become contaminated with sand or dust. Frequent washing reduces the possibility of inlet air or lubricating oil becoming impure. Also, the washing will allow normal engine cooling and prevent hot spots due to lack of heat dissipation on contaminated surfaces.

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20. Install engine inlet and air conditioning inlet plugs each time the engines are shut down. This will prevent sand or dust from entering the inlets and being ingested during engine starting.

21. Install engine tail pipe plugs after the engines have been shut down for approximately 30 minutes. This will prevent airborne contaminants from entering the turbine and causing turbine blade or vane sulfidation.

22. Borescope each engine turbine every 100 hours of operation in accordance with approved procedures to check for signs of overheating or mechanical damage.

23. Ensure that the alignment of the air inlet scoop to the engine inlet housing is maintained with no more than 1/4-inch step at any point; check visually daily. This check ensures that there is minimum distortion of the compressor face pressure pattern. During high ambient temperatures, engine compressor face pressure is more critical than at normal temperatures. Sufficient distortion of the compressor face pressure pattern results in compressor stall and engine bog-down.

24. Maintain the propeller ground idle blade angle at 5.0 to 5.5 degrees. This will ensure a positive aerodynamic blade angle for ground maneuvering and thereby reduce the possibility of sand and dust ingestion by the engines. However, this blade angle may also increase the start time under high ambient temperature conditions, and it may cause hotter brakes during taxi. The ground idle blade angle should be checked every 50 hours in accordance with the instructions in the applicable maintenance manual.

25. Check and lubricate the NTS bracket clearance every 50 hours in accordance with the instructions in the applicable maintenance handbook. In addition, ensure proper and free movement of the NTS bracket and lever by following this procedure:

Note: This procedure should be done with the propeller auxiliary pump running and throttle above flight idle.

a. Insert a screwdriver between the engine NTS plunger and the engine lever.

b. Manually actuate the NTS linkage by prying the engine lever forward. Observe blade movement.

c. Slowly release the pressure on the engine lever.

d. Ensure that the needle roller ring returns smoothly to its original position.

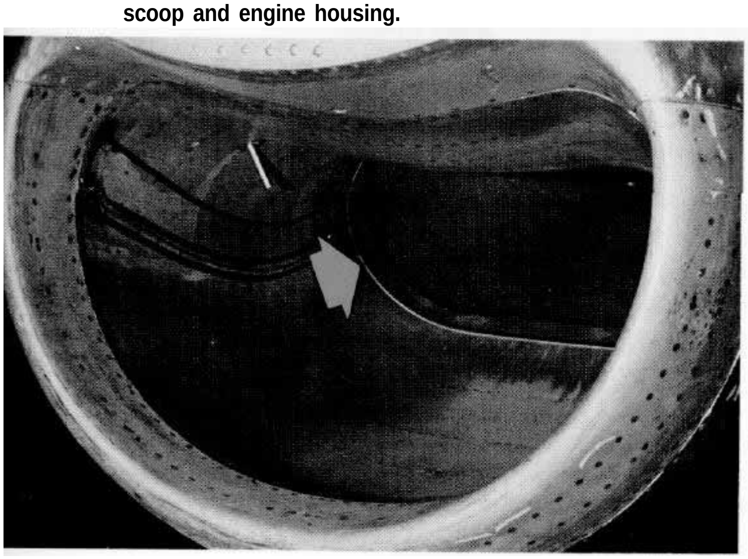
e. Should any erratic or jerky movement be noted in Step (d), remove, replace, repair, or lubricate the bracket as required.

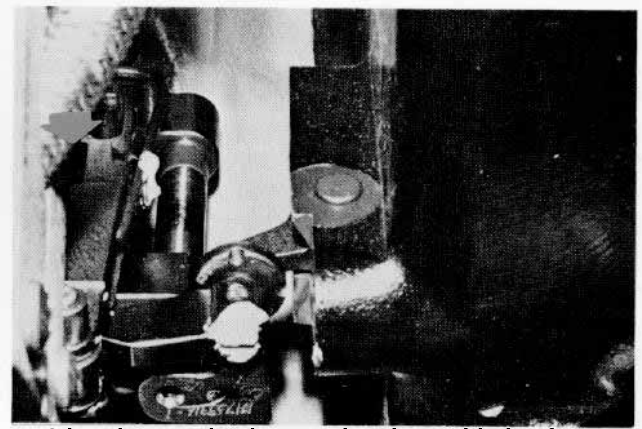
Note: If the NTS bracket is replaced, be sure to use Hamilton Standard P/N 738338.

26. Remove, clean with approved solvent, and reinstall the propeller control vent filter every 150 hours. Contamination of this filter can cause erratic propeller governing or an unscheduled engine rundown by causing too high a propeller blade angle for the engine power, resulting in rpm decay.

27. Drain the propeller control oil every 150 hours by removing the drain plug in the bottom of the propeller control assembly. Then service with fresh oil (approximately 6 qts). Although this does not replace all the propeller oil, it will reconstitute the oil and reduce contamination. This will reduce seal, gear, and bearing wear which causes erratic governing. In turn, poor propeller governing can cause too high a blade angle for the engine power and an unscheduled engine rundown.

**Correct alignment must be maintained between air inlet scoop and engine housing.**





**NTS bracket: to check operation, insert blade of** screw-**driver at point indicated (see text).**

28. During maintenance actions requiring APU/GTC or engine operation, do not use the air conditioning system unless it is required for system checks. This will prevent sand ingestion which can result in system contamination and cause abnormal wear, malfunctions, and unscheduled removal of components.

29. During maintenance engine runs, turn the APU/CTC off and close the door before operating No. 1 or No. 2 engines above LSGI. This prevents the APU from ingesting sand and dust generated by the propeller ground effect vortex.

30. During maintenance requiring APU and engine operation, keep operating time to a minimum and whenever possible operate the engines in LSGI only. This will reduce sand and dust ingestion into components which operate at a high rpm.

31. Remove, sonic clean, and reinstall the outflow valve bleed air filter every 100 hours and replace the throwaway filter to reduce the possibility of a cabin pressurization system malfunction. Refer to the appropriate maintenance handbook for filter location.

32. Remove and replace the two throwaway paper mat filters in the cabin pressure controller every 100 hours to reduce the possibility of cabin pressurization system malfunction. Refer to AiResearch publication number 21-30-37, Figure 1102, Items 16, 17, 18,23, 24, and 25 or the appropriate maintenance handbook for filter locations.



33. Clean and lubricate the main landing gear (MLG) and the flap jackscrews daily to reduce ball nut wear. It is also recommended that only P/N EA4344( ) flap jackscrew assemblies and Calco P/N 8353 screw assemblies for the MLG be used. These units are designed to remove contaminants from the screw threads before the threads enter the ball nut assemblies and induce a high wear rate.

34. Replace all hydraulic reservoir vent filters every 100 hours. This will reduce the possibility of contaminated hydraulic fluid or pump cavitation and damage because of poor reservoir venting.

35. Replace all hydraulic pressure filters at l/2 the normal interval. This will reduce wear of hydraulic seals around moving parts.

36. During maintenance, do not “power up” any electrical components that are not required to accomplish the maintenance action. This will avoid the generation of excessive heat which could lead to impaired operation of the components and an undue increase in the failure rate.

37. When the aircraft is stationary, allow air to circulate through the fuselage during dry weather if there is no serious problem with blowing sand or dust. Open the hinged windows in the flight station, the overhead escape hatch, the crew entry door, the rear entrance doors, the ramp, and the cargo door. The air circulation will prevent excessive heat build-up in the fuselage and the degradation of fuselage-installed components that can result.

38. Lubricate the aircraft every 100 hours of operation with new grease. Force the old grease out of all pressure-lubricated points. Wipe off all excess grease. This lubrication helps remove sand- and dust- contaminated lubricants from moving parts and reduces wear.

It is important to remember that an airplane and its components are designed and tested with certain environmental parameters in mind. The procedures that are established for operating and maintaining aircraft are predicated on the assumption that aircraft equipment will be used within the normal range of these parameters most of the time. Whenever an aircraft – or for that matter any piece of mechanical equipment – is operated extensively under environmental conditions which are significantly harsher than those for which it was designed, appropriate special operating and maintenance procedures are required to ensure normal service life.

The environmental conditions of the desert clearly place severe stresses on the components and systems of any aircraft. But it is possible to neutralize, or at least mitigate, the worst effects of desert operations. Careful and consistent application of the techniques described in this article will help keep your Hercules aircraft safe and dependable at the lowest possible cost.

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# the Air Turbine Motor

*by C.* E. Madison, ***Training Specialist***
A. K. Millsaps, ***Service Representative***

Although the air turbine motor (ATM) has over the years proven to be reliable and relatively easy to maintain, like all mechanical devices, it does demand a certain amount of attention. Also, some Hercules aircraft operators occasionally encounter ATM maintenance problems not covered in the maintenance manuals. This article describes the operation and purpose of the ATM, and includes servicing tips and hints on troubleshooting some of the less common problems that are encountered in the field.

The ATM is installed in all Hercules aircraft equipped with the gas turbine compressor (GTC). Nearly 1400 Hercules utilize the GTC/ATM combination, from the first A model through the early H models. The GTC/ATM combination has been replaced on recent model production Hercules by an auxiliary power unit (APU) which combines most of the functions of the two units. At present, there are no plans to retrofit the Hercules fleet with the newer APU, which means that the ATM should be around for a long time to come.

## Purpose of the ATM

The purpose of the ATM is to provide a standby source of electrical power and, on the earlier A models, to provide emergency hydraulic pressure. The ATM is an integral part of the self-sufficiency concept that allows the Hercules aircraft to operate in remote areas without the need for ground support equipment.

## Location and Access to the ATM

The ATM is installed in the upper left wheel well above the forward tire. Access is provided above the wheel well fairing. A small, rectangular access panel is used to check the oil, and a larger panel can be removed for access to the entire unit.

CAUTION

Do not use the ATM exhaust outlet as a step. To do so could bend the turbine exhaust duct and warp the turbine housing (the volute), possibly causing the turbine wheel to strike the housing.

## ATM System Description

Essentially, the ATM is a gear tram turned by an air-driven turbine wheel. It contains an integral oil pump, with the hollow gear housing utilized as an oil reservoir. There are two drive splines integral to the gear train, one turning 8,000 rpm for the AC generator and the other turning 6,000 rpm for a hydraulic pump mounted on the second spline on the A model Hercules, but not used on the later Hercules models. Air necessary for turning the ATM can be obtained from the GTC, from the 14th stages of the aircraft engine compressors, or from an external ground support compressor. If the engine-driven generators are not operating, DC electrical power necessary for the ATM control can be obtained from an external power cart or from the aircraft battery.

## OPERATION

The normal operating speed of the ATM is 43,000 rpm. This speed can be monitored by observing the ATM AC generator frequency meter for a reading of 400Hz. The speed is precisely controlled by modulating the amount of bleed air that turns the turbine wheel.

Two units control the bleed air flow - a governing device called the speed controller (governor) and a butterfly valve referred to as a modulating valve. Since a number of problems associated with the ATM can be traced to these two units, let us take a closer look at their operation.



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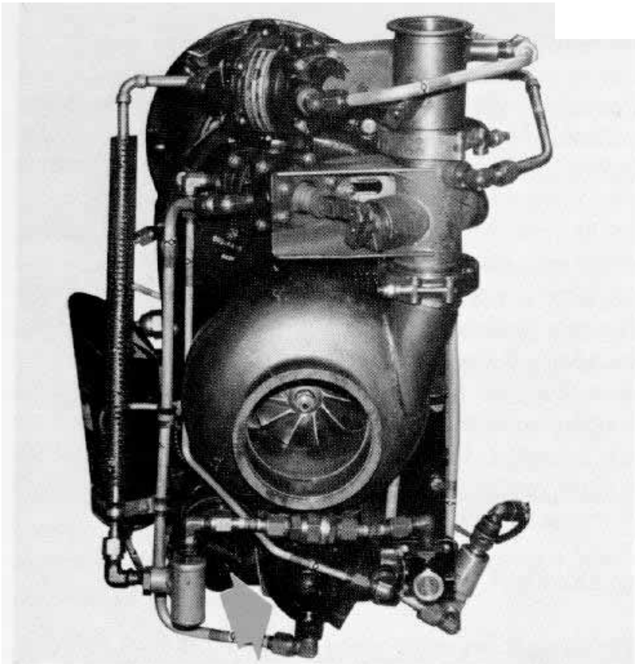


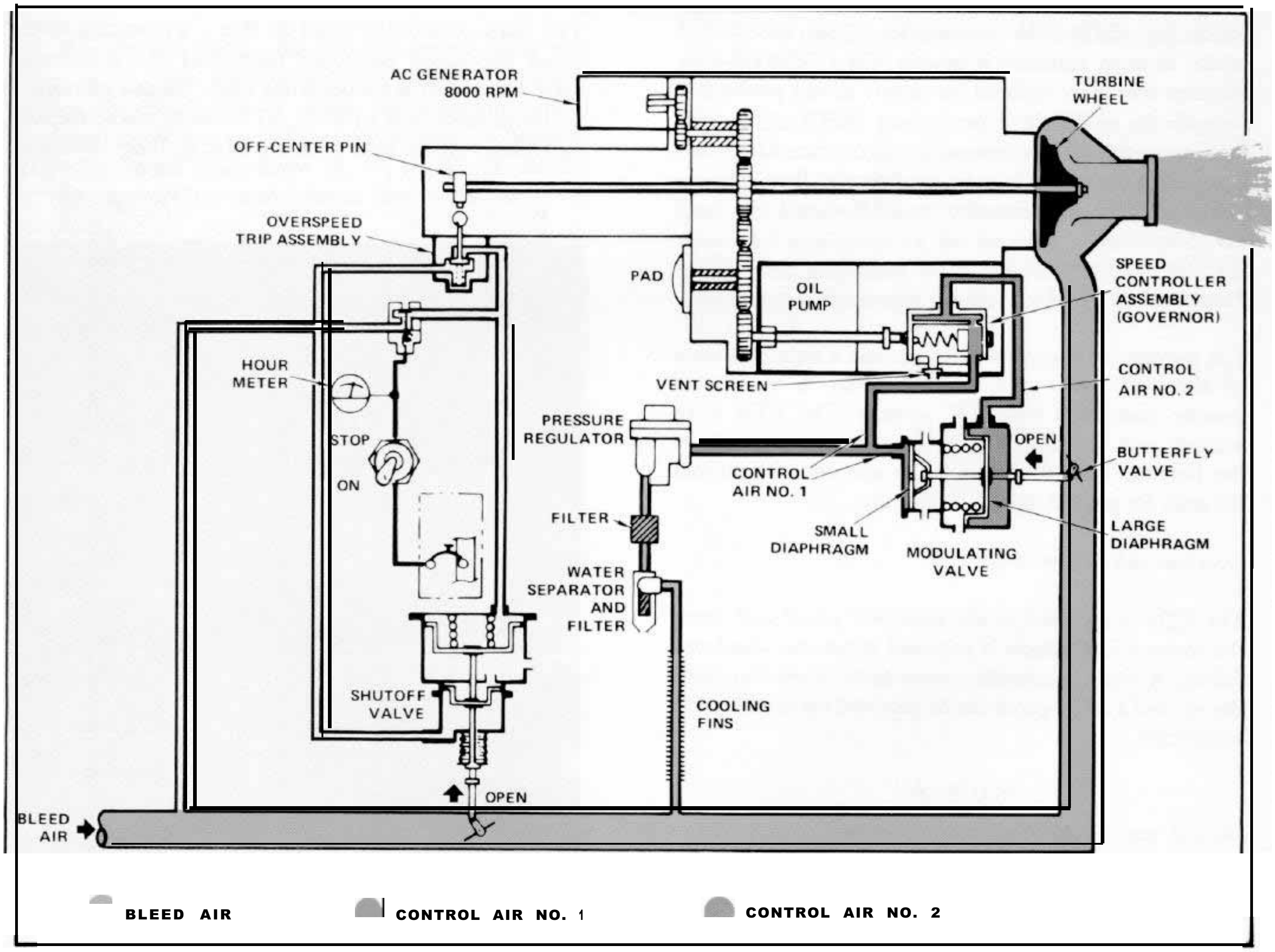
*Figure 1.* **ATM speed controller (governor).**

Speed Controller

The speed controller (governor) is mounted on the lower aft side of the ATM housing and is driven by a coupling in the oil pump (Figure 1). Control air tapped from the downstream side of the shutoff valve is directed into the speed controller and modulating valve by way of a water separator, filter, and a pressure regulator which limits control pressure to 55 psi (Figure 2). For the purposes of this discussion, we shall call the air paths which lead to the speed controller and the modulating valve ***control air No. 1.*** We shall refer to the air path from the speed controller assembly to the modulating valve large diaphram as ***control air No.*** 2.

If the rotating portion of the speed controller is sensing a speed of less than 43,000 rpm, it ports more control air No. 2 to the larger diaphragm of the modulating valve. The force of control air No. 2 acting on the large diaphragm is greater than the force of the spring and control air No. 1 acting against the small diaphragm, resulting in actuator shaft movement opening the modulating valve

*Figure 2.* **Typical ATM airflow – unit in operation.**



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butterfly. The ATM turbine wheel then begins rotating at a higher speed because of the increased air flow. As the speed of the turbine approaches 43,000 rpm, a centrifugal piston in the rotating portion of the speed controller begins closing off the path of control air No. 2 that is going to the large diaphragm of the modulating valve. The closed-off portion of control air No. 2 is vented overboard through a vent screen located at the bottom of the oil pump housing (Figure 3). The reduced pressure of control air No. 2 at the modulating valve's large diaphragm allows the spring force and control air No. 1 acting on the small diaphragm to move the modulating valve's butterfly toward the closed position. A balanced condition is reached, and the speed controller, by sensing small changes in turbine speed, regulates the pressure of control air No. 2 to the large diaphragm of the modulating valve. This action permits the modulating valve to regulate the flow of bleed air to the ATM turbine, controlling ATM speed.

### Modulating Valve

The modulating valve consists basically of a butterfly, a butterfly actuating shaft, two diaphragms, and a spring (Figure 2). Both diaphragms are mounted on the butterfly actuating shaft, but are separated into two separate chambers so that they tend to oppose one another. Control air No. 1 acts against the smaller of the two diaphragms, moving the butterfly towards the closed position. Control air No. 2 acts against the larger diaphragm and spring tension to move the butterfly towards the open position. A spring is mounted on the butterfly actuating shaft to aid the smaller diaphragm in closing the valve.

## SERVICING TIPS

For simplicity and ease of logistic support, it is best to service the ATM with the same oil used in the Hercules aircraft engines.

There are two sight glass windows on the aft outboard side of the ATM gear case (see Figure 4). Near the top of the sight glass, a full mark has been etched in the housing. The oil should be at this mark when the ATM is properly serviced. If it is not at the mark, remove the oil overflow cap located just inboard of the upper sight glass. Add oil through the oil servicing port, located on the top of the gearcase housing, until the oil flows out of the overflow port. Replace both the filler cap and the overflow cap. The oil level will now be even with the full mark of the upper sight glass window, indicating a correctly serviced ATM.

## TROUBLESHOOTING TIPS

The following troubleshooting guide will provide some additional information to supplement the maintenance manual troubleshooting data.

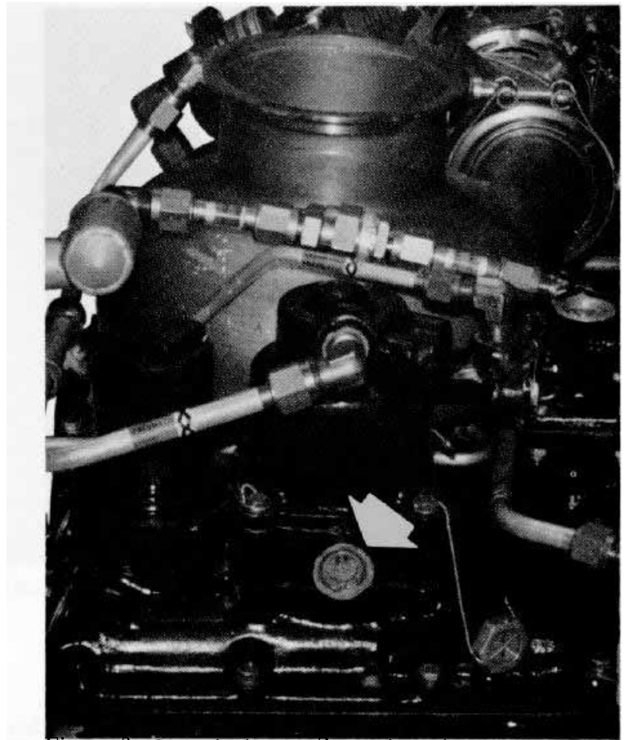
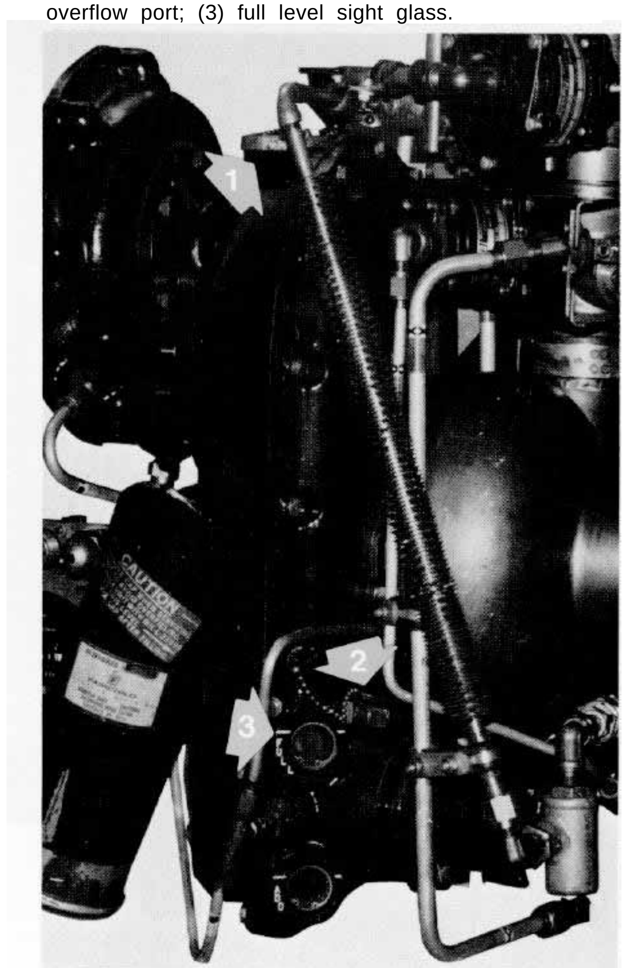


Figure 3. Control air No, 2 overboard vent

*Figure 4.* ATM servicing: (1) oil servicing port; (2) overflow port; (3) full level sight glass.



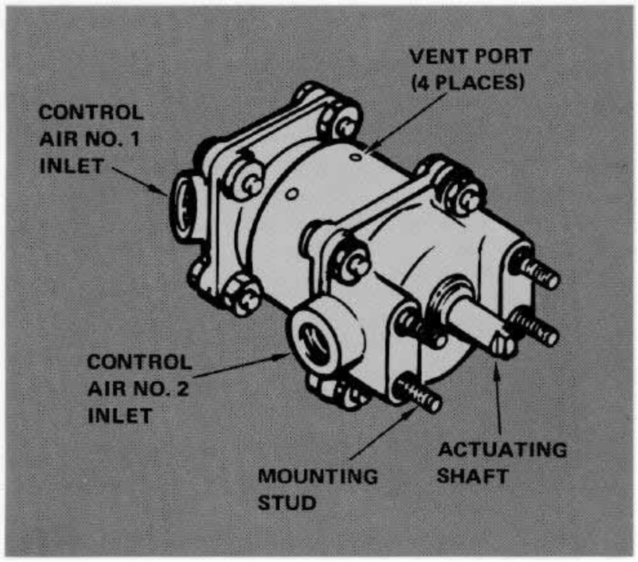
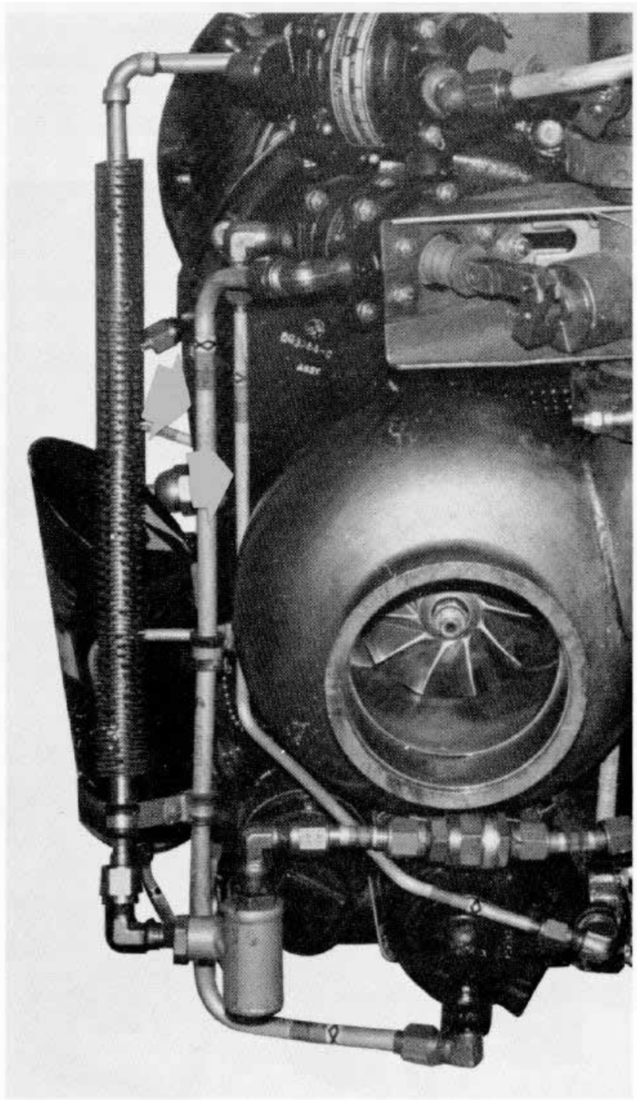



*Figure 5.* Modulating valve actuator assembly (typical).

Figure 6. ATM control air lines.



**Problem:**

The ATM speed **fluctuates after** the first 2 or 3 minutes of operation, as shown by the AC generator frequency meter.

**Possible Causes:**

. ***A ruptured or leaking diaphragm in the modulating valve.*** This discrepancy can be checked by covering three of the four vent ports on the modulating valve diaphragm body and checking for air flow from the fourth (see Figure 5).

. ***Loose control air line B nut or cracked line.*** Check for this discrepancy by removing the control air lines and inspecting the flares and AN fittings. Inspect the length of each line for evidence of cracks or holes. Reinstall the control air lines. and torque the B nuts to the appropriate value specified in the applicable maintenance manual (See Figure 6).

Problem:

The ATM generator output power drops off, indicated by the illumination of the GENERATOR OUT light, with no load indicated on the ATM loadmeter.

This condition can occur when the speed of the ATM is decreasing below the range of the AC generator frequency meter, or when the generator control relay is opened because the frequency of the ATM generator is below its operating limits.

**Possible Causes:**

. ***Insufficient aircraft air manifold pressure.*** This situation may be evident when the aircraft is operated at high altitudes, and/or the ambient temperature is extremely high.

Check for this condition by observing the aircraft bleed air manifold pressure gage at the time the discrepancy is noted. Pressures above 25 psi indicate that the problem lies with the ATM and not the aircraft bleed air. Pressure below this level indicates that the GTC is not producing sufficient air to support all bleed air needs, or that some other system is robbing the air needed for ATM operation.

• ***Control air filters dirty or clogged (see Figure 7).*** There are two filters in the control air path of some configurations and three on others. All the air filters are micronic filters and should be cleaned ultrasonically or replaced when dirty.

. ***Pressure regulator defective (see Figure 8).*** Disconnect the small control air line at the inlet of the speed



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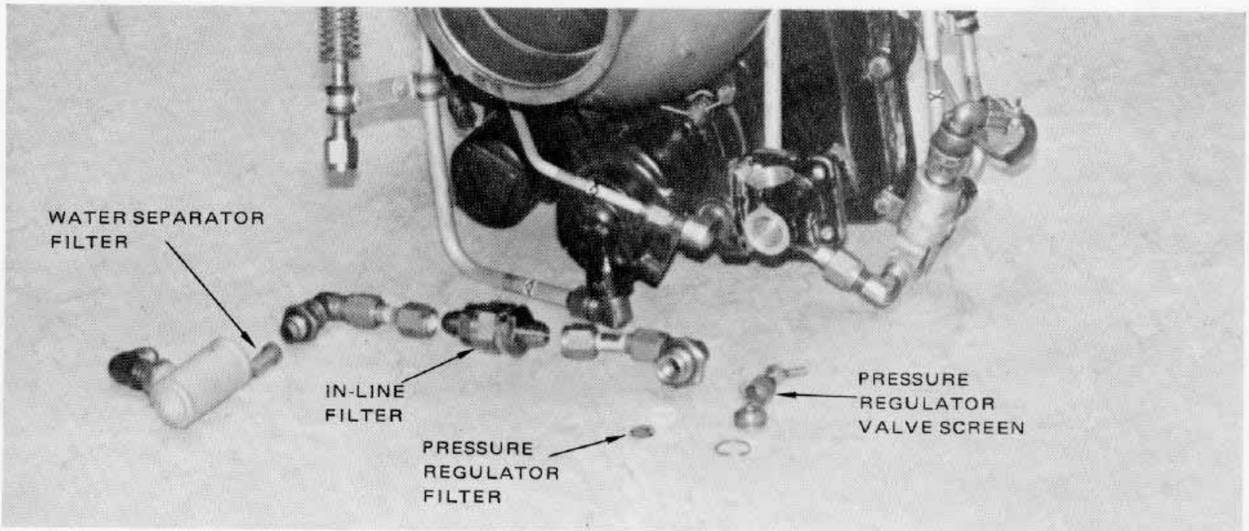
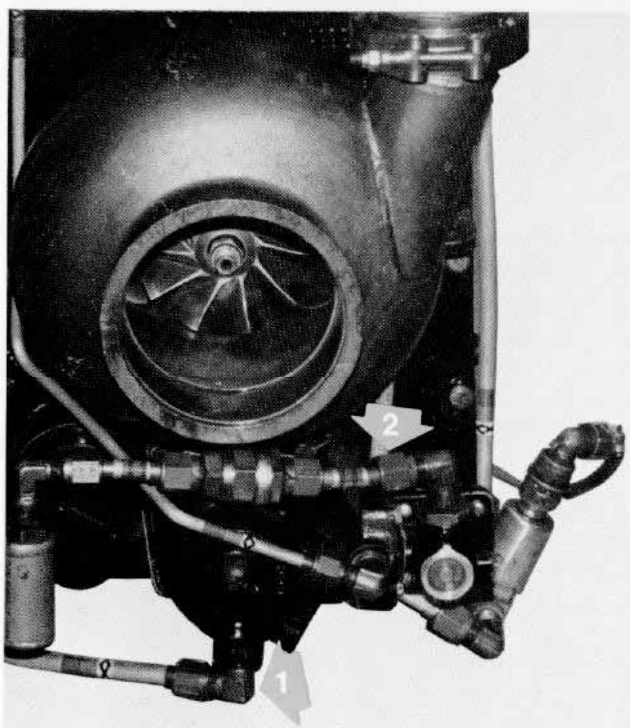



*Figure 7.* **Control air filter location (three-filter configuration).**

controller (Item 1), and attach an accurate air pressure gage with a range of 0 to 100 psi. Disconnect the control air inlet line to the pressure regulator (Item 2), and apply shop air to this port (maximum 100 psi). Pressure at the gage should be 55 psi.

. ***Diaphragm ruptured in shutoff valve.*** Check for air leaking through the bleed air hole in the ambient portion of the shutoff valve housing (Figure 2).

*Figure 8.* **Pressure regulator test attach points (see text).**




Problem :

The ATM overspeeds. This condition may or may not result in an overspeed high enough to trip the overspeed trip assembly.

**Possible Causes:**

- **Control *air No. 2 overboard vent screen (located on bottom of oil pump housing) is restricted or plugged (see Figure 3).*** Remove the snap ring, shim, washer, breather screen, and insert from the overboard vent orifice. Clean in a suitable solvent and reinstall in the reverse order.

- ***Faulty speed controller.*** Replacement of the speed controller (governor) is recommended.

The ATMs that are installed in Hercules aircraft are reliable and generally easy to maintain. But the equipment is no longer new, and a little extra care and maintenance savvy will go a long way toward keeping these units at top efficiency for their full operating lifetime.

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# Track Shoe Shop Aid

***new tool facilitates track shoe servicing . . .***

***by*** Jack McHaney, ***Aircraft Mechanic, General***

The proper operation of the Hercules aircraft main landing gear (MLG) requires proper adjustment and maintenance of the MLG shoes.

To adjust or replace the upper MLG shoes, it is necessary to loosen or remove the upper track shoe attachment bolts. When these attachment bolts are loosened or removed, the strut can move outboard enough to cause binding of the shoes against the tracks. A shop aid has now been designed that can relieve pressure on the track shoes.

The shop aid is used to position the shock strut so that there is no pressure against the shoes while the track shoe attachment bolts are loosened or removed during maintenance. This should make MLG shoe adjustment or replacement easier and faster.

Using **the Track** Shoe Shop Aid



The track shoe shop aid (Figure 1) is used in the following manner:

Jack the aircraft following instructions in the applicable maintenance manual.

Place the tool's flanged arms (1 and 2) over the forward and aft vertical beam flanges of the selected MLG shoe track assembly. See the example in Figure 1.

Close the shop aid's flanged arms (1 and 2) by tightening the wing nuts (3 and 4) of the threaded block thru-bolts.

Position the shop aid so that the screw jack contact block (5) is at least 3 inches from the top of the MLG shock strut (Figure 2).

Hold the shop aid in position by turning the screw jack handle (6) clockwise until the flanged arms and contact block are securely in place.

Shoe centering is accomplished by turning the screw jack handle clockwise to relieve the pressure between the outboard face of the shoes and inboard face of the shoe tracks.

With the upper track shoes held in the center of the tracks, the track shoe attachment bolts may be loosened or removed as necessary to carry out the required maintenance activity.

Remove the shop aid by turning the screw jack handle counterclockwise, then loosen the thru-bolt wing nuts.

Repeat the preceding operation as required to complete track shoe maintenance of all MLG upper track shoes.

Note

1. The shop aid will fit either the forward or aft MLG shock struts. Just rotate the tool 180” as required.

2. In Figure 4 (item 1A and 2A), multiple sets of holes arc shown. The extra holes permit adjustment of the tool to tit various MLG vertical beam configurations.

We believe that the use of this tool can save significant amounts of time and **money** when MLG track shoe maintenance is required. If you are interested in acquiring this useful new tool, please contact your Lockheed-Georgia Service Representative or Lockheed-Georgia Logistics, Dept. 65-11. Specify Lockheed Part Number 3402799.

The following list of construction materials and drawings should be helpful for those who prefer to build their own shop aid.

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**MLG track shoe shop aid in use.** *Photo courtesy of Jack McHaney*

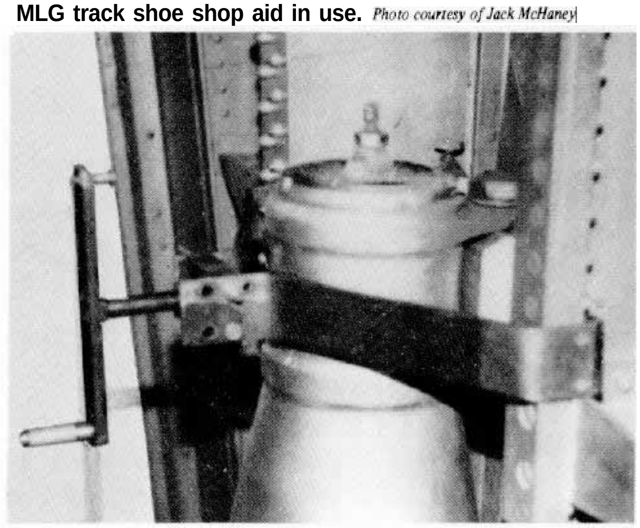
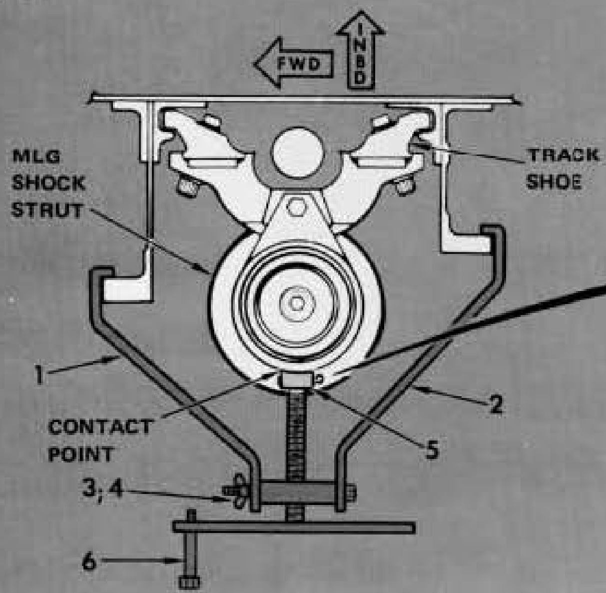
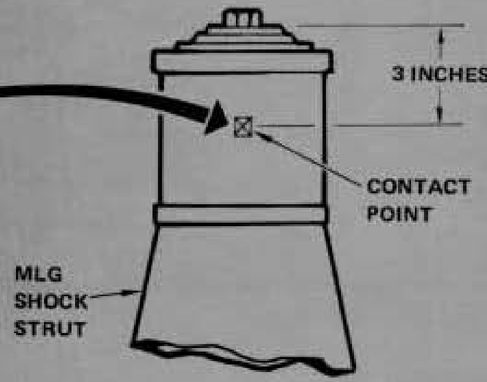


*Figure 1*




VIEW LOOKING DOWN

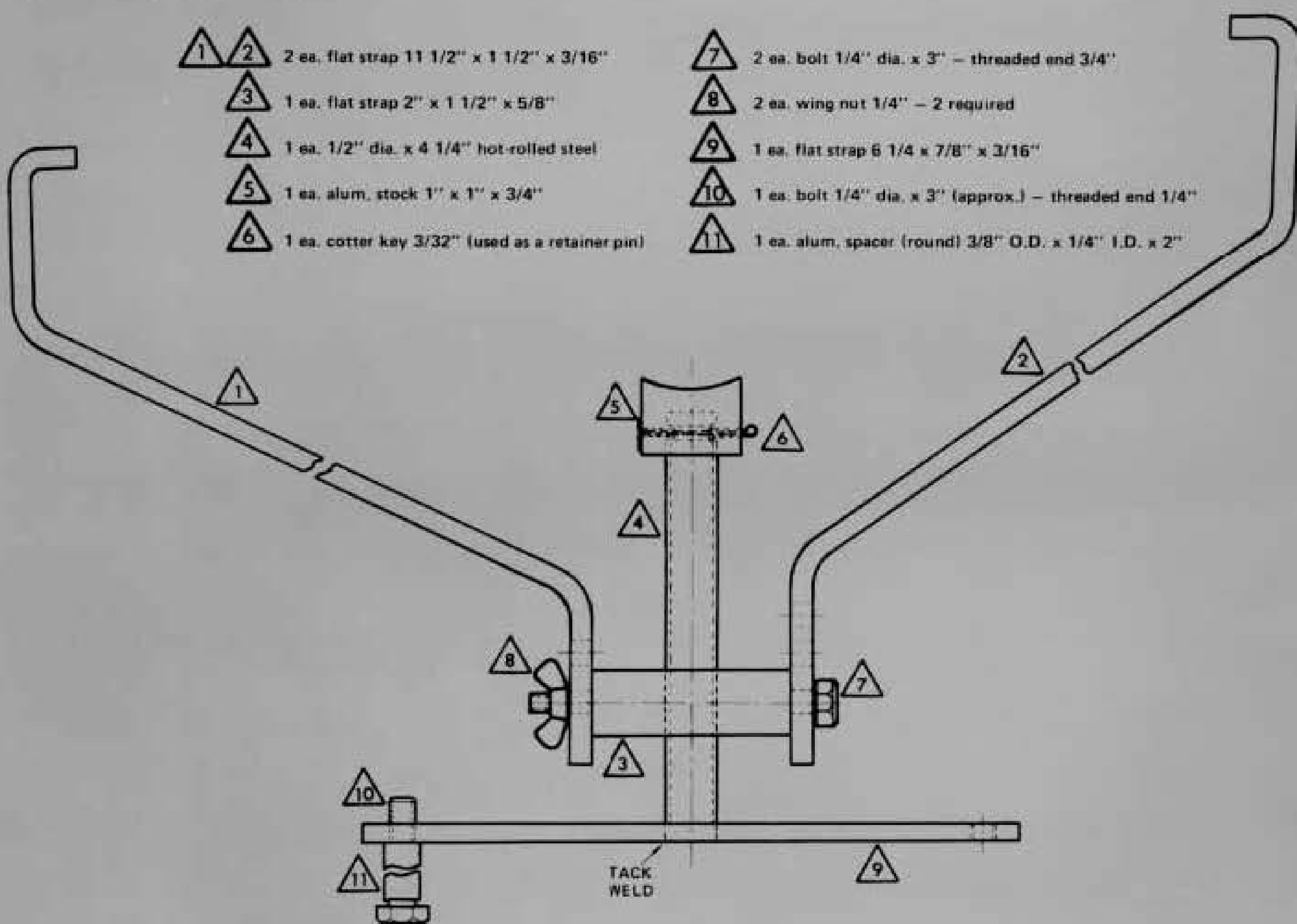
*Figure 2*




VIEW LOOKING INBOARD

*Figure 3.* Shop Aid Materials List

- 1, 2 — 2 ea. flat strap 11 1/2" x 1 1/2" x 3/16"
- 3 — 1 ea. flat strap 2" x 1 1/2" x 5/8"
- 4 — 1 ea. 1/2" dia. x 4 1/4" hot-rolled steel
- 5 — 1 ea. alum. stock 1" x 1" x 3/4"
- 6 — 1 ea. cotter key 3/32" (used as a retainer pin)
- 7 — 2 ea. bolt 1/4" dia. x 3" – threaded end 3/4"
- 8 — 2 ea. wing nut 1/4" – 2 required
- 9 — 1 ea. flat strap 6 1/4 x 7/8" x 3/16"
- 10 — 1 ea. bolt 1/4" dia. x 3" (approx.) – threaded end 1/4"
- 11 — 1 ea. alum. spacer (round) 3/8" O.D. x 1/4" I.D. x 2"



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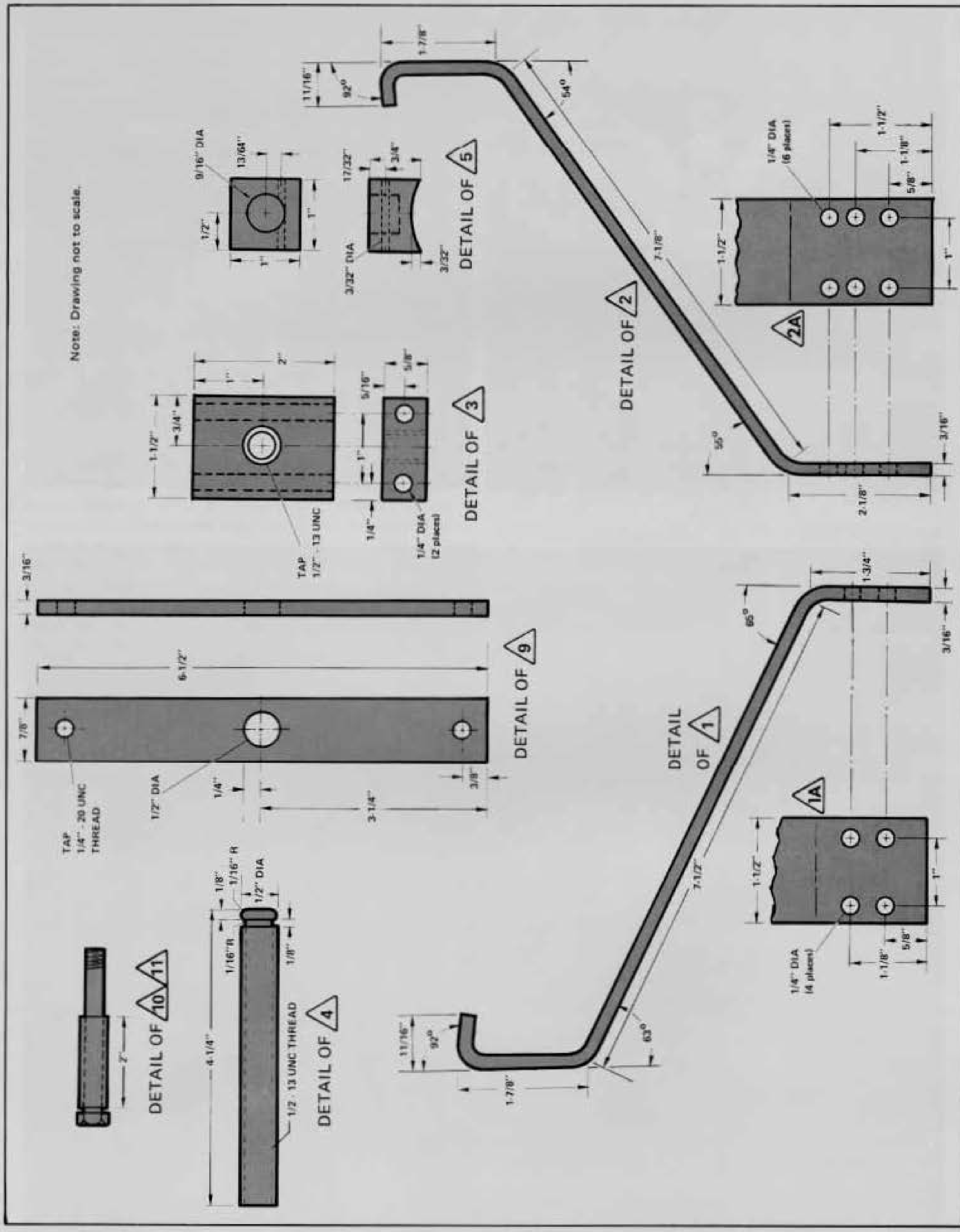


*Figure 4.* Construction plans for MLG track shoe shop aid.

The wives of several Sudanese Ah Force personnel recently visited facilities of Lockheed-Georgia, where Hercules aircraft similar to those operated by Sudan are being built. The visitors toured the production floor, the fligbt line, and the training classrooms. The ladies were in the U.S. to spend some time with their husbands, who have attended Lockheed classes for the past 11 months. The couples visited local points of interest, and were treated to local hospitality. Most of the wives returned to Sudan after a one-to-three-month stay.

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## CORRECTION:

In the "Shock Strut Servicing" article that appeared in V7N3, there is an error on page 13. Photograph B should show the "X" distance as being the distance between the upper and the lower torque arm bolts (photo at right), rather than the distance between the lower torque arm bolt and the torque arm disconnect bolt.

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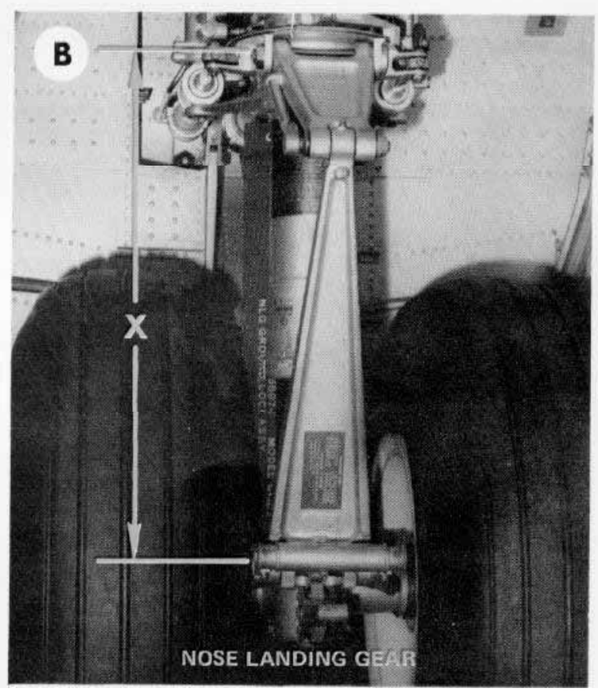


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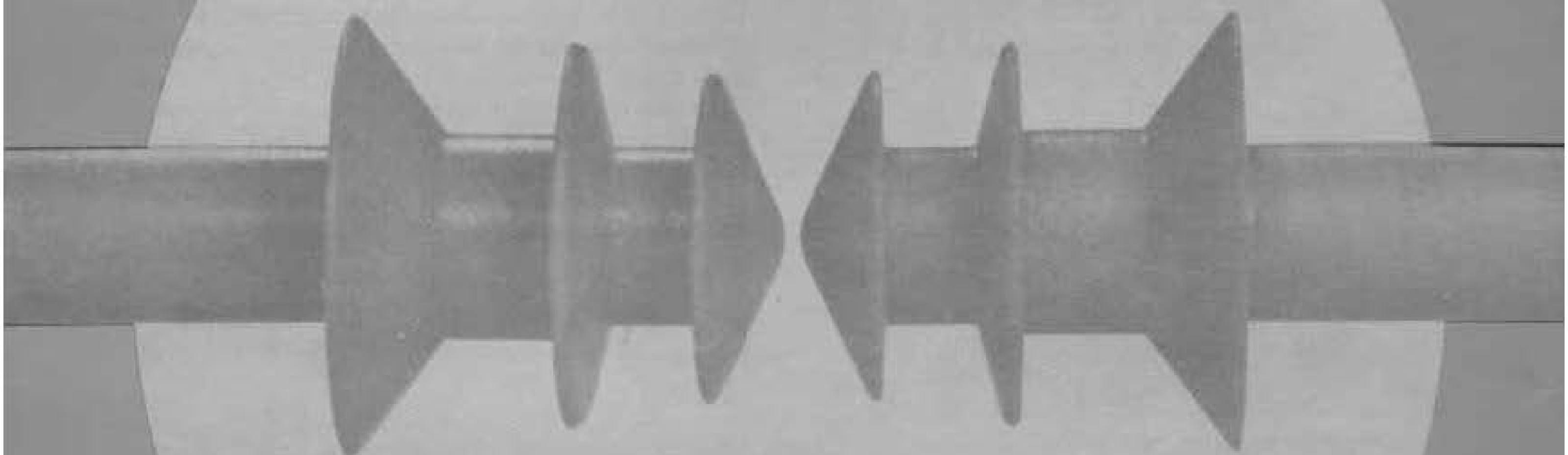
CUSTOMER SERVICE DIVISION
LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED CORPORATION
MARIETTA, GEORGIA, 30063

# STICK IT IN YOUR EAR



# Wear ear protection protect your hearing

When your work assignment requires extended exposure to high noise levels, always use proper ear protection to prevent permanent hearing loss.