

SERVICE NEWS

A SERVICE PUBLICATION OF LOCKHEED GEORGIA COMPANY, A DIVISION OF LOCKHEED CORPORATION

 **Service News**

A SERVICE PUBLICATION OF
LOCKHEED-GEORGIA COMPANY
A DIVISION OF
LOCKHEED CORPORATION

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Cover: A Hercules C Mk 1 and a Hercules C Mk 3 belonging to the Royal Air Force are shown flying in formation at Marietta, Ga. The C Mk 3 is a C Mk 1 that has been "stretched" 180 inches. All together, the RAF plans to stretch 30 of their more than 60 Hercules aircraft.

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Art McCrum in the new computer-graphics facility.

Focal Point

A UNIQUE PARTNERSHIP

We in Customer Service are indeed fortunate. Every day, our activities afford us the opportunity of working and associating with the finest people in the world - our customers! It has been our privilege to provide factory maintenance training on Lockheed-Georgia Company aircraft to over 10,000 customer personnel. Working side by side with our friends, we have successfully introduced Hercules and JetStar aircraft into service in 55 countries. Currently we have more than 100 service representatives assigned at over 50 locations around the

globe, assisting our customers in further training of their personnel and in achieving full utilization of the capabilities built into their aircraft.

Training is a key ingredient in the successful management of a complex system such as an aircraft. We spare no effort to make certain that the training programs we offer to our customers are second to none. Our professional training specialists constantly screen all field reports and engineering data to stay abreast of operational situations. They maintain our training materials current with changing conditions and configurations to ensure that training at the factory or by our service representatives in the field will reflect the latest technical information and service experience. Since even the best and most up-to-date training information is of little value unless it is readily available when needed, we have recently installed word-processing and computer-graphics equipment of the latest design to help us keep our training materials both accurate and accessible.

Making sure that our customers can always be provided with training materials and instruction of uncompromising quality is an important part of what we do in Customer Service, but the full scope of our mission is much broader. It includes maintaining an in-plant, field-experienced staff of service analysts dedicated to resolving any situation you might encounter in the maintenance and operation of our products. Through them, the entire resources of Lockheed and our vendors may be called upon to assist you. It also includes providing this magazine and all of the maintenance-related information it contains.

And there is much more. Customer Service represents the total commitment of our Company to maximize the value received for every investment in our products. The response that you, our customers, have made to this commitment is reflected in the unique spirit of partnership that has long been characteristic of the link between those who build Lockheed-Georgia aircraft and those who use them. We are extremely proud of what you have accomplished with our products. The nearly 22 million flight hours that have been accumulated on our aircraft in the last quarter century stand as eloquent testimony to the magnitude of your success.

We take great satisfaction in the contribution you have permitted us to make toward your achievement. First and foremost, our mission remains to assist you in every way possible. Please do not hesitate to call on us. Working together today to bring tomorrow's goals within reach is what partnership is all about.

Sincerely,

A. H. McCrum
Director - Customer Service

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LOCKHEED-GEORGIA COMPANY
MARIETTA, GEORGIA 30063

T. J. Cleland Director

CUSTOMER SERVICE

A. H. McCRUM
DIRECTOR

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DIRECTOR

CUSTOMER SUPPLY

M. M. HODNETT
DIRECTOR

The Hercules W Mk 2 weather reconnaissance aircraft at high altitude. It is operated by the Royal Aircraft Establishment Farnborough, U.K.



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Troubleshooting Pressurization Problems

by Arch H. McCleskey, Jr., Service Representative

Everyday wear and tear, together with the adverse effects of time and weathering, inevitably take their toll on an aircraft's structure and the components of its systems. As the flight hours and calendar years add up, it usually requires a greater maintenance effort and a more comprehensive arsenal of troubleshooting skills to keep an airplane's basic operating systems functioning like they did when they were new.

A case in point concerns pressurization systems. Probably no aircraft system is more vulnerable to the cumulative effects of age, wear, and physical damage than a modern airplane's complex – and crucial – air conditioning/pressurization system. With the passage of time, cabin leaks tend to increase in both number and volume, and pressurization equipment often declines in efficiency. The eventual result may be an airplane that starts to collect writeups because the crew is unable to obtain maximum differential pressure or maintain the desired cabin altitude above a certain flight level.

Not even the tough and reliable Hercules airlifter is immune from trouble in this area. If you happen to have a Hercules aircraft in your inventory that has begun to show symptoms of inadequate pressurization, this article is for you. In the next few pages you will find troubleshooting tips designed to help you restore full performance to a faltering pressurization system. Let's start by looking at a few basic facts about pressurization and then use them to determine what kinds of problems are most likely to be the cause of unsatisfactory pressurization performance.

The principle that underlies the use of pressurization in aircraft is the observation from elementary physics that whenever more air is pumped into a vessel than is allowed to escape from it, the pressure inside increases. As applied to high-altitude flight, the idea is to pump enough air into a more or less sealed cabin to maintain a safe and comfortable "cabin altitude" even though the actual altitude at which the aircraft is flying may be

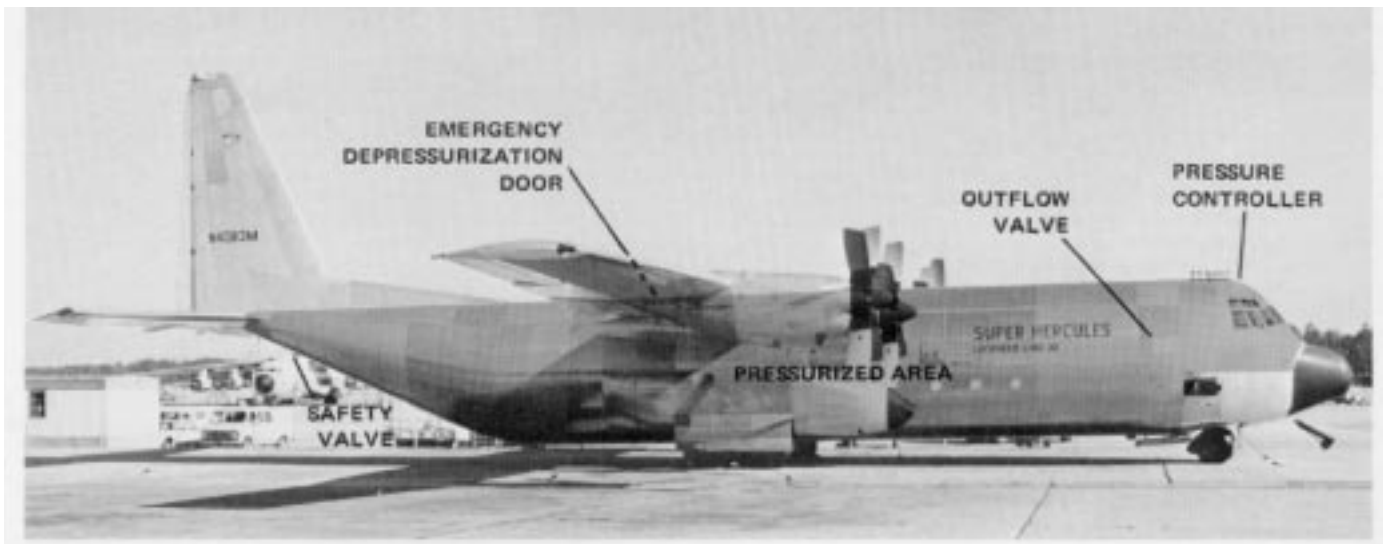


Figure 1. Pressurization system component locations.

much higher. The success of this arrangement is dependent upon having the ability to maintain a certain minimum air pressure within the cabin under all operational conditions. If this cannot be done, it is either because not enough air is getting in, or too much air is getting out.

Pressurization problems are commonly traceable to one or another of several possible trouble spots, but sometimes a combination of factors is to blame. Cabin leakage is the first thing that usually comes to mind when insufficient pressurization is reported. Excessive cabin leakage may in fact be involved, particularly with older airplanes, but air leaks can be difficult and time-consuming to find. Unless there is obvious damage to a seal or to the aircraft structure, it is usually best to check out some of the other possibilities first. Even where cabin leakage is somewhat greater than normal, pressurization may not become inadequate until another problem impairs the system's efficiency.

TROUBLESHOOTING THE SYSTEM

One of the first questions to ask is: Can pressurization be obtained in the MANUAL mode but not in the AUTO mode? If the answer is yes, the problem is trouble in the cabin pressure control equipment, not an inadequate air supply. The following troubleshooting procedure may be used to help you isolate a defective pressure controller or outflow valve (Figure 1).

Pressure Controller and Outflow Valve Check

The test equipment required is a vacuum gage with a flexible hose that can be connected to the pressure controller and to the flex lines which attach to the controller.

1. Apply external power to the aircraft so that 28 VDC will be available for operation of the various components.
2. Remove the fasteners holding the air conditioning and pressurization control panel and lower the panel so that you can gain access to the rear of the cabin pressure controller.
3. Pressurize the bleed air manifold, using the aircraft gas turbine compressor (GTC) or auxiliary power unit (APU).
4. Disconnect the jet pump flex line from the ATMOS 3 port located on the back of the pressure controller (Figure 2) and connect the vacuum gage to the jet pump flex line. On A-model Hercules aircraft, you may find that it is easier to connect the vacuum gage directly to the jet pump, which is located on the outflow valve (Figures 2 & 3). To do so, first disconnect the jet pump line from the aft port of the jet pump.
5. Check the vacuum gage reading. If it is greater than 5 inches of mercury (in. Hg), proceed to Step 6. If the indication is less than 5 in. Hg, clean the jet pump filter (Figure 2) and inspect the lines to and from the jet pump. Recheck the output of the jet pump, and if it is now greater than 5 in. Hg, go on to Step 6. If not, check the tightness of the bleed air line fitting at the jet pump and make sure that the closure of the jet pump O-ring (P/N 58990-114) is airtight.
6. Reconnect the jet pump flex line to the pressure controller (or the jet pump line to the jet pump).
7. Disconnect the pneumatic relay line from the OUTFLOW VALVE port at the back of the pressure controller and attach the vacuum gage to the OUTFLOW VALVE fitting on the pressure controller (Figure 2).

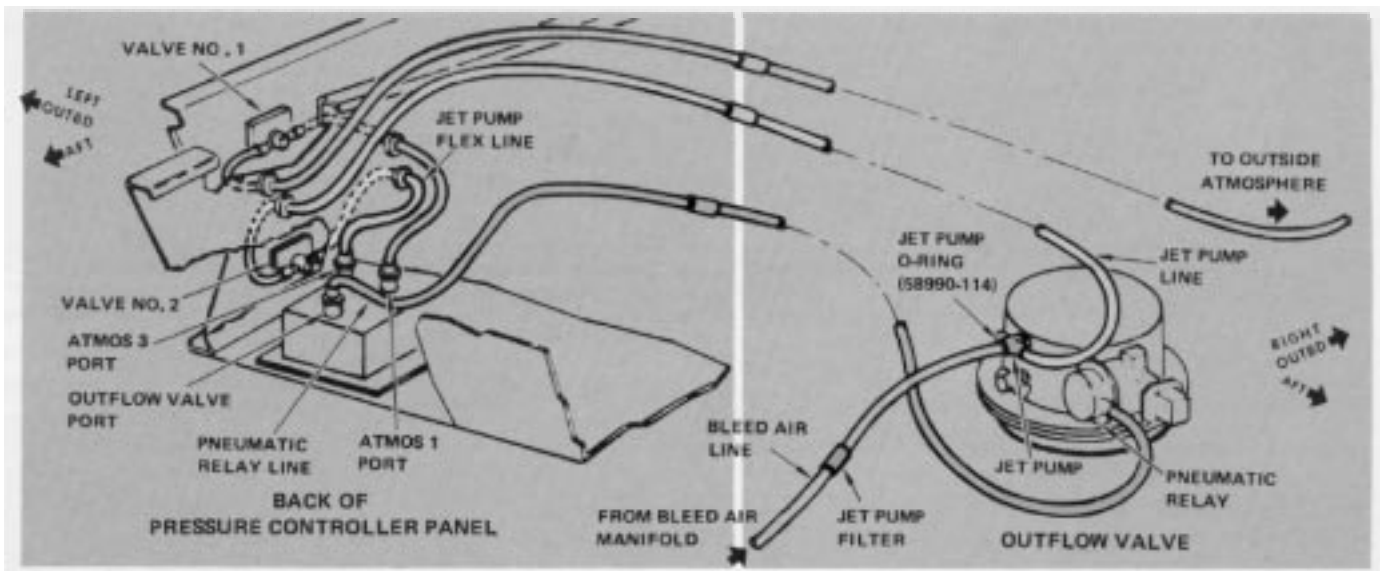


Figure 2. Cabin pressurization control components.

8. Move the cabin altitude selector knob to the minus 1000-foot position, and position the air conditioning master switch to AUTO PRESS or AIR COND AUTO PRESS, depending on the model of Hercules aircraft you have.

9. Check the vacuum gage. If the gage indicates 0.4 in. Hg or less, proceed to Step 10. If the gage indicates 0.5 in. Hg or greater, replace the pressure controller.

10. Move the cabin altitude selector knob to 8000 feet and the rate knob to MAX. Check the vacuum indication on the gage. If the pressure is less than 1 in. Hg, replace the pressure controller. If the pressure is greater than 1 in. Hg, reconnect the pneumatic relay line to the OUTFLOW VALVE port on the pressure controller and then check the position of the outflow valve.

a. If the outflow valve is open, move the cabin altitude selector knob to minus 1000 feet; the valve should soon close. If the valve closes, the system is satisfactory. If the valve remains open, clean the pneumatic relay and repeat this step. If the valve still fails to close, replace the outflow valve.

b. If the valve is closed, clean the pneumatic relay and repeat Step 10. If the valve remains closed, replace the outflow valve.

Cabin Leakage Check

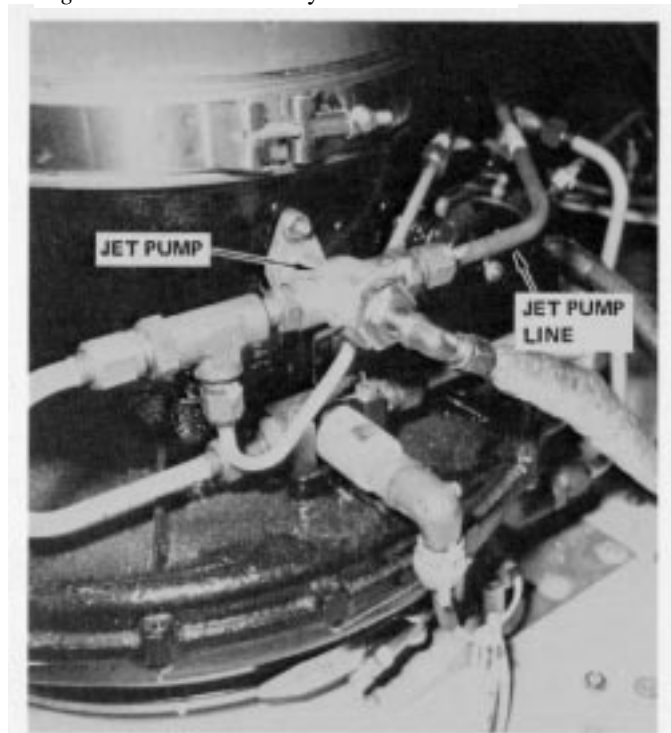
Up to this point, the troubleshooting procedure has involved a pressurization system which operates normally in the MANUAL mode, but not in the AUTO mode. If normal pressurization cannot be maintained in MANUAL or AUTO, the problem is probably not in the pressurization control part of the system, but elsewhere. The

problem is probably caused by cabin leakage, or by an insufficient amount of air being pumped into the aircraft.

To measure the rate of cabin pressure leakage, you need to perform a cabin pressure leakage or decay check. Several kinds of leak checks are described in the various maintenance manuals dealing with the pressurization system. To pressurize the aircraft, you can use bleed air from the engines, GTC, APU, or an external compressor such as the MA-1A. The basic idea in each of these checks is to close the aircraft as tightly as possible,

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Figure 3. Pressurization system outflow valve.



to pressurize it to a certain level, and then to measure how long it takes for the pressure to decay to another level of pressurization.

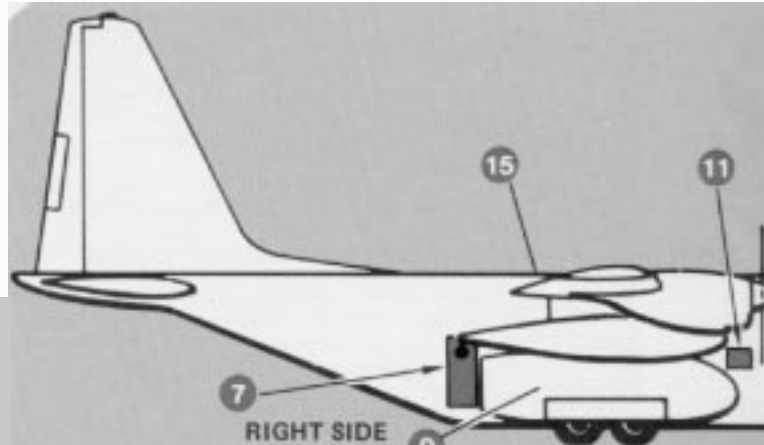
Lockheed engineering recommends using the following procedure when accomplishing the pressure decay check:

1. Pressurize the aircraft to above 8 in. Hg (3.93 psi) differential, using the procedures outlined in the appropriate Hercules aircraft maintenance manual.
2. Position the flight station and cargo compartment air conditioning shutoff switches, located on the air conditioning and pressurization control panel, to OFF.
3. Check pressurization decay from 8 in. Hg (3.93 psi) to 6 in. Hg (2.95 psi). The time should not be less than the number of seconds shown below for each of the listed basic Hercules aircraft types.

U. S. Military:	
C-130A.	35 seconds
C-130B.	35 seconds
C-130E.	35 seconds
C-130H.	35 seconds
Other Military:	
C-130E.	52 seconds
C-130H.	52 seconds
C-130H-30.	65 seconds
Commercial:	
L-100.	72 seconds
L-100-20.	82 seconds
L-100-30.	90 seconds

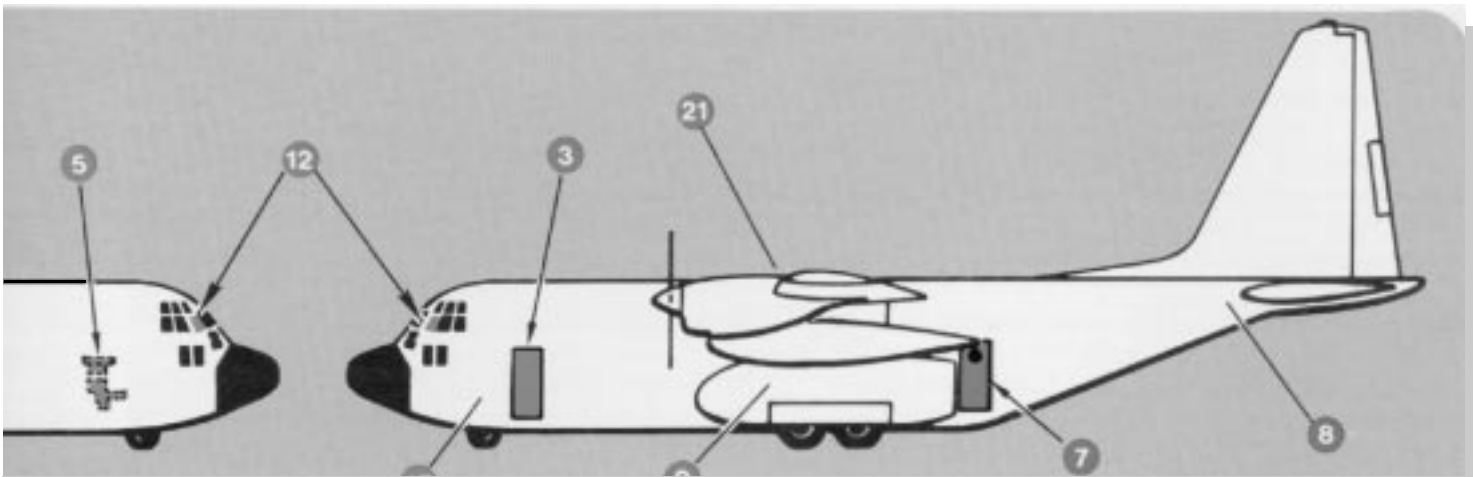
An element you should consider when doing this test is the elevation above sea level of the location at which you are performing the test. Add one second to the above values for each thousand feet above sea level of your facility.

If the timed pressure decay leakage test is unsatisfactory, the cabin is leaking excessively. To find where the leaks are, pressurize the aircraft to 2 to 3 in. Hg (0.98 to 1.47 psi) and inspect the fuselage door seals, exterior surfaces, and joints. Leaks can be located by feel or by using an approved liquid leak detector or soapy solution. Figure 4 shows those areas of the Hercules aircraft which tend to leak most often. In the table, these areas are listed in the approximate order of their susceptibility to the kinds of wear and damage that can result in pressure leakage problems. A systematic approach to finding a pressure leak in an unknown location would be simply to start at the top of the list and work down.

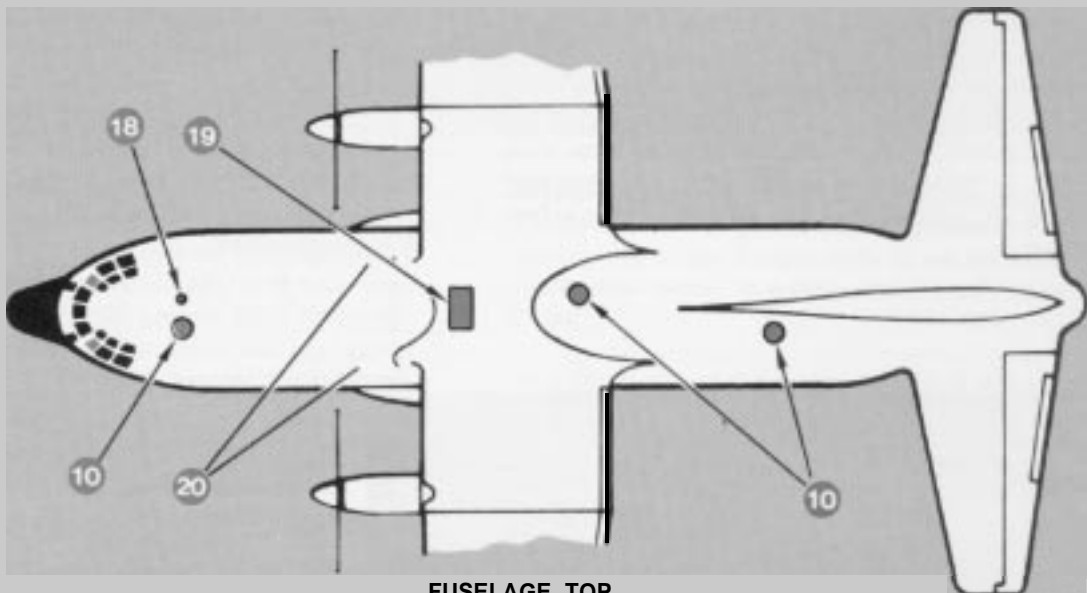


INDEX NO.	NOMENCLATURE	LEAK POINTS
1	Aft cargo ramp	Seal assembly
2	Aft cargo door	Seal assembly
3	Crew entrance door	Seal
4	Safety valve	+ Butterfly Valve
5	Outflow valve	* Butterfly valve
6	Flapper valve	seals
7	Paratroop door (2 ea)	Seal assembly
8	Elevator, rudder push pull rods	Seal assembly and boot assembly
9	MLG inspection windows 14 ea) MLG access doors 14 ea) MLG attach structure	Seals Seals Sealant and fasteners
10	Fwd, center, and ah emergency exits	Seals
11	Side emergency exit	Seals
12	Swing windows	Seal assembly
13	ADF radome	Sealant and fasteners
14	Doppler radome	Sealant and fasteners
15	Life raft cables, aileron push pull rods, and flap torque tube	Seals
16	Nose wheel well diaphragm coven (3 ea)	Saab
17	NLG inspection window and door	Seal assembly
19	Pyrotechnic pistol door	Seal assembly
19	Center wing dry bay	Cracks, duck, and conduit sealant
20	Upper recirculation duct and flapper check valve	Cracks
21	Control cables	Seals

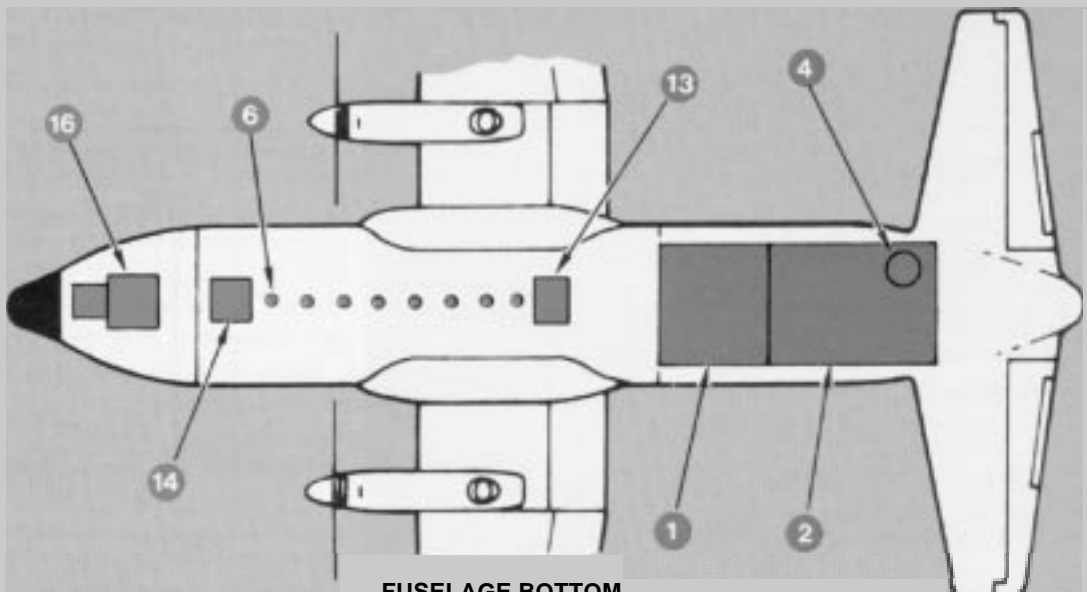
May be c from inside aircraft.



LEFT SIDE



FUSELAGE TOP



FUSELAGE BOTTOM

Figure 4. Pressurization Leak Locator Chart.

Inadequate Pressurization

If the timed cabin leakage test is satisfactory, but you are still having problems getting adequate pressurization, the problem must be insufficient airflow into the aircraft. Since air for pressurization comes from the air conditioning system, you must determine why this system is not delivering the proper amount of air.

There should be a strong flow of air from the ducts. If the flow is weak, check the position of the flight station and cargo compartment flow control and shutoff valves. An indicator on the side of each flow control and shutoff valve shows whether it is open or closed. The cargo compartment flow control and shutoff valve is designed to regulate the flow of air at 70 pounds per minute on all Hercules aircraft. The flight station flow control and shutoff valve is designed to regulate the flow at 30 pounds per minute on Hercules aircraft prior to LAC 4579 and 70 pounds per minute on Hercules aircraft LAC 4579 and later. If the flow control and shutoff valves are operating properly, but the airflow into the cargo compartment or flight station is still weak, the cause may be bleed air leaking from the affected system's heat exchanger.

Heat Exchanger Leak Check

The following check of the air conditioning system heat exchangers (flight station or cargo compartment) has been successful in solving many pressurization problems on Hercules aircraft prior to LAC 4579. This check is not practical for Hercules aircraft LAC 4579 and later since it would be necessary to remove, or loosen and turn, the cooling turbine in order to disconnect the duct between the heat exchanger and the turbine.

1. Disconnect the duct between the heat exchanger and the turbine and cap the end of the duct from the heat exchanger (Figure 5), using a locally manufactured leak test fitting (Figure 6).
2. Start the GTC or APU, or an MA-IA compressor (or equivalent) and turn on the air conditioning system being checked. Drive the temperature control valve to the full cold position.
3. Check for leaks by feeling for the presence of escaping hot air in the air intake scoop or exhaust. Leaks are very evident when they exist. Replace the heat exchanger if leaking is evident.

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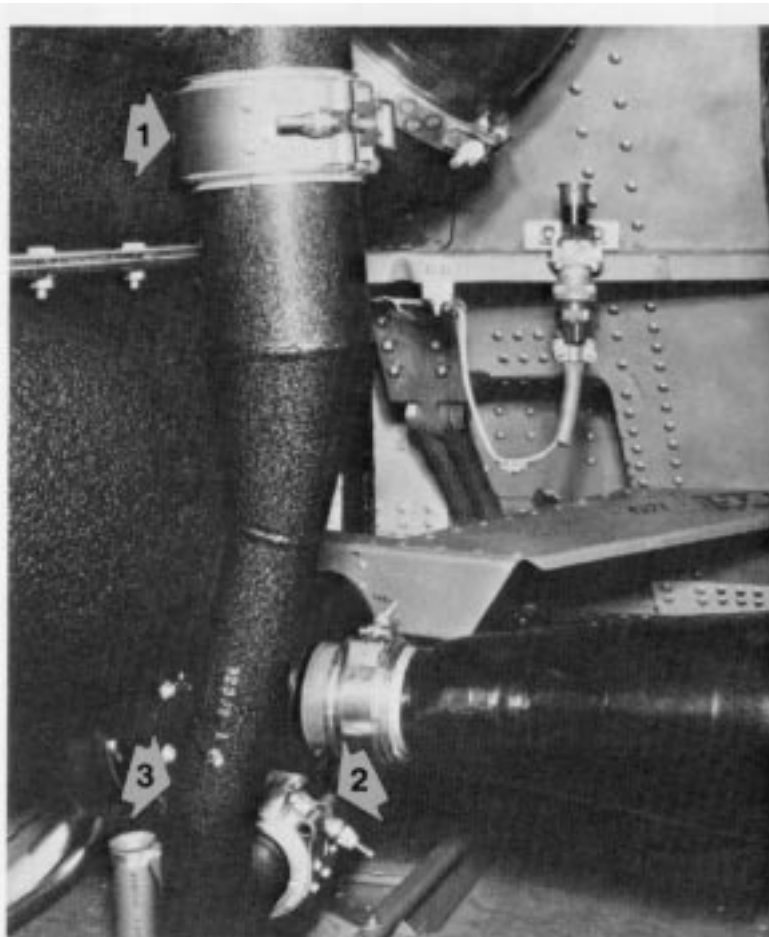
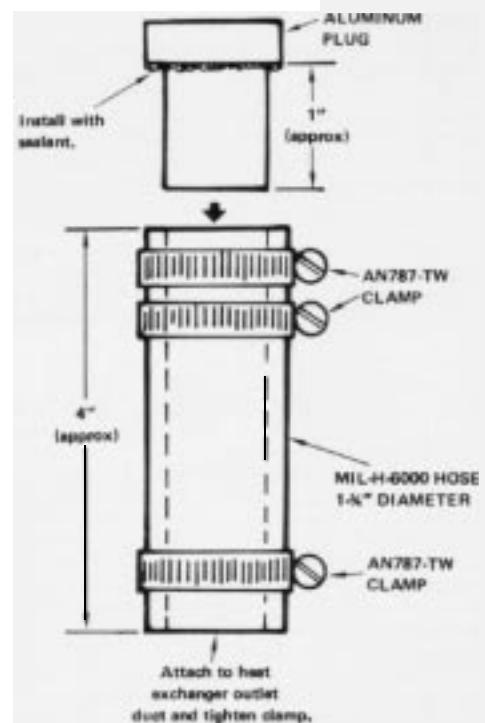


Figure 5 Heat exchanger leak check: (1) Loosen upper clamp. (2) Disconnect lower clamp. (3) Rotate duct 180 degrees to install leak test fitting. Figure 6 (below). Heat exchanger leak test fitting.



LIST OF MATERIALS			
NOMENCLATURE	PART NUMBER	SPECIFICATION	MATERIAL
Globe valve	✕ MCM NO. 4893M	3/4" - 250	Bronze globe and angle pattern valve
Air pressure gage	✕ MCM NO. J-4000	0-100 intervals of 10	
Nipple	✕ MCM NO. 45493K	3/4" x 2"	Galvanized steel
Nipple	✕ MCM NO. 45493K	3/4" x 6"	Galvanized steel
Reducing Tee	✕ MCM NO. J4520	1/2" on tee 3/4" on straights	Galvanized steel
Hex bushing	✕ MCM NO. 4535L	1/2" TO 1/4"	Galvanized steel
Adapter	NSN 4920-00-480-6191		

NOTE:
 1. Seal threaded connections with pipe cement.
 2. May be ordered from McMaster-Carr Supply Company, P. O. Box 4388, Chicago, IL 60690
 Locally obtained product must be equivalent.

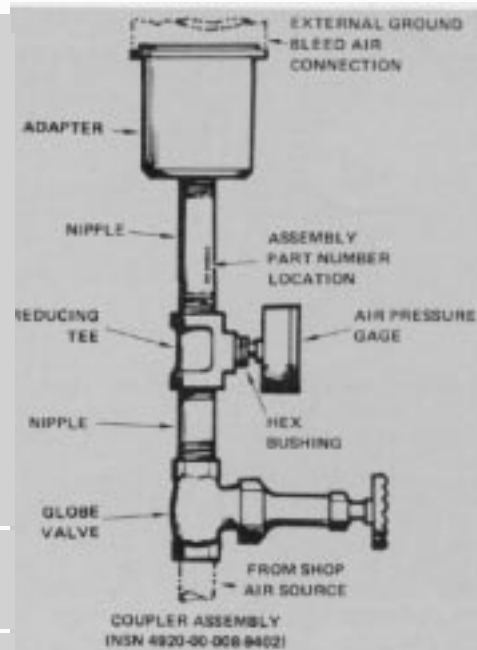


Figure 7. Ground bleed air coupler assembly.

An alternate method of checking heat exchangers for leaks is available to Hercules operators who have access to the U. S. Air Force supply system. Shop air can be made to serve in place of the GTC/APU or MA-1A compressor through the use of the ground bleed air coupler assembly shown in Figure 7. This device can be obtained as a unit from normal Air Force sources. A satisfactory substitute can be locally manufactured for use with the NSN 4920-00480-6191 adapter or the equivalent (see materials list, Figure 7).

The coupler assembly is intended to be attached to the external ground bleed air connection in the left wheel well. When shop air is used, the escaping air will not be hot. In addition to feeling for leaks, you may also hear the escaping air. This alternate method is a good procedure to use during a minor or major inspection.

Auxiliary Vent Valve and Ducting Check

Finally, the operation of the air conditioning system auxiliary vent valves and the condition of the associated ducting can play a role in pressurization problems. Insufficient airflow into the aircraft can be caused by a partially open auxiliary vent valve which allows air to escape through the exhaust port, or by leaky ducting. Note that while the following troubleshooting checks apply specifically to cargo compartment systems – which in older aircraft are more commonly affected – the corresponding components of flight station systems may be checked in a similar manner.

The auxiliary vent valve incorporates a position indicator that shows whether the valve is open or closed. If you are trying to pressurize an aircraft and suspect that the

auxiliary vent valve is not closing completely despite a CLOSED indication, feel the temperature of the air coming out of the exhaust port. If the air seems to be cooler than normal, it is likely that the valve is not fully closed.

You can verify whether or not the valve is actually closing by disconnecting the adjacent sections of ducting and examining it visually. On Hercules aircraft before serial number LAC 4579, this can be done by removing flexible coupling P/N 3439394, which connects the auxiliary vent valve to the refrigerator ram air duct assembly. On LAC 4579 and later, remove duct assembly P/N 3313859-1 or -9 in order to see the valve flapper.

On Hercules aircraft prior to LAC 4579, another possible source of leaks in this general area can be the flexible coupling (P/N 343939-3) located above the auxiliary vent valve. These couplings may deteriorate and crack with age. Also, the clamps holding the flexible coupling have been known to loosen. A careful inspection of the auxiliary vent valve and related ductwork is always justified anytime insufficient airflow into the aircraft is indicated and there is no evidence that the flow control and shutoff valve is operating improperly.

There is one other point that is important enough to be worth repeating. Pressurization problems are not limited to excessive cabin leaks, or faulty valves, or inefficient air conditioners. They are often a combination of deficiencies in two or more of these areas. So, if you check the cabin and subsequently find and fix several leaks, don't forget to go ahead and check the rest of the possible problem areas mentioned in this article as well.



Starting with Hercules aircraft LAC 3609, Lockheed began replacing P/N 363676-1L left wing fillet, located between fuselage stations 617 and 667 and between left buttock lines 61.625 and 77.42, with a compartment installation, P/N 388152-1. The purpose of this compartment was to provide a space for installation of the AN/ART-31 emergency radio. Since that time, the AN/ART-31 radio has been replaced on Hercules aircraft by a more compact radio, which is now stowed in the life raft compartment; Even so, the Hercules is still being built with the AN/ART-31 emergency radio compartment in place. Since the AN/ART31 radio is no longer being used and the compartment remains empty, its existence is sometimes forgotten. Unfortunately, neglect of this area may be causing some of our Hercules operators problems.

The AN/ART-31 compartment installation includes a P/N 388151-37 door, which covers the compartment and

is approximately 16 x 50 inches in size. This door is hinged on one side and held closed by a latching mechanism on the other. The release handle for the latching mechanism is covered by a 2.5 x 8.75-inch access door (P/N 388151-39) which is part of the larger AN/ART-31 compartment door assembly. The latch release handle access door is attached with a hinge pin and held closed by two closure springs. This is where the problems can start.

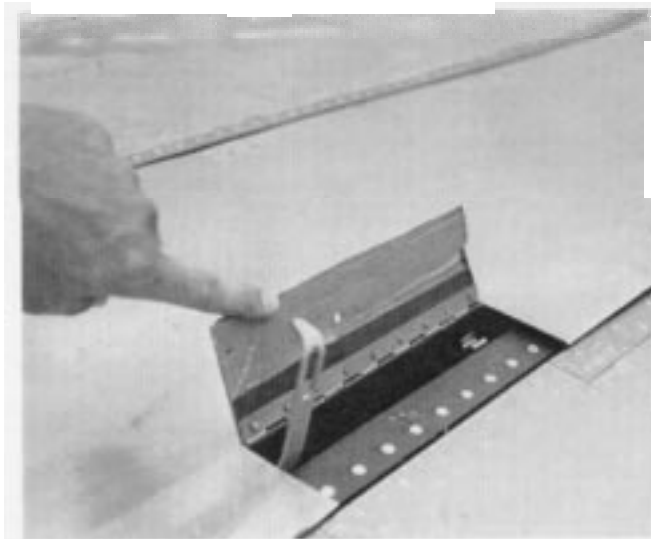
The springs on the latch release handle access door assembly can become weakened through vibration, corrosion, and age. The same factors can also affect the door hinges. As the springs weaken, the access door acquires a tendency to flutter, especially during propeller reversal. With weak or broken springs and excessive hinge corrosion, the suction created by propeller reversing could conceivably pull the access door loose.

To prevent the possible loss of the access door in service, Lockheed has developed a means of securing the door. It involves adding a screw and nut plate to hold the door closed. The modification is being incorporated on all new production Hercules aircraft Lockheed serial number 4900 and up. It can be accomplished on your organization's Hercules by following the procedure outlined in this article.

Modification Procedure

1. Gain access to the former beneath the latch release handle access door and locate the position of the hole to be drilled in the former. The correct position is 3.50 inches aft of the forward edge of the access door and 0.40 inch from the inboard edge of the former. The OAO-inch measurement is critical, so measure it carefully,
2. Drill a 0.201- to 0.204-inch diameter hole in the former at the previously marked location, using a No. 8 (0.1990.inch) drill bit.

Latch release handle access door and handle.



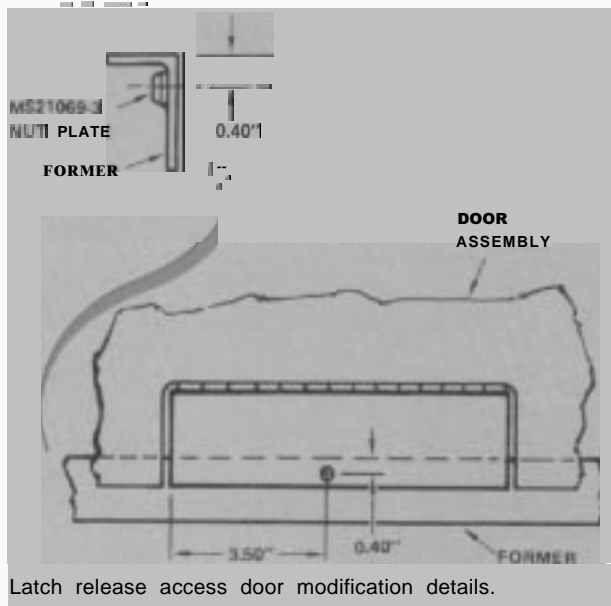
3. With the access door in place, locate the hole to be drilled in the door by back locating it with a hole locator.

4. Drill a 0.193- to 0.199-inch diameter hole in the access door, using a No. 10 (0.1935-inch) drill bit at the previously marked location. Countersink the hole for an NAS517-3-3 low-degree flathead machine screw.

5. Locate the positions for the two holes required to mount an MS21069-3 nut plate to the underside of the former. Drill the two holes, using a No. 41 (0.0960-inch) drill bit. Countersink the two holes in the upper surface of the former for installation of MS20426AD3 rivets.

6. Mount the nut plate, using two MS20426AD3 rivets.

7. Secure the access door closed by installing the NAS517-3-3 screw.



SERVICE NEWS

StarTip

A Flexible Fiber-Optic Borescope

Lockheed-Georgia Company has approved an innovative borescope for use on Hercules aircraft. The Model 6200 Flexible Fiberoptic Borescope, manufactured by Lenox Instrument Co. of Philadelphia, Pa., is a ruggedly constructed inspection instrument containing a precisely aligned bundle of ultrahigh-quality glass fibers which transmits light to, and images from, remote areas. This allows visual inspection of the normally inaccessible interior parts of complex machinery without requiring complete teardown of the assembly.

This new borescope contains a number of noteworthy advanced features. The unit's probe features an articulating tip with a total scanning range of 240 degrees and an objective lens that can be focused by remote control. System resolution is also excellent: up to 34 line pairs per millimeter. This level of performance is made possible by the extremely uniform pattern of the Lenox fiber-optic bundle, which results in distortion-free images.

The borescope is available with probes of 40-, 60-, and 96-inch working lengths. The complete outfit includes a light source, a light-connecting bundle, a spare lamp, an instruction manual, and a heavy-duty instrument case.

Options available are:

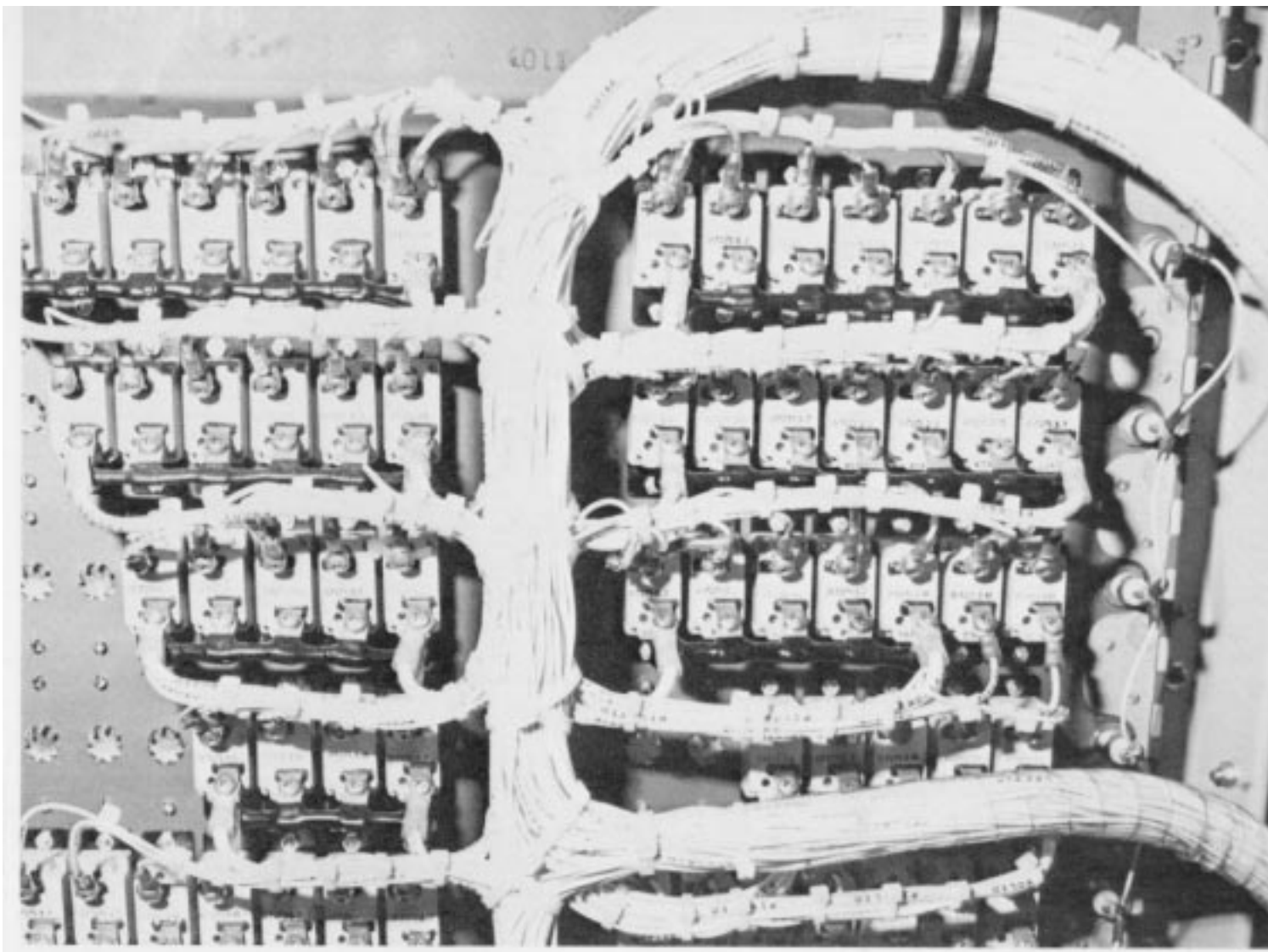
- A right-angle viewing attachment.
- Camera attachments, including adapters for Polaroid photography and closed-circuit TV.



Model 6200 Flexible Fiberoptic Borescope.

Price and availability data can be obtained by contacting our Supply Sales and Contracts Department, D/65-11, Z/287, Lockheed-Georgia Co., Marietta, Georgia 30063.



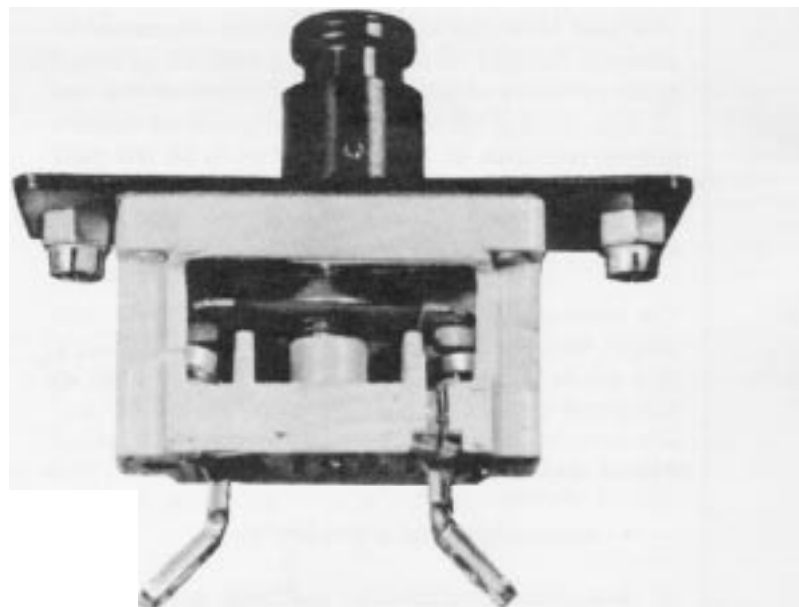


Circuit Breakers

The electrical system of the Hercules aircraft, like that of any large, modern aircraft, contains miles and miles of electrical wiring. This wiring allows the operation of electrical and avionics equipment throughout the aircraft. It must be protected from the hazards that could be caused by possible shorts or faulty wiring. The device used to protect the wiring is the simple but reliable circuit breaker.

Most people know what a circuit breaker is and what it does, but not many know exactly how it works. This is too bad, because knowing how the circuit breakers that protect your Hercules aircraft actually function can save troubleshooting time and contribute to overall maintenance safety. Let's take a look at how these circuit breakers work and note some of the special features of their operation.

All circuit breakers used on the Hercules aircraft are of the thermal, trip-free type. In general, thermal circuit breakers are ones which "pop" open to break a circuit when excess heat builds up in the circuit breaker because



Cutaway view of D7271-3-X circuit breaker.

of greater-than-normal current loads. A trip-free circuit breaker is one which cannot be reset to complete an electrical circuit until the breaker's components have cooled. If the fault which caused the circuit breaker to "Pop" is still present, the circuit breaker will again pop and open the circuit after it has been reset.

If a circuit overheats because of a fault, the thermal, trip-free circuit breakers used on the Hercules aircraft open the circuit by the bending action of a metallic strip which occurs in a known direction at a calibrated temperature.

Figure 1 shows a cutaway view of the circuit breaker most commonly used on all but A-model Hercules aircraft. (A-model circuit breakers are also of the thermal, trip-free type, but are somewhat different in construction. The following discussion does not apply to them.) The part number for the circuit breaker shown in Figure 1 is D7271-3-X. The X in the part number will be a number corresponding to the rated capacity of the circuit breaker in amps, e.g., D7271-3-5 for a 5-amp circuit breaker.

Referring to Figure 2, you can see the internal components of a D7271-3 circuit breaker and follow how it works,

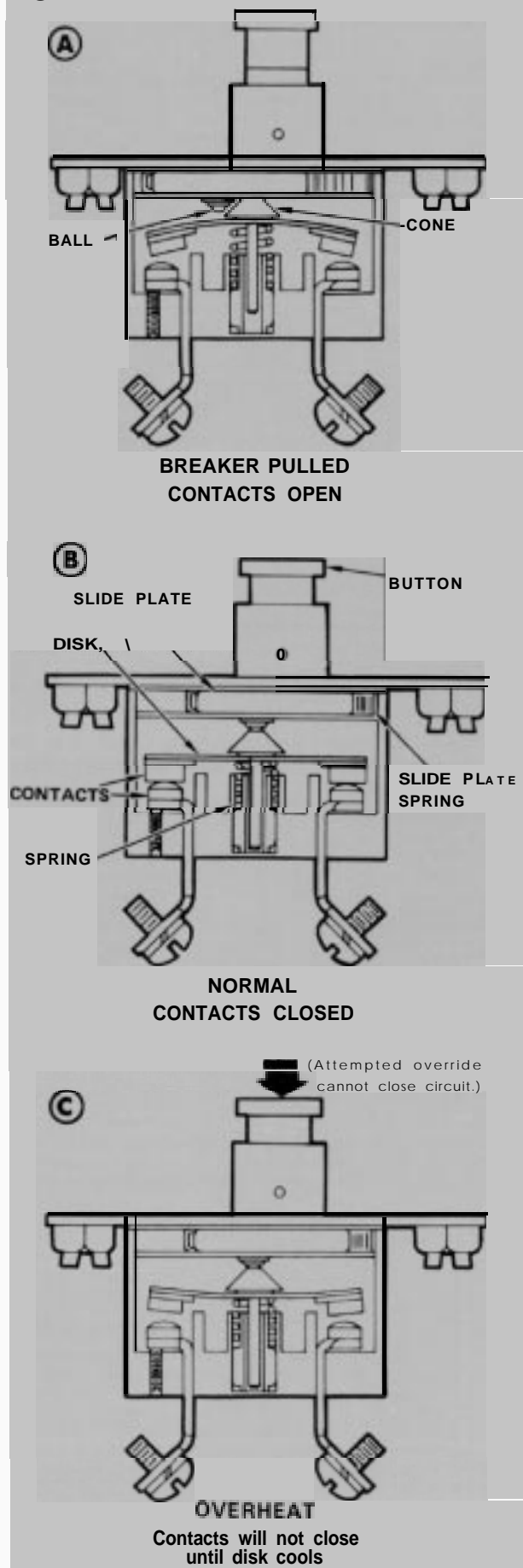
Figure 2, A and B, shows a pair of circuit breakers. In A, the circuit breaker is shown disengaged, in B, it is engaged. When the button is pulled, as in the first example, the upper and lower contacts are not touching; therefore, the circuit is broken. When the button is pushed in, however, a toggle moves a slide plate to the side to engage a ball into a cone. This action presses the contacts together and completes the circuit. Spring tension supplied by both the spring and the metal disk supporting the upper contacts holds the ball in the cone socket.

If a fault occurs in a circuit and the temperature of the upper contacts starts to increase, the ends of the disk will snap upward when the precalibrated temperature is reached (Figure 2C). When both ends of the disk snap up, the slight spring tension present because of the small downward bend of the disk supporting the upper contacts (when cool) is relieved. This allows the ball to be pushed out of the cone socket by the slide plate spring.

When a circuit breaker has popped because of a circuit malfunction, it is impossible to reset the circuit breaker until it has cooled down. Even if the button were held in, the contacts would not close because the ends of the disk are bent upward. After cooling, the ends of the disk will snap back down to the normal position, allowing the contacts to close when the circuit breaker is reset.

It should be mentioned at this point that if a circuit breaker pops, the cause should be determined before resetting it. Often only a minimum amount of troubleshooting actually takes place before an attempt is made to

Figure 2. Circuit breaker: three operational conditions.



EFFECT OF AMBIENT TEMPERATURE ON ULTIMATE TRIP

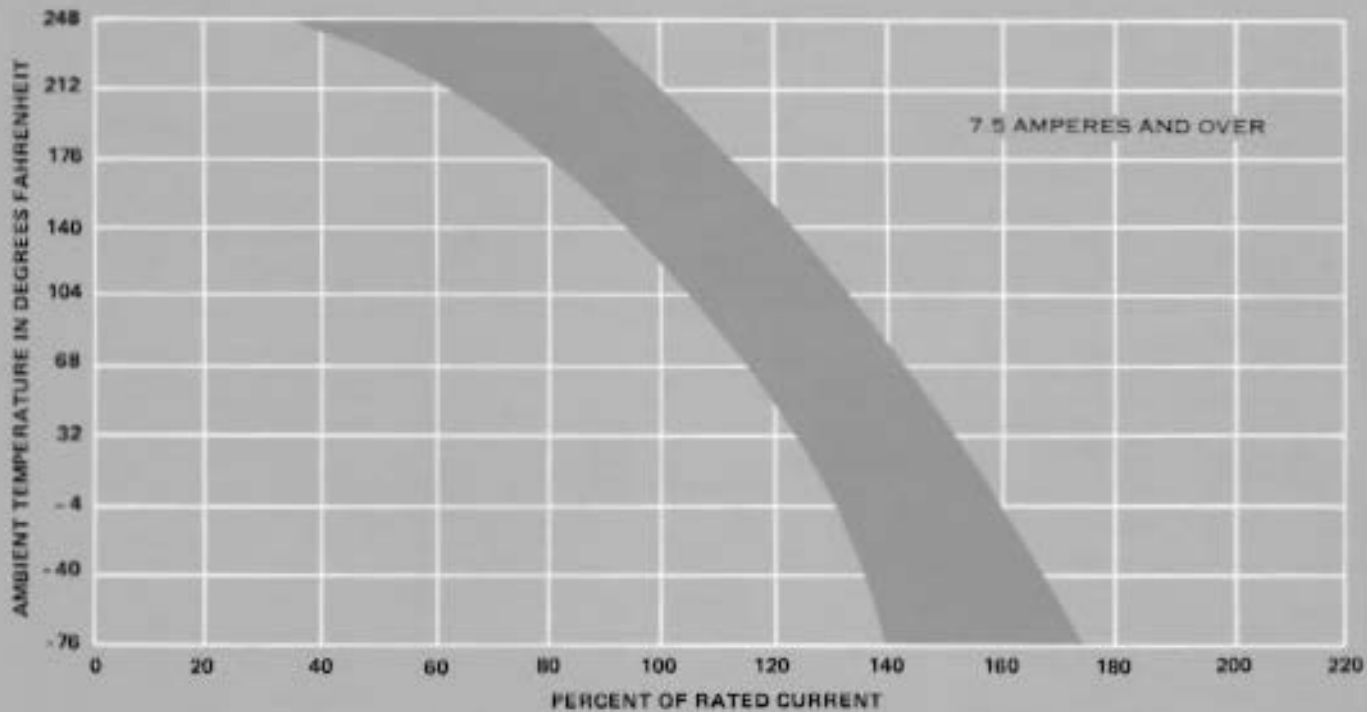


Figure 3. Ambient temperature versus percentage of rated load that can be carried.

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TIME-CURRENT CHARACTERISTICS, 10-AMP CIRCUIT BREAKER AT 77°F AMBIENT TEMPERATURE

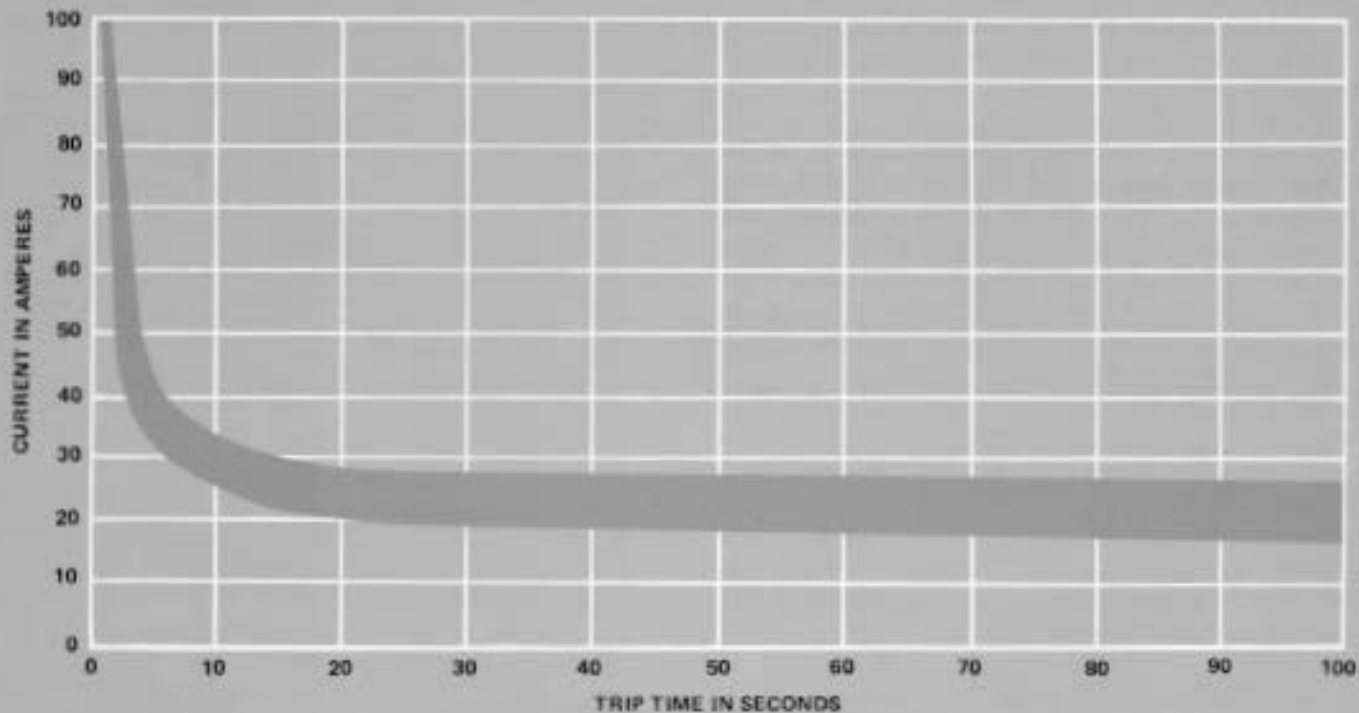
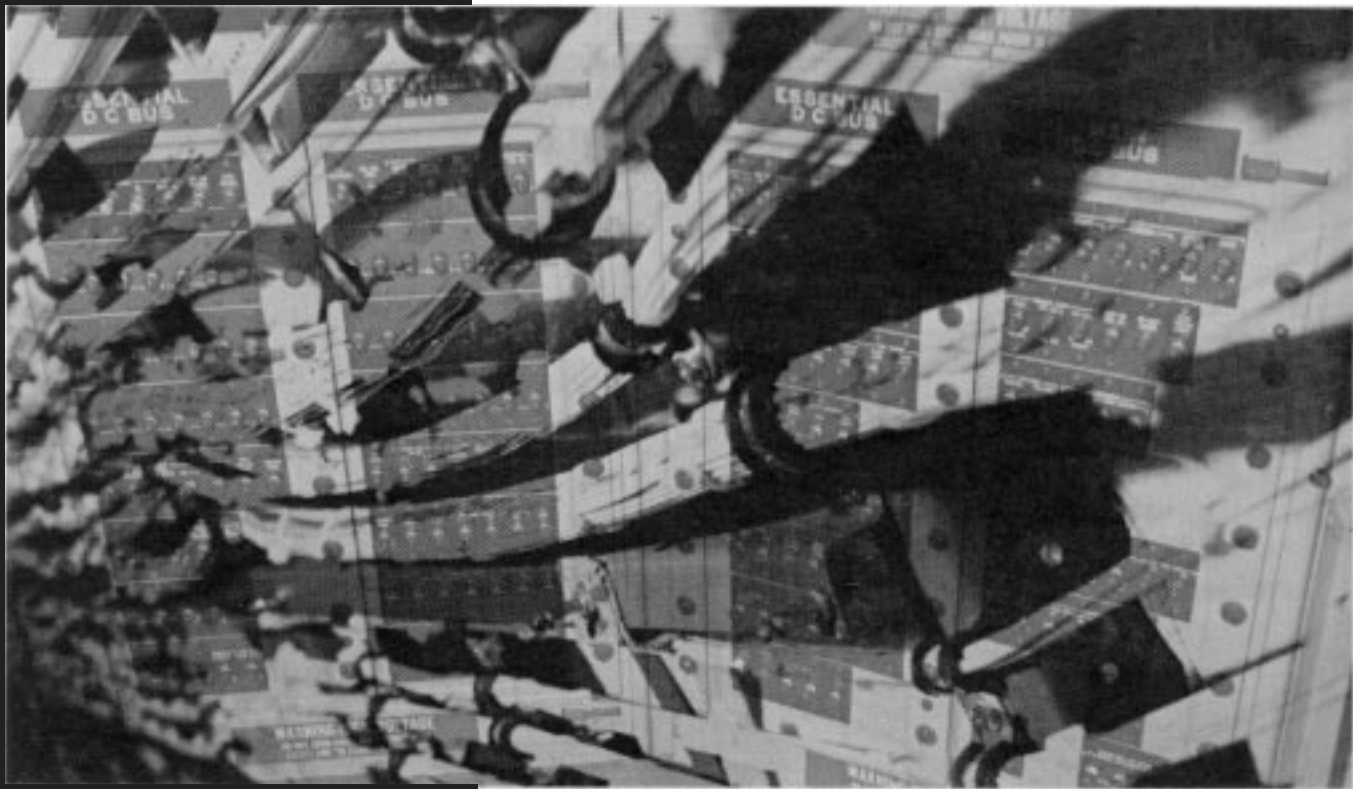


Figure 4. The relationship between current load and trip time.



reset a circuit breaker, and this is unfortunate. Resetting a circuit breaker without thoroughly investigating what caused it to trip can be a very dangerous practice.

A little-known fact is that circuit breakers are designed to permit much more current to flow at room ambient temperature than their rated capacity would indicate. Figures 3 and 4 show charts which give the break curves for certain ambient temperature effects and time-current characteristics.

Figure 3 indicates the ultimate trip current in percent of rated current at various ambient temperatures. This shows the percent of rated current at which the circuit breaker will operate indefinitely at a given ambient temperature without breaking the circuit. As the ambient temperature rises, the percent of rated capacity lowers towards 100% and drops below 100% at approximately 140 degrees F. In other words, more current can flow in the conductor at low temperatures without breaking the circuit.

Figure 4 shows the trip time in seconds with respect to the actual number of amps flowing through a 10-amp circuit breaker at 77 degrees F. You can see from the chart that a 10-amp circuit breaker can carry a load of approximately 15 amps for an extensive period of time, and higher amperages for progressively shorter periods of time.

The curves in Figures 3 and 4 illustrate typical conditions under which the circuit continues unbroken, and when it

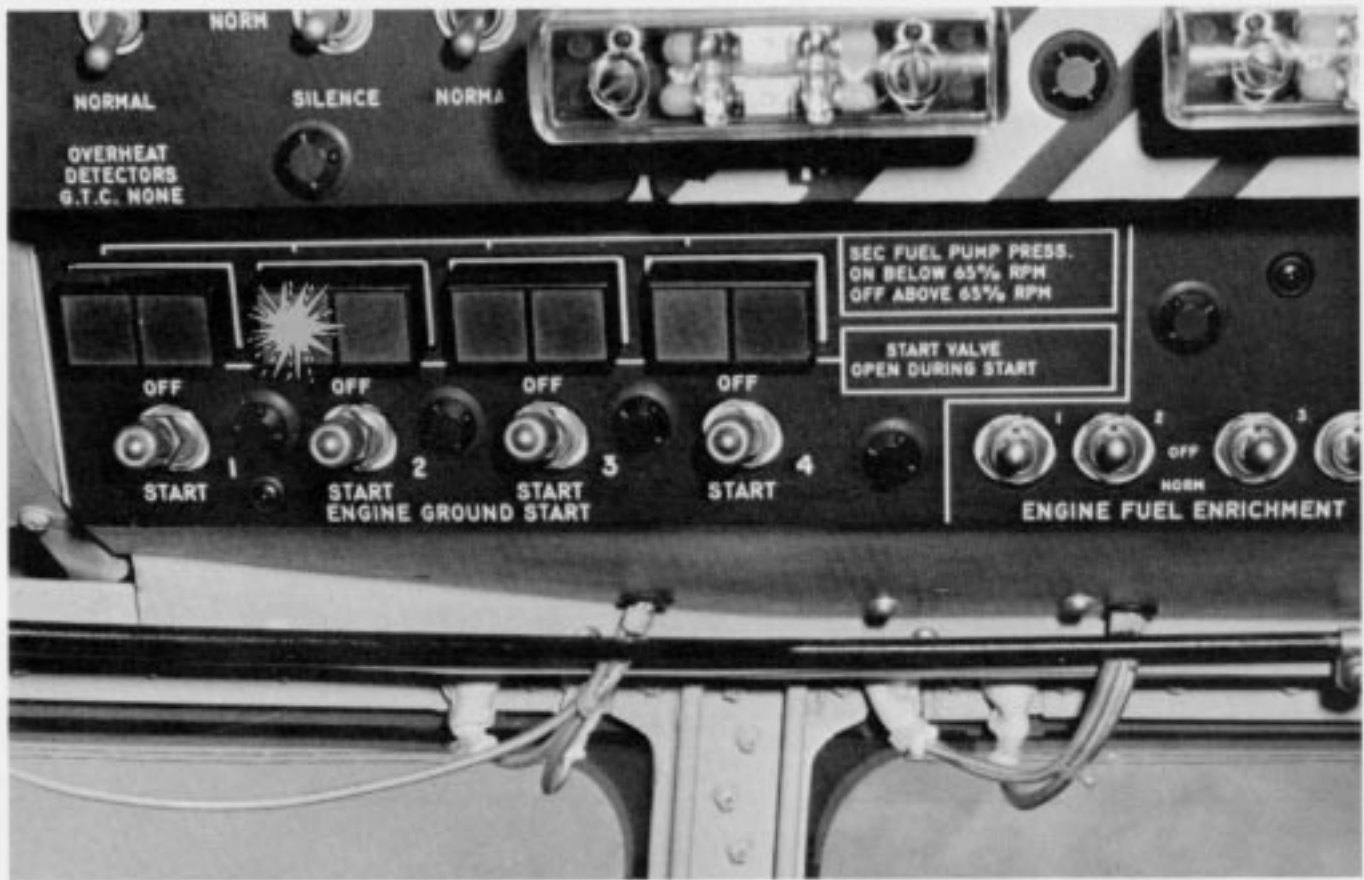
will break. They are not absolute for any particular circuit breaker or circuit. For example, Figure 3 shows a wide range of permissible temperatures for any particular circuit breaker or circuit. Circuit breakers are designed to match predicted wire temperatures, but in some installations there will be significant ambient temperature difference between the breaker location and where most of the wire is located. From a practical standpoint, circuit breakers must have sufficient operational latitude to compensate for such conditions.

Remember that circuit breakers are designed primarily to prevent overheating of the wiring, which could cause deterioration of the insulating materials or even a fire. They also allow the circuits that are not affected by a fault to continue operating and thus ensure continuity of power for the remainder of the electrical system. To a limited degree, circuit breakers also protect the equipment being supplied with power, even though most aircraft equipment is protected by internal fuses.

Circuit breakers are often taken for granted, and even go unnoticed, in a properly functioning electrical circuit. However, they are perhaps the most important part of that circuit. If a fault does occur, they can prevent damage to and even the possible destruction of a valuable aircraft.

SERVICE NEWS

Secondary Fuel Pump Pressure Light Flicker



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Momentary illumination or flickering of the engine secondary fuel pump pressure light during flight is not an uncommon occurrence on Hercules aircraft. Some misunderstanding of the exact nature of the problem seems to exist, and the result is sometimes inappropriate corrective action in an attempt to clear the discrepancy.

In order to understand the origin of secondary fuel pump pressure light flicker, it is helpful to first review the design of the engine fuel pump system and the main features of its operation.

Fuel Pump Operation

Each engine has a fuel pump assembly and a high pressure filter assembly. The fuel pump and filter assemblies are

bolted together as a unit and mounted on the right side of the power section accessory drive housing (page 18). The fuel pump assembly consists of a centrifugal boost pump, two gear-type pumps, and a boost pump bypass valve. The high pressure filter assembly consists of a high pressure fuel filter element, a bypass valve, two check valves, the secondary fuel pump pressure switch, and a paralleling valve. The centrifugal boost pump receives fuel from the fuel tank boost pumps and increases pressure sufficiently to ensure a positive head of pressure to the gear-type pumps.

The two gear-type pumps are referred to as primary and secondary pumps. The primary pump has about a 10 percent higher output capacity than the secondary, but either pump is capable of supplying enough fuel flow to satisfy engine requirements.

There are two important advantages in having a dual pump arrangement supplying each engine. One is that each pump can serve as a backup for the other in case of failure. The other is that incorporating two pumps in the system permits the use of two distinct modes of operation, each designed to best meet engine requirements under a specific set of conditions.

The two modes are called series operation and parallel operation. Series operation is used when the engine is being accelerated from 0 to 16 percent RPM, and also when it is operating above 65 percent RPM. The pumps operate in parallel when the engine is accelerating from 16 to 65 percent RPM. Parallel operation of the pumps in this range ensures that adequate fuel flow will be available for starting when pump RPM, and consequently pump output, is relatively low.

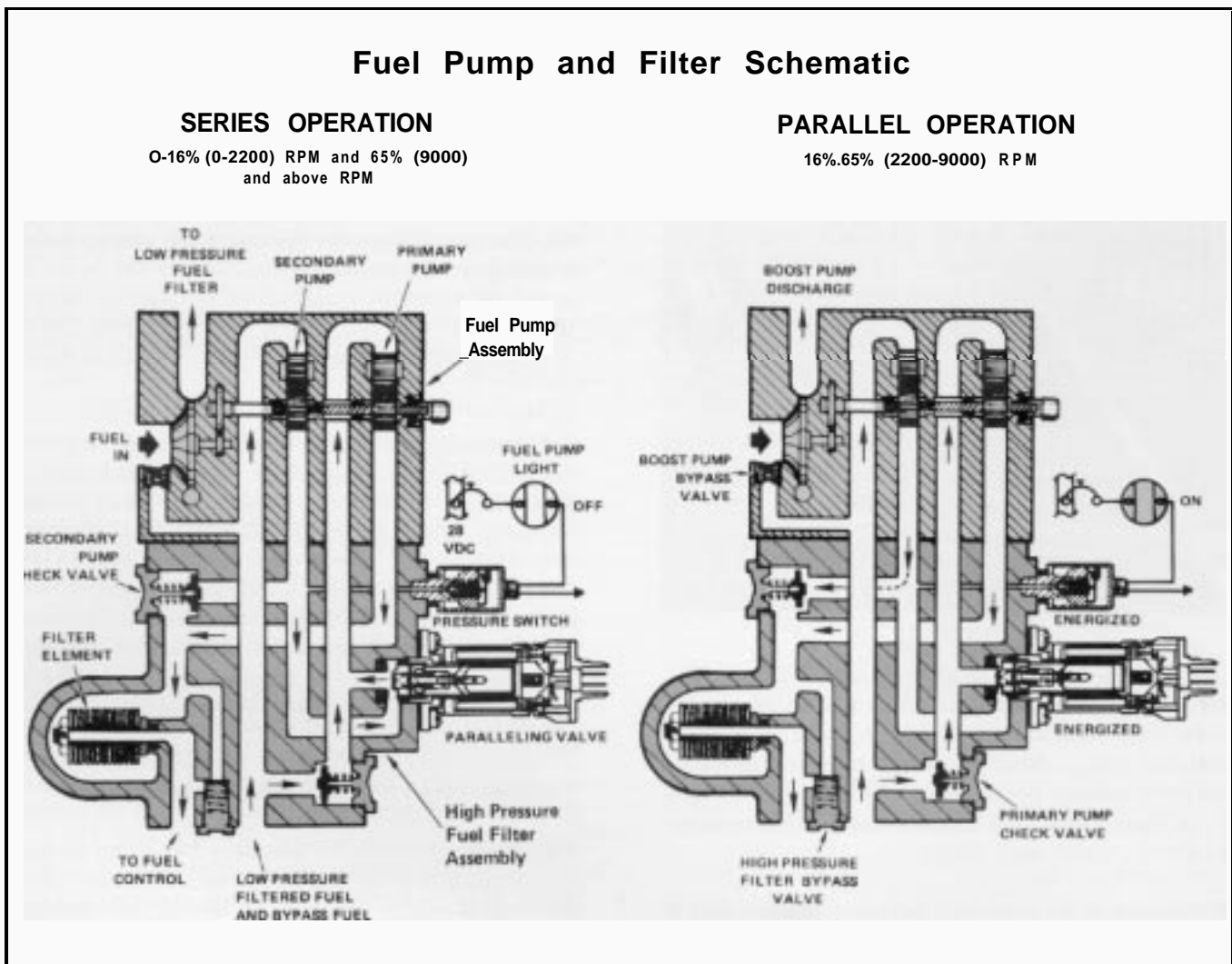
The change from series to parallel operation (and vice versa) is accomplished by the paralleling valve, whose operation is governed by the speed sensitive control. The

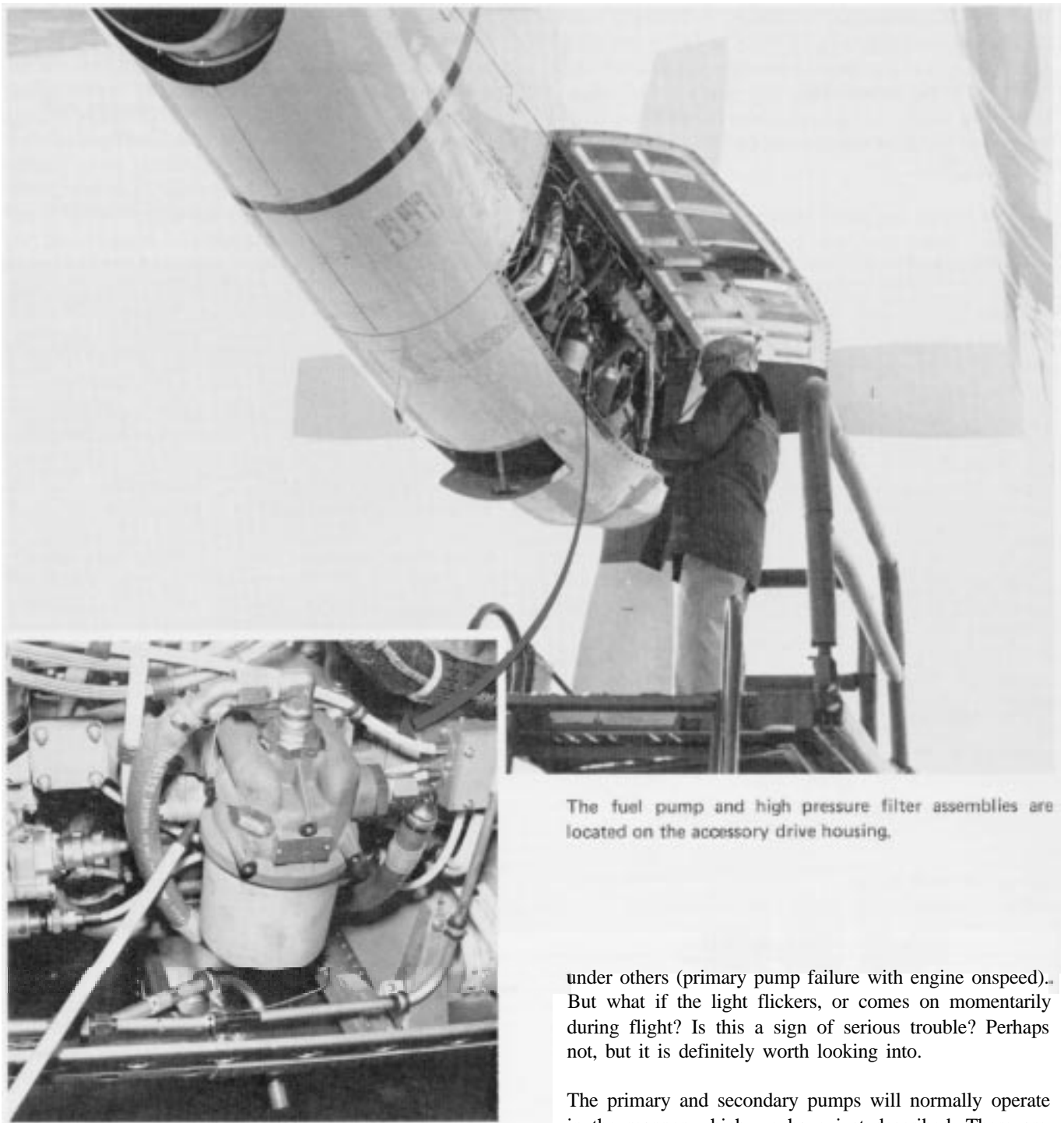
paralleling valve is open from 0 to 16 percent RPM and at engine speeds greater than 65 percent RPM. This allows fuel from the secondary pump to flow to the inlet of the primary pump for series operation. At engine speeds between 16 and 65 percent RPM, the paralleling valve is energized closed, causing the fuel flow from the secondary pump to be diverted around the primary pump circuit. In this mode of operation, the increase in pressure in the secondary output circuit closes the secondary fuel pump pressure switch, causing illumination of the secondary fuel pump pressure light located on the engine ground start panel in the flight station. This indicates to the flight crew that the pumps are operating in parallel.

Failure Indications

Secondary fuel pump pressure light illumination can signal more than parallel operation, however. If the primary pump fails and obstructs the normal flow of fuel, the pressure in the line between the secondary pump and the primary pump builds up. Fuel from the secondary pump

Fuel pump and high pressure filter schematic, showing series and parallel modes of operation.





The fuel pump and high pressure filter assemblies are located on the accessory drive housing.

will then pass through a check valve and on to the engine fuel control, thus maintaining fuel flow to the engine. Under these conditions too, the rise in fuel pressure in the secondary pump output circuit will cause the secondary fuel pump pressure switch to close and illuminate the light in the flight station. The indicator lamp will burn steadily in cases of primary pump failure.

Illumination of the secondary fuel pump pressure light is thus normal under some conditions (engine accelerating between 16 and 65 percent RPM) and a sign of trouble

under others (primary pump failure with engine onspeed). But what if the light flickers, or comes on momentarily during flight? Is this a sign of serious trouble? Perhaps not, but it is definitely worth looking into.

The primary and secondary pumps will normally operate in the manner which we have just described. There are, however, several conditions which will cause the secondary fuel pump pressure light to illuminate briefly or flicker at times when, strictly speaking, it should remain extinguished.

Troubleshooting a Flickering Pressure Light

When investigating why a secondary fuel pump pressure light illuminates or flickers during "normal" engine operation, a good way to start is by eliminating the possibility that the signal is entirely spurious; that is, not related to a pressure indication at all, but caused by an electrical

problem in the indicator light circuit. Any condition that would furnish a ground to the light circuit – loose, frayed, or burned wiring, for example – will cause the light to illuminate. While trouble in the electrical circuitry is not a common problem, it remains a possibility that should always be considered.

In most cases, secondary fuel pump pressure light flickering is a reliable indication that high or borderline-high pressures are being developed at the secondary pump pressure switch. One of the more common causes has to do with high fuel tank boost pump pressures and improper operation of the paralleling valve. The problem characteristically shows up when the fuel is being supplied from an auxiliary or external tank, but disappears when the affected engine is supplied from a main fuel tank. Let us see how this can occur.

When an engine is being supplied fuel from a main tank (tank-to-engine operation), the main tank boost pumps furnish fuel to the engine centrifugal boost pump inlet at a pressure of between 15 and 24 psi, depending on the flow rate. On the other hand, if the fuel is being supplied by an auxiliary or external tank (crossfeed operation), the boost pumps in these tanks furnish fuel to the centrifugal boost pump inlet at a pressure of between 28 and 40 psi. The fact that fuel is being delivered to the fuel pump at somewhat higher pressures during crossfeed operation may not at first glance appear very important. Remember, however, that the pressure being sensed by the secondary pump pressure switch is the combined product of the input pressure and the subsequent pressure increases resulting from the action of the centrifugal pump, the inflow of fuel being bypassed back to the fuel pump by the fuel control, and the output of the secondary pump. Thus a relatively minor increase in input pressure can yield a significant increase at the pressure switch.

If, in addition to the relatively high pressures caused by crossfeed operation, some other condition is present within the pump which tends to raise the pressure in the secondary circuit still more, the point may be reached where the total pressure in the body of the fuel pump rises high enough to cause the secondary fuel pump pressure light to illuminate. Such a situation can arise as a result of the failure of the paralleling valve to open completely after the starting sequence.

The reason that the paralleling valve fails to open completely is usually binding caused by scored valve plunger and seat surfaces. Since the valve does not open completely, secondary pump output is restricted, which increases the pressure in the secondary pump outlet circuit. During crossfeed operation, the pressure increase caused by a malfunctioning paralleling valve may be sufficient to raise the total pressure sensed by the pressure switch to the 150 (+ 10) psi value needed to close it. If the light extinguishes or stops flickering when the fuel feed is switched

from crossfeed operation to tank-to-engine operation, the paralleling valve should be disassembled and checked for scoring.

The scoring of the valve parts is usually caused by uneven and/or excessive torquing of the four screws that secure the paralleling valve during installation. To correct the problem, remove the paralleling valve and polish any scored contact areas between the plunger valve and the seat with crocus cloth. Replace the two O-rings that are installed on the valve seat and then reinstall the valve.

Use extreme care during valve installation. The four mounting screws must be tightened alternately in 5-inch-pound increments, to a total of 15 inch-pounds. If these screws are overtightened or tightened unequally, the paralleling valve will probably bind and cause the secondary fuel pump pressure light to illuminate. Note that when the valve is properly installed, there will be an obvious gap between the valve retainer plate and filter body.

Another condition that can cause the pressure to build up and illuminate the light is internal leakage of the secondary pump check valve, located in the high pressure fuel filter assembly. If the check valve leaks a sufficient amount of fuel from the primary pump, the secondary pump pressure may intermittently increase enough to cause the secondary fuel pump pressure light to flicker. Replacement of the high pressure fuel filter assembly should alleviate the problem.

And finally, keep in mind that the high-pressure signals that show up at the flight station in the form of an illuminated secondary fuel pump pressure light originate in the secondary fuel pump pressure switch. It follows, therefore, that this unit itself should not be overlooked as a possible source of trouble. Improper adjustment of the pressure switch can cause the indicator light to flicker or illuminate even though the pressure in the secondary pump circuit is actually within tolerances. If misadjustment is suspected, remove the pressure switch and bench check it. The switch should not close until the pressure has increased to 150 (+ 10) psi. The switch should open before the pressure has decreased to 90 psi. Replace the switch if it does not meet these criteria.





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