Lockheed

service news

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Nondestructive Evaluation

Lockheed SERVICE NEWS

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Cover: New U.S. Coast Guard HC-130H-7s **patrol** the skies over Florida's Gulf coast.

Focal Point

T. J. **CLELAND**

An Uncommon Achievement

This summer we at Lockheed-Georgia will mark the 30th anniversary of the first flight of the C-110. To date, over 1700 Hercules aircraft have been delivered, and the airplane continues in full production. From having just one customer for the C-130 in 1954-the U. S. Air Force-we have now provided this amazing airlifter to 55 countries throughout the world. It is a remarkable record, one which is unprecedented in the annals of aviation.

The past 30 years have firmly established the Hercules aircraft as one of the most successful airplanes in history, but much of the credit must go to you, our customers.

Your achievements are evident on every page of the Hercules success story. It is our customers who have shown us how tough and versatile this airplane really is. You have taken the Hercules aircraft to every continent, probed every corner of the world from the oil fields of Alaska's North Slope to the frozen wastes of Antarctica. Your aircraft are the ones that have brought relief and hope to disaster-ravaged towns and villages. It is you who have challenged uncharted peaks to reach the jungles of the Amazon: it is your airplanes that have tamed the burning sands of the central Sahara. It is you who have shown the world how a cargo plane can build a nation.

We salute you for what your enterprise has helped us accomplish as a company, but what you have done has much broader significance. With the Hercules aircraft. you have individually and collectively demonstrated the enormous potential of aerospace technology for the progress and betterment of mankind. Yours is truly an uncommon achievement.

Sincerely,

T. J. Cleland
Director of Product Support

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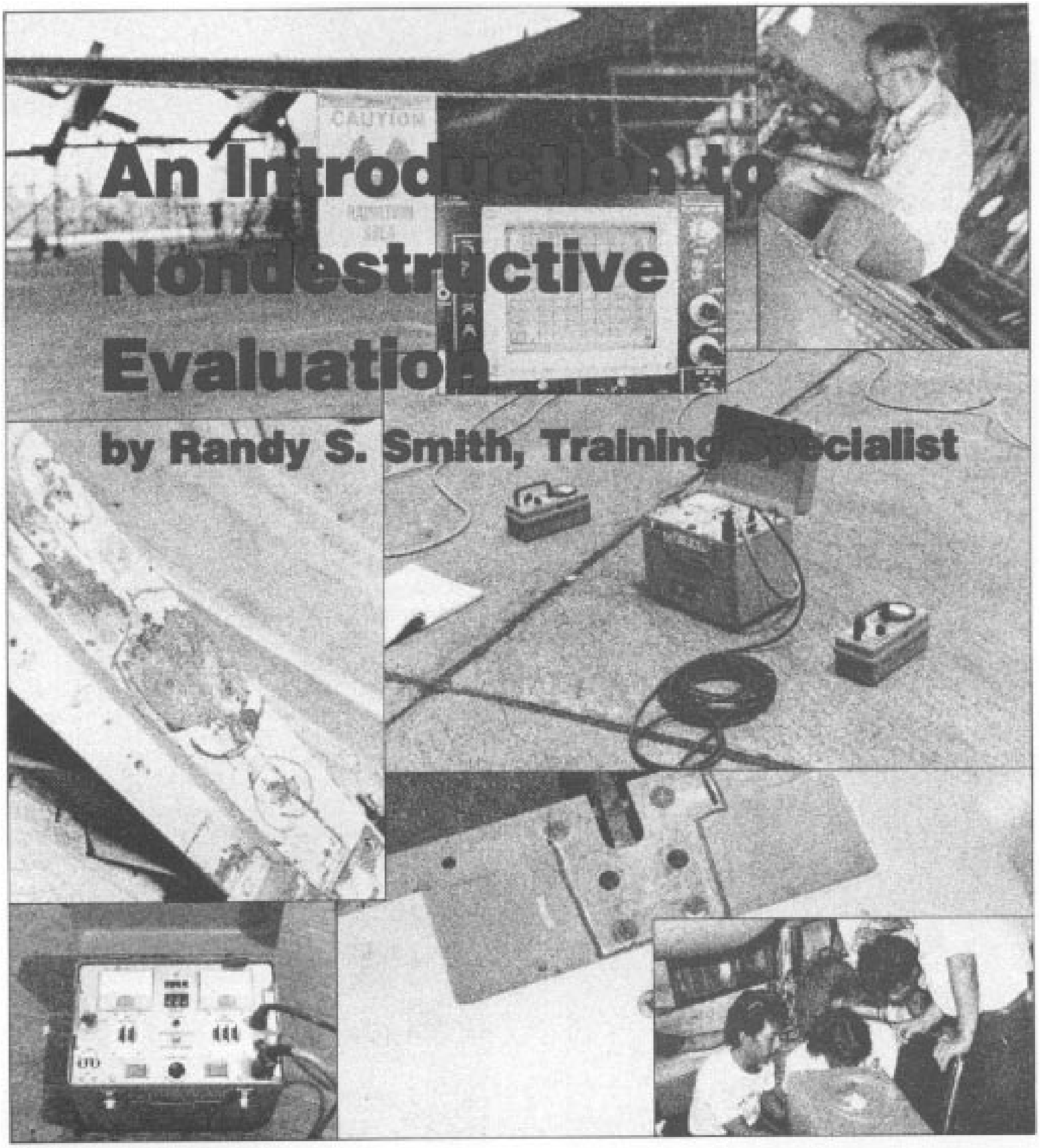
An Introduction to Nondestructive Evaluation

by Randy S. Smith, Training Specialist



Nondestructive evaluation (NDE) assesses the results of performing nondestructive inspection (NDI) and nondestructive testing (NDT) techniques in conjunction with system requirements to determine the serviceability of a component or assembly. NDE is the technique of inspecting or testing materials and components without destroying them or reducing their serviceability. Visual examination is no longer the only means of ensuring adequate serviceability. NDE methods are used, for example, to detect variations in the structure of materials, to detect the presence of discontinuities, to detect flaws or changes in surface finish, and to determine physical properties of materials. NDE increases system and component reliability, helps to prevent accidents, lowers operating costs, and increases product utilization. In this article we will describe the basic methods of NDE used on Hercules aircraft and other aircraft in commercial and military inventories.

There are six NDE methods commonly in use today to determine the integrity of aircraft materials and components: visual inspection, liquid penetrant evaluation, magnetic particle evaluation, eddy current evaluation, ultrasonic evaluation, and radiographic evaluation.

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Figure 1. Some of the items used in liquid penetrant inspection.

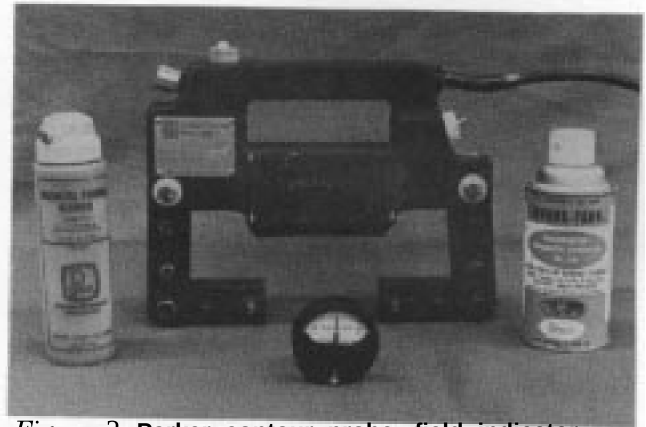

Figure 2. **Parker contour probe, field indicator, and magnetic particles used in magnetic particle evaluation.**

Visual Inspection

Visual inspection was the first method of nondestructive evaluation, and it is still the one most widely used for detecting discontinuities. Technical manual T.O. 33B-1-1, Nondestructive Inspection Methods, defines discontinuities as interruptions in the normal physical structure or configuration of a part such as cracks, laps, seams, inclusions, and porosity. Discontinuities may or may not affect the usefulness of a part. Visual inspections are a quick and economical way of detecting various types of surface discontinuities before they progress to failure. The reliability of visual inspections depends on the ability, experience, and diligence of the inspector.

In order to perform a satisfactory visual inspection or any other form of NDE, the surface of the test specimen must be clean and dry. Foreign substances remaining on the part being tested may mask defects. Flashlights, inspection mirrors, microscopes, magnifying glasses, and borescopes are often used in conjunction with visual inspections to facilitate the detection of surface flaws.

Liquid Penetrant Evaluation

The liquid penetrant method is used to detect various types of discontinuities open to the surface of a component. Most nonporous materials such as metal alloys, plastics, rubber, glass, and some ceramics can be inspected by this method. All that is needed for this method is a penetrant, a cleaner, a developer, and a suitable light source (Figure 1).

The basic principle of penetrant testing is to increase the visible contrast between a discontinuity and its background. After cleaning the component surface, penetrant is applied to the surface and capillary action causes it to enter surface imperfections. After a predetermined time, the excess surface penetrant is removed. A developer is then applied to the surface being inspected. If there is a discontinuity present, the developer will act as a blotter and draw out any penetrant that has seeped into it, highlighting the discontinuity. Best results are generally obtained by the use of fluorescent penetrants, which glow when exposed to ultraviolet (“black”) light. This makes discontinuities more readily visible.

Magnetic Particle Evaluation

Magnetic particle evaluation is also a widely employed NDE method. It is used to locate surface and subsurface discontinuities. This method has some limitations as far as the aerospace industry is concerned because it can only be used on ferromagnetic materials.

Figure 3. M-500 **mobile power pack used in magnetic particle evaluation.**

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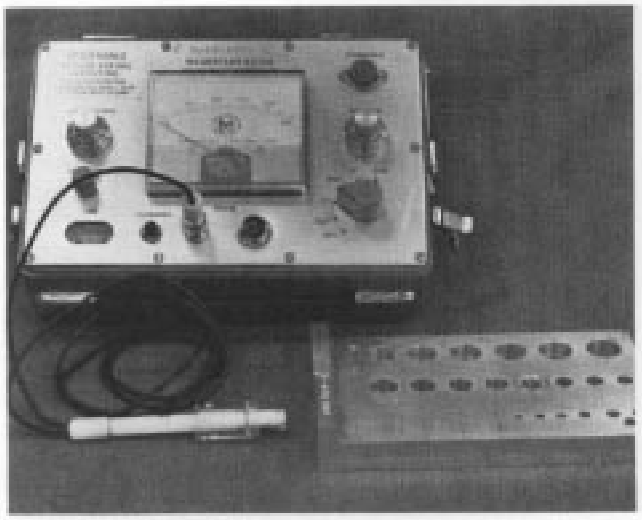


Figure 4. ED-520 eddy current test instrument and reference standard.

Magnetic particle evaluation involves the use of iron filings, a source of electric current, and a magnetic-field inducing device (Figures 2 and 3). A magnetic field is induced in a test specimen, using either alternating current or pulsating direct current. After the magnetic field is established, iron filings are sprinkled over the test specimen surface. When the magnetic field in the test article is interrupted by a discontinuity, some of the field is forced into the air above the discontinuity, forming a leakage field. The iron filings sprinkled over the surface will be attracted to the leakage field, indicating its location, size, and shape.

Eddy Current Evaluation

Eddy current evaluation is a nondestructive technique designed to detect small discontinuities which are open to or just below the surface of a test specimen. It can also be used for sorting metals, hardness testing, conductivity measurements, and coating thickness measurements. Eddy current testing is useful on all electrically conductive test specimens, including those made of nonferrous alloys. Since most aircraft are made primarily of aluminum alloys, eddy current testing is widely used in the aerospace industry.

The test equipment needed for this method consists of an eddy current test instrument and reference standards (Figures 4 and 5). The test instrument typically contains a test coil, an oscillator to generate AC current, a bridge circuit, a circuit to process returned signals, and a test meter.

Eddy current evaluation also makes use of a magnetic field. A test coil carrying alternating current is placed near the surface of a test article. The alternating current in the coil produces an alternating magnetic field. When the alternating magnetic field comes in contact

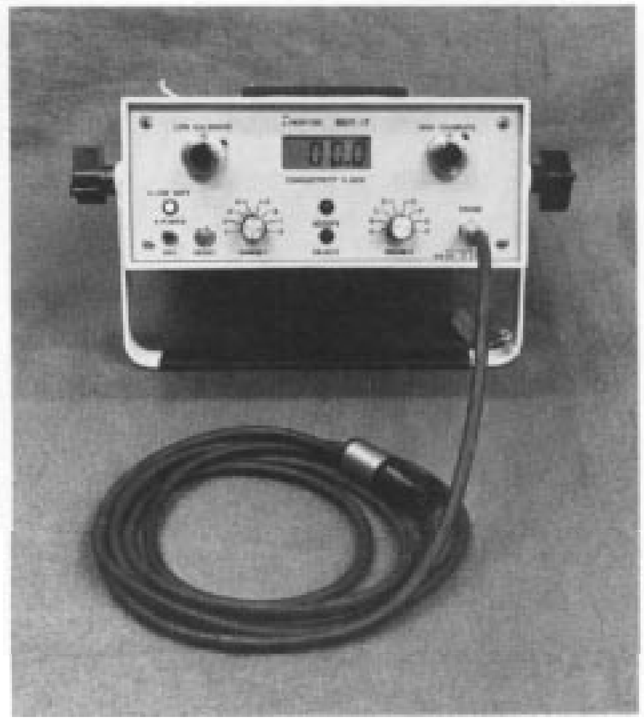
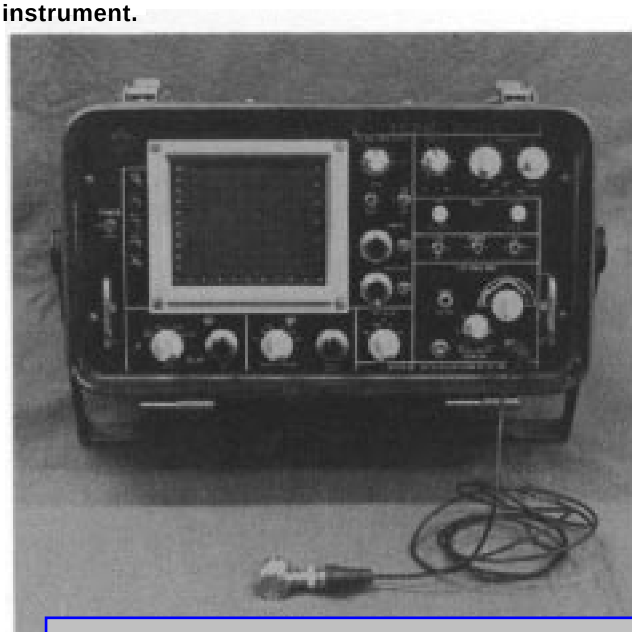


Figure 5. **NDT-17 eddy current test instrument.**

with the test material, circular electrical currents called eddy currents are established in the test specimen. These eddy currents will be parallel to the surface of the test article. When the eddy current path is disrupted by a discontinuity, the current in the test coil will change. The change will be registered by a test meter attached to the coil through a bridge circuit. Reference standards are used to calibrate the test instrument for the material being tested. The width, depth, and length of the discontinuity can often be determined by this technique.

Figure 6. **Sonic Mark IV ultrasonic test instrument.**



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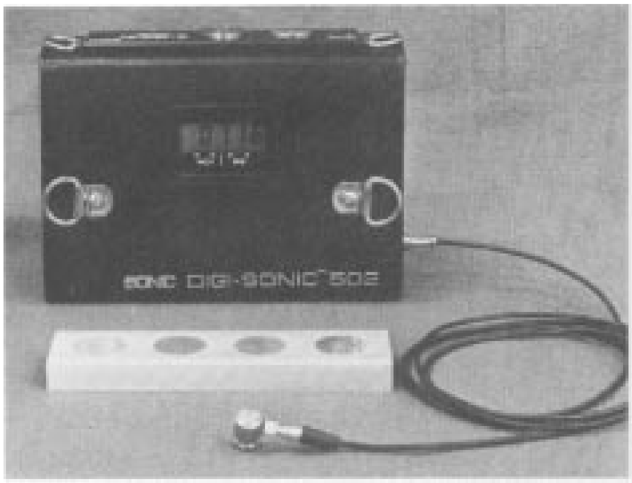


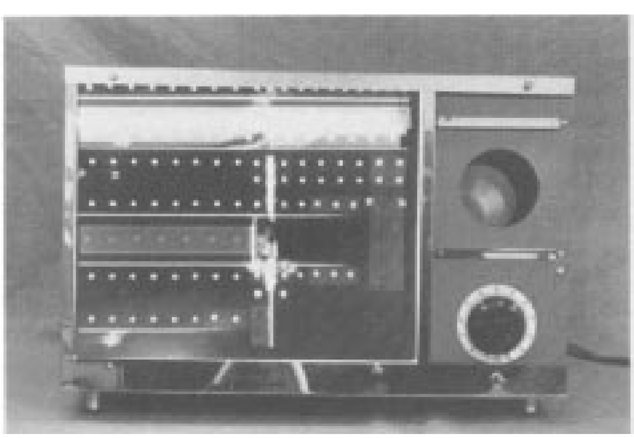
Figure 7. Digi-Sonic 502 ultrasonic test **instrument and reference standard.**

Ultrasonic Evaluation

Ultrasonic evaluation uses high-frequency sound waves to detect surface and subsurface discontinuities. It is a sensitive method for detecting small discontinuities, but requires that the operator be highly experienced for signal interpretation. Ultrasonic testing can be used on many different materials including metals, composites, bonded honeycomb, plastics, rubber, and synthetic materials. Ultrasonic testing can also be used for accurately measuring material thicknesses.

Ultrasonic test equipment includes an ultrasonic test instrument and reference standards (Figures 6 and 7). The test instrument generally contains a power supply, a transducer, a pulser/receiver, and a cathode ray tube or other display device.

Figure 8. **X-ray of aircraft part illuminated by a high-intensity viewer.**



To determine if a test specimen has a discontinuity, high-frequency sound waves (above 20,000 Hz) are introduced into the material, using a transducer element. As the sound waves travel through a material, a discontinuity will reflect the waves. If the major axis of the discontinuity is perpendicular to the sound beam, the waves will be reflected back to the transducer, which converts the sound waves into an electrical signal. This signal is displayed on a cathode ray tube and interpreted by a trained technician, using reference standards to evaluate the indications.

Radiographic Evaluation

Radiographic evaluation is one of the oldest techniques of NDE and can be used to detect internal and external discontinuities in almost any type of material. Radiography uses high-energy X-ray radiation and radiographic film to examine a test specimen in the same way that low-energy X-rays and radiographic film are used to examine the human body (Figure 8). Radiographic testing can be used on almost any material or part as long as the radiation has enough energy to penetrate the material and expose the film.

Radiography measures a change in material thickness and density. Where the material is reduced in thickness or less dense, more radiation will pass through that area and the corresponding area on the film. When a test specimen is irradiated, discontinuities will show up as dark images on the film since the total thickness that the radiation must pass through is reduced by the discontinuity. Radiographic testing is used extensively in the aerospace industry because of its ability to examine parts and areas not accessible to other techniques without extensive disassembly.

The six methods of nondestructive evaluation that we have just described are by no means the only methods, but they are the ones that are currently being used most extensively in the aerospace industry. In future issues of *Service News we* plan to discuss these techniques in more detail, and their application to the Hercules aircraft.

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MLG Brake Application After Loss of Hydraulic Pressure

by John Walters, Group Engineer

If you **are a** Hercules aircraft flight crew member or involved with hydraulic system maintenance, you may be familiar with the paragraph in some of the flight manuals in the section on brake system accumulators that discusses the number of brake applications available in case of a hydraulic system pressure failure. The gist of the statement is that the normal brake system accumulator, when fully charged with hydraulic fluid, is capable of supplying pressure for about two brake applications.

Some flight crews have put this statement to the test and discovered that the results do not always appear to agree with the above assertion. Instead of having sufficient pressure for two brake applications, the normal brake system accumulator may provide for only one. This has been a source of concern for some personnel; in fact, occasionally aircraft have been refused by flight crews because it had been determined that only one brake application was available.

Actually, the braking system was probably working properly in these cases. The key point is the position of the anti-skid system switch. If the normal brake system accumulator's ability to provide hydraulic pressure for braking is tested with the anti-skid system switch in the ON position, one application is likely all that will bc available.

Here is why. When the anti-skid system switch is in the ON position, power from the main DC bus is supplied to the parking brake off solenoids in the LH and RH anti-skid control valves (Figure I).

This in turn **opens** the solenoid-controlled shutoff valve (Figure 2) in each anti-skid valve. Hydraulic fluid from each anti-skid valve will leak down at a rate of about 61 cubic inches per minute when the shutoff valve is open, for a total rate of 122 cubic inches per minute for both anti-skid valves.

When the first brake application is made, approximately 20 of the 50 cubic inches of hydraulic fluid stored in the normal brake system accumulator goes to fill brake cylinders. This leaves approximately 30 cubic inches of fluid in the accumulator.

At a combined leak-down rate of 122 cubic inches per minute, the anti-skid valves can deplete the 30 cubic inches of fluid remaining in the accumulator in about I5 seconds. This accounts for the lack of pressure necessary for a second brake application; after only 5 seconds, there would be insufficient fluid available.

If the anti-skid system switch is in the OFF position, however, two brake applications will be available.

The explanation for this is as follows. From Figure 3, it can be seen that power from the main DC bus cannot travel past the anti-skid system switch when the switch is selected to OFF. Since no power is available to the solenoid-controlled shutoff valve in each anti-skid

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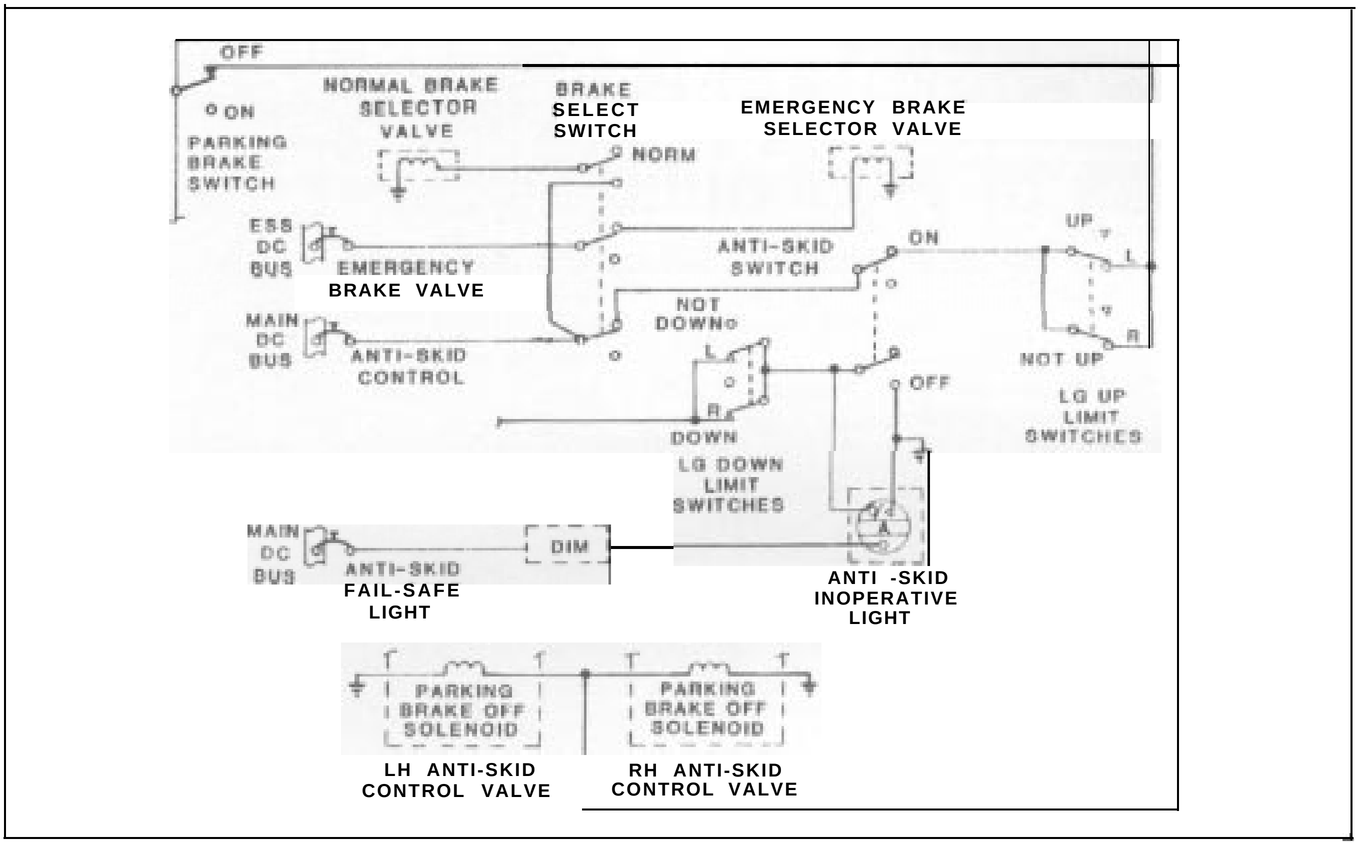
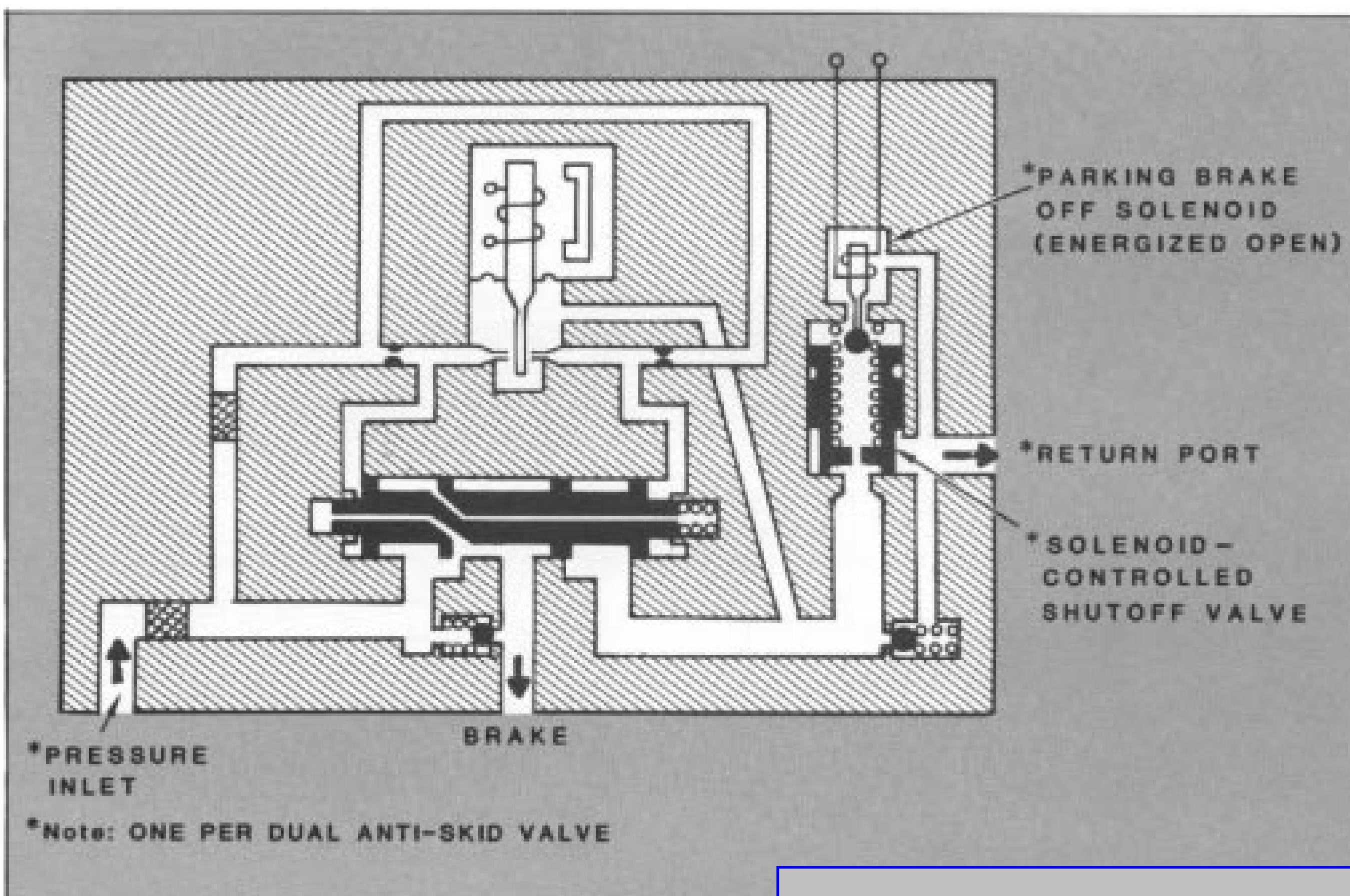


Figure 1 A. Anti-skid system switch on-parking brake off solenoids energized.

Figure 2 One half of dual anti-skid valve.



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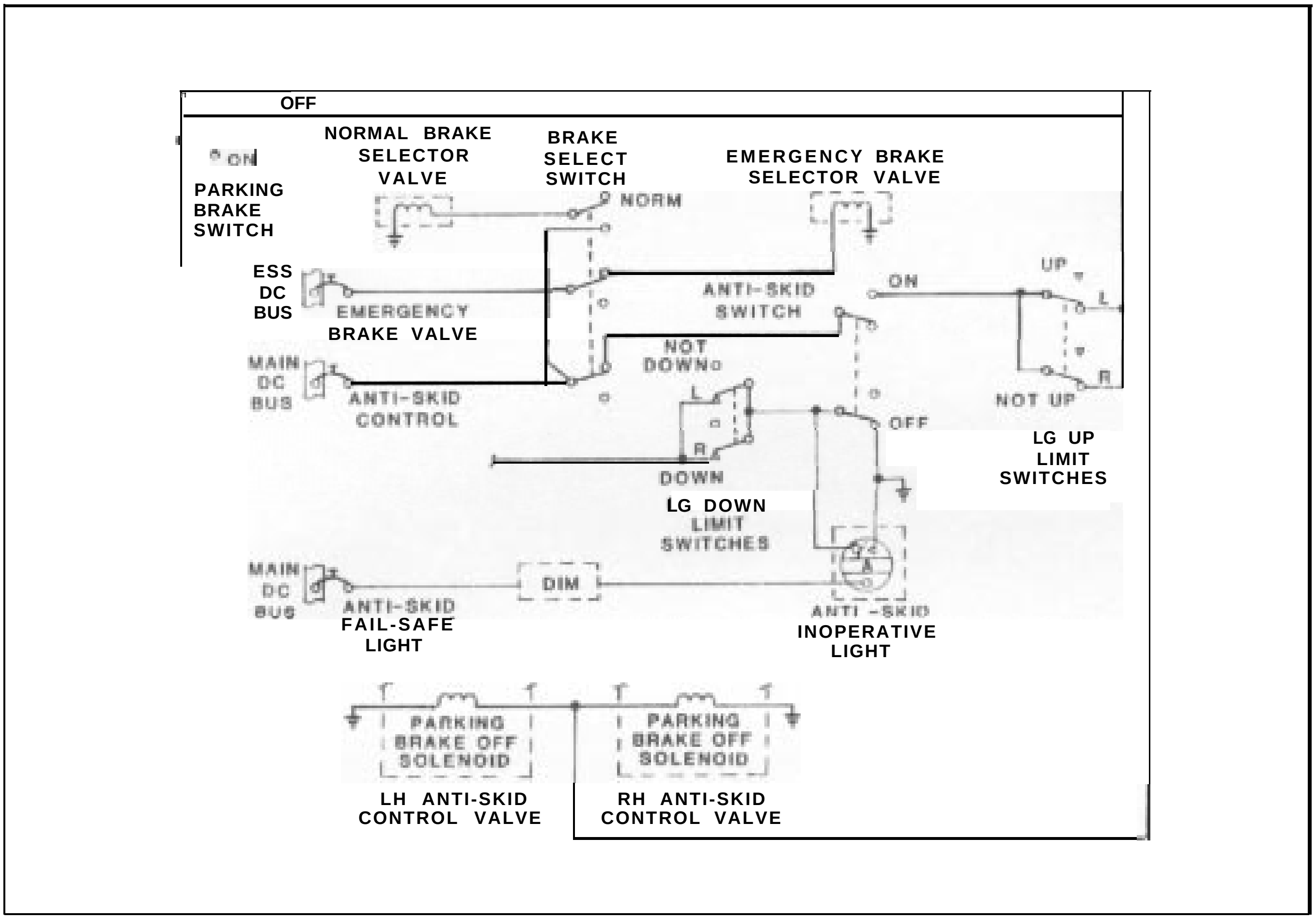

Figure 3. **Anti-skid system switch off-parking brake off solenoid deenergized.**

control valve, the shutoff valves remain closed. When the valves are closed, each anti-skid valve will only leak about 10 drops of hydraulic fluid per minute. This means that most of the 30 cubic inches of fluid still in the normal brake accumulator after one brake application is available for another application and will remain so for some time.

Perhaps the old adage that appearances can be deceiving is appropriate here. You may think that you have a brake problem when you don't. A quick scan of the anti-skid control panel and the switch position will give you a clue. Just remember that the anti-skid control switch should be in the OFF position for the brakes to "perform as advertised?

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New FCS-105/C-12 Simulation Test Set

by Raymond E. Yearty, Supply Sales Planner Senior

A problem encountered by many Hercules aircraft operators during routine ground maintenance has been the inability to effectively test the FCS-105 flight control system. Conventional methods for evaluating this system have proven cumbersome and have involved unacceptable levels of guesswork and expense.

In January 1983, a competition was held by the U.S. Air Force for the development and procurement of a more cost-effective method of testing this system. This competition ended with the selection of a new lightweight, carry-on-board FCS-105/C-12 Simulation Test Set (P/N 3402904-l, NSN 4920-01-156-4522) manufac-

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tured by Lockheed-Georgia Company.

By following a step-by-step procedure, this test set enables a maintenance technician to simulate flight conditions heretofore not achievable during ground checks. As a result, a more **complete** and timely analysis of the system can be accomplished, avoiding unnecessary downtime. The test set also enhances the technician's ability to accurately diagnose a malfunction, thus reducing the probability of replacing an operational component needlessly.

The test set, which operates on aircraft power, comes in two units weighing approximately 40 pounds each. Both are used on the flight deck. One is a simulation unit, which the technician uses for observations of the various instruments and manipulation of the controls. This unit provides the simulated heading, pitch, roll, and instrument deviations necessary to operate the flight control system.

Figure I. **Simulation unit.**

The other unit consists of the breakout panels, controls, and mounts for the mode selector, autopilot amplifier, and the flight director computer, and interfaces with the appropriate aircraft equipment mounts. The test set comes with all cables and data necessary to troubleshoot the FCS-105 flight control system.

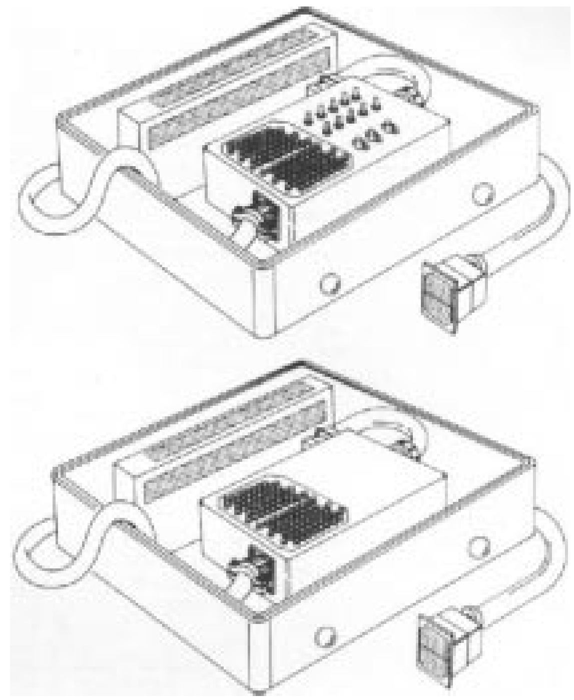
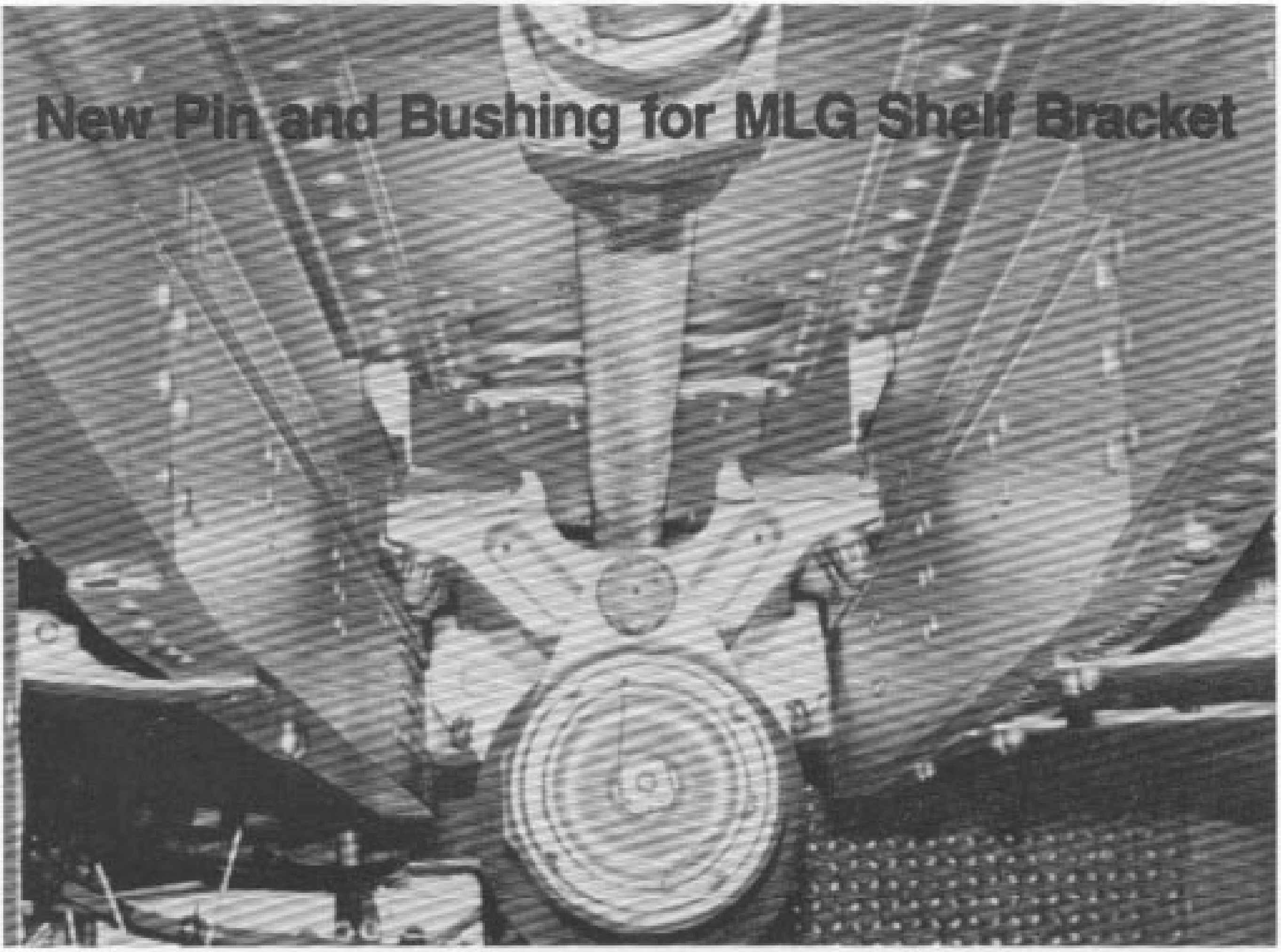


Figure 2. **Breakout panels.**

The FCS-105/C-12 Simulation Test Set represents a significant technological advancement in troubleshooting the flight control system. If you would like additional technical or procurement information about this test set, please direct inquiries to the Manager, Supply Sales and Contracts Department, at the following address:

Lockheed-Georgia Company
Supply Sales and Contracts Dept.
Department 65-11, Zone 451
Marietta, Georgia 30063
Telephone (404) 424-4214
TELEX 542642



Those of you who are involved with landing gear maintenance on the Hercules aircraft are undoubtedly well acquainted with the vital role that the MLG shelf bracket plays in the proper operation of the main landing gear.

The shelf brackets are designed to provide a stable platform to retain the MLG when the landing gear is fully extended. Each shelf bracket incorporates two holes, provided with bushings, which accept drag pins attached to the associated shock strut flange when the gear is fully extended. When properly engaged in the bushings, the drag pins prevent side loads from deflecting the main landing gear laterally during landings.

Securing the Bushings

The shelf bracket bushings are held in place by retainers. A retaining pin is used to help prevent the bushing and the retainer from unscrewing and separating. The pin is installed through a predrilled hole in the bushing and seated in a hole in the retainer which must be specially drilled at the correct location for each installation.

For many years, the method used to keep the retaining pin in place was to stake the top of the bushing in two places and the bottom of the retainer in one place (see illustration). This approach was usually satisfactory for the initial factory installation, but it proved less reliable when the original bushings wore out and had to be replaced in the field. Unless the new parts were staked in a rather precise way, wear and repeated landing gear operating cycles sometimes combined to cause the retaining pin to work free and drop out.

Without a retaining pin, the bushing can unscrew and separate from its retainer. If this occurs, the drag pin may pull the bushing out of the shelf bracket when the landing gear is retracted. The bushing usually drops off as soon as the drag pin clears the shelf bracket and the side loads are removed, but more often than not it falls back into its hole in a cocked position. With the misaligned bushing blocking the hole, the landing gear cannot be fully extended because the drag pins are prevented from engaging the shelf bracket in the normal way.

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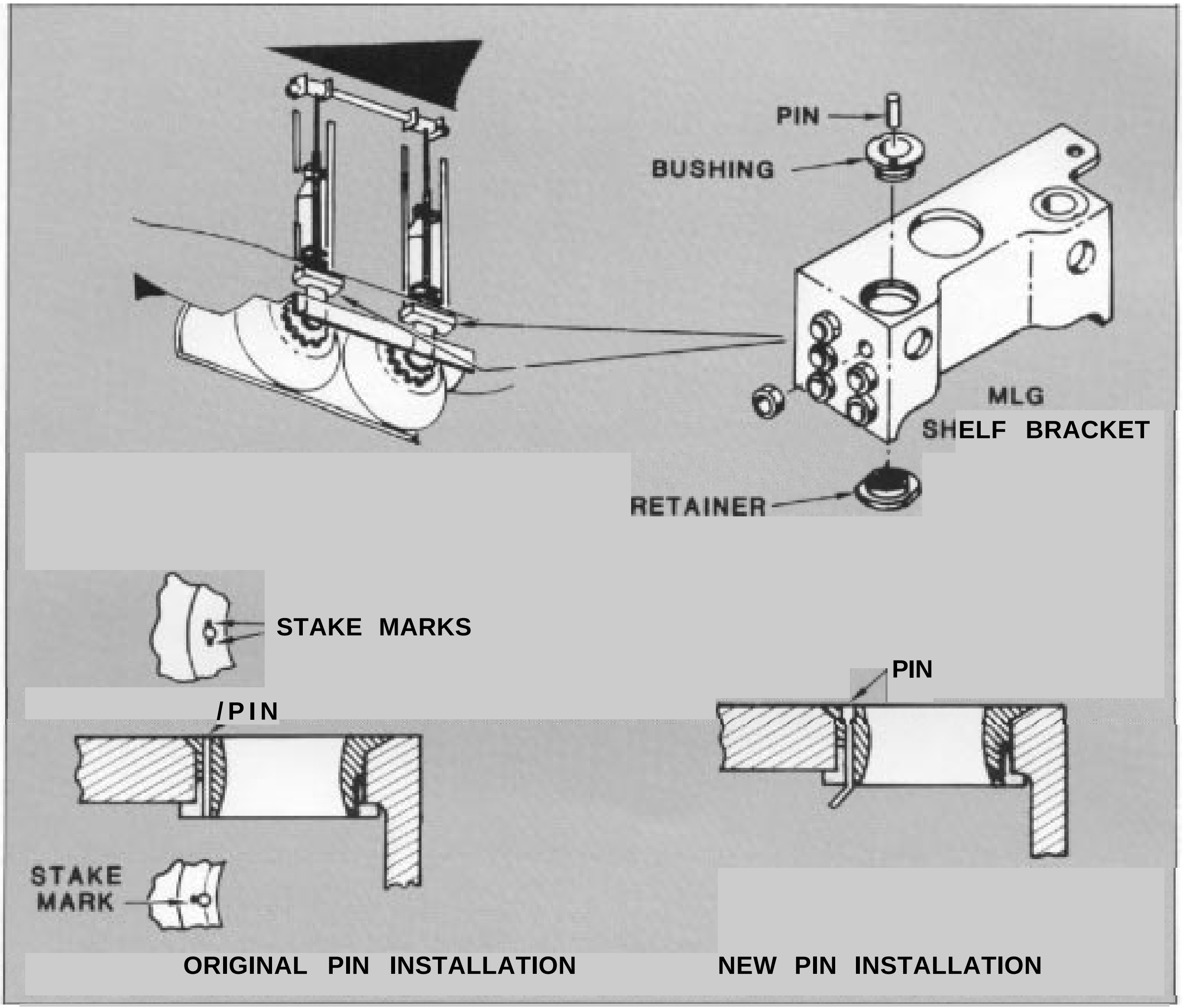

Figure I. **Original and new shelf bracket and pin installations.**

A Better Way

Lockheed has recently developed a new way of securing the pin in the bushing retainer that helps avoid such unpleasant possibilities. The new arrangement consists of substituting a P/N 389438-3 bushing for a -1 bushing and using a headed retaining pin, P/N 3319688-l. The predrilled hole in the -3 bushing is countersunk to accommodate the headed pin. You still must drill a matching hole (0.093 to 0.098-inch diameter) through the retainer. Instead of inserting the pin through the bushing and bushing retainer and then staking, the new pin is inserted through the bushing and retainer head up; it is then bent to a 45-degree angle where it exits the retainer (see illustration). This new arrangement virtually eliminates loss of the pin and resultant loosening of the bushing.

If you find it necessary to replace a bushing and bushing retainer with the headed pin, but do not have the new -3 bushing in stock, a -1 can be reworked to accept the headed pin. All that is required is to counterdrill the hole in the -1 bushing to a depth of 0.120 inch with a l/S-inch diameter drill.

Regardless of which bushing you use, we think that the new pin arrangement will prove to be both timesaving and timely. The potential for MLG extension problems will be significantly reduced once the new pin configuration is installed on your aircraft.

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Improving the General Purpose Sling Assembly

by Earl D. Allen, Engineering Specialist

The General Purpose Sling Assembly, P/N 3400961-L was originally designed to be used in removing and installing ailerons, rudders, elevators, outboard wing flaps, vertical and horizontal stabilizers, and vertical stabilizer leading edges. Experience has shown that this sling assembly as presently configured is not ideally suited for removing or installing the rudder on the Hercules aircraft. When attached to the rudder, the sling cables are not long enough to allow the hoist plate to clear the top of the rudder; in addition, the center of gravity of the rudder is offset from the lifting attach points. The rudder therefore tends to pivot from the vertical position during removal or installation. This makes it rather tricky to remove or install a rudder without causing damage to the vertical stabilizer, the rudder, or both.

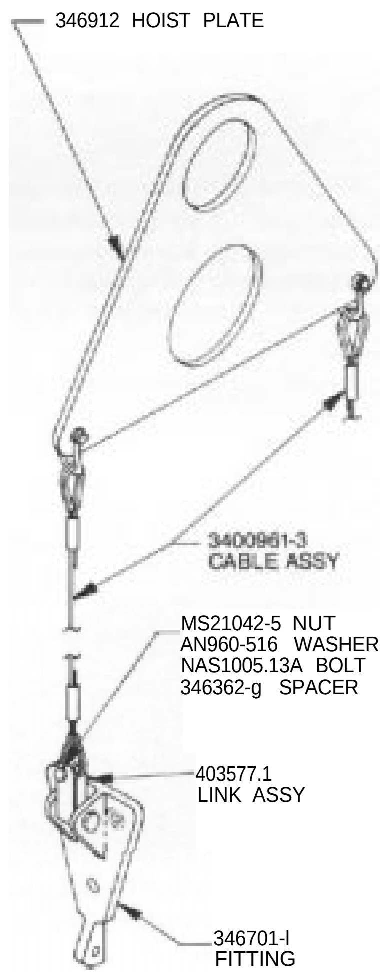
A modification to the 3400961-l sling assembly has been developed in the form of a balance weight plus extension cables which completely eliminates this problem. The modification consists of removing two fittings and two links and adding two new attach fittings, two extension cables, two weight-attach cables, and a balance weight. Modification of an existing sling to the new configuration for use on the rudder is simple and requires little time and effort. The modified sling can just as quickly be returned to the original configuration for use on another flight control or stabilizer.

To modify a 3400961-l sling assembly, first obtain the necessary parts from the Lockheed-Georgia Company. The modification kit, P/N 3403147-1, contains one P/N 3403147-3 weight assembly, two P/N 3403147-s wire rope assemblies, two P/N 3403147-7 wire rope assemblies, two P/N 3403147-11 fittings, two G-209 l/2-ton shackles, two G-210 l/2-ton shackles, and modification instructions.

Modification Procedure

To modify the 3400961-l sling assembly, begin by making sure that the sling is configured for rudder removal or installation in accordance with the appropriate flight control systems maintenance manual. Now take off the 348701-l fitting and 403577-l link assembly from the lower end of each 3400961-3 cable assembly by removing the MS21042-5 nut, AN960-516 washer,

Figure 1. **First disconnect fitting and link assembly from P/N 3400961-3 cable assembly.**



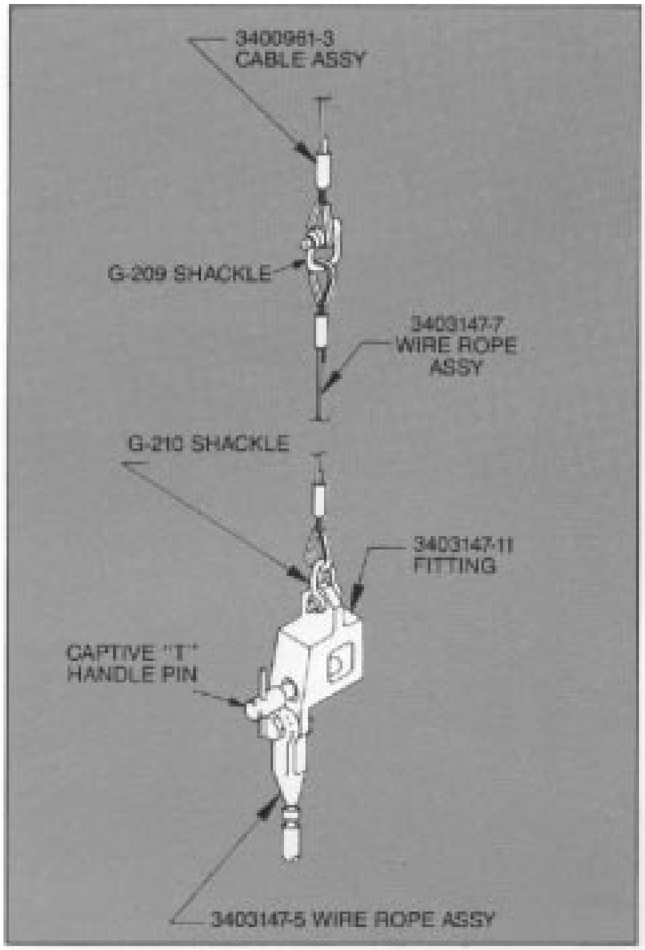


Figure 2. **Next attach the new fitting and wire rope assemblies to the -3 cable assembly.**

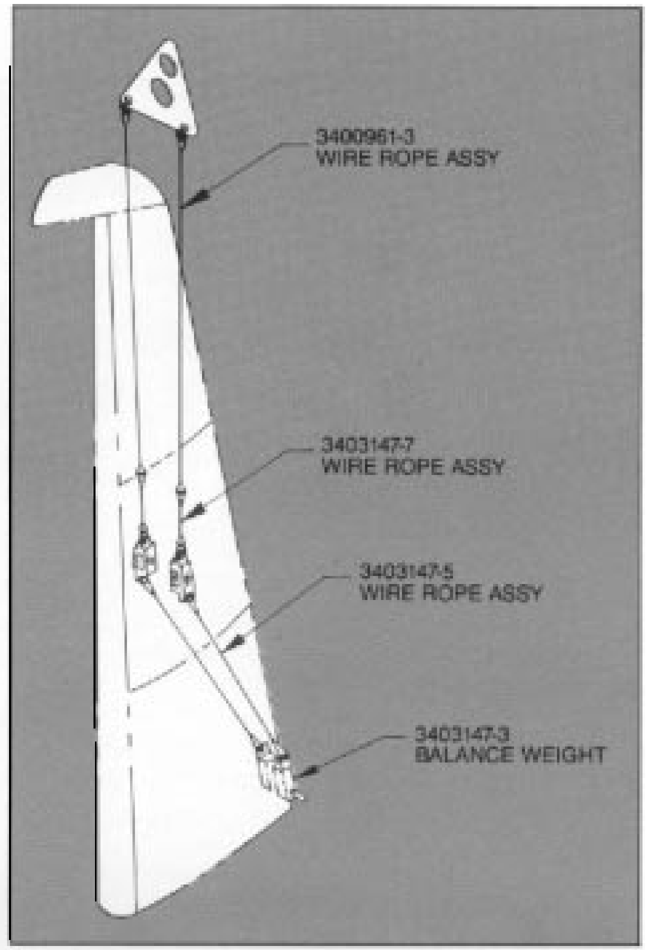


Figure 3. **Then connect the modified sling to the rudder.**

NAS1005-13A bolt, and 348362-9 spacer (Figure 1). Store all of these parts with the other parts of the 3400961-l sling assembly that are not used for rudder removal or installation.

Next attach a 3403147-7 wire rope assembly to the free end of each 3400961-3 cable assembly, using a G-209 l/2-ton shackle (Figure 2). To the free end of each 3403147-7 wire rope assembly, connect a 3403147-11 fitting, using the G-210 l/2-ton shackle. Finally, connect the 3403147-5 wire rope assemblies to the -11 fittings and the 3403147-3 balance weight, using the hardware furnished with the -5 wire rope assemblies. The sling assembly is now ready for removing or installing a Hercules aircraft rudder.

To install the modified sling for use, suspend it from whatever hoisting device will be used and mate each -11 fitting to the sling attach point on each side of the rudder with the fitting's captive "T" handle pin (Figure 3). The 3403147-3 balance weight fits over the trailing edge of the rudder. Make sure that control is maintained over the balance weight when connecting the fittings or damage could occur to the rudder.

With the modified sling attached to the rudder, the rudder can now be removed or installed, safely and easily, using the standard procedures outlined in the flight control systems maintenance manuals.

For technical information on the 3403147-l modification kit, contact:

Lockheed-Georgia Company
Support Equipment Design Dept.
Department 72-68, Zone 450
Marietta, Georgia 30063
Telephone (404) 424-5468
TELEX 542642

For quotations or purchase of the 3403147-l modification kit or the 3400961-I General Purpose Sling Assembly incorporating the modification, contact:

Lockheed-Georgia Company
Supply Sales and Contracts Dept.
Department 65-11, Zone 451
Marietta, Georgia 30063
Telephone (404) 424-3842
TELEX 542642

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C-130Hs for Japan

Japan became the 55th nation to own and operate the Hercules aircraft when two advanced C-130Hs were delivered to the Japan Air Self Defense Force in December of 1983. The second of these versatile airlifters had the additional distinction of being the 1700th C-130 to be delivered by the Lockheed-Georgia Company. The occasion was marked by appropriate ceremonies at the Lockheed production facility in Marietta, Georgia (see picture at right).

The Air Staff Office of the JASDF selected the C130H to serve their heavy airlift mission requirements after several years of thorough study and detailed analysis. Among the important factors that led to the selection of the Hercules aircraft was its operational flexibility. This remarkable airplane can serve effectively in many roles, from meeting national defense airlift commitments to bringing emergency supplies, rescue personnel, and construction equipment to regions laid waste by natural disasters.

Other considerations that placed the Hercules aircraft in the forefront of the selection process were its legendary durability and proven design. Operational efficiency in such matters as fuel requirements and maintenance costs also weighed heavily in the C-130's favor, as did its respect for the environment with regard to airport community noise levels.

In addition to the two aircraft received in December, Japan has two more C-130Hs on order, with deliveries scheduled for the second half of 1984. We want to extend our best wishes to the Japan Air Self Defense Force for many years of successful operations with the c-130.

Lockheed-Georgia Company

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A Division of Lockheed Corporation
Marietta, Georgia 30063