 Lockheed

VOL. 21 NO. 4, OCTOBER-DECEMBER 1994

SERVICE NEWS

A Publication of Lockheed Aeronautical Systems Company



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Vol 21, No.4, October-December 1994

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Covers: Pike's Peak and the Rocky Mountains offer a striking backdrop for one of four brand-new C-130H airlifters recently delivered to the 302nd Airlift Wing of the U. S. Air Force Reserve, based at Peterson AFB, Colorado. The 302nd will receive 8 additional new Hercules aircraft in the coming months.

Cover photographs by John Rossino

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Focal Point



Larry Arnold

Powering Up for the Future

The basic design of the electrical power system that equips today's Hercules was conceived over 30 years ago when the C-130B was still on the drawing boards. The fathers of this concept have now all retired, but they are to be commended for building a power system that has so well withstood the test of time. Their design has provided power in the quantity and with the required quality and redundancy so successfully that few changes have been needed, despite years of evolution in the systems used on the aircraft.

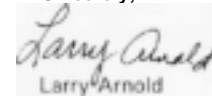
Only quite recently have a few selected changes to the C-130's electrical power system been deemed justified. These updates were driven mainly by the advent of digital avionics systems that require high-quality electrical power for their operation. One of the improvements that helps meet this goal is the generator control unit (GCU), which ensures that well regulated, quality power is received from the generators. The other is the bus switching unit (BSU), which provides more stable AC power during normal bus transfers among the generators.

The GCU was introduced to the C-130H at Lockheed serial number LAC 5271. It replaces three types of existing components, and not only provides improved power, but also makes maintenance easier. Service News V19N2 and V20N3 contain articles that describe many of the features of the new GCUs. The BSU was first put into service on LAC 5310. It was designed to solve a specific problem that impacted the operation of the new digital avionics equipment. During normal operation, the AC buses experience brief switching transients. These power fluctuations had little effect on the avionics of the vacuum-tube era, but interruptions that would pass unnoticed in analog units seem like a lifetime to fast-reacting digital designs. The result can be errors and memory dumps which require an affected system to be rebooted or reprogrammed, possibly several times in the course of a single flight. The BSU, which is discussed in detail in this issue, protects these new systems by providing uninterruptible AC power to the aircraft's avionics buses.

As we move into the next generation of the Hercules airlifter, the C-130J program has offered us a unique opportunity to bring the electrical power system up to standards that will serve for many years to come. But why fix something that isn't broken? When we looked at the requirements of the C-130J, we discovered that only improvements that enhance reliability and maintainability, like simplified wiring, electronic circuit breakers, and oil-cooled generators, would serve any real purpose.

Once again, the basic design that was conceived so many Years ago has proven ready to meet whatever challenges the future demands of it. The next century will be able to rely on the Hercules as its premier all-purpose airlifter. The world's most thoroughly proven aircraft electrical system is an important part of the reason why.

Sincerely,



Manager

C-I 30 Electrical Systems Design

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a Practical Guide to the **BSU**

understanding the Bus Switching Unit

by **Norm Stevens**, Training Specialist
Customer Training Systems Department

New production Hercules airlifters now being built at Lockheed's assembly plant in Marietta, Georgia, are equipped with updated electrical AC power systems which include Leland or Bendix generators and generator control units (GCUs). In addition, C-130 aircraft Lockheed serial number LAC 5310 and up ordered by the U.S. military, and all Hercules airplanes Lockheed serial number LAC 5358 and up, have electrical systems that include two bus switching units (BSUs), a new external AC power contactor, and solid-state inverters.

These improved systems help provide the high-quality AC power demanded by many types of modern digital avionics equipment. The main features of the electrical power upgrade are covered in articles in *Service News* Vol. 19, No. 2, dated April-June 1992, and Vol. 20, No. 3, dated July-September 1993. This

article describes the update of the electrical AC bus distribution system and the new avionics AC buses.

BSU Function

Two identical bus-switching units (BSUs), located on the top shelf of the underfloor electrical control and supply rack (Figure 1), are designed to provide continuous, uninterruptible AC power to the avionics systems. These Leland-built units monitor the status, voltage, frequency, and current of the electrical power available on the aircraft, and then use this information to select the best AC power source. One BSU provides output power to the essential avionics AC bus, and the other BSU powers the main avionics AC bus.

The BSUs are automatically bypassed (go to bypass mode) if they fail, or when specific anomalies exist in

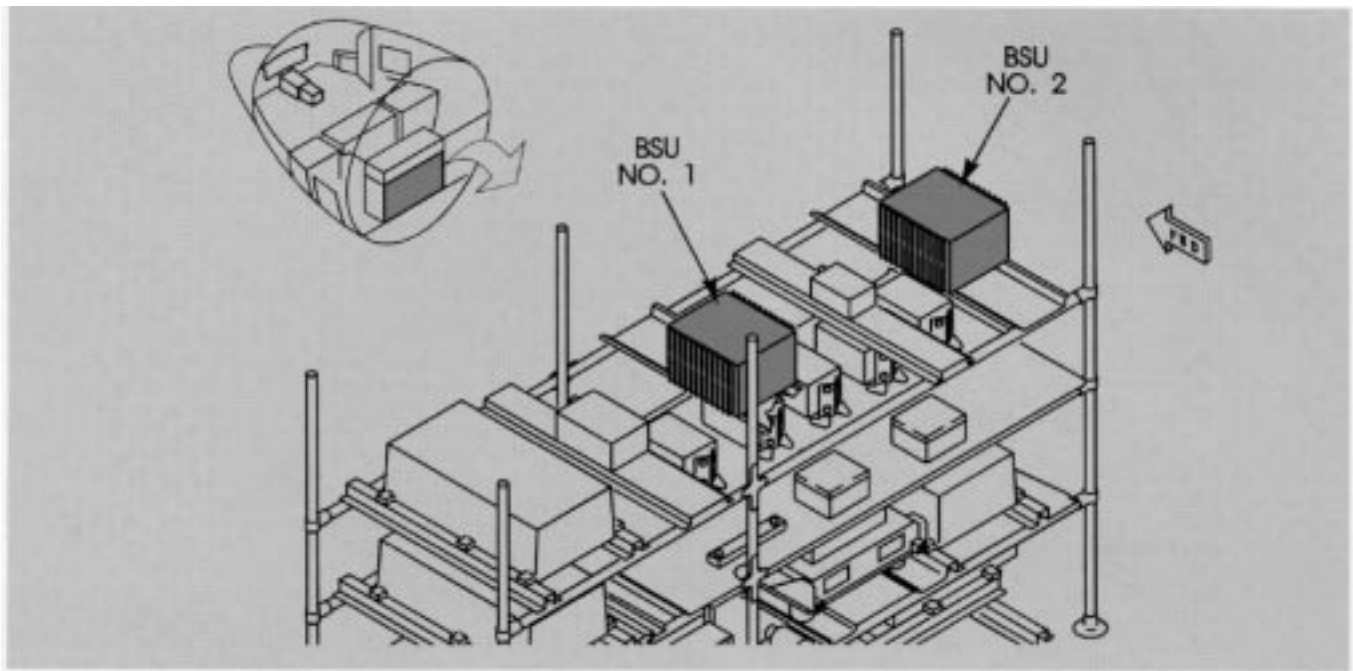


Figure 7. BSU locations – electrical control and supply rack.

the aircraft's electrical power system. Bypass mode can also be selected manually, by setting the BSU control switch located on the overhead electrical control panel (OECF) to the OFF position. Note, however, that the BSU cannot prevent power interruptions on the avionics AC bus when it is in the bypass mode.

BSU AC Bus Inputs (115/200 VAC)

Each BSU receives AC power through the AC bus distribution system from three of the aircraft AC buses. BSU No. 1, which supplies the essential avionics AC bus, has power inputs from the left-hand (LH) AC bus, the essential AC bus, and the main AC bus. These inputs constitute its external, primary, and alternate AC power sources respectively. BSU No.2, which supplies the main avionics AC bus, has power inputs from the right-hand (RH) AC bus, the main AC bus, and the essential AC bus. These comprise its external, primary, and alternate AC power sources (Figure 2).

Each of these BSU inputs is provided through a three-phase AC, ganged circuit breaker (C/B). The LH and RH AC bus BSU C/Bs are located on the pilot's upper circuit breaker panel, the essential AC bus C/Bs are on the pilot's side C/B panel, and the main AC bus C/Bs are on the copilot's upper C/B panel (Figure 6, page 9).

BSU Control and Logic Inputs

The BSU receives logic inputs which provide data about the status of the electrical AC bus distribution system contactors. It monitors each engine-driven generator line contactor (GLC) coil input, and the APU

GLC coil input from the GCU. The APU essential-to-main AC bus tie contactor (BTC) coil is also monitored. Similarly, the B coil of the new, two-section external power contactor is monitored as a BSU logic input. These logic inputs ensure that the BSU will be provided with advance information of an impending AC bus transfer, which is accomplished by the contactors.

Operation of the BSU is also controlled by an ON/OFF input from the BSU control switch located on the OECF (Figure 3), plus a 28 VDC BSU control input from C/Bs on the essential DC bus. These C/Bs are located on the copilot's lower C/B panel (Figure 6). The DC power is used as a backup source, allowing the BSU built-in-test (BIT) to be performed with no AC input power applied.

Each BSU monitors the primary and alternate AC power sources and the appropriate logic inputs in order to select the best available AC power source for use with the avionics AC buses. During normal steady-state conditions with the engine generators operating, BSU No. 1 selects power from the essential AC bus-its primary input bus-and BSU No. 2 selects power from the main AC bus, which is its primary input bus. When operating on external AC power, BSU No. 1 selects power from the LH AC bus, while the BSU No. 2 selects power from the RH AC bus, which are the external input buses.

BSU Built-In Test (BIT)

Each BSU has the capability to perform a BIT that will verify the operation of the BSU control and monitoring circuits. The BSU front panel includes four

light-emitting diode (LED) indicators that display an operating status code, or a failure code of the BIT checks (Figure 4). Below the LED display is a truth table showing all of the various status and failure codes which are monitored by the BSU.

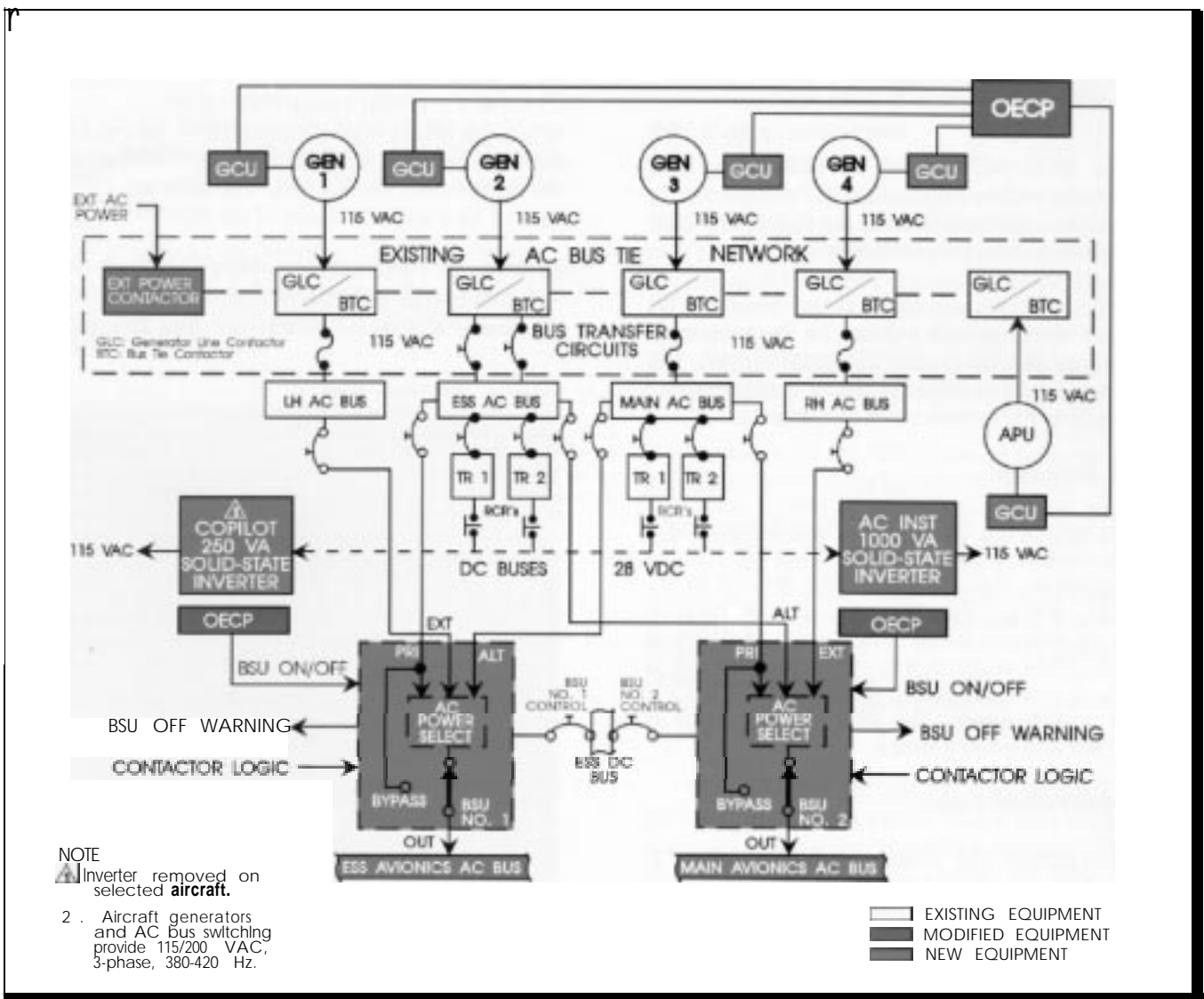
When the BSU is initially powered up by external AC power or aircraft generator power and the BSU control switch on the OECP is in the ON position, the BSU internal power supply receives 115/200 VAC input power from one or more of the three possible AC bus inputs and, as a backup power input, 28 VDC from the essential DC bus. At this point the BSU will automatically perform the BIT.

During the BIT, all four LEDs on the BSU will be illuminated (BIT IN PROCESS). The BSU operates in the bypass mode from the primary AC input bus while the BIT takes place. The BSU BIT internal checks consist of the following:

- Previous overcurrent check.
- Contactor checks (energized or not, plus auxiliary contact positions).
- +28 VDC internal power supply check ($> + 18$ VDC).
- + 12 VDC internal power supply check (regulating within ± 1 VDC)
- ON/OFF circuit check (by injecting high and low voltages).

The BIT takes approximately 5 seconds to complete. If the BIT was initiated with external AC power on the aircraft AC buses and no failures are detected, the BSU ALTERNATE BUS ACTIVE code will be displayed upon completion of the test. If the BIT was initiated with the APU or engine generators powering the buses, either

Figure 2. C-130H power distribution system with BSUs – block diagram.



The original cause of a failure must

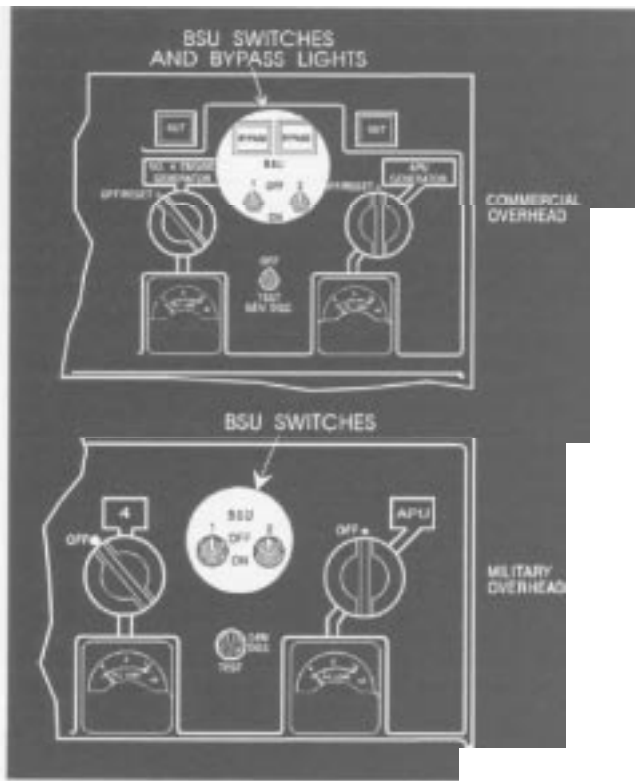


Figure 3. OECP configurations (typical).

PRIMARY BUS ACTIVE or ALTERNATE BUS ACTIVE codes will be displayed at BIT completion. In most cases, the LEDs will indicate the PRIMARY BUS ACTIVE code under these conditions.

If a BSU malfunction is detected, one or more LEDs will remain illuminated to indicate by the truth table the type of problem that has been detected. If a failure has occurred, a BSU fail output is provided and the BSU selects the bypass mode of operation.

BSU BIT Initiation

As we have noted, the BIT takes place automatically if the BSU control switches located on the OECP are in the ON position when power is first applied to the aircraft AC buses. The BIT can also be initiated manually by pressing the BIT pushbutton on the front panel of the BSU. Another way of initiating the BIT is to cycle the appropriate control switch from ON to OFF and back to ON again. The BSU control switch is normally left in the ON position.

BSU Status/Failure Codes

In interpreting and clearing failure codes, it is important to keep in mind that overcurrent, previous overcurrent, and short circuit failures activate a latching circuit that prevents the BSU from powering up until a “cold” shutdown has been performed. A cold shutdown requires that all the AC and DC power inputs be

removed and then reapplied. In all cases where failures have caused the bypass mode to be selected, it is also necessary to clear the original cause of the failure or attempts to reset the system will not be successful.

●●●● ● BIT IN PROCESS

All LEDs lit. This indicates that the BIT is currently being carried out. The test lasts 5 seconds.

0 0 0 0 NO FAULTS

No LEDs lit after completion of BIT. This indicates that no failures have been detected and no AC power is on the aircraft buses. The BSU is in the bypass mode.

0 0 0 ● PRIMARY BUS ACTIVE

Display of this status code indicates that the primary AC source bus is in use with the BSU to power the avionics AC bus.

0 0 ● 0 OVER CURRENT TRIP

When this failure code is displayed, it indicates that an overload has been detected, and the BSU has selected the bypass mode and latched. The latch set can only be cleared by a cold shutdown of the BSU.

0 0 ●● PREVIOUS OVER CURRENT

This failure code indicates that an overload was detected previously and the latch was set. The BIT has been

Figure 4. BSU truth table.

LED RUTH TABLE	
●●●●●	NO FAULTS
●●●●●	PRIMARY BUS ACTIVE
●●●●●	OVER CURRENT TRIP
●●●●●	PREVIOUS OVER CURRENT
●●●●●	TOO MANY INTERRUPTS
●●●●●	NOT USED
●●●●●	SHORT CIRCUIT
●●●●●	NOT USED
●●●●●	ALTERNATE BUS ACTIVE
●●●●●	NOT USED
●●●●●	PRIMARY CONTACTOR FAILURE
●●●●●	ALTERNATE CONTACTOR FAILURE
●●●●●	OUTPUT CONTACTOR FAILURE
●●●●●	DIGITAL BOARD FAILURE
●●●●●	POWER BOARD FAILURE
●●●●●	BIT IN PROCESS (ALL LIT)

Identified and cleared before proceeding.

initiated subsequently without clearing the latch. The BSU will remain in the bypass mode until a cold shutdown has been accomplished.

0 ■ 0 0 TOO MANY INTERRUPTS

If an excessive amount of noise exists on the AC source in use, the BSU will select the bypass mode and display this failure code. The BSU can be reset by cycling the BSU control switch on the OECP to OFF, and then back to ON again.

0 ● ■ 0 SHORT CIRCUIT

Display of this failure code indicates that the feeder wires to the avionics AC bus have shorted. The BSU is in the bypass mode and the latch has been set. A cold shutdown is required to reset. The primary AC input C/B may open in this situation. Note that a wiring short-circuit condition may damage the BSU output contactor. If this has occurred, the BSU will have to be replaced.

■ 0 0 0 ALTERNATE BUS ACTIVE

Display of this status code indicates that the alternate AC source bus is in use with the BSU to power the avionics AC bus.

■ 0 ■ 0 PRIMARY CONTACTOR FAILURE

Failure of the BSU input contactor on the primary AC bus causes this code to be displayed. The BSU is in the

bypass mode, but may be reset by cycling the BSU control switch to OFF and then back to ON.

■ 0 ■ ■ ALTERNATE CONTACTOR FAILURE

Failure of the BSU input contactor on the alternate AC bus causes this code to be displayed. The BSU is in the bypass mode. Reset by cycling the BSU control switch to OFF and then back to ON.

■ ■ ■ 0 OUTPUT CONTACTOR FAILURE

Display of this code indicates that the BSU output contactor has failed and the bypass mode has been selected. The unit can be reset by cycling the BSU control switch to OFF and then back to ON.

■ ■ ■ 0 ● DIGITAL BOARD FAILURE

Display of this code indicates that the BSU digital board has failed. The BSU is in bypass mode; reset by cycling the BSU control switch to OFF and then back to ON.

■ ■ ■ ■ 0 POWER BOARD FAILURE

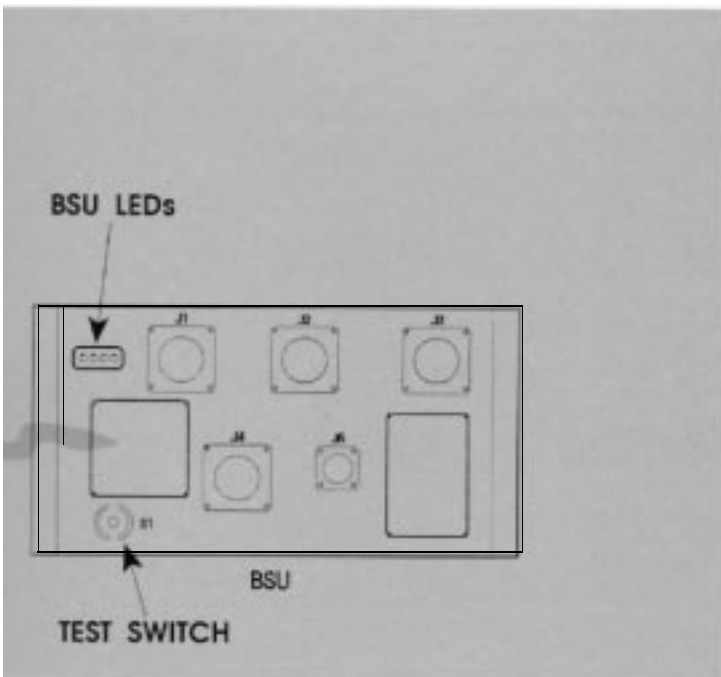
Display of this code indicates that the BSU power board has failed. The BSU is in the bypass mode. To reset, cycle the BSU control switch to OFF and then back to ON.

BSU Failure Indications

In addition to the failure codes displayed on the BSU's front panel, a BSU OFF (1 and 2) advisory light or BYPASS light (depending on aircraft model) is used to provide BSU failure indications in the flight station area. These lights will also be illuminated for approximately 5 seconds while the BSUs perform the BIT checks. If the BSU passes the BIT, the lights will extinguish and normal operation will commence.

However, if the BSU fails or fails the BIT, the applicable annunciator light(s) will remain illuminated. Whenever the BSU is in a failed condition, it remains in the bypass mode. This allows the essential or main avionics AC bus to be powered by the BSU primary AC input source without being monitored or controlled by the BSU. If the primary AC input source is powered, the associated BSU avionics AC bus will operate. Note, however, that a momentary power interruption occurs on the avionics AC bus anytime the BSU goes into the bypass mode.

Two avionics AC bus-off caution lights are also provided in the flight station. These give indications of a power loss on the respective avionics AC buses. During the 5-second BIT check, the BSU is in the bypass mode, but if the primary AC input buses were powered prior to running the BIT, the avionics AC buses will continue to be powered and the bus-off lights will remain extinguished.



Initial Startup BSU Transfer Sequence

During a normal startup of the aircraft, a specific set of BSU power transfer sequences takes place. When external AC power is initially applied to the aircraft AC buses, the BSUs go through the startup BIT, and then switch to use their respective external AC input buses. As we have seen, BSU No. 1 will be on the LH AC bus, and BSU No. 2 on the RH AC bus. The BSUs stay in this mode until an aircraft generator is turned on.

When the APU is started and the APU generator control switch on the OECP is selected to ON, the A coil of the external power contactor will deenergize. This causes the essential and the main AC buses to be transferred to the APU generator through the APU GLC and BTC (assuming that the main AC bus tie switch on the OECP is in the ON position). The LH and RH AC buses remain on the external AC power source because the B coil of the external power contactor is held energized by a time delay relay for 0.5 seconds.

The time delay gives the essential and main AC buses time to stabilize on the APU generator. After the time delay has elapsed, the B coil of the external AC power contactor also deenergizes, and the BSUs transfer to the primary buses with no power interruption on the avionics AC buses. The AC buses are now no longer powered by the external AC power source.

The next transfer occurs with BSU No. 2 when the first engine-driven generator is brought on line via the GLCs and the BTCs. At this time, the main AC bus transfers to the engine-driven generator. The APU generator stays on the essential AC bus and BSU No. 1, which powers the essential avionics AC bus.

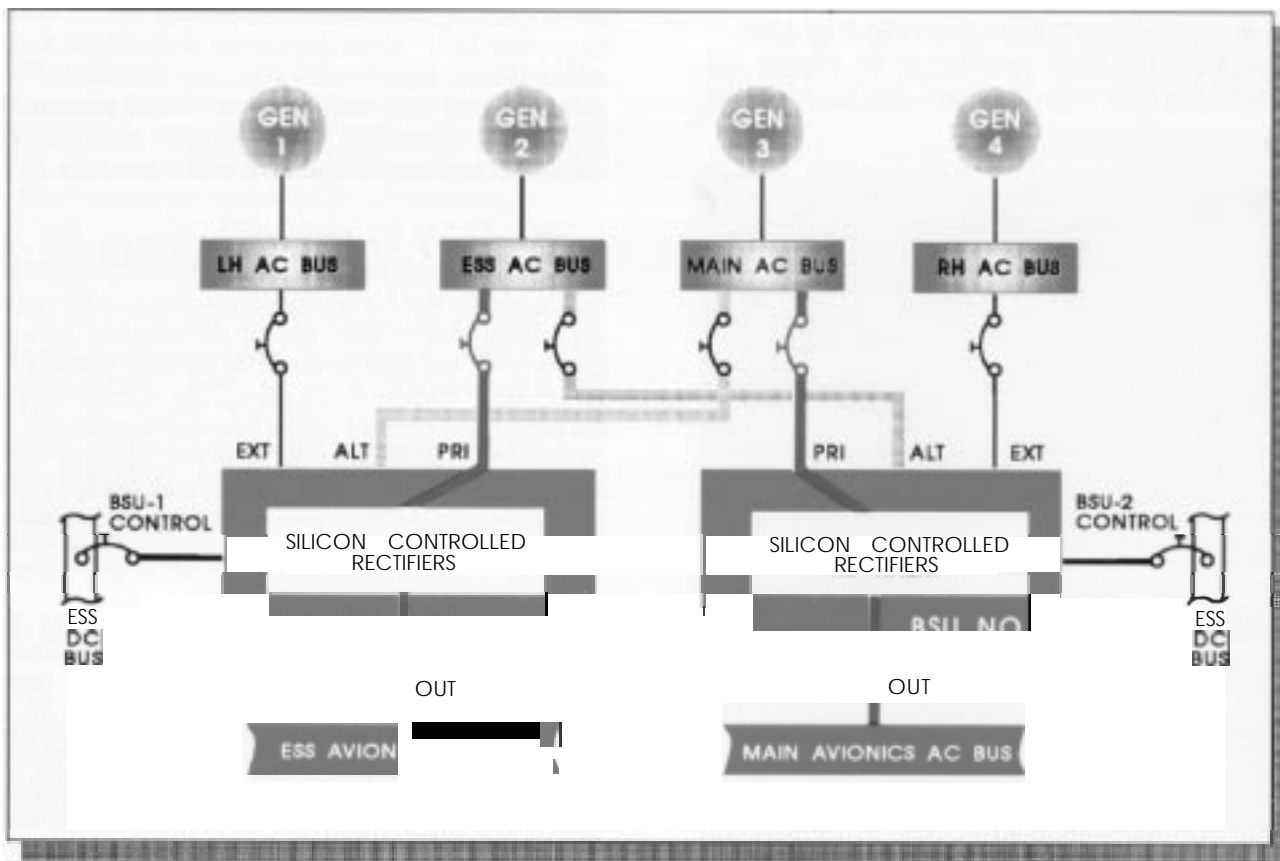
To prevent a break in power to the main avionics AC bus, BSU No. 2 transfers momentarily to the alternate input essential AC bus. After the main AC bus stabilizes on the selected generator and a 7-second delay has elapsed, BSU No. 2 transfers back to the primary input main AC bus. As more generators are brought on line, the main avionics AC bus will again be transferred by BSU No. 2 if the selected generator will affect the main AC bus, which is the primary input source.

The transfer that affects BSU No. 1 occurs when the APU generator control switch is positioned to OFF/RESET. When this occurs, BSU No. 1 transfers momentarily to the alternate input main AC bus. After the essential AC bus stabilizes on the engine generator and a 7-second time delay has elapsed, BSU No. 1 will transfer back to the primary input essential AC bus.

BSU Operation

The BSU's function is to monitor and select the primary AC power source that is applied to the avionics

Figure 5. AC power distribution during normal BSU operation.



AC bus, while observing an alternate power source. If the primary power is degrading or is about to be interrupted by a bus configuration change, the BSU will transfer the avionics bus load to the alternate source as long as its voltage, frequency, and current are within the proper limits.

An ON/OFF BSU control switch controls the BSU operation. When the switch is in the ON position, the BSU will select suitable power for the avionics AC bus. Placing the switch in the OFF position, on the other hand, prevents the BSU from selecting a bus source for the avionics AC bus.

When OFF is selected on the BSU control switch, the output contactor remains deenergized and the BSU stays in the bypass mode. This allows only the primary bus to power the avionics AC bus. If the primary AC bus power becomes degraded, that power remains on the affected avionics AC bus and no transfer is available. If no primary power is available, the applicable avionics AC bus-off light will be illuminated in the flight station.

When the BSU control switches on the OECP are in the ON position and external AC power is applied, external AC power is connected to the aircraft AC buses and to the BSU AC inputs. No automatic BSU transfer can occur from the primary or alternate AC inputs

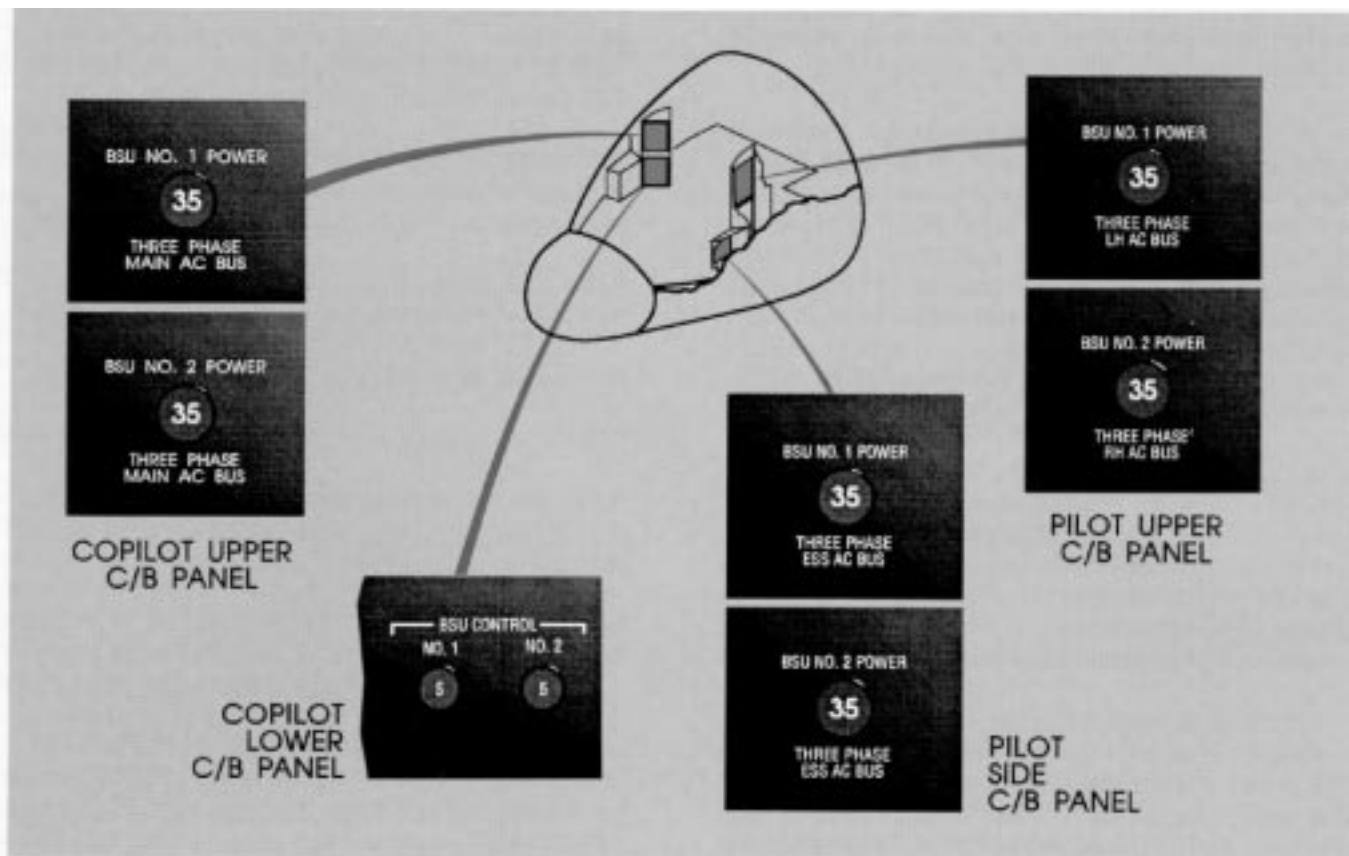
during external power operation. The LH and RH AC buses will power the BSUs and the associated avionics AC buses.

However, when the aircraft generators are supplying the AC buses, BSU power transfer will take place if the BSU detects a situation that would cause AC power degradation, or a bus configuration change in the primary AC input source. In either of these situations, the BSU will transfer to the alternate AC bus, providing that the power available from the alternate AC bus is within the proper limits and is not in the process of being transferred.

After a 7-second time delay, the BSU will transfer back to the primary AC input source if the voltage and frequency are now within limits. If the alternate AC power input source fails while it is in use, transfer back to the primary source will be accomplished without the time delay. If the primary source has also failed, the bypass mode will be selected.

Power transfers between the primary and alternate AC input sources occur with no loss of voltage or current. The switching is completed within a maximum of 200 to 450 microseconds, depending on the AC source power factor. The transfer always occurs at the zero or near the zero current crossover point.

Figure 6. Circuit breaker locations.



This is accomplished by silicon-controlled rectifiers (SCRs) which are backed up by electromechanical relays for fail-safe operation in case of a short circuit in the SCRs. All logic functions are accomplished by a micro-processor. Status reporting is built into the BSU in the form of the four LEDs and truth table previously described. The status of the monitored AC source bus or a failure condition of the BSU can readily be determined from the LED display.

No transfer will occur if the AC input bus configuration change does not interrupt the power on the primary AC bus. Transfer will also not take place if the AC input bus configuration change will interrupt power on both the primary and alternate AC buses. The BSU monitors both AC input buses, and resumes power to the avionics AC bus when either the primary or alternate AC bus returns to normal operation. If both AC input buses are interrupted or off, the BSU bypass mode is selected.

BSU Transfer Requirements

With the generators operating, the BSU will transfer to the alternate AC source if the primary AC source is outside the voltage or frequency specifications as follows:

FREQUENCY TRANSFER -If the primary AC source is between 360-445 Hz, the primary source will remain in use. However, if the primary source is outside this “window,” the BSU will transfer to the alternate AC source, providing the alternate source is within the window.

If the alternate source is outside the window, a wider window of 340-465 Hz will be used. As long as the primary is within the second window, no transfer will occur. But if the primary AC input source is not within this window, transfer to the alternate source will occur, providing that the alternate source is within the second window. No transfer will occur if the alternate source is outside the second window. If both sources are outside both windows, the BSU output contactor will be deenergized and the BSU will go to the bypass mode.

VOLTAGE TRANSFER - The BSU monitors the AC voltage and current to coordinate the transfer from one source to the other. Under normal load conditions, the BSU will transfer from the primary AC source to the alternate AC source when the primary source voltage is outside the window of 100 - 125 VAC and the alternate source voltage is within these limits.

If an undervoltage and an overcurrent condition occur simultaneously, there will be no transfer (because overcurrent could possibly be the cause of the problem). However, if the alternate source voltage is also outside the limits, the BSU output contactor will be deenergized

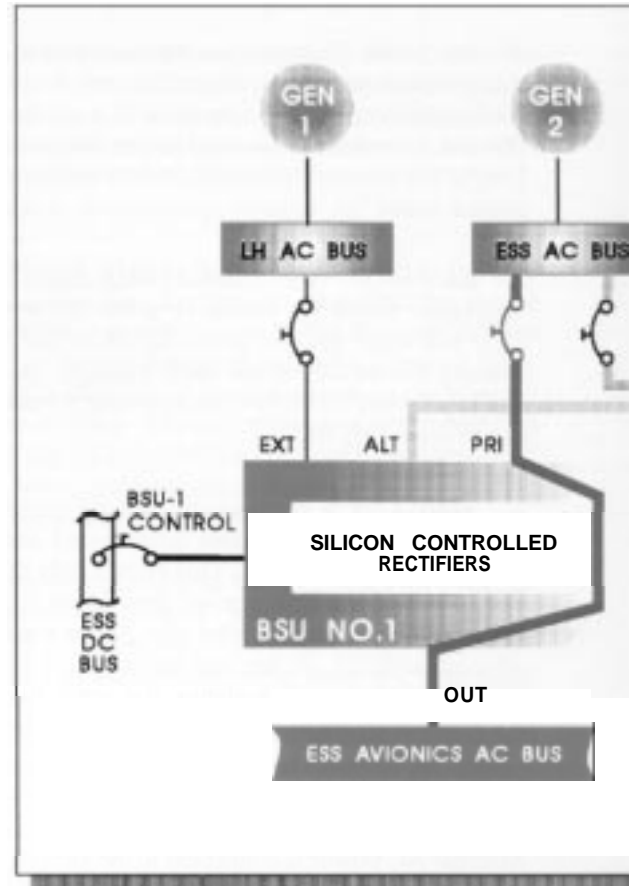


Figure 7. AC power distribution - BSU in bypass mode.

and the BSU will select the bypass mode. In most cases, BSU operation will automatically return to normal when the voltage is within these windows for the primary or alternate source. The exceptions are described under BSU Status/Failure Codes.

BSU OVERLOADS - The BSU can handle a specific overload condition for a specific amount of time. Examples of the BSU’s output ratings are as follows:

- 10 KVA - continuous
- 15 KVA - 5 minutes with a voltage drop of 2.0 volts.

An example of an overload parameter is as follows:

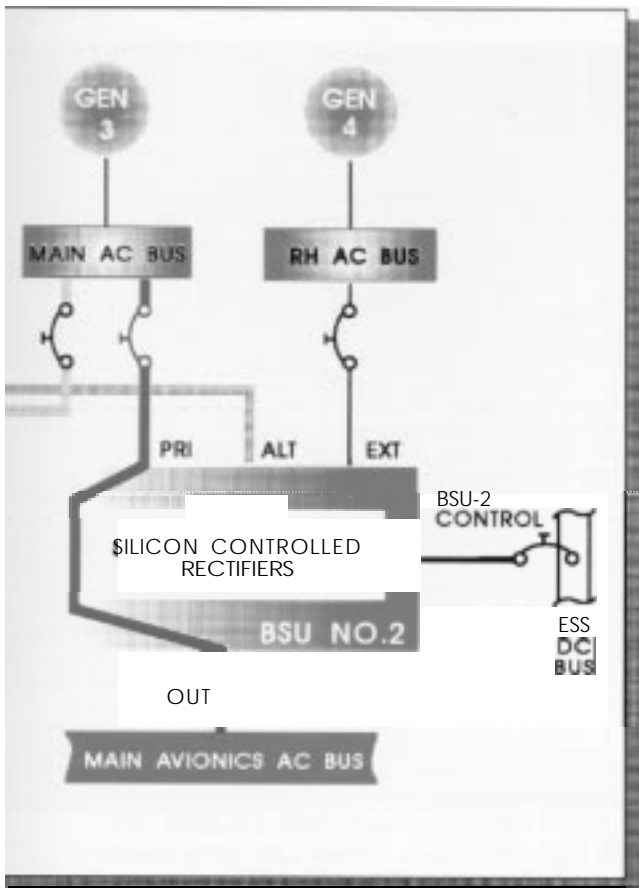
- 15 KVA - 5 minutes

If an overload exists for the time duration specified, the BSU output contactor will be deenergized and the BSU will go to the bypass mode.

BSU Interface

Each BSU has five electrical connectors, J1 through J5. These connectors provide the interface through the aircraft wiring, as follows:

- J1- Primary AC Bus Input. Essential AC bus input for BSU No. 1; main AC bus input for BSU No. 2.



- J2- Alternate AC Bus Input. Main AC bus input for BSU No. 1; essential AC bus input for BSU No. 2.
- J3- External AC Bus Input. LH AC bus input for BSU No. 1; RH AC bus input for BSU No. 2.
- J4- Avionics AC Bus Outputs. Essential avionics AC bus output from BSU No. 1; main avionics AC bus output from BSU No. 2.
- J5- BSU ON/OFF control switch input, 28 VDC control voltage input from the essential DC bus, logic inputs, and failure warning outputs. Same for both BSUs.

BSU Operational Summary

The AC bus distribution system bus switching depends on the operation of the unregulated AC power systems and associated components, and the power sources available. Switches, lights, and meters are provided in the flight station to control and monitor these systems AC voltage, frequency, and AC load. The AC bus distribution system powers the BSU.

Each BSU has three AC source inputs from the AC bus distribution system, and a DC control input from the essential DC bus. The AC source is determined by which of the AC power sources are available. These

inputs, along with the contactor logic inputs and BSU power switch input, control the BSU bus transfer operation.

A BIT is initiated automatically at power on. The BIT can also be initiated by cycling the BSU power switch to OFF then ON, or by pressing the pushbutton on the BSU. The BIT requires a period of 5 seconds to complete, during which the BSU will be in the bypass mode and the BSU OFF or BYPASS light will be on.

Four LEDs on the front face of the BSU will be illuminated during the test. Upon successful completion of BIT, the BSU OFF or BYPASS lights will extinguish and normal BSU operation will begin. At this point a status code reflecting the AC input source will be displayed on the BSU's LEDs.

If the BSU fails during operation or BIT, the BSU is bypassed and the primary AC source is used with the avionics AC bus. Initial selection of the bypass mode, automatically or manually, causes a momentary power interruption on the avionics AC bus. The BSU OFF or BYPASS light illuminates and the BSU LEDs will indicate a failure code. Some BSU failures can be reset by setting the BSU control switch to OFF and back to ON again. Latched failures require removal of all AC and DC BSU power inputs—a cold shutdown.

The BSU bypass mode uses the primary AC source for output to the avionics AC bus as a result of any of the conditions as follows:

1. BSU power switch in OFF. The BSU's LEDs are off.
2. BSU BIT in process.
3. BSU failed.
4. BSU primary and alternate AC sources failed during generator operation.
5. BSU external AC source failed during external AC power operation. The avionics AC power will also fail.

During normal operation with AC power on the aircraft, the BSU power switch should be ON and the BSU OFF or BYPASS light off. If the aircraft is on external AC power, BSU No. 1 uses the LH AC bus, and BSU No. 2 the RH AC bus and the BSUs status LEDs will indicate ALTERNATE BUS ACTIVE.

The AC voltage and frequency from the external AC ground power unit (GPU) can be monitored at the GPU, and on the OECP. When the external AC is in use, the combined AC bus loads on all of the aircraft buses can only be monitored at the ground power unit.

BSU COMPARISONS	BSU NO. 1	BSU NO.2
DC Control Input	ESS DC Bus	ESS DC Bus
Power Switch	BSU NO. 1 on OECP	BSU NO.2 on OECP
Warning Light	BSU NO. 1 OFF/BYPASS	BSU NO.2 OFF/BYPASS
Logic Inputs	GLC's No. 1 - No.4	GLC's No. 1 - No.4
	APU GLC	ESS/Main AC BTC
	Ext Pwr Contactor	Ext Pwr Contactor
External AC Source	LH AC Bus	RH AC Bus
Primary AC Source	ESS AC Bus	Main AC Bus
Alternate AC Source	Main AC Bus	ESS AC Bus
Bypass AC Source	ESS AC Bus	Main AC Bus
Avionics AC Bus	ESS AV AC Bus	Main AV AC Bus
Bus Warning Light	ESS AV AC OFF	MAIN AV AC OFF

Figure 8. BSU operational differences.

With the APU generator on and the main AC bus tie switch on (tied), or an engine generator on, the generator in use supplies the essential and main AC buses. The BSU No. 1 will use the primary AC source (essential AC bus), and BSU No. 2 will use the primary AC source (main AC bus). The BSU's LEDs will indicate PRIMARY BUS ACTIVE.

With the APU generator on and the main AC bus tie switch off (not tied), the APU generator supplies the essential AC bus, and the main AC bus is off. BSU No. 1 will use its primary AC source (the essential AC bus), and BSU No. 2 uses its alternate AC source (the essential AC bus). BSU No. 1's LEDs indicate PRIMARY BUS ACTIVE, and BSU No. 2's LEDs indicate ALTERNATE BUS ACTIVE.

When the generators are on, the BSU LEDs can indicate either PRIMARY BUS ACTIVE or ALTERNATE BUS ACTIVE, depending upon which AC power source the BSU has selected. The primary bus has priority. Generator operational conditions that will cause bus transfer of the essential and main AC buses at the same time should be avoided since this will interrupt the BSU output to the avionics buses.

With the generators in operation, if the primary AC source bus switching is anticipated, the BSU transfers to the alternate AC source at or near the zero current crossover point. When the primary bus switching is completed and a 7-second delay has elapsed, the BSU transfers back to the primary AC source if it is within limits.

If the selected alternate AC source fails, the transfer back to the primary AC source is not delayed. If the

primary and alternate AC sources have failed, the BSU will go to the bypass mode and the primary AC source is the BSU output to the avionics AC bus. The BSU OFF or BYPASS light illuminates. Power interruptions can occur on the avionics buses when the BSU bypass mode is in use.

The essential avionics AC bus loads include the majority of the avionics AC systems and the synchrophaser system. On later aircraft, it also supplies power to the engine instruments. The rest of the avionics AC systems are loads on the main avionics AC bus. Most avionics systems operate from single-phase AC from these buses. The avionics AC bus loads are part of the AC power systems loads displayed on the AC generator loadmeters.

The AC bus distribution system AC bus-off warning lights are illuminated when the three-phase AC buses are not powered, or have low voltage. These buses are also the AC source inputs to the BSUs. The essential avionics or main avionics AC bus-off lights illuminate if the BSU three-phase AC outputs to the avionics AC buses are not available, or are at low voltage.

BSU Wiring Differences

The BSUs are internally identical; differences in their operation result from differences in the aircraft wiring, as shown in Figure 8, above.

The author and *Service News* wish to extend special thanks to Bob Parker for his invaluable assistance in the preparation of this article.

SERVICE NEWS



The 1930 Lockheed Altair featured the world's first successful fully retractable landing gear.

*by Dolcena Sanderson, Product Support Engineer
Reliability and Maintainability Engineering Department*

The landing gear of an aircraft is the assembly that supports the aircraft while it is parked or moving on the ground. In the early days of aircraft development the landing gear was quite simple, usually consisting of a system of skids, wheels, or a combination of both. This was adequate at the time because aircraft were very light in weight. Most were constructed of wood and cloth, and held together with glue and wire. But the rapid growth in aircraft size and weight during World War I and in the years thereafter pointed up the need for an improved method of absorbing the increasing loads being borne by aircraft landing gear.

At this point in history, hydraulic shock absorbers had already been in use on other types of equipment for several decades. One of the first uses of hydraulic shock absorbers dates back to the early 1890s, when a "recuperator," a kind of brake incorporating spring and hydraulic action, was installed on heavy field artillery to absorb the recoil shock when the gun was fired.

It was soon discovered that hydraulic shock absorbers were also effective in handling the shock loads experienced by aircraft during takeoff and landing, and the devices were quickly incorporated into the design of most landing gear systems. These self-contained hydraulic units, also known as shock struts, did an excellent job of protecting the aircraft structure by absorbing and dissipating the ever-growing shocks loads

involved in launching increasingly heavier aircraft into the air and returning them safely to earth.

Aircraft Shock Struts

In its simplest form, the aircraft shock strut consists of a piston with orifices which moves through a cylinder containing oil and compressed air. The oil is pushed through the orifices as the piston is forced upward by the landing load, absorbing energy in the process. The compressed air then pushes back in the opposite direction, attempting to return the piston to its extended position. Snubbing devices are employed to modulate this action and help prevent excessive bouncing when the aircraft makes contact with the runway.

While the incorporation of the hydraulic landing gear shock absorber can be seen as a major step in the development of the modern airplane, it also brought with it new maintenance requirements. The high-pressure air charge had to be maintained, and the hydraulic fluid needed to be replenished periodically. To accomplish this, a fluid filler port was located near the upper end of the shock strut and an air valve fitted into the port to permit strut inflation.

The traditional method employed to replenish the strut fluid involves opening the air valve to release the strut pressure, removing the valve, and pouring the fluid

into the strut. Once filled to the proper level with fluid, the air valve is replaced and the strut reinflated, using high-pressure air or dry nitrogen.

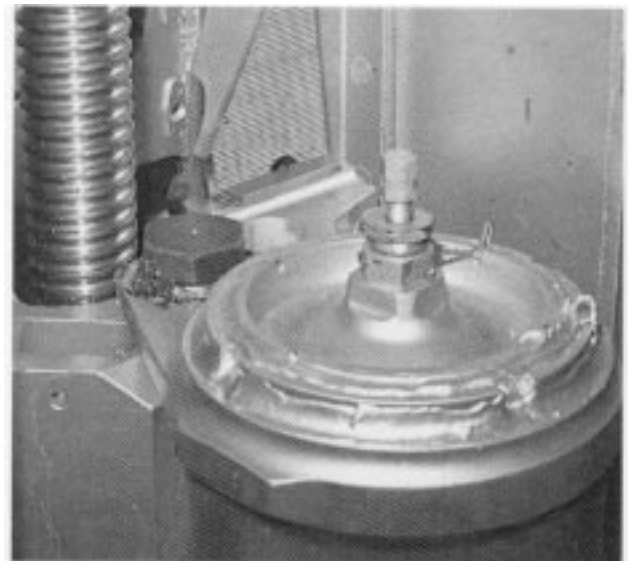
Unfortunately, the process is not nearly as convenient or simple in practice as it sounds in theory. From the standpoint of the maintenance technician, the task is both time-consuming and messy, and there are environmental complications as well. During deflation, the escaping air carries entrained hydraulic fluid with it. This can form a mist that blankets the work area, contaminating workers, tools, equipment, and the aircraft. Additionally, air coming out of solution with the fluid causes bubbling at the filler port, especially on larger struts. This makes it difficult to pour new fluid into the strut and ascertain the correct fluid level.

A further problem is that this untidy but essential task cannot be carried out quickly. This can lead to flight delays and cancellations, a costly deficiency in a schedule-oriented, high-demand transport system.

Enter the Hydro Mite

The introduction of the Hydro Mite Landing Gear Strut Service Stand enables operators to perform complete strut servicing (fluid and nitrogen) in essentially the same amount of time as previously required to inflate the strut with nitrogen alone. Struts can be reserviced on the ramp in as little as five minutes, and because both fluid and nitrogen servicing is performed at the same time, there is no need to schedule the aircraft for further maintenance at a later time.

The Hydro Mite servicing stand is housed in a steel cabinet and mounted on a trailer assembly for portability.

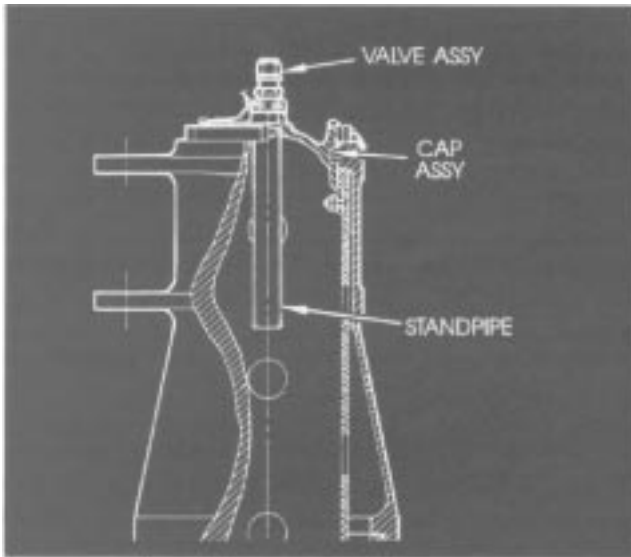


Shock struts typically include filler ports at the top end.

This unit is designed to service aircraft oleo-pneumatic landing gear shock struts at all maintenance levels with fresh, filtered hydraulic fluid and nitrogen. It is a self-contained, portable hydraulic pumping unit which accurately services single, dual, and multi-chambered struts in minutes without jacking the aircraft.

The system includes a high-pressure pump with a pressure compensator powered by a gasoline or diesel engine, or an electric motor; micron filters; one 40-gallon fresh hydraulic fluid reservoir; one 40-gallon



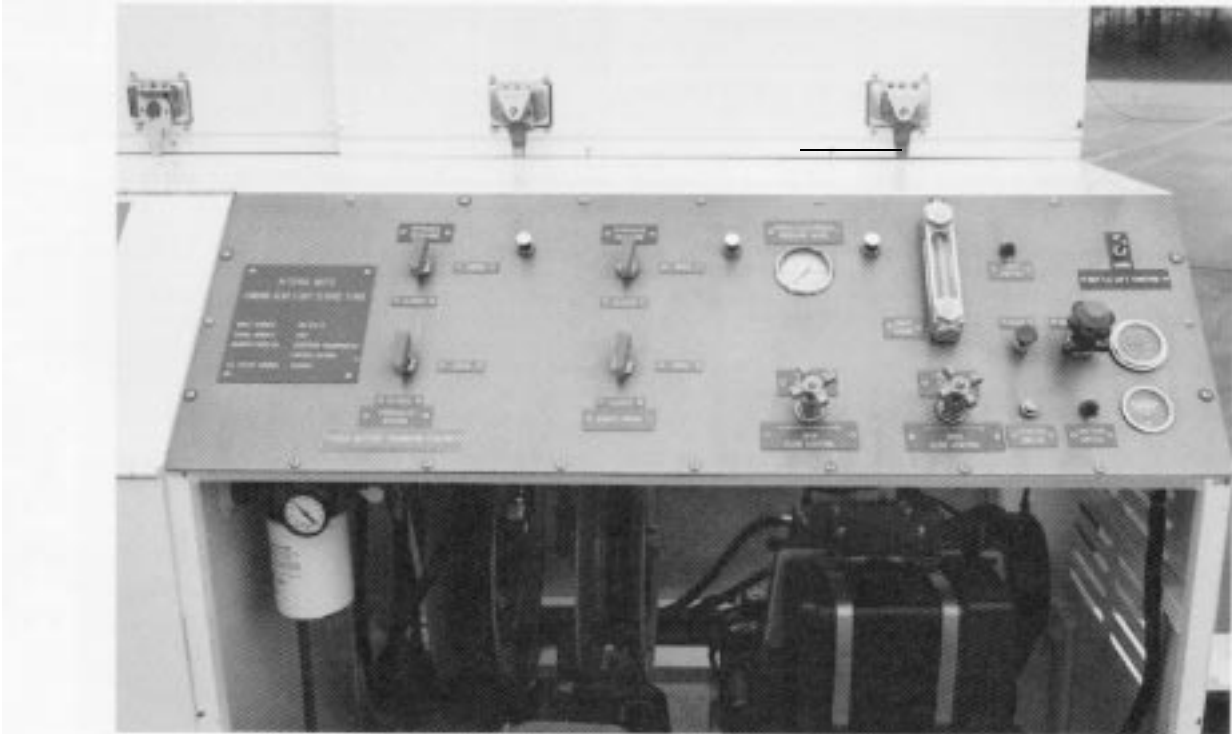


The ports are fitted with air valves to permit inflation.

waste hydraulic fluid reservoir; and 40 feet of high-pressure hose on two retractable hose reels. Control of flow to and from the strut is achieved through the use of valves on the instrument panel.

The servicing stand is housed in a weather-resistant steel cabinet mounted on a trailer assembly with pneumatic tires. Instruments and controls are permanently nameplated to identify their function, and hinged doors provide quick access for routine inspection, maintenance, and service.

The instruments and controls on the operator's panel are clearly marked with permanent nameplates.



A heavy-duty towbar with lunette eye and steerable front wheel make the unit highly maneuverable, allowing it to be moved by hand or towed at speeds up to 20 mph. Manual parking brakes on the aft wheels are controlled by a lever located on the front of the chassis.

The Hydro Mite can be used on flight lines, in hangars, in hostile environments (rain, snow, arid, salt air, extremes in temperature and altitude), and at remote sites around the world. It is completely transportable and can be lifted by inserting a forklift fork under the unit's frame at marked locations.

Component Breakdown

Major components of the Hydro Mite include Kohler gasoline engines, Hatz diesel engines, Dayton electric motors, Vickers pumps, Harris and Victor regulators, Lincoln hose reels, Parker needle valves, check valves, and hose assemblies, Hoke ball valves, Cross filters, WIKA liquid-filled gages, and other brand names well known to industry.

All of these component brands are readily available throughout the United States and most of the rest of the world. Distribution centers are maintained in Latin America, the United Kingdom, Europe, Canada, the Far East, and elsewhere. Most components have exact replacement parts available from several manufacturers. Users can, for example, choose from eight different brands of filter elements exactly compatible with the Cross filter head.

Equipment Maintenance

Total access to every component is designed and built into the Hydro Mite. No special maintenance capability is required to support this equipment. The overall requirements are low, and deal primarily with the engine and hydraulic fluid filters.

The most important part of the engine maintenance is ensuring that the crankcase oil is maintained at the proper operating level and changed on schedule. The dry-filter air cleaner should be kept clean, and replaced as necessary. As far as the fluid filters are concerned, because they filter only clean fluid, they rarely become contaminated. Annual filter changes will ordinarily be sufficient.

Durability

Unlike high duty-cycle equipment such as air compressors, ground cooling units, hydraulic test stands, and light carts, the Hydro Mite has a very low duty cycle. The engine runs only during the fluid pumping portion of strut servicing. This results in a very slow accumulation of operating hours.

For example, complete strut servicing can usually be accomplished in 5 or 6 minutes, which means that the

engine will actually be needed perhaps 2 or 3 minutes per strut servicing. If a user services one Hercules aircraft per day (5 struts) every day for a year, and the engine operates 5 minutes per strut, the engine will only accumulate about 150 hours operating time per year.

Equally important, the engine on this servicing stand is not required to operate at full throttle. The engine is adjusted to operate at about one-half throttle, or 1600 to 1800 rpm, which significantly prolongs engine life. The first of these units was placed in commercial service in 1985, and since that time, no engine failure has been reported.

All other components in the system are low-usage, low-wear parts as well. The Vickers pump is well known for its reliability, and unless it is run without fluid, it is unlikely ever to fail. This pump is designed for continuous duty, but it pumps only clean fluid for a few minutes each duty cycle.

Training

With the introduction of this new equipment, a training program was developed and is offered to each purchaser. Since 1985, Rentfrow Inc. has trained several hundred commercial airline employees, including mechanics, leadmen, training supervisors,

Hinged doors provide quick access for routine maintenance; note also the convenient forklift lift points.



maintenance supervisors, and managers to operate Hydro Mite equipment.

One hour of training at the aircraft is sufficient to ensure operator competency. All functions of the service stand are straightforward and easy to understand. The simplicity and efficiency of the unit helps ensure operator acceptance, and once trained, the technician's retention of his skills with the Hydro Mite is usually excellent.

Strut Servicing

The Hydro Mite method of strut servicing is fast, safe, clean and simple. One of the two retractable hoses is connected to the strut Schrader valve, and the valve is opened. Using control valves on the service stand, the strut is first deflated, venting waste fluid and nitrogen into a waste hydraulic fluid reservoir. Next, the strut is filled with fluid, inflated to the proper extension, and the Schrader valve is closed.

The pressure is then released from the stand, the hose disconnected from the aircraft and retracted on the reel. The task is completed in minutes, and no clean-up is required. This procedure is not only quick and efficient, but it does not waste fluid. Only enough fluid is used to purge the air and fill the strut.

Use of the Hydro Mite can dramatically reduce the time and effort required to service C-130 struts.



A unique low-profile, high-pressure inflating connection with double-shutoff quick couplings is included with the unit. It allows users to connect the stand to most aircraft in just a few seconds. The couplings swivel to reduce hose stress, and seal when disconnected to prevent fluid leakage and 'contamination.

Environmental Concerns

The U.S. government, other national governments, and state governments are becoming increasingly concerned with the release of hazardous and toxic fluids into the environment. They are enacting legislation that is making it more difficult and costly to handle and dispose of waste oil.

Because large numbers of struts are serviced daily, this activity may become the target of Environmental Protection Agency (EPA) action, and in some of the more stringent jurisdictions, the release of hydraulic fluid into the ecosystem may be prohibited. Most operators are aware of the prospect that EPA action on this particular source of environmental pollution is coming, and that alternative methods of strut servicing will be required.

Users of this servicing stand will be well prepared for such changes. With Hydro Mite equipment, all waste fluids and gases are vented into the waste fluid hydraulic reservoir. Baffles, filters, and screens are provided to control misting, and all waste fluid is captured. Valves are provided for easy draining of the waste hydraulic fluid reservoir. Because waste fluid is totally controlled, there is no contamination of the aircraft, atmosphere, or work area. This helps operators comply with both present and future EPA and OSHA guidelines.

Safety

Jacking the aircraft is not required using Hydro Mite, which immediately removes one major area of hazard exposure. Complete strut servicing is done with the aircraft weight on the wheels, avoiding both possible injuries to maintenance personnel and the possibility of damaging the aircraft. The rate of descent of the aircraft during deflation is totally controlled, and can be stopped at any point in the procedure. Infinite flow control is provided by needle valves to control and compensate for strut binding.

C-130 Applications

Compatibility tests have been conducted on the Hydro Mite at several Air Force bases in the United States and the results have shown that the use of the new servicing stand lowers the actual manhours required for fully servicing C-130 struts from the standard 64 hours to 2.5 hours per airplane for the complete job.

Availability

The Model HM-GT-1-C Hydro Mite Landing Gear Strut Service Stand is being NSN-stocklisted, and it is available from the manufacturer, Rentfrow Inc., P.O. Box 55597, Phoenix, AZ 85078-5597; telephone 602-

433-0000; fax 602-971-2249. These units may also be ordered through Lockheed by contacting the Lockheed Aeronautical Systems Support Company (LASSC), P.O. Box 121, Marietta, GA 30061-0121; telephone 404-431-6665; fax 404-431-6666.

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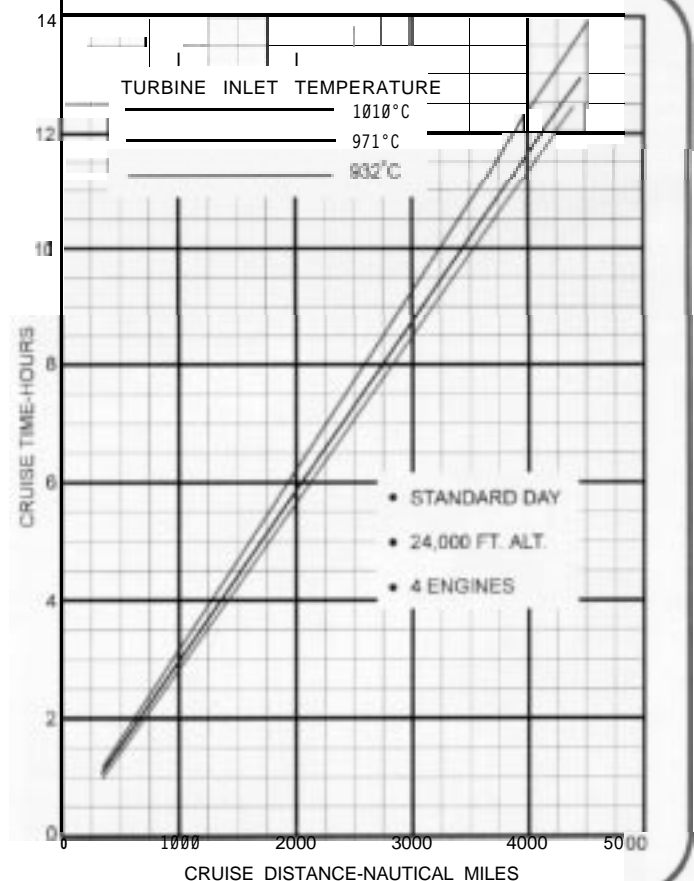


For the Record:

Singing the Reds/Blues

Because of a production miscue, the red and blue lines shown in Figure 2 on page 5 of our previous issue (Vol. 2 1, No. 3), were interchanged. The correct chart is printed at the right. *Service News* regrets the error.

- Ed.



Engine Fireseal Installation by the Numbers !!

by Wayne Thompson, *Field Service Representative*
Airlift Field Service Department
Lockheed Aeronautical Systems Support Company

In recent months some C-130 operators have been complaining that engine firewall seals keep popping out. The reappearance of this particular problem at this point in time has been somewhat perplexing because it was believed to have been solved a number of years ago. Investigation of the circumstances surrounding these cases has pointed to a likely explanation of the mystery.

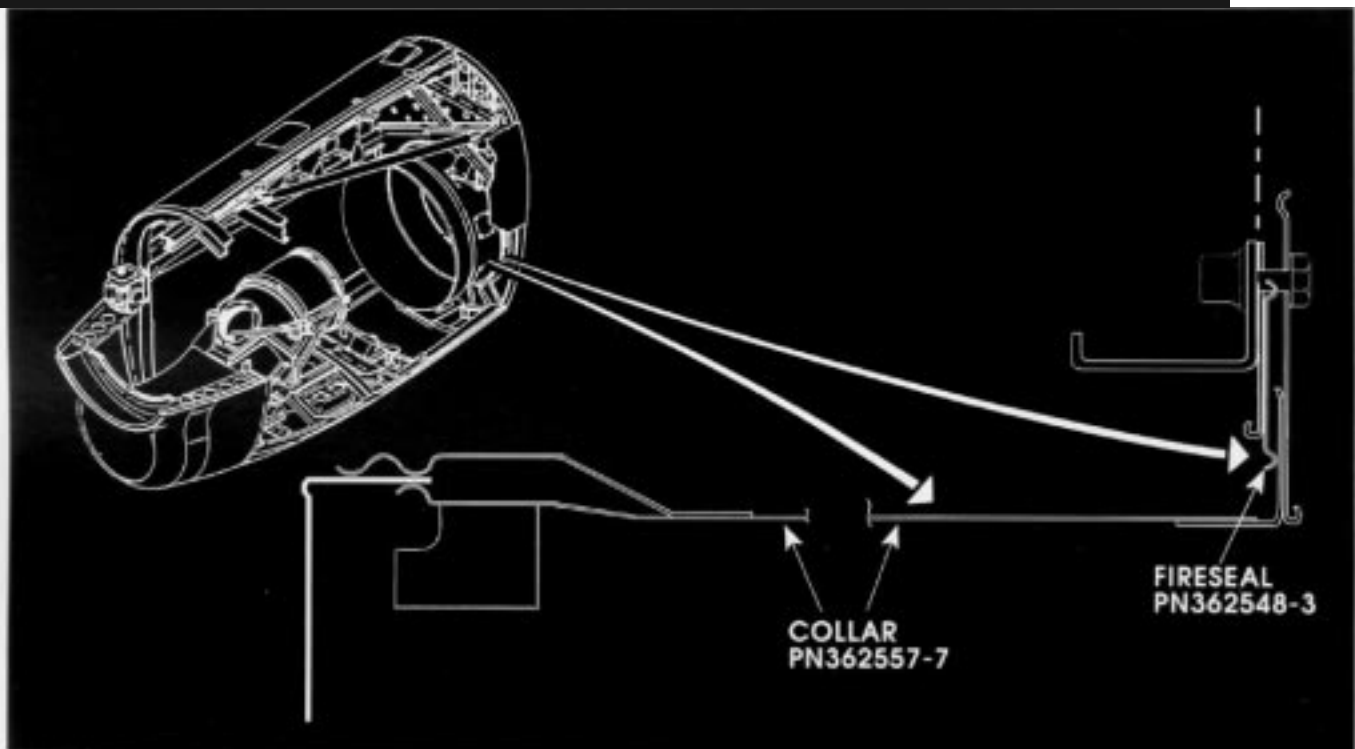
Back in 1985, both of the components involved, the PN 362548-1 fireseal and the PN 362557-1 fireseal collar, were redesigned to improve their installation and retention in the QEC. The upgraded parts were provided with new dash numbers, PN 362548-3 and PN 362557-7 respectively, and designated as preferred spares for replacement purposes. At the same time, the improved parts also began being installed in all new QEC build-ups on the Hercules production line.

Unfortunately, the technical manuals were not updated to reflect these changes, and no NSN numbers

were assigned to the new parts. As a consequence, most users continued to order replacement parts exclusively under the old numbers. The result is that the improved fireseals and fireseal collars are not being installed when the older QECs are reworked. Moreover, the newer QECs, which contained the updated parts as original equipment, are unwittingly being "retrofitted" with parts of the older design when their fireseals and collars require replacement.

All of the military and commercial manuals will soon be updated to list the PN 362548-3 fireseal and the PN 362557-7 fireseal collar. In the meantime, operators are reminded to use the new numbers when ordering replacement parts for these components. Installation of the improved fireseal and fireseal collar will help ensure a good fit and a long and trouble-free service life.

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Aeronautical Systems Company

Customer Training Systems Department

Lockheed - LASC

Marietta, GA 30063



***Rocky Mountain Herk!
New C-130Hs for the 302nd Airlift Wing.***