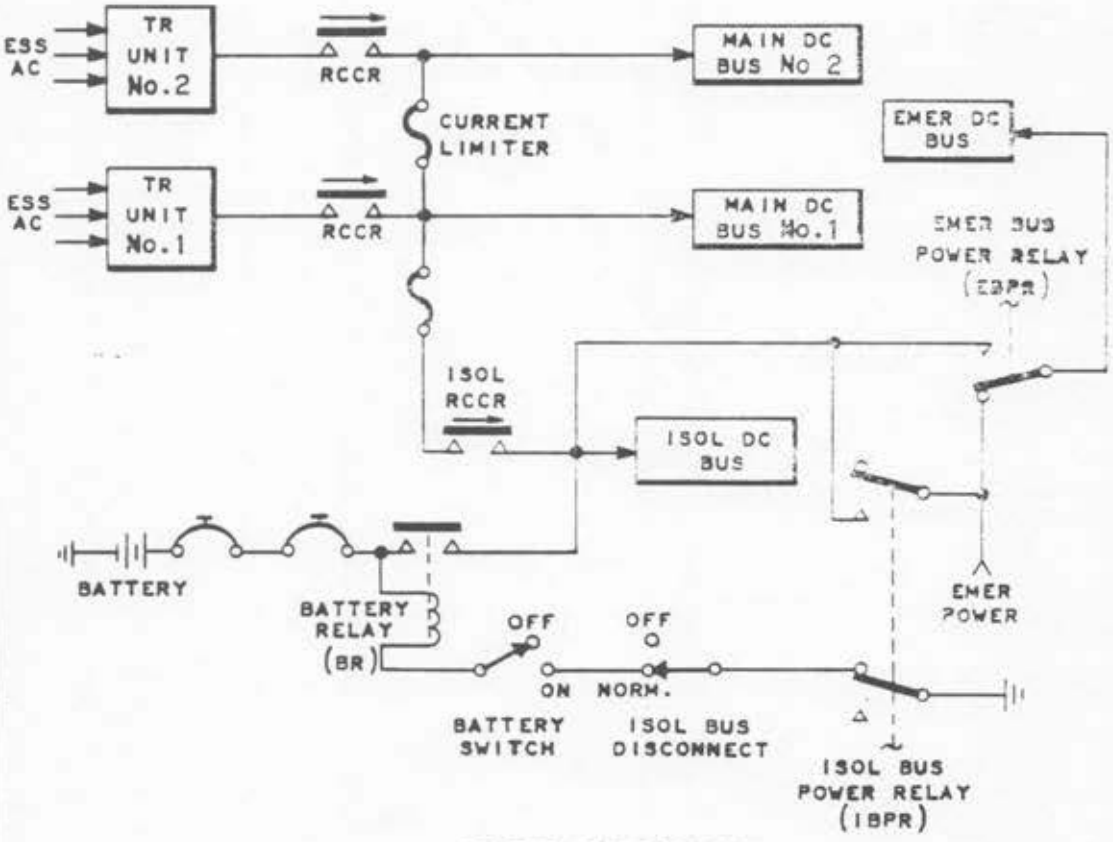
# D-C POWER SYSTEM

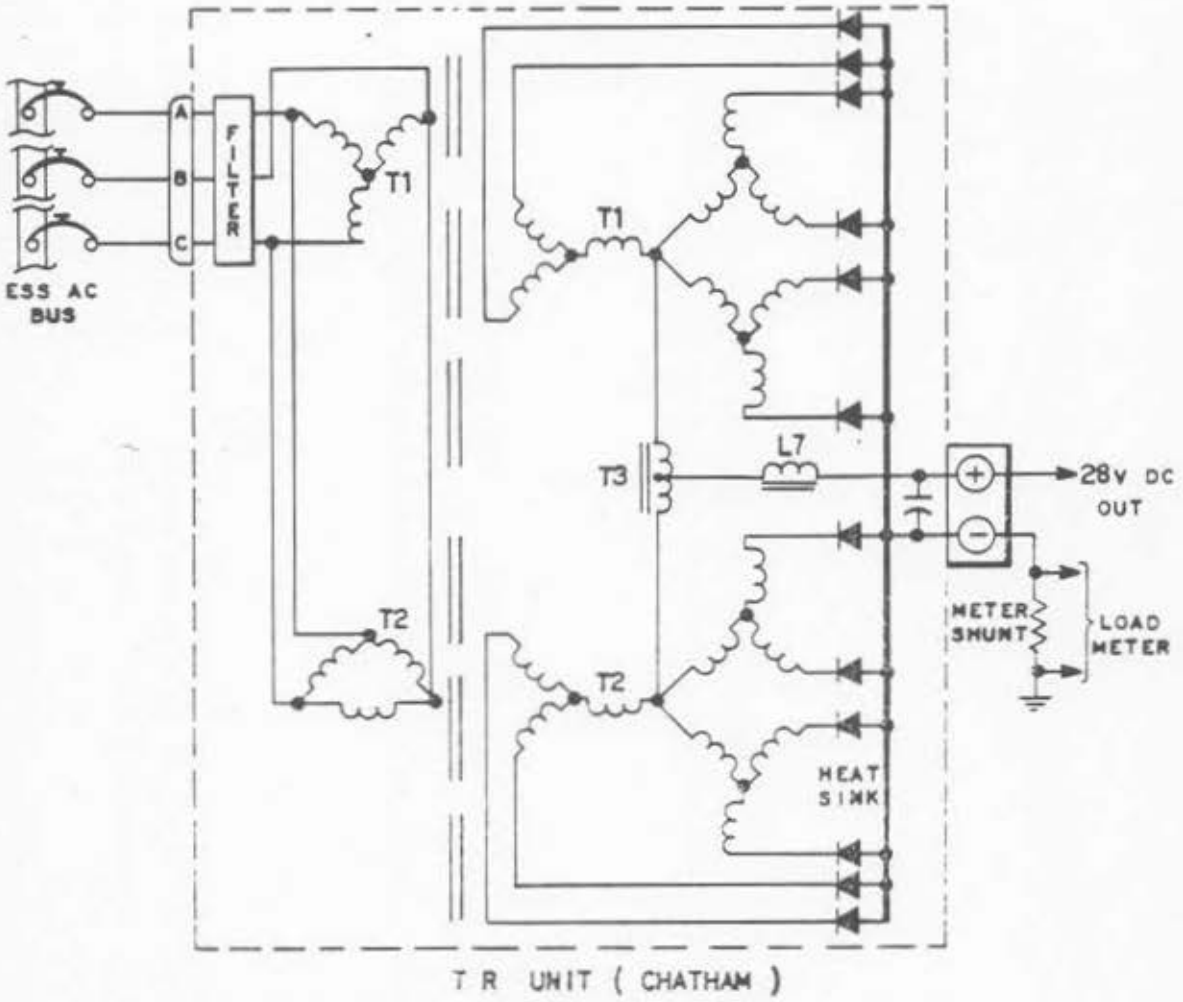
## GENERAL

The normal source of D-C power for the StarLifter is two transformer-rectifier (TR) units. These units change three-phase AC to 28-volt, DC. Each unit is rated at 28 volts and 200 amperes. The units are located on the right hand forward underdeck rack. Cooling of these units is provided by normal air circulation.




DC BUS DISTRIBUTION

A 24-volt lead-acid battery is provided as an emergency source of power. The battery is used primarily to start the auxiliary power unit but may also be used in flight if the emergency generator is inoperative. Inflight emergency power is supplied by a hydraulically-driven A-C/D-C generator as long as hydraulic pressure is available.

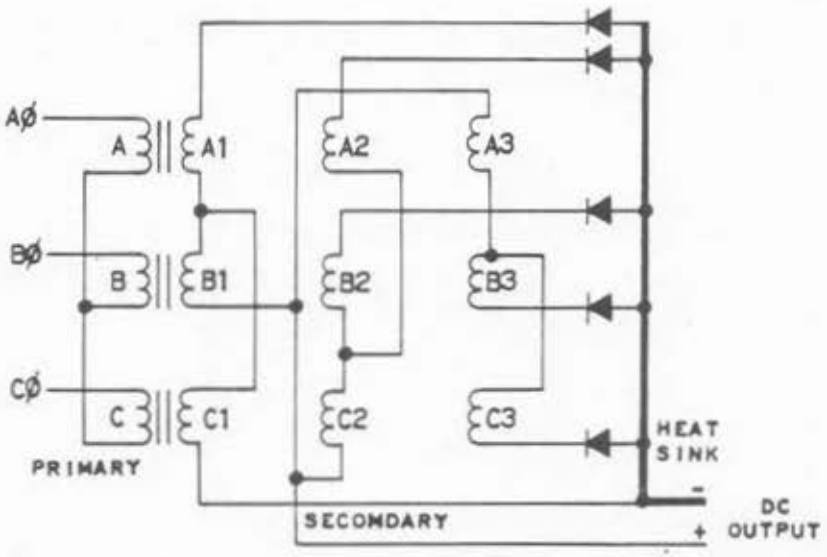


T R UNIT ( CHATHAM )

## TR UNITS

The input to each TR unit is 200-volt, phase-to-phase, 400 Hertz AC from the No. 1 or No. 2 essential A-C bus. One unit is connected to each bus. The output is supplied through reverse current cutout relays to the D-C buses. No. 1 and No. 2 DC buses are interconnected and both can furnish power to the isolated D-C bus. The TR units contain step-down transformers to reduce the input voltage to a lower value and silicon rectifiers to change the AC to DC. The silicon rectifiers are mounted on a heat sink to dissipate heat.

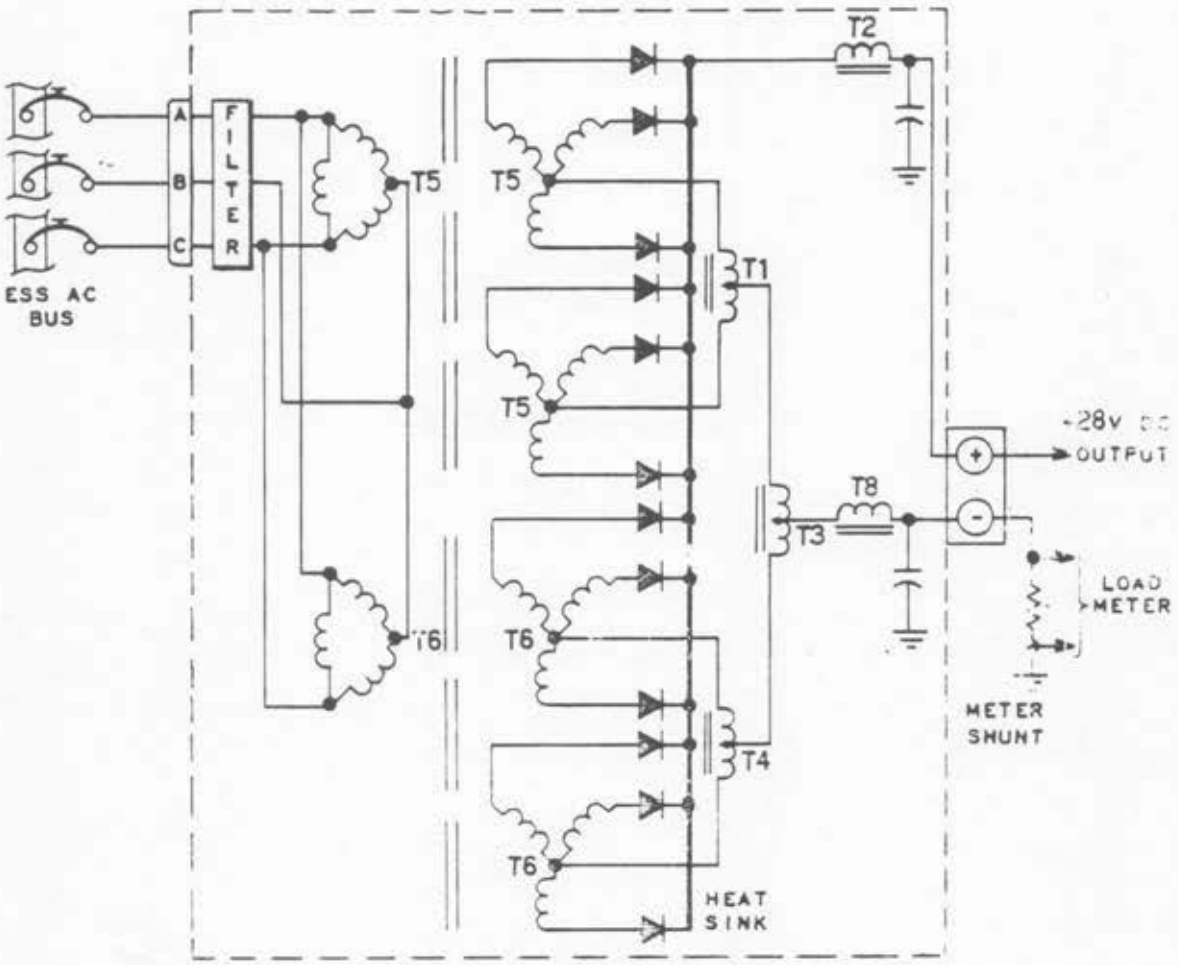
TR units from three different manufacturers are used interchangeably on the airplane. The three manufacturers are Chatham, Westinghouse, and Electrosolids. The three different TR units are described in the following:




SIX-PHASE HALF WAVE RECTIFICATION

The Chatham TR unit essentially is two, three-phase, half-wave power supplies which are connected in parallel. One of the power supplies has a wye-to-wye, step-down transformer followed by six diodes to give half-wave rectification and a ripple frequency of 1200 pulses per second. The other power supply has a delta-to-wye step-down transformer which also has six diodes for half-wave rectification. It also develops a ripple frequency of 1200 pulses per second. Due to the 60-degree phase shift between a delta-to-wye transformer, the ripple developed by the two power supplies is also out of phase by 60 degrees. The two power supplies are connected in parallel to double the ripple frequency to 2400 pulses per second.

The Westinghouse TR unit also consists of two power supplies which are connected in parallel. The difference between the Westinghouse unit and the Chatham unit is in transformer connections. The Westinghouse unit has two wye-to-wye, step-down transformers. One of the wye-to-wye transformers is 180 degrees out of phase with the other. Even through each of the power supplies has half-wave rectification, the fact that one power supply is out of phase with the other gives effective full-wave rectification. The ripple frequency of the Westinghouse unit is 2400 pulses per second.

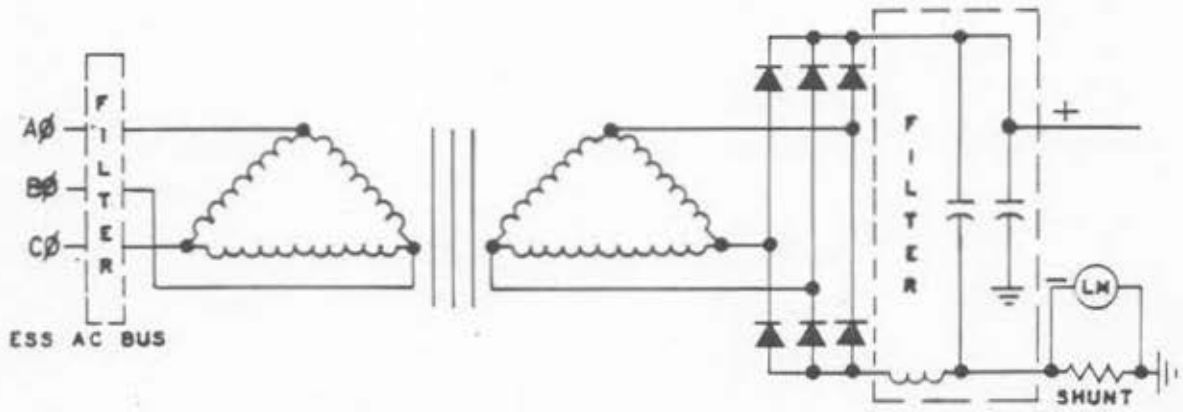



T R UNIT ( WESTINGHOUSE )

The Electrosolid TR unit has a delta to delta step-down transformer. Rectification is accomplished by a full-wave, three-phase bridge. Again, ripple frequency is 2400 pulses per second.

Voltage output of the transformer rectifier unit is dependent on the load. With no load on the TR unit, the voltage would rise to an over-voltage condition. To improve voltage regulation, the D-C electrical system is designed to provide a nominal load for the TR units at all times.

The TR units are the normal source of D-C power for the StarLifter. They are capable of supplying all the D-C power requirements of the D-C electrical systems. To protect the D-C buses in the event of a failed TR unit, Reverse Current Cutout Relays (RCCR) are installed in series between the TR unit and the bus that it supplies.

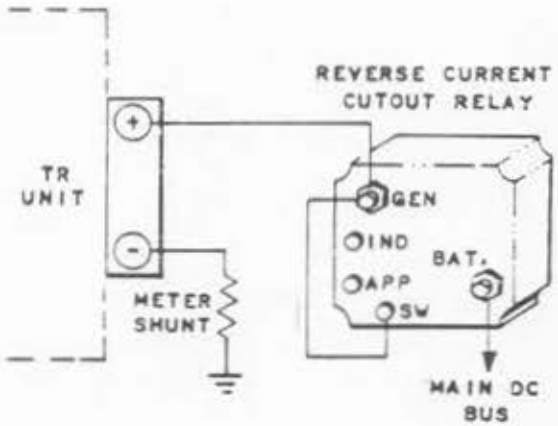



TR UNIT 26.1 V DC 200 AMPERES
(ELECTROSOLIDS CORP)

## REVERSE CURRENT CUTOUT RELAY

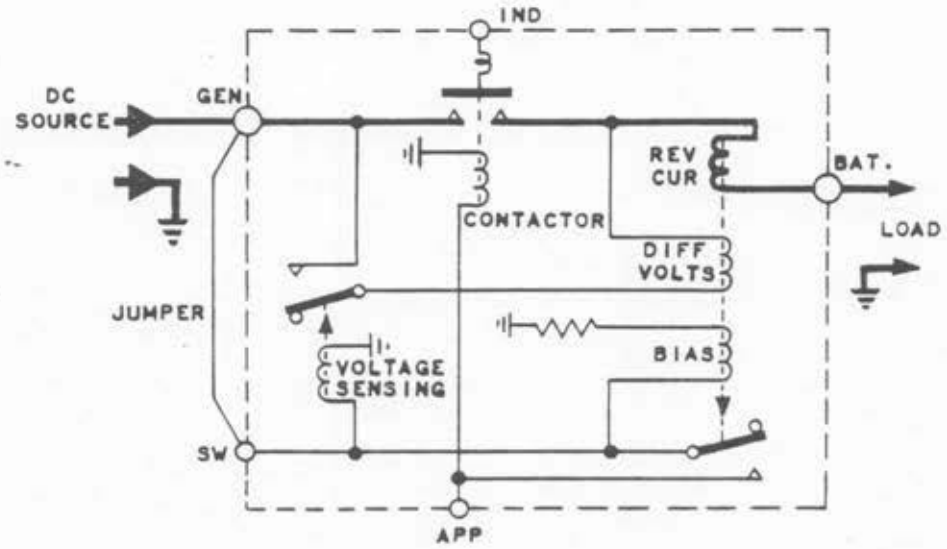
The reverse current cutout relay is composed of three individual relays which are the voltage, control, and current relays. The current relay has three separate coils which are wound on one common core. The three coils are the differential voltage coil, bias coil, and the reverse current coil.

## OPERATION




R C C R

When 28-volt DC is applied to the switch terminal, the voltage sensing coil will close its contacts. The bias coil sets up a magnetic field which tends to close the bias contacts. This field is not strong enough due to a series resistor. The voltage sensing contacts complete the circuit between the generator terminal and the battery terminal through the differential voltage coil. When the generator terminal is at a higher potential than the battery terminal, this field and the bias field will aid in closing the bias contacts. The bias coil will hold the contacts closed. The bias contacts apply 28-volt DC to the main contactor coil from the switch terminal; the contactor energizes, closing the heavy duty contacts which completes the circuit between the generator and battery terminals.

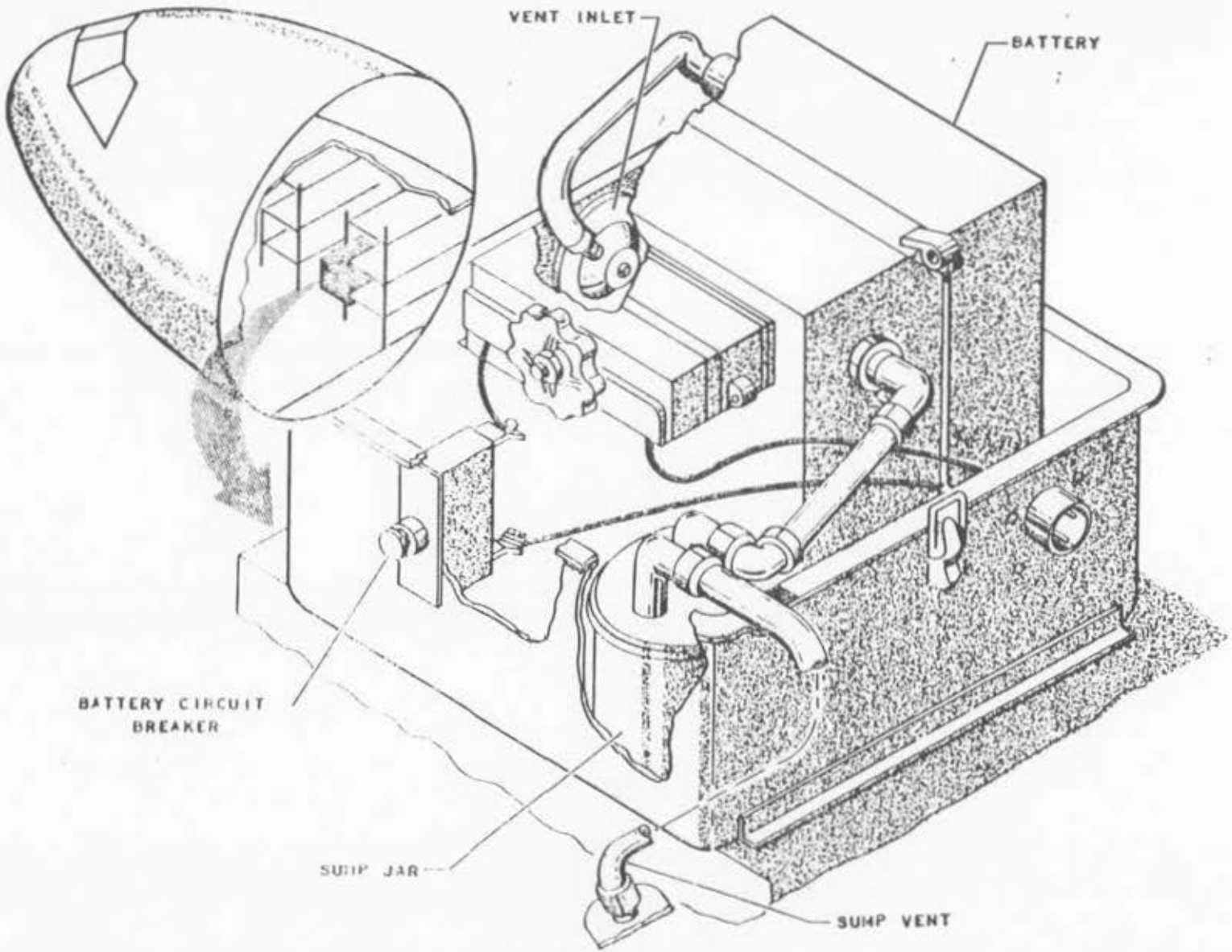



REVERSE CURRENT CUTOUT RELAY

The reverse current coil is one or two turns of heavy wire wrapped around the bias and differential voltage coils. Its field has little effect under normal operating conditions. If the current reverses, its field opposes the bias coil. Flux developed by the reverse current will cancel enough of the flux in the current relay to cause it to open. Reverse current occurs when the battery terminal is at a higher potential than the generator terminal. Reverse current could be causes by a faulty TR unit. When the current relay contacts open, the circuit for the coil of the main contactor is opened. This action opens the circuit between the load and the source. The reverse current cutout relay will reconnect the load source when the generator terminal becomes more positive than the battery terminal. The RCCR's between the TR units and the bus are rated at 200 amperes. Another RCCR, rated at 100 amperes, is used to connect the isolated D-C bus to main D-C bus No. 1. All of the reverse current relays are mounted behind the flight engineer's No. 3 circuit breaker panel.

## BATTERY SYSTEM

The battery system consists of a battery, battery relay, battery switch, power circuit breaker, and an indicator light. The battery switch is used for ignition in starting the APU. It also provides a standby source of power for emergency operations. The 24-volt, 11 ampere-hour, lead-acid battery is installed in a removable battery box located in the right hand underdeck area. A venting system is provided to conduct the explosive gases overboard through an opening in the bottom of the fuselage. The venting system consists of a sump jar tubing and works on a difference in pressure between the cargo compartment and outside air pressure. When outside pressure is less than the cargo compartment pressure, air flows through the battery box, through the sump jar, and then to outside air.

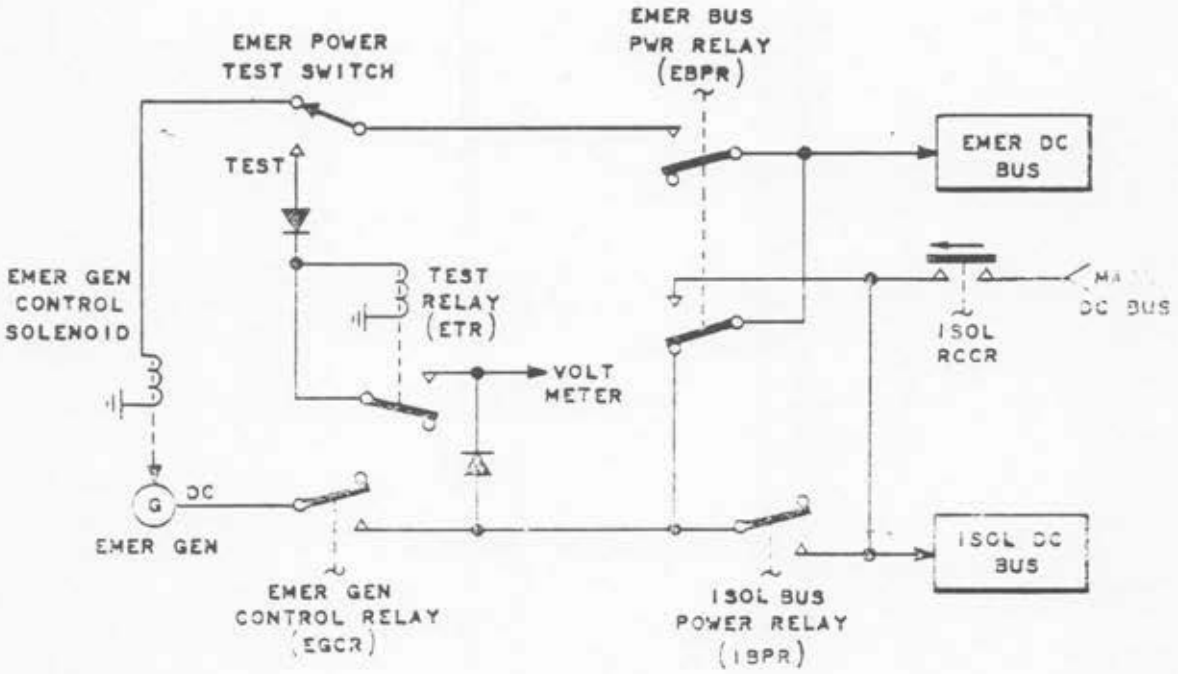



BATTERY COMPARTMENT

A check valve on the battery box allows air to flow from the cargo compartment to the outside but blocks airflow in the reverse direction.

## OPERATION

The battery switch is located on the flight engineer's electrical control panel. When the switch is in the "ON" position, the battery relay is closed to connect the battery to the isolated D-C bus. The battery cannot be connected if the emergency generator is operating or if the isolated bus disconnect switch is in the disconnect position. The battery relay is located behind the flight engineer's number 3 circuit breaker panel. With power on the isolated D-C bus and the battery switch "ON," the battery is on charge. There is no charge-regulating system for the battery. Battery charging current is determined by bus voltage and the state of charge of the battery.

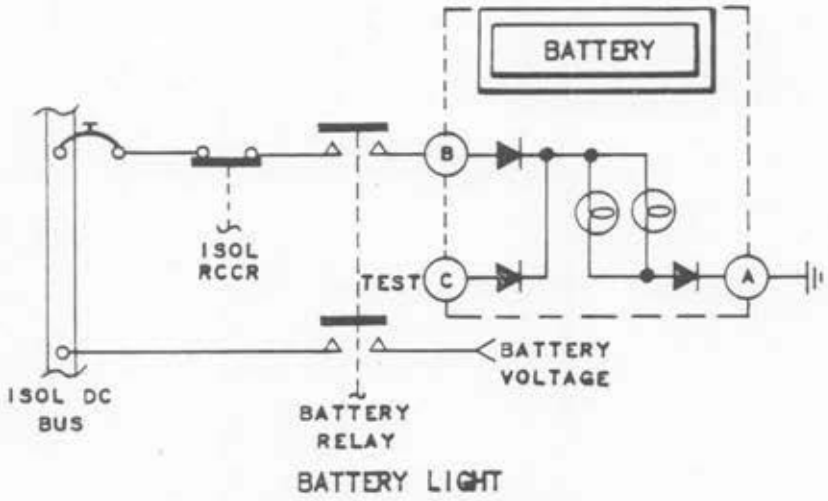



EMER GEN DC OUTPUT

## BATTERY INDICATOR LIGHT

The battery indicator light is located on the flight engineer's electrical control panel. When illuminated, the light indicates that the battery is the only source of power on the isolated buses. If the isolated D-C bus reverse current relay is energized, the open auxiliary contacts will interrupt the battery on the indicator light circuit. If the emergency generator is connected, the isolated D-C bus

bus power relay will be energized, and a set of auxiliary contacts will prevent the light from illuminating.



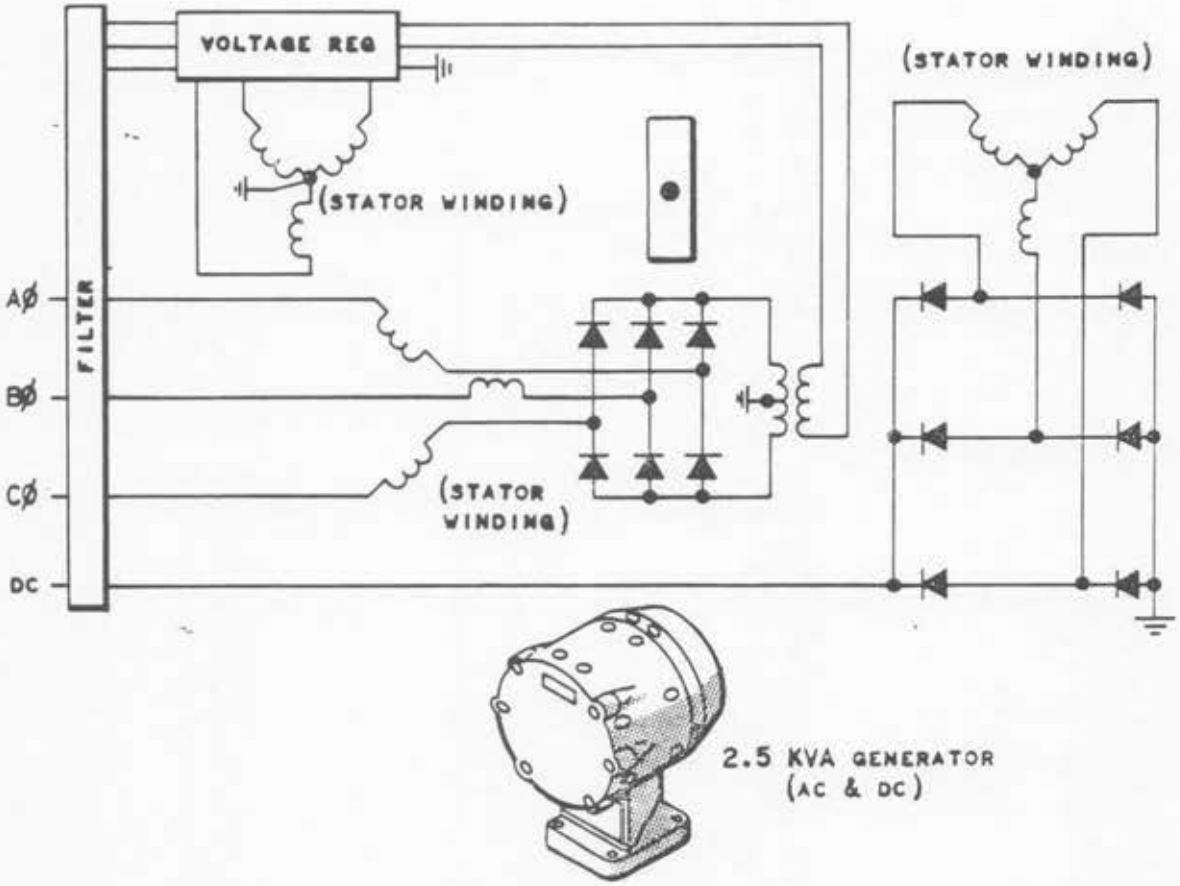
BATTERY LIGHT

## EMERGENCY GENERATOR SYSTEM

A hydraulically driven A-C/D-C emergency generator is provided to furnish emergency D-C power in the event of loss of the normal D-C power system. In the event that power on the essential A-C bus No. 1 is lost, the hydraulically driven A-C/D-C emergency generator will be actuated. When the emergency bus power relay deenergizes, the hydraulic motor control solenoid deenergizes to allow hydraulic pressure to drive the hydraulic motor which drives the emergency generator. When the generator comes up to speed, the frequency sensitive relay energizes and provides a ground for the emergency generator control relay. When energized, the control relay connects the generator output to the emergency bus. Emergency generator output is also supplied to the isolated D-C bus and the isolated D-C avionics bus through the closed contacts of the isolated D-C bus power relay.

NOTE: A loss of D-C power will not automatically activate the emergency generator.

The emergency generator can be manually activated by placing the INSTRUMENT POWER switch on the left side of the pilot's instrument panel in the "EMERGENCY" position. Positioning the instrument power switch to "EMERGENCY" removes the ground from the emergency bus power relay and causes the relay to deenergize.




EMERGENCY GENERATOR SCHEMATIC

An emergency power test switch is located on the flight engineer's electrical control panel. In the "TEST" position, the emergency generator is operating but is not connected to the buses. The voltmeter can be used to check the output voltage of the generator.

The emergency D-C generator consists of a wye-wound stator and six silicon diodes. The generator develops a 28-volt, D-C output and a load capacity of 20 amperes continuously, or 30 amperes for 5 minutes out of each 30-minute period of operation. The rotating field strength is controlled to maintain desired voltage output to the rectifiers which furnish full-wave rectified voltage to the emergency D-C bus distribution system.

## D-C BUS DISTRIBUTION SYSTEM

There are seven D-C buses on the Starlifter: No. 1 main, No. 2 main, No. 1 main avionics, No. 2 main avionics, isolated DC, isolated D-C avionics, and

B - BATTERY POWER
M - MAIN DC - ESS AC
E - EMERGENCY GEN
* - ENERGIZED

| EMER GEN TEST | EMER GEN | ESS AC AND MAIN DC BUS | BATTERY | RELAYS | | | | | | | | | ISOL DC BUS | EMER DC BUS | ISOL AC BUS | EMER AC BUS | MAIN DC BUS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | RCCR | BR | IBPR | EBPR | EGCR | FSR | NBR | ETR | IPR | | | | | |
| | | | | ISOL RCCR | BATTERY RELAY | ISOL DC BUS PWR RELAY | EMER BUS PWR RELAY | EMER GEN CONT RELAY | FREQ SENS RELAY | NAV BUS PWR RELAY | EMER PWR TEST RELAY | ISOL AC BUS PWR RELAY | | | | | |
| | | | * | | * | | | | | | | | B | | | | |
| | | * | | * | | | * | | | * | | | M | M | M | M | M |
| | | * | * | * | * | | * | | | * | | | M | M | M | M | M |
| | * | | | | | * | | * | * | | | * | E | E | E | E | |
| | * | | * | | | * | | * | * | | | * | E | E | E | E | |
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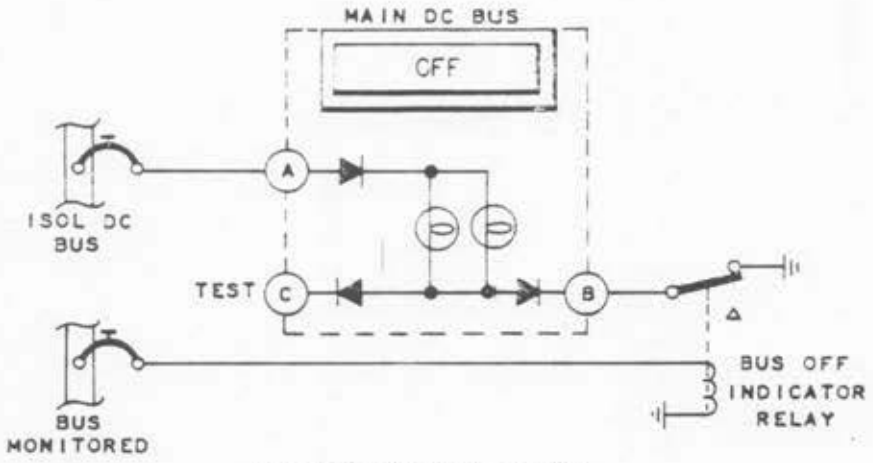
DC POWER SOURCE - RELAY - BUS DISTRIBUTION CHART

emergency D-C bus. During normal operation, the buses are interconnected, allowing power from both TR units to be supplied to the buses as shown in the D-C bus diagram. The No. 1 and 2 main D-C bus will supply the isolated D-C bus; however, the isolated D-C bus cannot supply No. 1 or 2 main due to the isolated D-C bus RCCR. The RCCR opens if the isolated D-C bus attempts to supply the main buses.

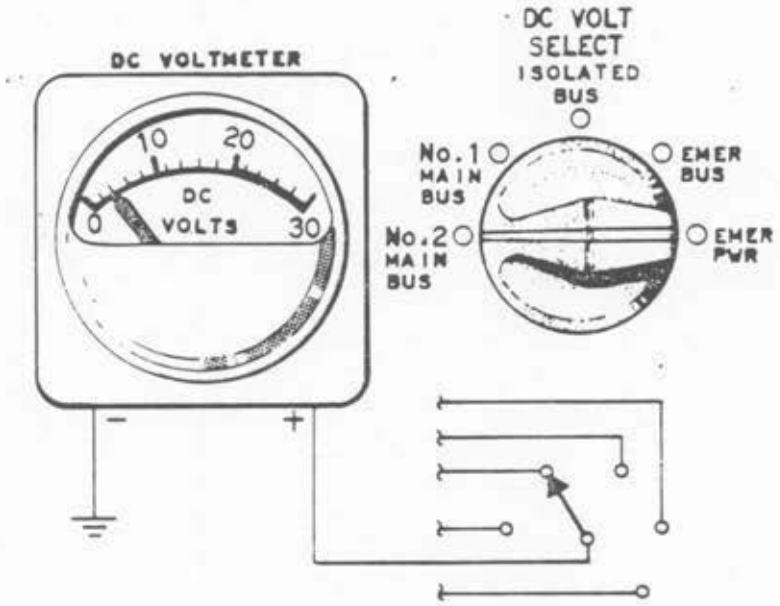
The No. 1 main D-C bus power feeder circuit breakers are on the main A-C power distribution panel. Distribution circuit breakers are located on the flight engineer's No. 4 circuit breaker panel. The No. 2 main D-C bus power feeder circuit breakers are located on the main D-C power panel. Distribution circuit breakers are also on the flight engineer's No. 4 circuit breaker panel. The main D-C avionics bus receives power from the main D-C power distribution panel. The isolated D-C bus is normally powered from main D-C bus No. 1 through the closed contacts of the isolated bus RCCR. Distribution circuit breakers are located on the flight engineer's No. 3 circuit breaker panel. The isolated A-C avionics bus is normally supplied with power from the No. 1 main D-C bus through the energized contacts of the isolated D-C bus RCCR. During emergency operation, it will be supplied power from the isolated D-C bus which can be powered by the battery or the emergency generator. The emergency D-C bus is normally supplied from the No. 1 main DC bus through the closed contacts of the energized isolated D-C bus RCCR and through the closed contacts of the energized emergency bus power relay. Feeder circuit breakers are located on the main D-C power panel. The emergency D-C generator can supply power to the emergency D-C bus through the power circuit breaker located on the emergency generator control box.




MAIN DC BUS OFF LIGHT

## BUS INDICATOR LIGHTS

The indicator light control circuit for the No. 1 main D-C bus is energized by power from the No. 1 main DC bus. In the event that No. 1 main D-C bus loses power, the indicator light relay will deenergize and furnish a ground for the "OFF" light causing it to illuminate. The light is located on the flight engineer's electrical control panel. Operation of the No. 2 bus indicator light is the same as No. 1. These lights also represent their respective avionics buses.




DC VOLTMETER CIRCUIT

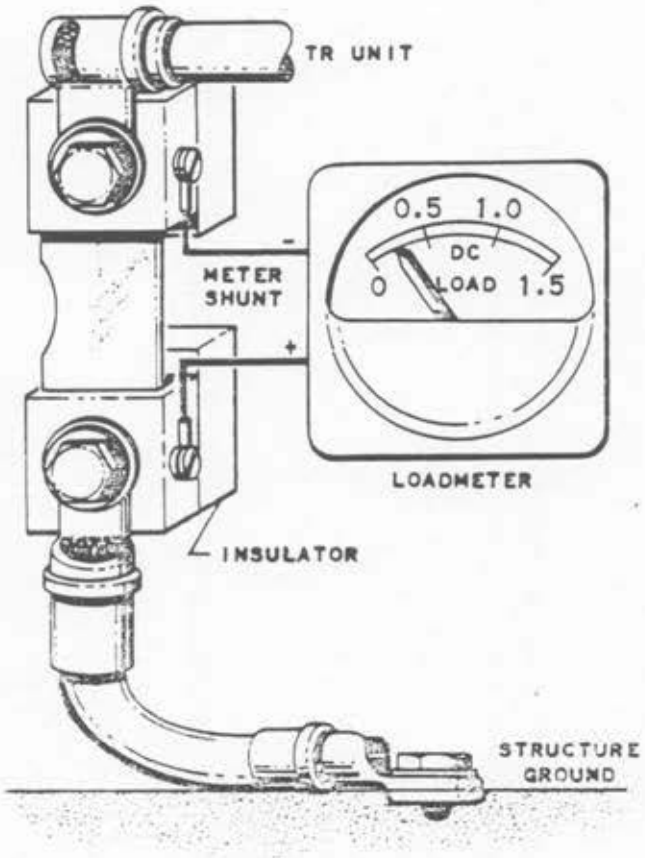
## VOLTMETER AND SELECTOR SWITCH

The voltmeter and selector switch are located on the flight engineer's electrical control panel and are used to monitor D-C bus distribution system voltages. The meter has a 0 to 30-volt scale, and the selector switch has five positions as shown in the illustration. The "EMER PWR" position monitors the output of the emergency generator.

## D-C LOADMETERS

Two D-C loadmeters are installed on the flight engineer's electrical control panel below the D-C voltmeter. The loadmeter monitors current of the TR unit with one loadmeter for each TR unit. Calibration of the loadmeter is in terms of percent of rated load of the TR unit. Full scale on the loadmeter is 150 percent but the scale is marked 1.5. 1.0 or 100 percent on the loadmeter

is 200 amperes. The loadmeter is made up of the meter and a loadmeter shunt. The shunt is connected in the negative lead of the TR unit. The loadmeter shunt is a 50-millivolt, 200 ampere shunt.



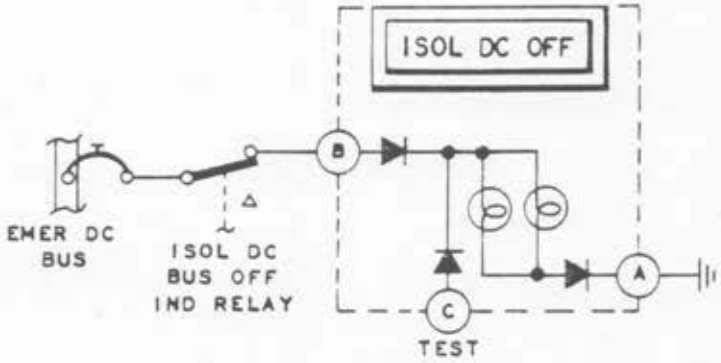

D-C LOADMETER

## ISOLATED BUS DISCONNECT SWITCH

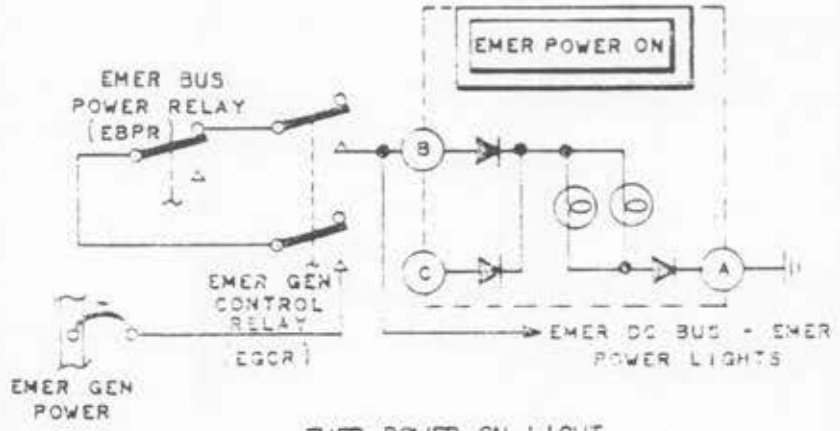
A two-position switch on the flight engineer's electrical control panel, decaled ISOL BUSES - "ON-OFF" can be used to disconnect the isolated D-C bus from the emergency generator by deenergizing the isolated D-C bus power relay.

## EMERGENCY POWER TEST SWITCH

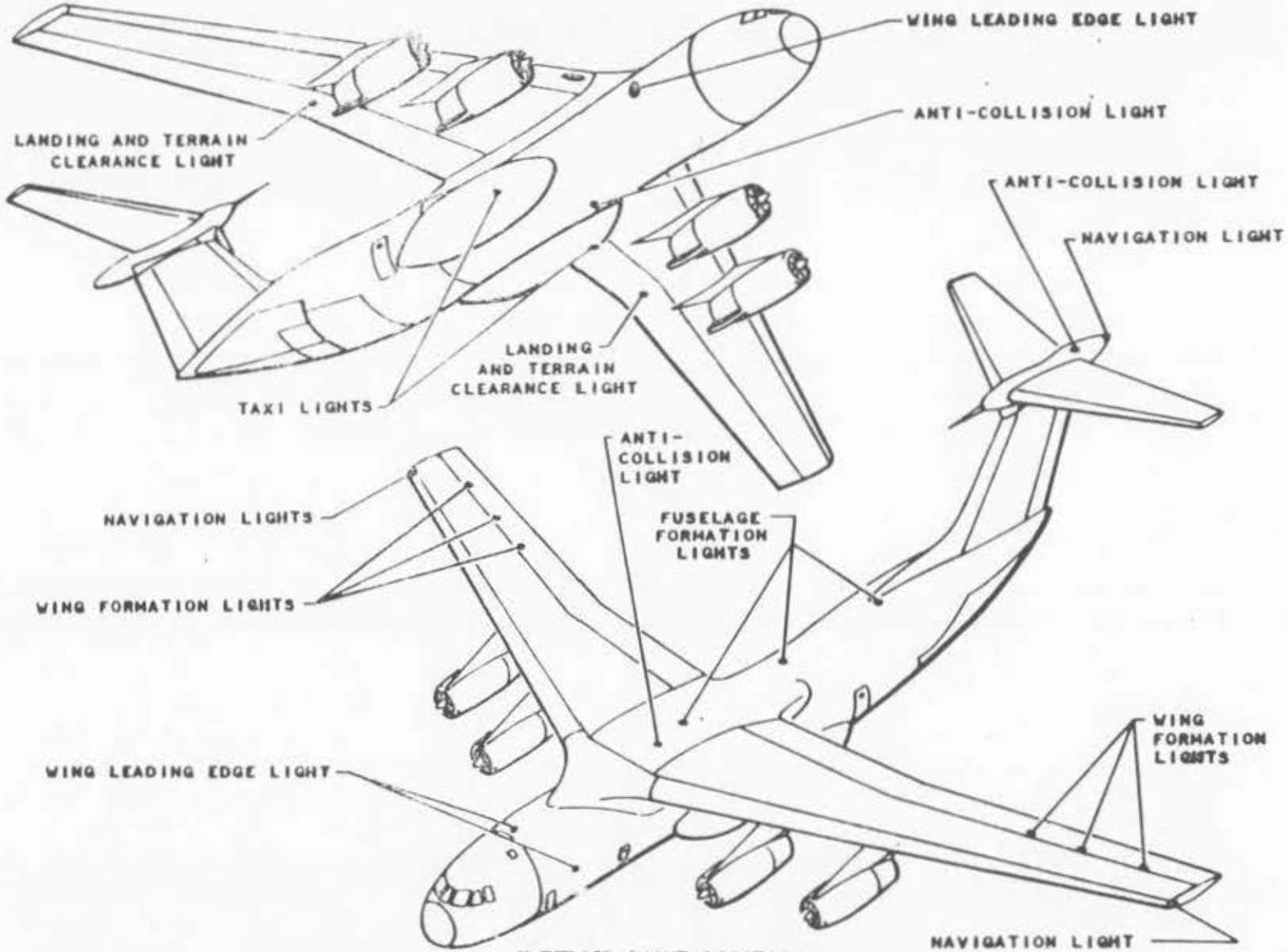
This switch is used with the D-C voltmeter and D-C volt selector switch to check the D-C generator output without putting it on the line. Positioning the test switch to "TEST" removes the ground from the hydraulic motor control solenoid and the isolated bus power relay coils.




ISOL DC BUS OFF LIGHT




EMER POWER ON LIGHT




EXTERIOR LIGHT LOCATIONS