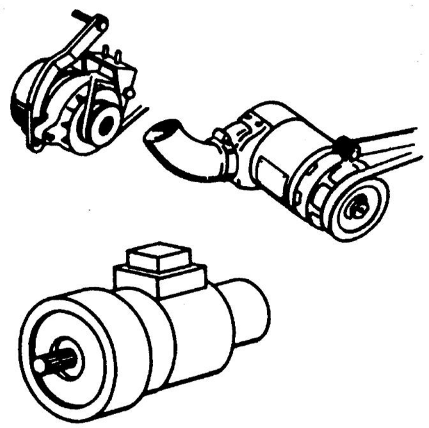
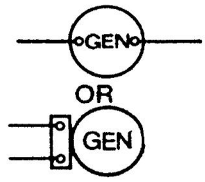
ELECTRICAL SYSTEM - COMPONENTS & INDICATORS

This section provides a brief description, diagrams and symbols of many common electrical components. With an understanding of these components, aircraft circuit diagrams found in flight manuals can be read with ease and confidence.

Generator or Alternator

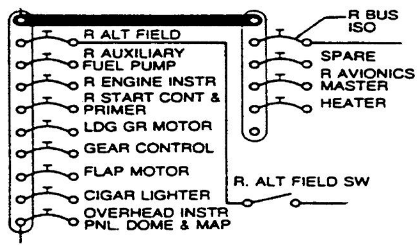
Generators and Alternators provide DC or AC power to the aircraft electrical system for normal operations. While some excess capacity is usually available, emergency power is often provided by stand-by equipment such as batteries, air (pneumatic or ram air) driven generators, hydraulic driven generators or generators driven by auxiliary power units (APU).





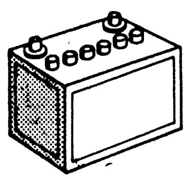
Bus Bar

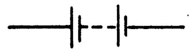
The major terminal where all consumers of that power, depending on their priority are connected.



Battery

1. Provides engine starting power.
2. Provides field excitation to independently excited alternators.
3. Provides emergency electrical systems power when the alternator is not operating.
   <u>Note</u> : *Additionally, the battery operates as a type of damper - it reduces voltage fluctuation by providing energy below the 24V level and absorbing some energy above the 24V level.*





Multi-cell

Inverter

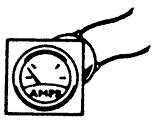
Provides AC from a DC source - can be used in both the normal and standby systems.

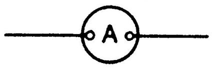
Ammeter - Indicator of Current Flow

There are two common types of ammeter :

1. Load Ammeter, which indicates current flow or load from a generator or alternator.

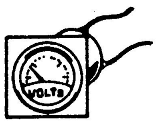
2. Centre Zero Ammeter, which indicates current to or from the battery, with the exception of the starting current.

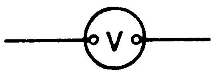




Voltmeter

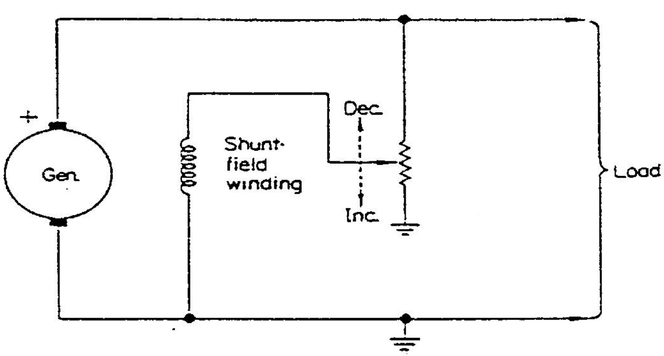
Indicates system or battery voltages.





Voltage Regulator

Senses the 'line' or output voltage of the generating device that causes an adjustment to the generator 'field' current which in turn adjusts the output voltage back to its preset value.



Control of field circuit current

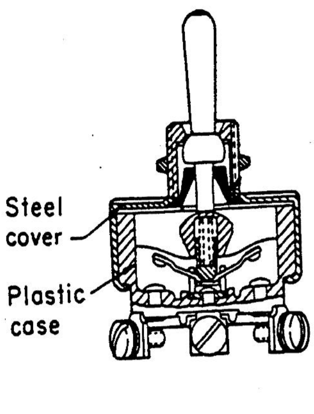
Switches

A switch may be defined as a device for closing or opening (making or breaking) an electric circuit. Switches of many types have been designed for a wide variety of applications. The switches can be manually operated, electrically operated, electronically operated. The manual switch is usually operated by either a lever or by a push button. Electrically operated switches are generally called **relays**. An electronically operated switch uses a transistor to control the current in a circuit, and the 'switch' is turned on or off by means of an electric signal applied as a voltage to the base of the transistor.

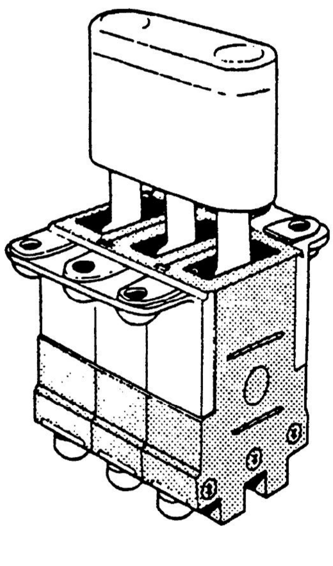
To be suitable for continued use, a switch must have contacts which are capable of withstanding the number of cycles of operation without deterioration due to arcing or wear. The contacts are usually made of special alloys which are resistant to burning or corrosion. Switches allow manual or automatic control of electrical circuits - ON/OFF or function selection.

Switches can be :-

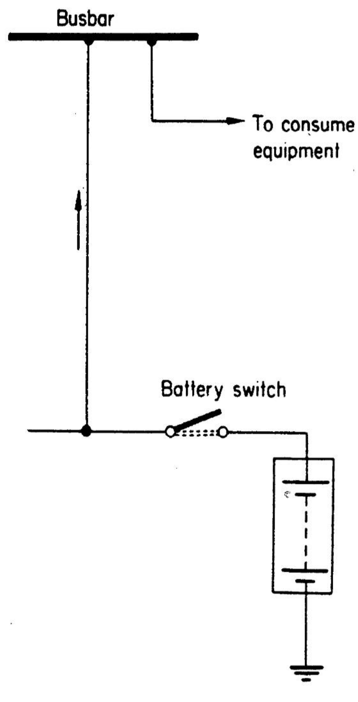
a) ganged - joined so multiple contacts occur simultaneously.
b) rotary - sequential selection.
c) toggle - a lever switch which can incorporate a circuit breaker or be sprung to one position.
d) push - push on, push off.
e) rocker - a sprung two position switch.
f) micro - an accurate switching device where the difference between 'make' and 'break' is a few tenths of a millimeter. Often spring mounted, they are used to indicate undercarriage up/down positions, squat switches etc.



Toggle switch

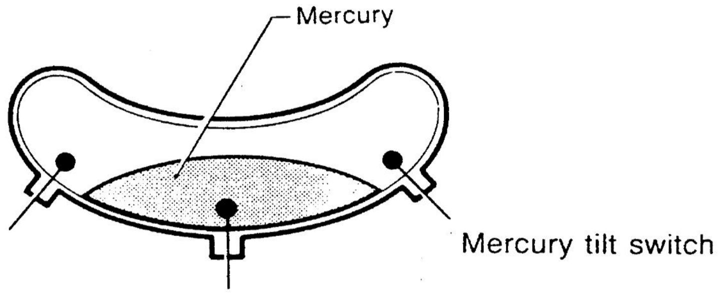


Ganged Switch



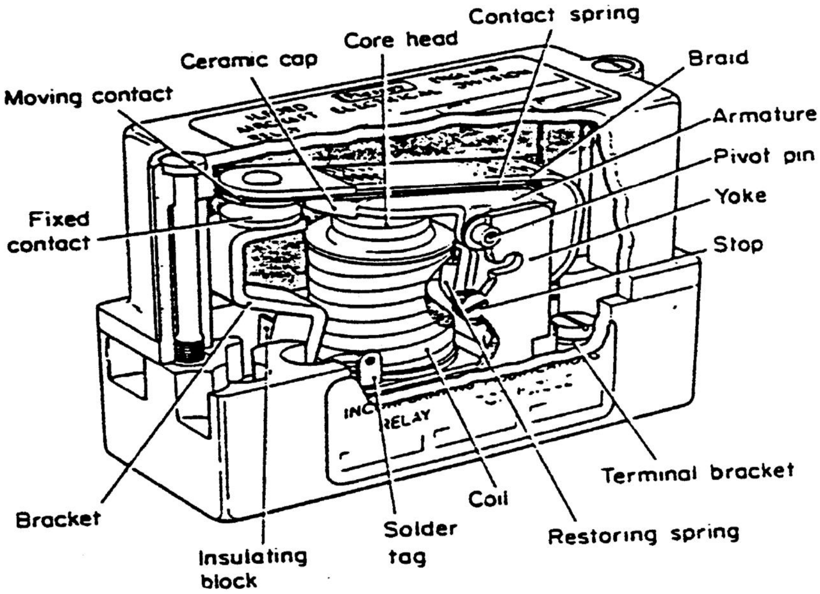
Inertia Switches

Sense the change in forward motion (inertia) of an aircraft and cause an electrical contact to make or break to produce the desired indication or action. Typically used in crash systems to cause the activation of an emergency radio transmitter beacon.



Relay

A remote controlled switching device. Usually a control circuit switched by the pilot, causes a relay to operate elsewhere in the aircraft. The relay can make a single connection or may cause multiple contacts to make or break circuits.

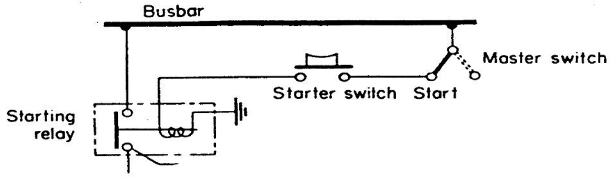


Solenoid

A heavy duty electromagnetic switching device similar to a relay. Older types of starting solenoids were either remotely controlled or push activated.

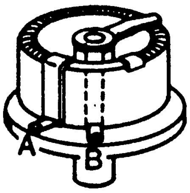
Battery Contactor

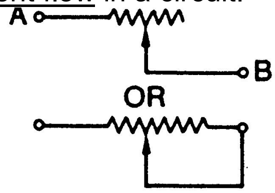
The battery solenoid is a heavy duty relay which will allow 100 amps or more to flow during starting operations.



Rheostat

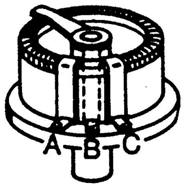
A variable resistance device used to control <u>current flow</u> in a circuit.

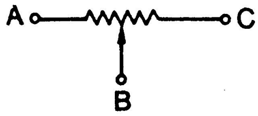




Potentiometer

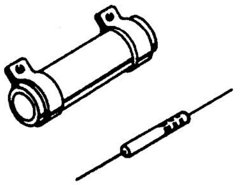
A variable resistance device used to control the <u>voltage</u> at a given point in a circuit.

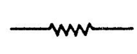




Fixed resistors

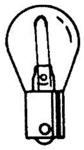
Used to limit the current in a circuit or to drop voltage. The resistor symbol may also be used to represent any resistive load.





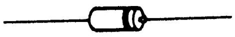
Lamps

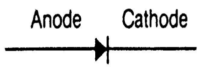
Light source. Also used as warning and condition indicating devices.



Diode

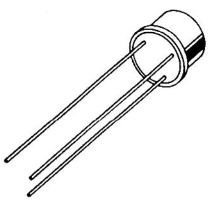
A diode has low resistance current in one direction It blocks or has high resistance to current in the other direction. Used to rectify AC to DC

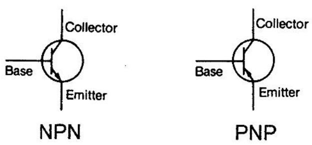




Transistor

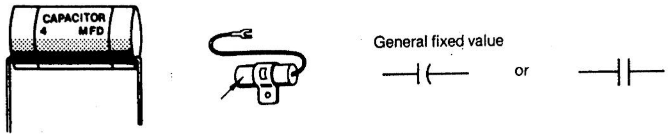
A semi conductor (solid state) device which can be used as an amplifier or a switch





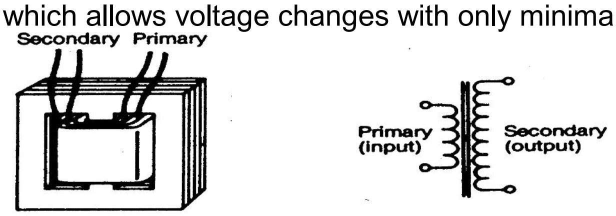
Capacitor

A device that can be charged and discharged. In a circuit, it will block DC or act as a short term accumulator. A capacitor will pass AC depending on its value and the frequency of the AC.



Transformer

An AC device which allows voltage changes with only minimal losses.



Inductor (choke)

An AC device, often used 'like' a resistor in AC circuits. Can be used in DC circuits to help filter voltage changes

Inductor with air core

Inductor with ferromagnetic core

Earth.

Ground, frame or chassis connections
In aircraft applications the terms 'earth' and 'ground' are frequently used for airframe or frame connections

ELECTRICAL INDICATORS

Many indicators are required on aircraft to display to the pilot parameters that would otherwise be unknown.

The types of information a pilot needs or simply wants to know are things like engine temperature, oil pressure, fuel quantity remaining, battery voltage, amount of current taken from the bus bar (load), the physical position of flaps and control surfaces and more. Most of these indications are presented on meters or indicators which come from a family of five basic electrical indicator movements.

These devices are:-

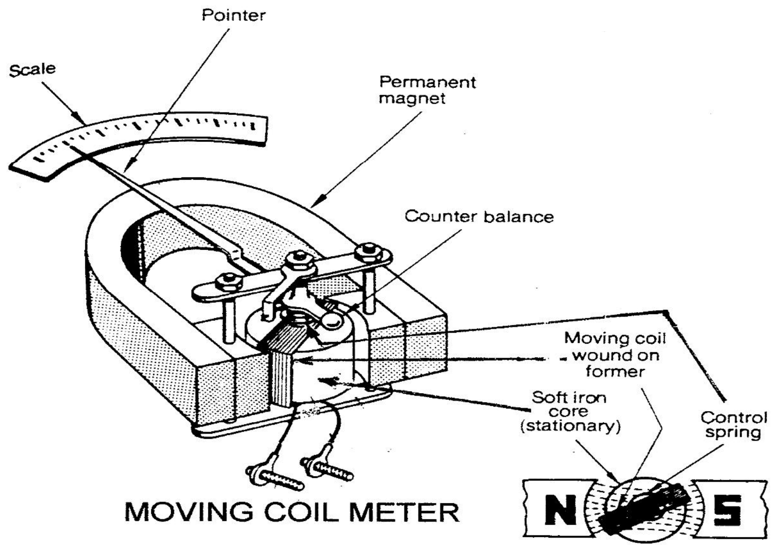
a) moving coil indicators
b) moving magnet indicators
c) moving iron indicators
d) electro-dynamic indicators, and
e) electro-thermal indicators.

The basic movement only is described here. Additional circuits are used to make the instrument into the required indicator. The calibration of the scale is also important to have the indicator read accurately.

Moving Coil Meter

A thin insulated wire conductor is wound around a square former to form a coil and placed between the poles of a permanent magnet. The coil is fitted with a pointer, pivoted for free movement and spring loaded to its zero position.

Current, proportional to an analogue of the required parameter, is made to flow through the coil. The coil sets up its own field that will react with the permanent field, and the resulting torque displaces the coil against the spring to provide the indication.



MOVING COIL METER

Moving Magnet Indicator

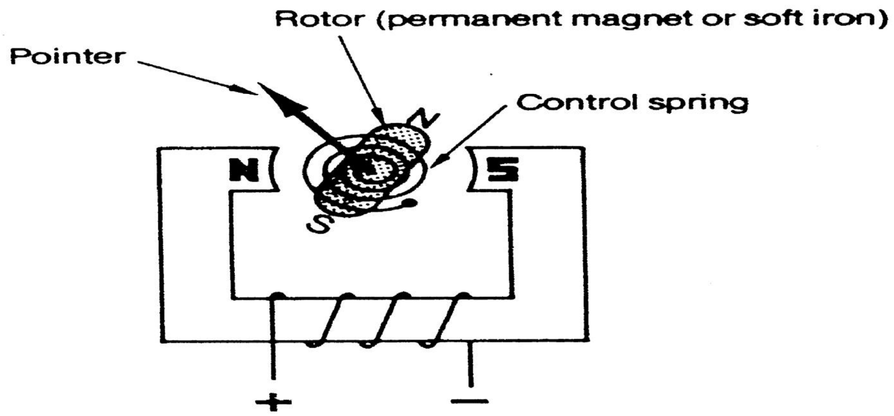
In this indicator, a small permanent magnet is fitted with a pointer, pivoted and spring loaded to its zero position. This movement is placed between the core ends of an electro-magnet. These become poles when a current activates the electro-magnet. The amount of current flow in the windings of the electro-magnet determines the strength of the magnetic field. The displacement of the pointer will be proportional to the parameter that generates the current flow. The moving magnet indicator is 'polarity sensitive' so it can only be used in DC circuits.

Moving Iron Indicator

The moving iron movement looks very similar to a moving magnet device. However, instead of a magnet being set up to pivot, a piece of soft iron takes its place.

When the electro-magnet is activated, the iron piece and the pointer will deflect in the same direction, regardless of the polarity of the voltage causing the current flow.

The moving iron indicator is therefore not polarity sensitive and can be used in both DC and AC currents.



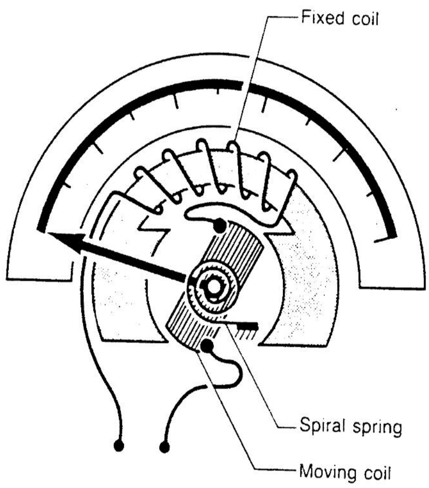
THE **MOVING MAGNET** AND **MOVING IRON** INDICATOR APPEAR SIMILAR

Electro-dynamic indicator

The device has both fixed and moving coils.

When current flows it must move through both coils. The resulting field reaction produces the torque to position the pointer.

The electro-dynamic indicator is not polarity sensitive because any reversal of current reverses both fields and the pointer is displaced in the same direction.

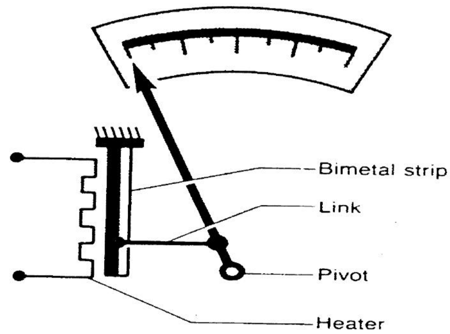


ELECTRO-DYNAMOMETER

Electro-thermal Indicator

The simple electro-thermal movement allows current to flow through a heating element. A bimetallic strip, which functions by the differential expansion of metals, is anchored at one end and as it heats up the strip bends.

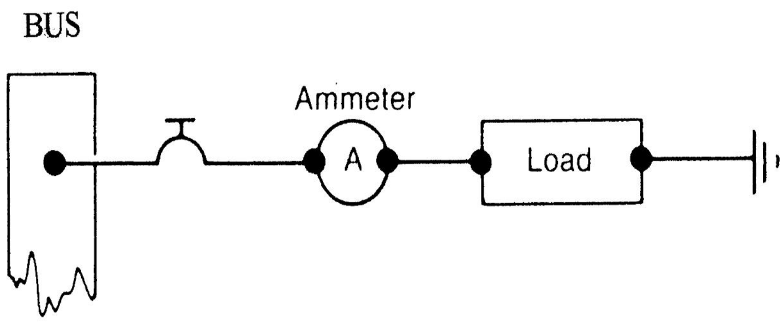
The movement is then applied to some type of mechanical lever system to produce the required indication.



ELECTRO-THERMAL MOVEMENTS

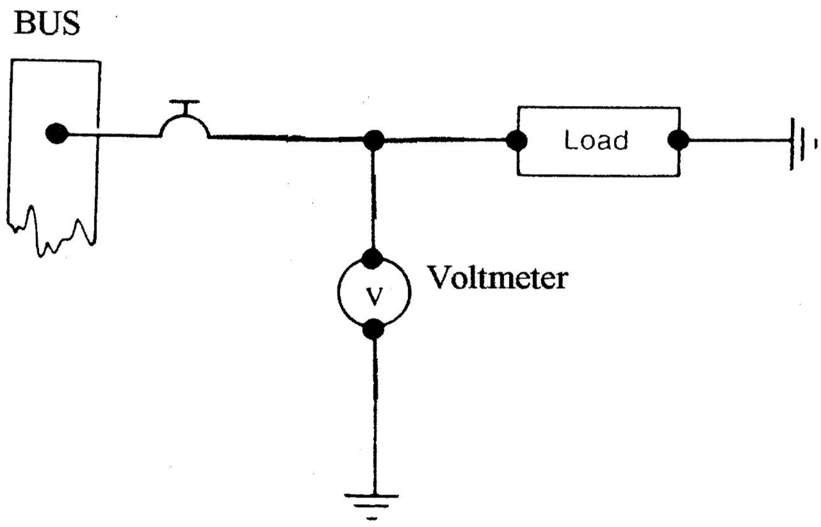
These movements require very little current to operate them. When used in ammeters, a low value resistor, a shunt, is connected in parallel with the movement. This shunt resistor can be physically placed inside or outside the indicator. This allows a large current to flow through the shunt while only a small but proportional current flows through the meter movement to generate the indication.

An Ammeter is always connected in **series** to measure circuit current.



AMMETER

A voltmeter also uses a sensitive movement that requires very little current to drive it. Because a voltmeter must be connected in **parallel**, in the circuit where the voltage is measured, its internal resistance must be very high. Inside the indicator, it will have a high value resistance in series with the movement.



VOLTMETER

CAUTION

The indicators discussed here require aircraft electrical power to operate. In many modern light aircraft, the oil pressure and temperature gauges, fuel quantity gauges, voltmeters, ammeters and tachometer use these movements that require electrical system power. Should supply device fail (DC generator or alternator) and the battery be consumed (flat) these critical indications will be lost. This situation is a total electrics failure and warning lights and horns would also be lost.

A no radio approach at the nearest suitable airfield should be a priority consideration at this stage.

EARTH RETURN or SINGLE WIRE CIRCUITS

All DC and many AC circuits are not complete, and will not function, unless a current can leave one pole of the power source, flow through the components then return to the opposite pole. Technically, this requires two wires, a supply wire and a return wire.

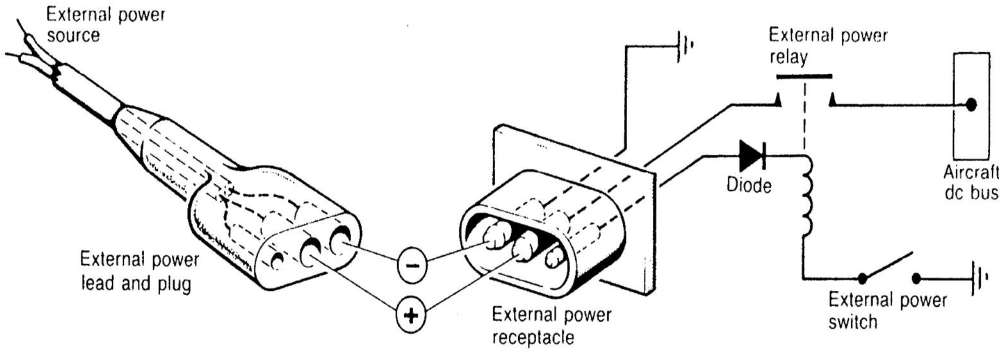
By connecting electrical equipment to the metal airframe, which is one type of ‘bonding’, and then using only one wire to supply power to the equipment, reduces cost and weight. This is known as a single pole(wire), earth return system. The metal frame of the aircraft takes the place of the return wire. The airframe becomes the ‘common’ or ‘earth’ and it remains at zero electrical potential.

DC GROUND POWER SUPPLIES

For aircraft servicing where DC electrical power must be on for an extended period, a separate external supply is connected to the aircraft. This electrical power bypasses the aircraft battery thus allowing many operations of high power consuming devices, such as engine starting, flaps etc., while leaving the battery charged for normal operations.

The external DC power can be provided from underground lines, but this is not common. A generator can be provided, but it is more usual to have four or five aircraft batteries connected in parallel, fitted to a small cart and wired with an aircraft connector.

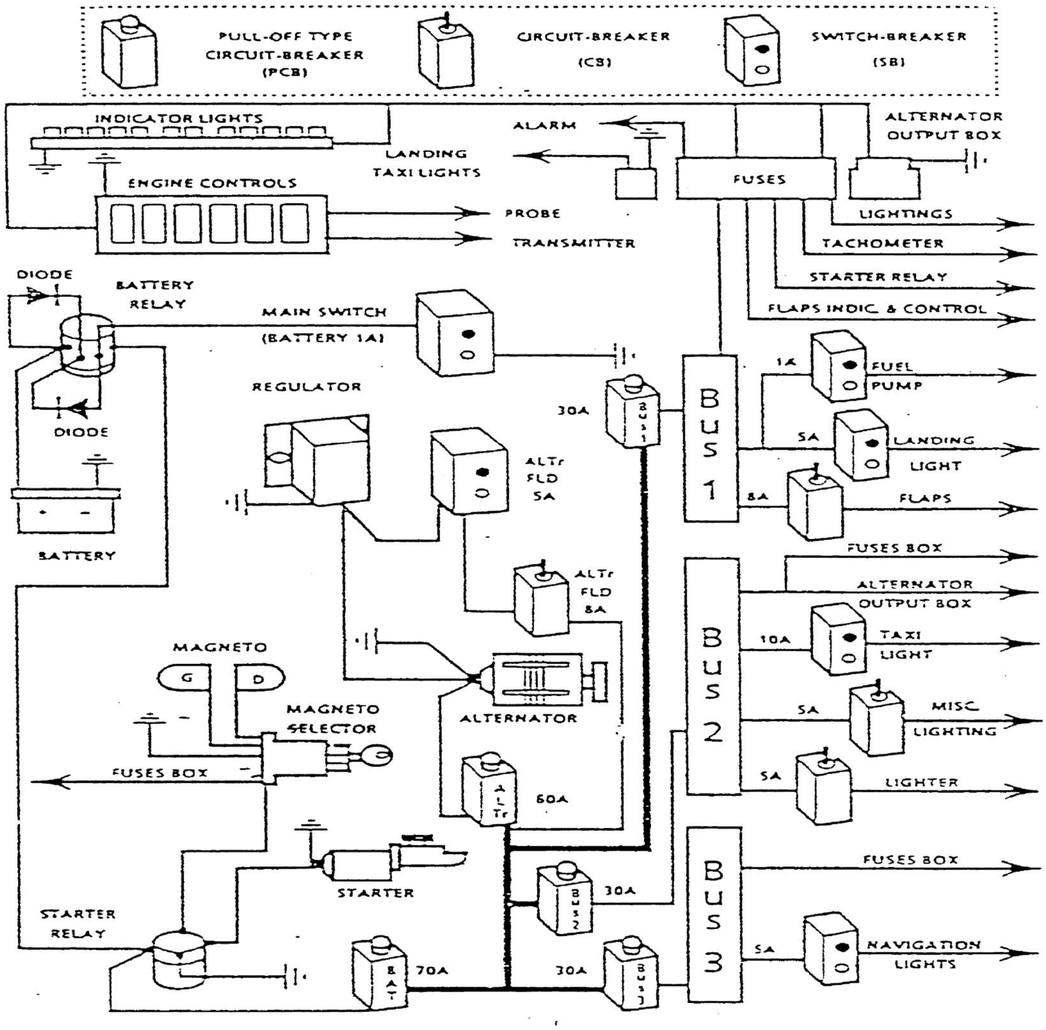
The external power receptacle is wired to prevent accidental reverse polarity connection of the DC supply.



DC GROUND POWER CONNECTION

The following diagrams are samples of aircraft electrical systems which should be understood at the CPL stage of training.

TB-10



A SMALL AIRCRAFT DC SCHEMATIC DIAGRAM

Circuit Description

When the main switch (centre of diagram) is pushed ON, the battery relay is energized. This makes power available from the battery through the battery relay to the starter relay, BAT circuit breaker (CB). Before start, when the BAT CB is pushed ON, power is supplied to all three BUSES, providing the circuit breakers are closed and to the ALTrFLD CB.

To start the engine, the magneto selector switch is placed in the START position, the starter relay engages and turns the starter motor. With the engine running, the armature of the alternator, which is belt driven is now rotating. Pushing ON the ALTrFLD CB will allow battery power to activate the alternator field and the generator will produce electrical power, outputting via the ALTrCB. The alternator system output is usually regulated at 28VDC so it automatically takes over from the 24VDC battery. Significantly, the 4V potential difference is sufficient to maintain the battery at full charge.

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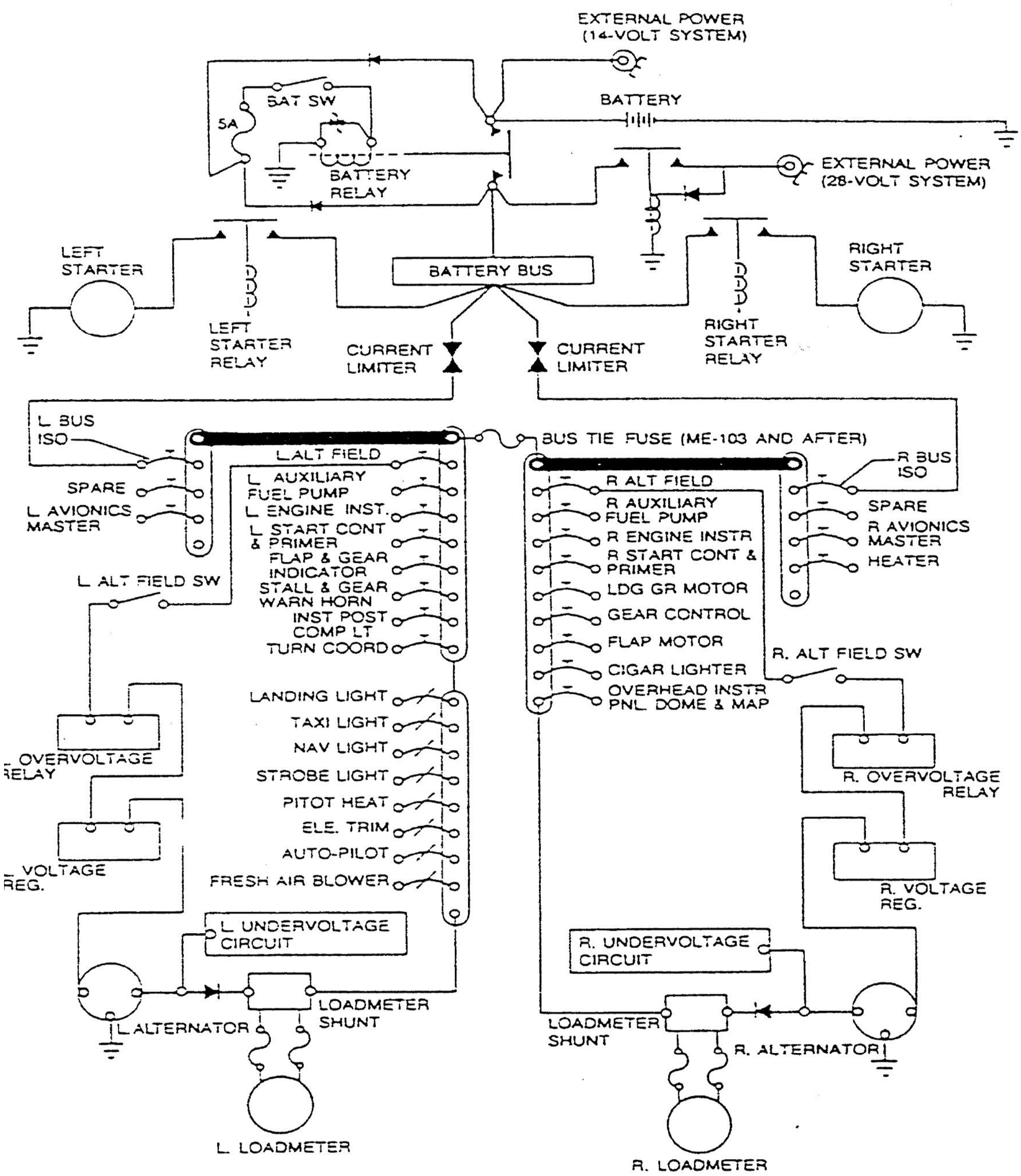

Circuit Description

This electrical schematic of a light twin is presented in a different format than the previous TB-10 diagram. However, all the features previously discussed are present. In addition to the equipment powered by each bus bar being more descriptive, this system features current limiters in the centre and a bus tie fuse below them.

Connecting the left and right buses together with the bus tie fuse means that both buses can be powered from the battery or from either alternator. Importantly when both alternators are functioning, the current demanded by the equipment (the LOAD) is shared between the alternators. Load sharing means each alternator does about the same amount of work. If they had unbalanced loads the hardest working unit would have a shorter working life. It may fail before regular maintenance upkeep can prevent that inconvenience.

SUMMARY

This chapter has listed some components and terminology which are not yet fully explained. Capacitor and inductors have definite functions in DC circuits, however, these are explained in the alternating current (AC) section of this book. These are 'reactive components, which are best explained when electrical terminology and the changing wave form of AC is more familiar.