Chapter 9

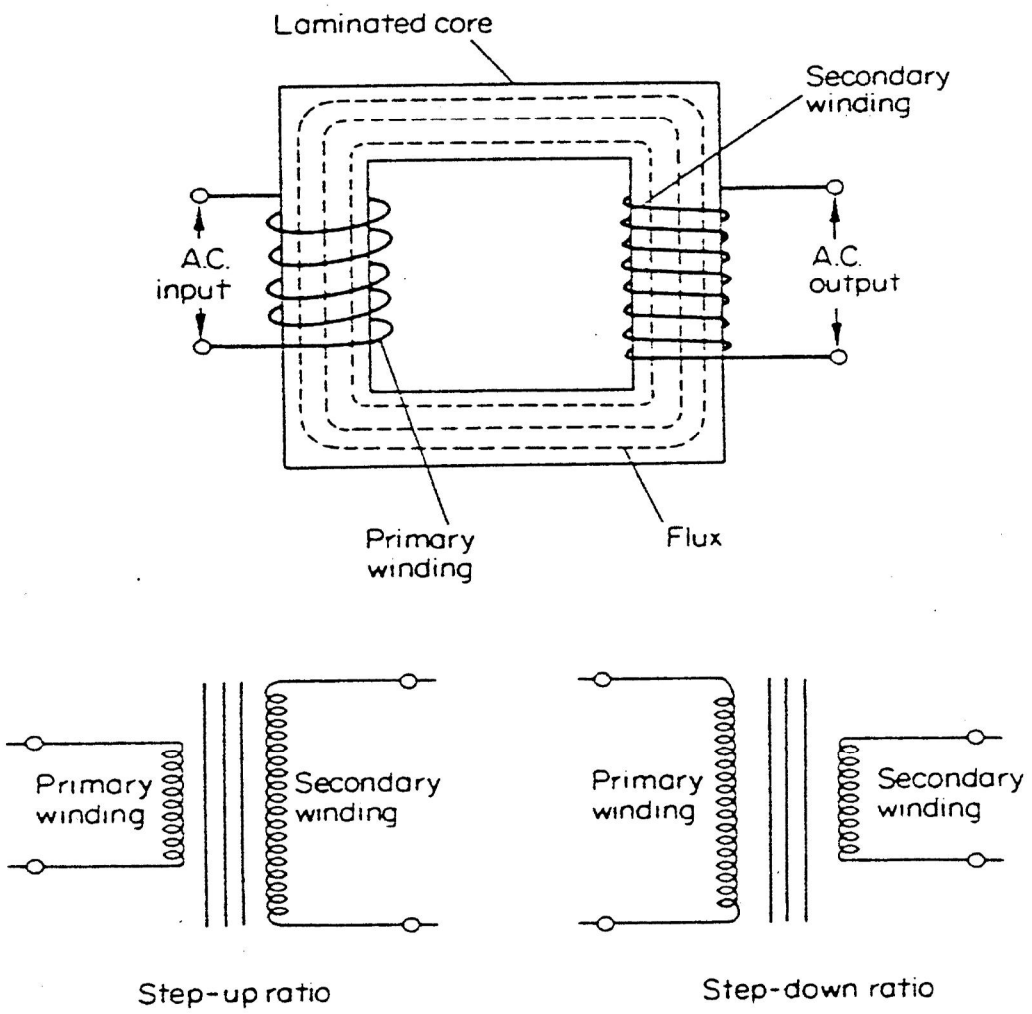
AC POWER CONVERSION & MANAGEMENT

TRANSFORMERS

Transformers are inductive devices that have no moving parts. They are used only with AC. The factors affecting transformer operation are :-

i. Strength of field.
ii. Number of windings of each coil.
iii. Rate of change of the applied voltage, (frequency of AC).

A transformer consists of two coils, designated primary and secondary, physically separate but magnetically linked by an laminated iron core. The core concentrates and focuses the magnetic field produced by the primary coil so it has maximum effect on the secondary coil.

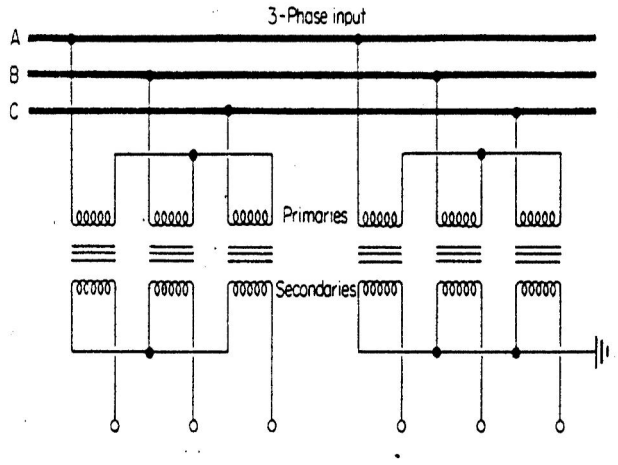


TRANSFORMER PRINCIPLE

THREE PHASE TRANSFORMERS

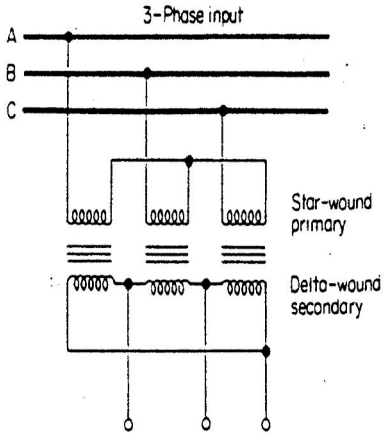
As each phase of three phases of AC is a sine wave, three single phase transformers can be used to step up or step down to the required voltage.

Alternatively, a three phase transformer can be used to ensure the integrity of the phase relationship. The primary and secondary windings of each phase are wound together on separate limbs of the transformer core.

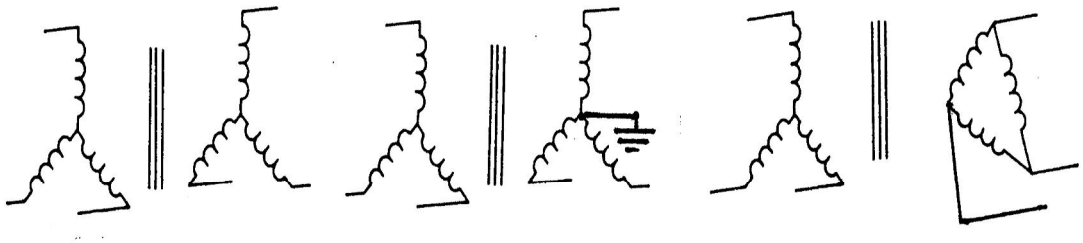


Star connection three-wire

Star connection four-wire



Star and Delta connection

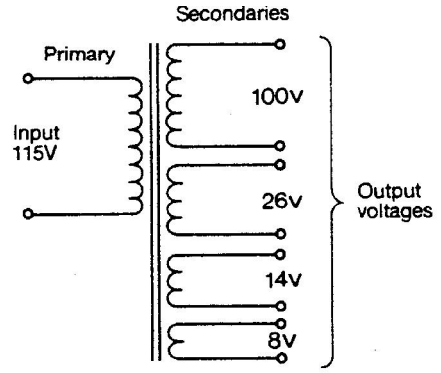


3∅ TRANSFORMERS: STAR AND DELTA WINDINGS

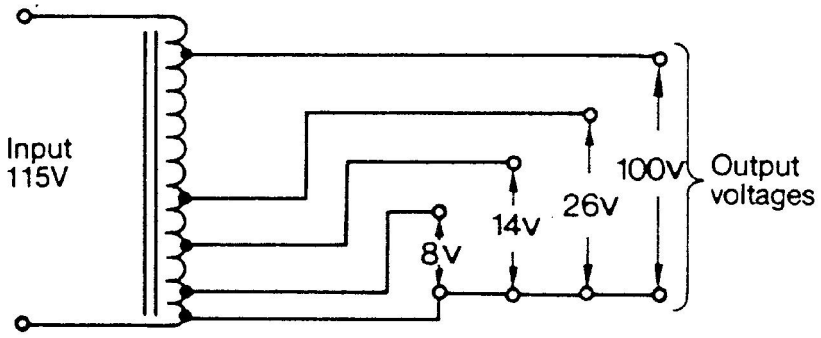
Auto Transformers

An auto transformer is a self excited device where the primary coil is also part of the secondary coil.

The following diagrams of a conventional transformer and an auto transformer, show a comparison of how the output coils can be wound or tapped off to provide the required output voltage.



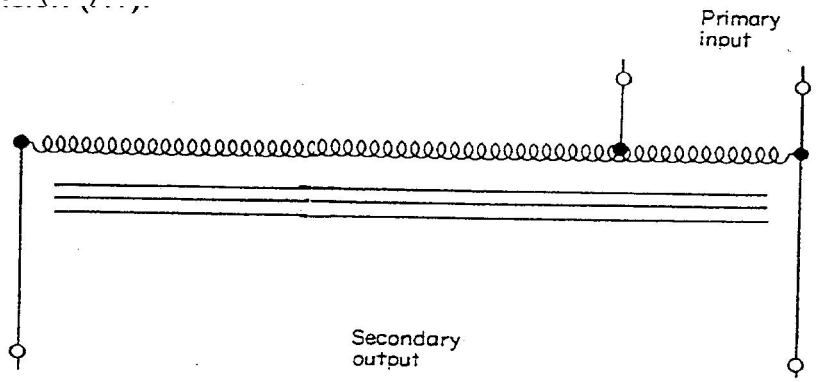
CONVENTIONAL TRANSFORMER



AUTO TRANSFORMER

Auto transformers can be used as very high ratio step up transformers. The coil in the light aircraft magneto, and the ignition coil of a car, are auto transformers. In the magneto, the primary winding receives about 300V AC which, when a rapid change is caused by opening the contact breaker points, transforms to approximately 30,000 volts in the Secondary.

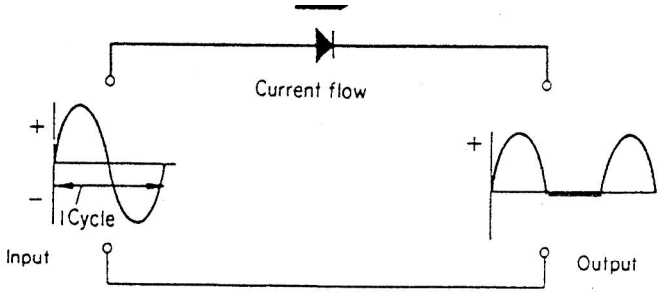
This very large voltage is required to make the current flow across the 0.5 mm air gap at the spark plug. As a given amount of energy has been transformed, at this high voltage only a small amount of current is available. The relatively low voltage in the primary is referred to as low tension (LT) and the high voltage in the secondary is called high tension (HT).



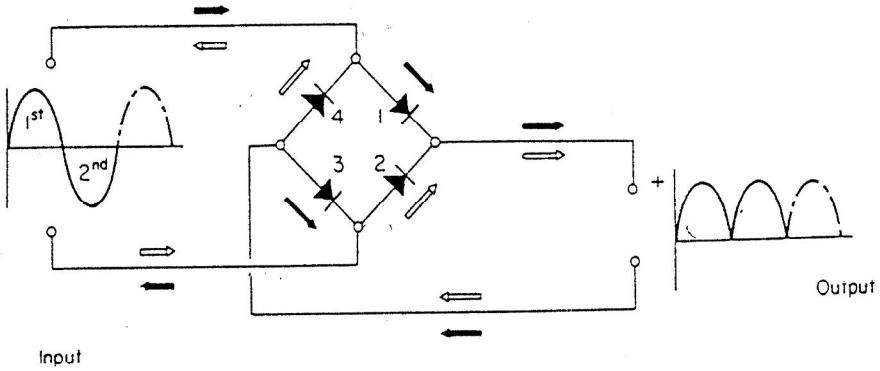
MAGNETO COIL: AUTO TRANSFORMER

AC - DC CONVERSION

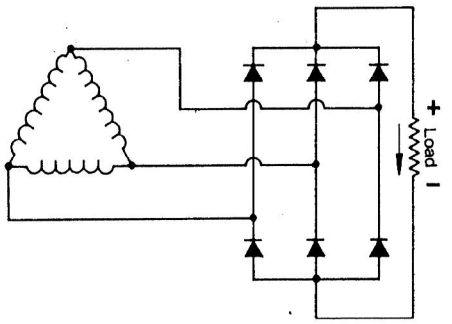
To convert AC power to DC power a diode or set of diodes is used

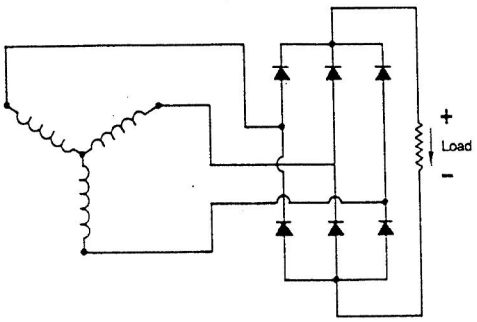


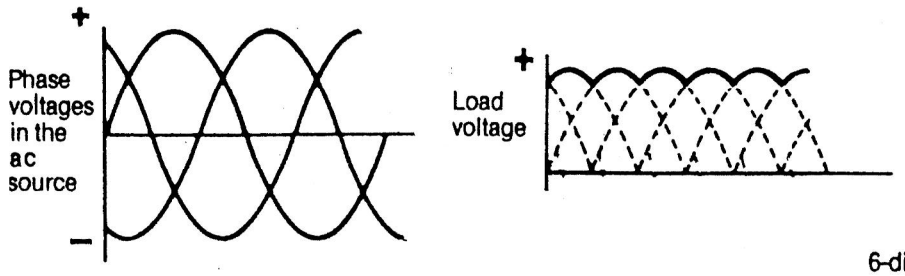
SINGLE DIODE - HALF WAVE RECTIFIER



DIODE BRIDGE - FULL WAVE RECTIFIER





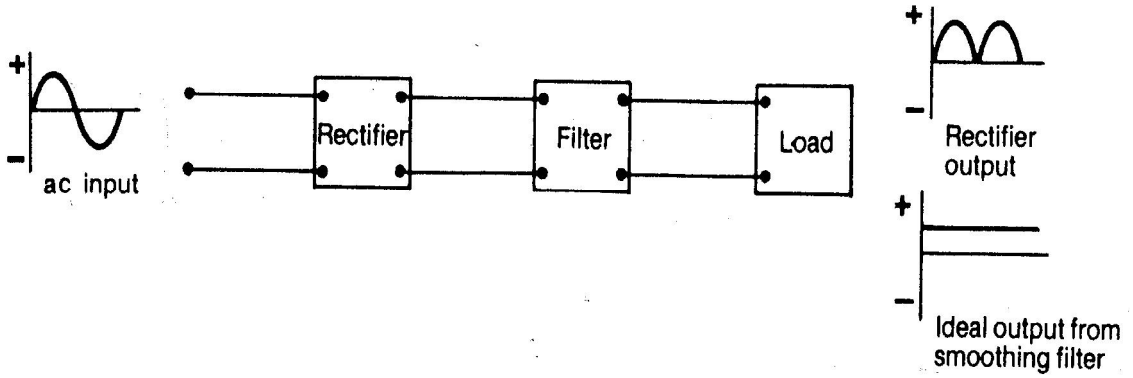


6-diode rectification

THREE PHASE AC RECTIFIED

In the previous diagram, the three phase AC is rectified to DC and in aircraft this is designed to produce 28vDC. However, generator and load changes may cause this DC to vary between about 25 and 31 volts, but if this variation is likely to have an adverse effect on sensitive equipment, a filtering circuit is provided.

A filter or smoothing device using other electronic components which include inductors and capacitors, is used to remove the oscillation and provide a steady DC.



DC-AC CONVERSION

The conversion of DC to AC is more complex than the rectification of the AC to DC.

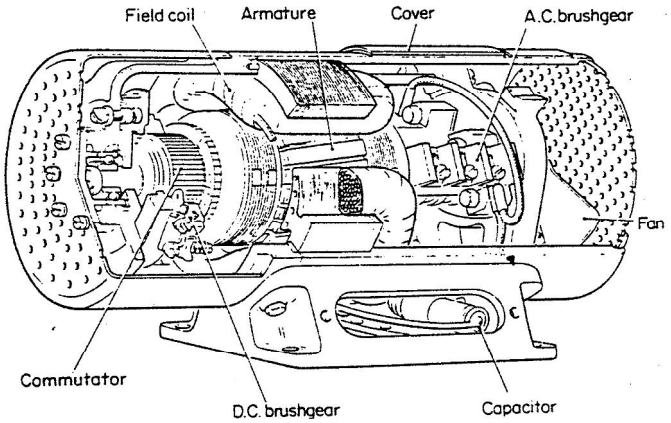
AC energy has an oscillating period time base; this frequency must be designed into the conversion equipment which uses DC to produce a suitable AC supply. This type of device is called an inverter. Inverters are either the rotary type or the static type.

The Rotary Inverter

When the current required in the DC circuit is very large, a rotary converter can be used. An AC motor drives a DC generator, however these devices are no longer common in aircraft as the weight penalty is large.

Battery power is used to drive a DC motor and this motor in turn drives an alternator.

To produce the specific output voltage, the alternator field current is controlled. To produce the specific output frequency the motor RPM is controlled. Rotary inverters are used only when large currents are required. They have generally been replaced by static inverters and solid state devices.

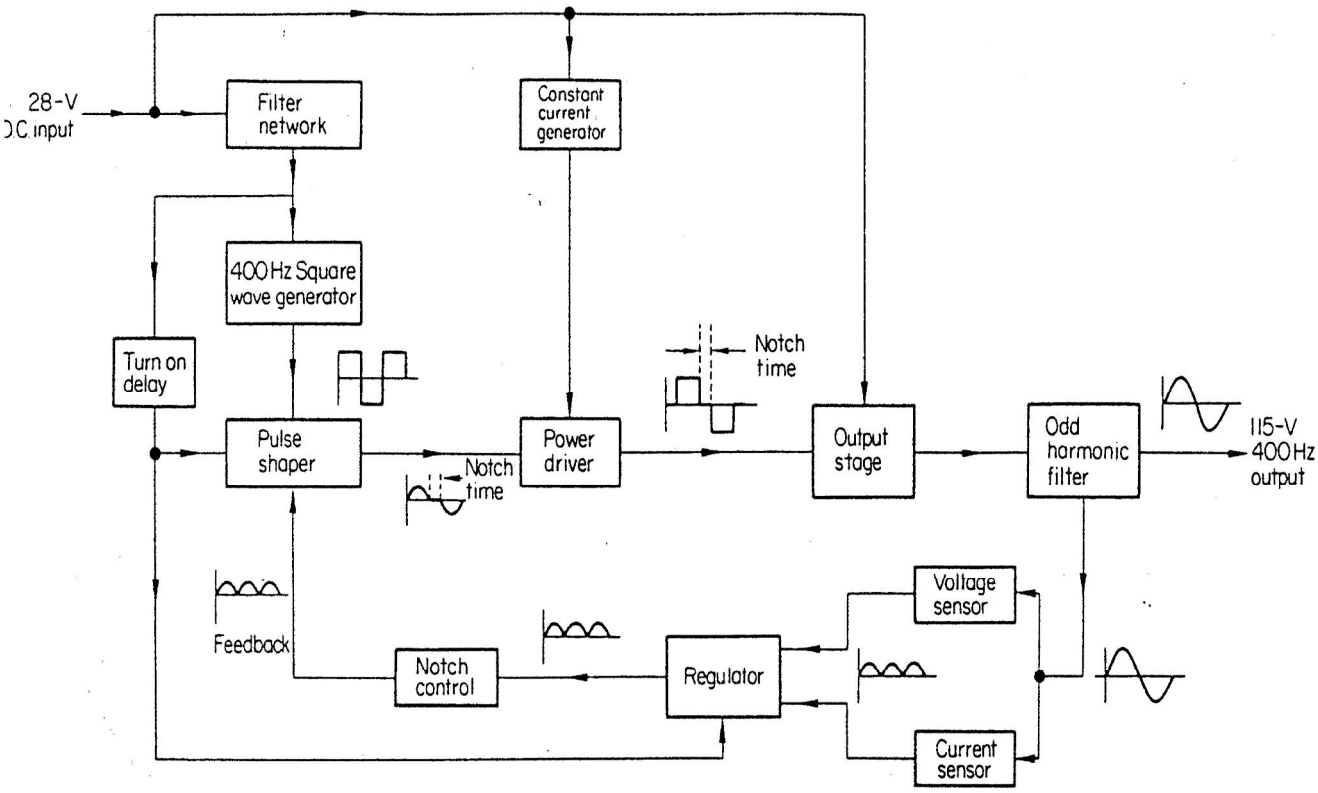


ROTARY INVERTER

The Static Inverter

Inside a static inverter, the DC is changed to AC by electronic switching using transistors. The frequency is determined by the switching rate. The output voltage is amplified and shaped electronically to achieve the desired values.

An inverter of this type is used to supply 26V AC 400 Hz for the flux valve of a remote indicating compass in many light aircraft (TB-10, BE-76). In large aircraft, static inverters are used to provide emergency or standby AC power. Static inverters are usually single phase devices.



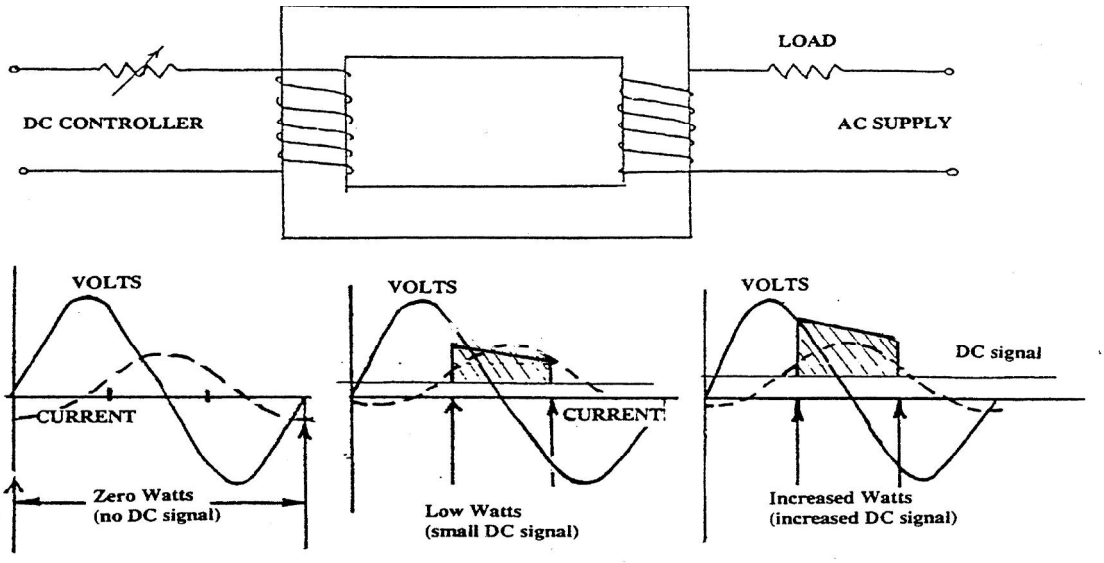
STATIC INVERTER

OTHER INDUCTIVE DEVICES

Magnetic amplifiers

A Magnetic Amplifier is sometimes called a 'saturable reactor'. It is a device used to control large amounts of AC electric power. It is used when currents are too large or conditions are too severe for conventional transistor amplifiers. For example, magnetic amplifiers often used to control the speed of very large electric motors or the brightness of airport runway lights.

A magnetic amplifier consists of two coils of wire. They are a main coil and a control coil - wound around an iron core (similar to a transformer). The core of a conventional transformer is never completely saturated with magnetic flux, so the energy in the primary coil is readily transformed into the secondary coil. The core of a magnetic amplifier can be saturated by design, when a DC control current is applied. Once saturated, the flux in the core can no longer change, so the self-induction or the back EMF effect is reduced. This reduces the impedance of the AC coil and allows more current to flow. Hence, the power control is related to the effective time the core is saturated. This control is achieved by manipulating a few amps of DC in the control circuit using a rheostat.



MAGNETIC AMPLIFIER

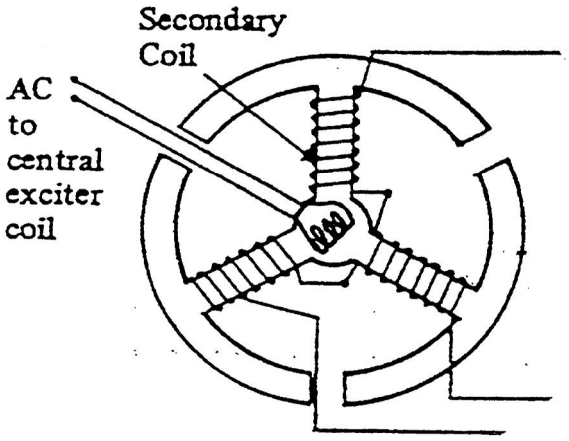
When compared to modern electronic (solid state) amplifiers, some advantages of magnetic amplifiers are - very efficient, losses are low.
- suitable for very high power operations.

The main noted disadvantage is that magnetic amplifiers when compared to conventional amplifiers, is, that being transformer type devices, they are very heavy.

Main applications :-
- speed control of electric motors.
- voltage and frequency control of aircraft generators.
- intensity (brightness) control of airport runway and approach lighting.

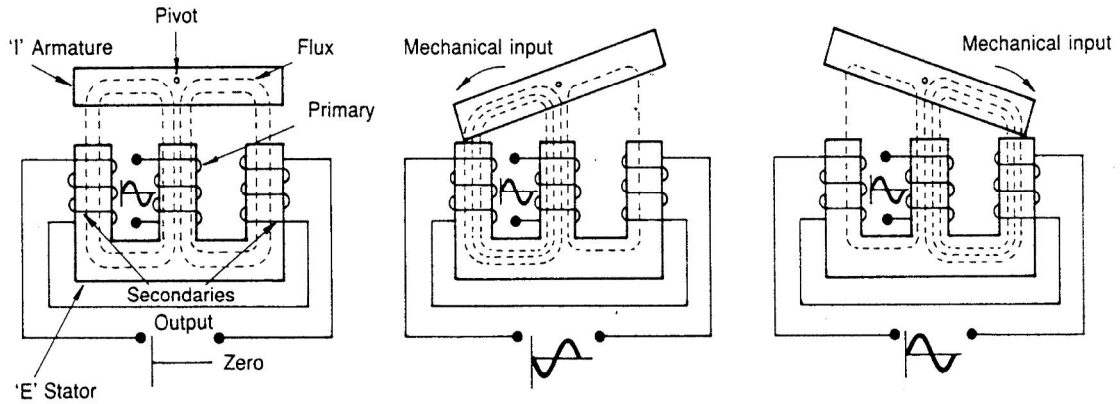
Flux valve

The flux valve used on small and medium aircraft is a transformer. It is an AC excited device and outputs a signal representative of Magnetic North.



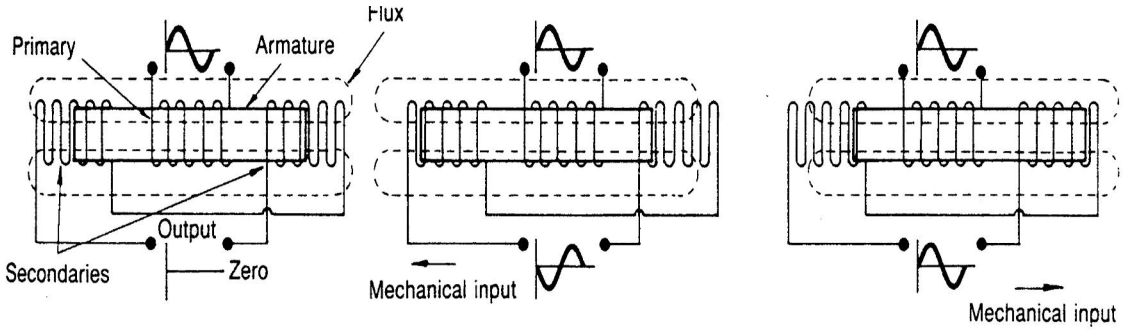
E.I.Transformer

The E and I core differential transformer is used to sense small position changes as the I bar is pivotted or moved.



Linear Voltage Differential Transformer (LVDT)

An inductive sensing device which outputs phase change.



Single core differential transformer