AN INTRODUCTION TO SMALL ELECTRIC MOTORS

An electric motor is a machine that converts electrical energy into mechanical energy, normally in the form of a rotating shaft. The types used in broadcasting equipment are usually small, developing only fractional horse power, and can be classified as either

(a) commutator motors

or (b) induction motors

The type of motor can be determined by examining details of the two main assemblies:-

1. the stator or field magnet - the part that does not rotate, normally the outer assembly
2. the rotor or armature magnet - the part that rotates, normally the inner assembly

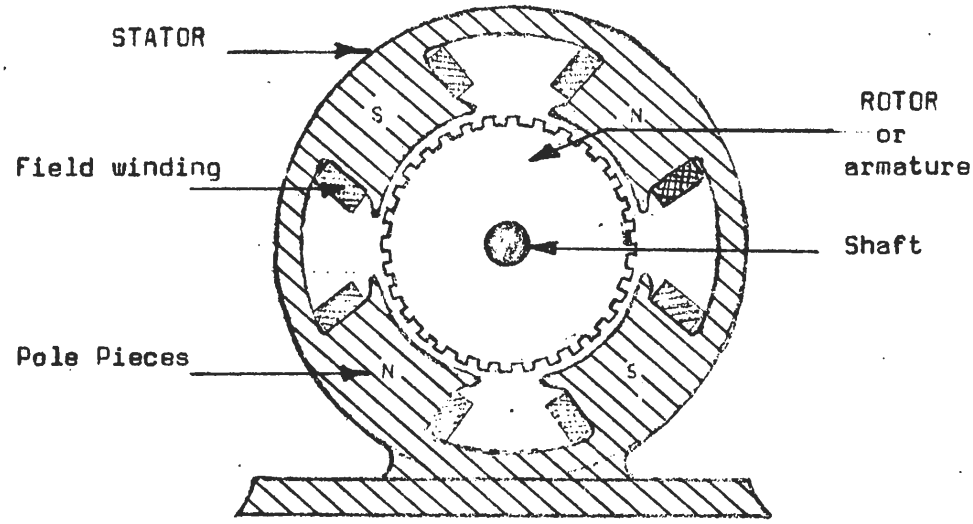


Fig. 1 Main assemblies of a motor

Motors could also be classified according to the electricity supply for which they are designed, i.e. d.c., universal (a.c. or d.c.), single phase or three phase a.c. Commutator motors can be either d.c. only or universal so there would be some overlap in this method of classification. Induction motors are always a.c. but may be single or three phase.

Commutator type motors

The force on a current carrying loop of wire situated in a magnetic field as shown in fig. 2 will tend to turn the loop until its' axis is in line with the field. To obtain complete rotation the current through the coil must be reversed at this point by a set of contacts that rotate with the coil. The assembly of contacts and brushes is called a commutator.

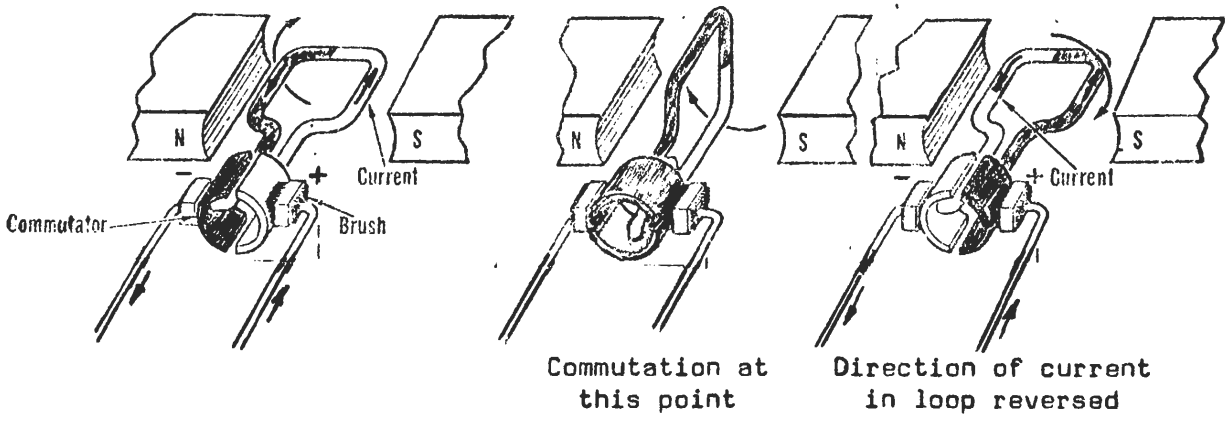


Fig. 2 Current carrying loop in magnetic field

In practice the armature contains many loops and the commutator many segments (as shown in fig. 3) with a pair of carbon brushes providing the external contact to the segments.

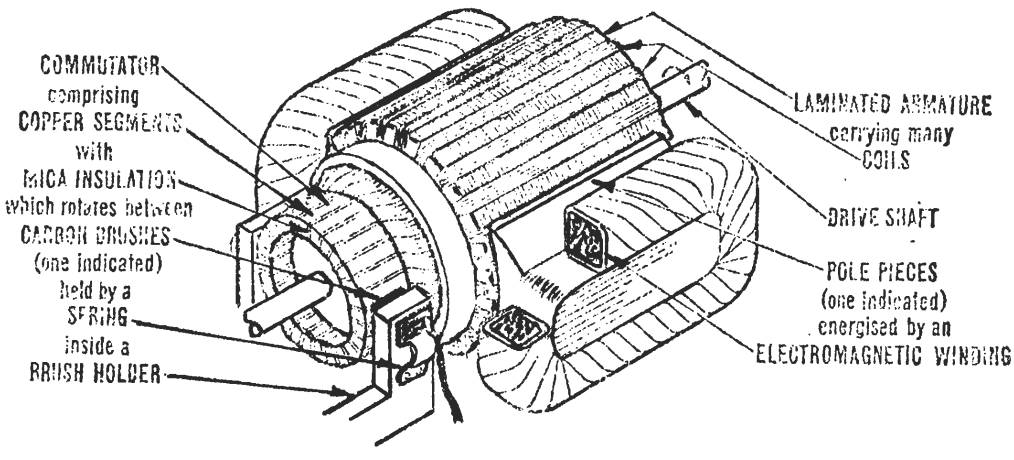


Fig. 3 Typical small armature from d.c. motor

The stator assembly for this type of motor is either a permanent magnet, in very small motors, or an electromagnet.

If the winding of the electromagnet is fed in parallel with the armature the motor is called a shunt wound motor, if in series a series wound motor.

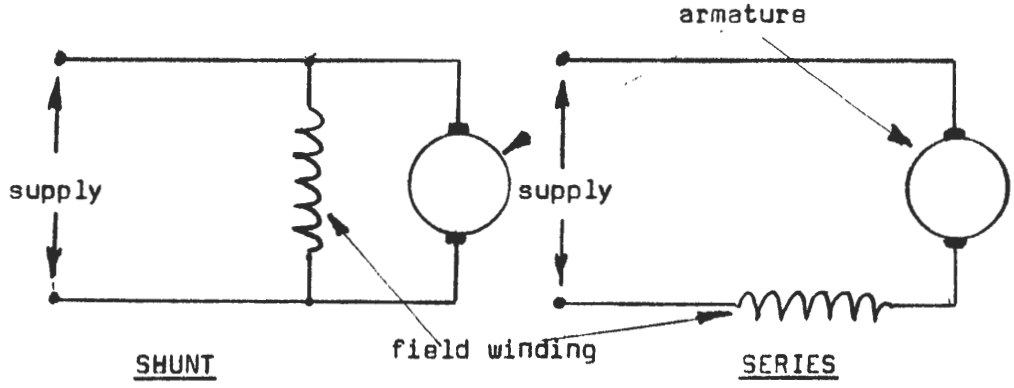


Fig. 4 Methods of connecting field windings

If either the armature supply or the field supply are reversed the direction of rotation reverses, if both are reversed the direction remains the same. Thus although this type of motor is normally considered a d.c. motor it will work on a.c. Normally only the series-wound are used on a.c. as this type of connection ensures that both field and armature current reverse together - these are called universal motors and are the most common type found in domestic appliances - vacuum cleaners, hand drills etc.

One problem with the universal motor, that tends to preclude its use in broadcasting equipment, is that, if not properly maintained, sparking occurs at the commutator causing radio interference. Domestic appliances must be suppressed to minimise this problem.

Induction type motors

The principle of the induction motor can be demonstrated using the magnet and coil assembly in fig. 2. If we short circuit the coil and rotate the magnets about the coil axis, current is induced in the coil setting up a magnetic field that tries to line itself up with the rotating field - hence the coil rotates. The speed of rotation of the coil is always slightly less than the rotating field. If however the armature has projecting poles or is magnetised it locks onto the rotating field and rotates in synchronism - a synchronous motor.

The essential requirement of an induction motor (or synchronous motor) is a stator field that rotates.

As a general rule a rotating field will be produced when the angular spacing of the poles is the same as the angular phasing of the supply.

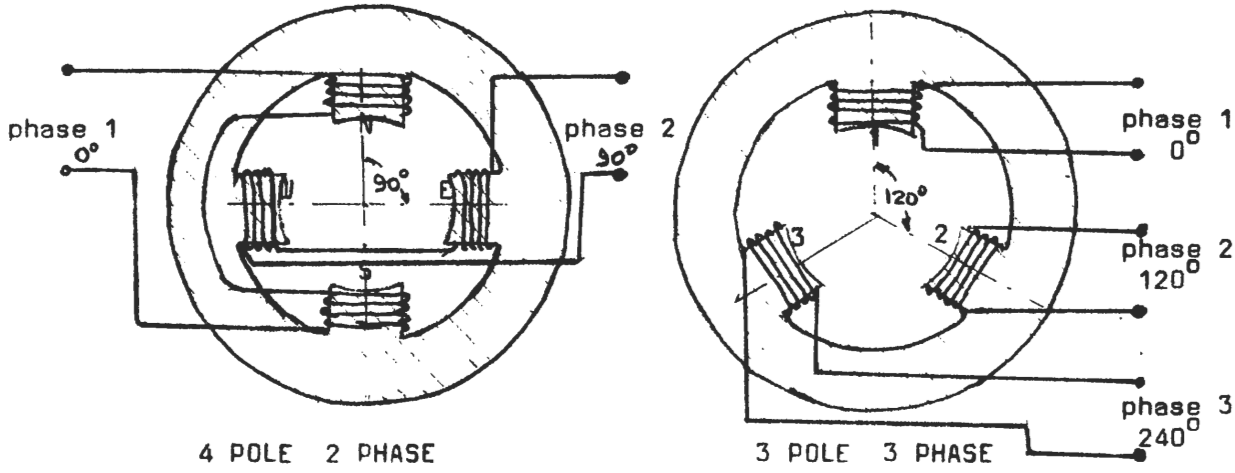


Fig. 5 Stators for producing a rotating field

A rotating field can be produced from a single phase supply by

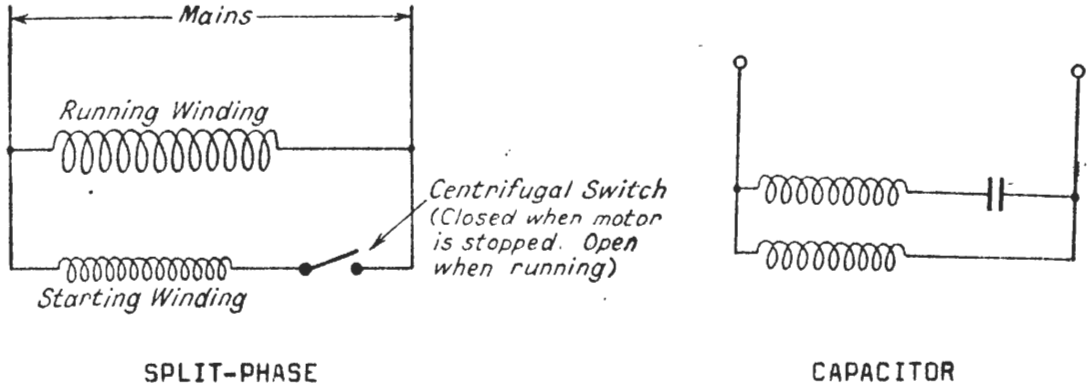
(a) using two sets of coils one of which has low resistance and high inductance, the other high resistance and lower inductance - split phase motor.

(b) using two sets of coils one of which is fed via a capacitor - capacitor motor.

(c) embedding a short circuit coil off-centre in each pole piece - shaded pole motor.

With split phase and some capacitor motors one winding is open circuited by a centrifugal switch when the motor has run up to speed. The rotating field is then maintained by the field produced by current induced in the rotor. Various forms of these arrangements are shown in fig. 6.

The rotating field produced from a single phase supply is not constant amplitude, this gives rise to vibration and noise and limits the size of single phase motors.



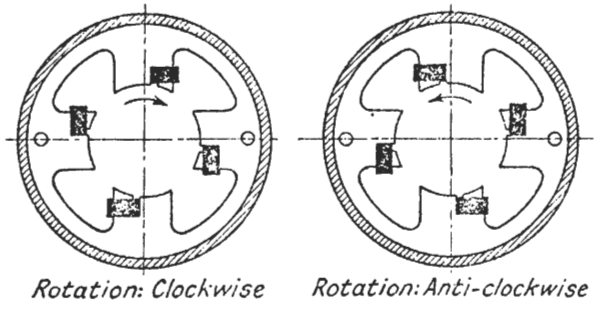


Fig. 6 Methods of producing rotating fields from single phase supply

Armature Construction

The armature of most small induction motors consists of a laminated iron cylinder with conducting rods embedded in the circumference as shown in fig. 7. The ends of the rods are connected together so forming a number of short circuited coils - this is called squirrel cage armature.

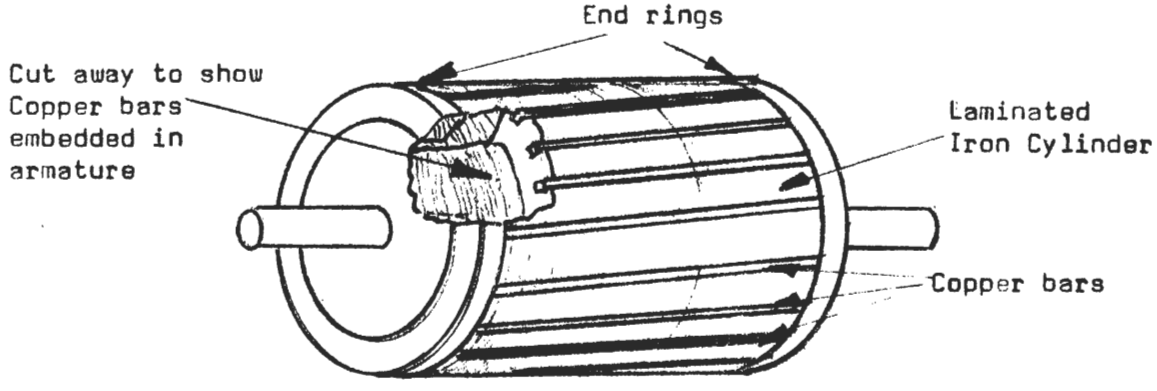
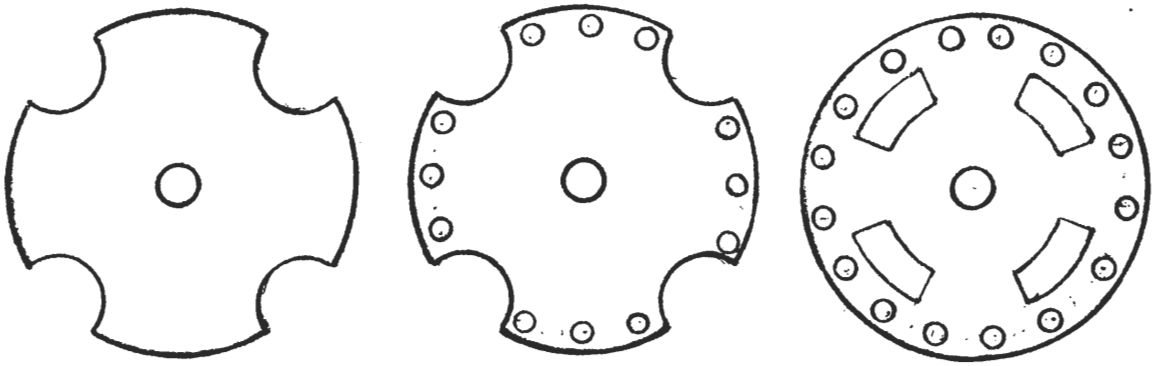


Fig. 7 Squirrel cage armature

A motor can be made to run synchronously by simply arranging projecting poles in an iron armature as shown in fig. 8 (a), these are called "salient poles". If the poles are magnetised the motor will be capable of remaining in synchronism under heavier loads.

This form of motor can be made self starting by embedding a squirrel cage into the armature (fig. 8 (b)). A rather smoother running design is that of fig. 8 (c) where the "salient" poles are produced by removing some of the centre of the armature, thus gives a smooth circumference and a uniform squirrel cage.



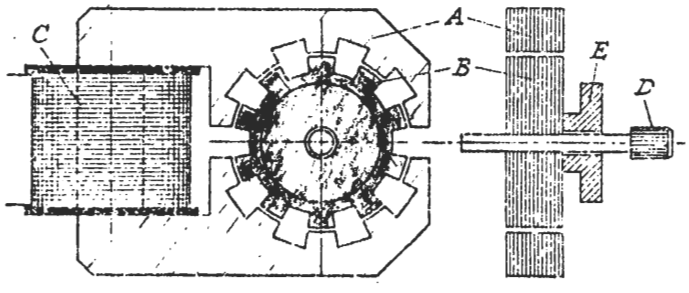
(a) Salient pole

(b) Salient pole with Squirrel cage

(c) Salient pole formed by cutting away armature

Fig. 8 Types of armature found in f.h.p. synchronous motors

Small clock motors use a cogged stator and rotor as shown in fig. 9, the rotor moves one pair of cogs per supply cycle. This type is not self starting.



(A) Stator

(B) Rotor

(C) Energising Coil

(D) Starter knob

(E) Flywheel

Fig. 9 Clock motor with cogged stator and armature

SUMMARY

TYPE	SUPPLY	DISTINGUISHING FEATURES	TYPICAL USES
SMALL d.c.	Battery or d.c.	Commutator and permanent magnet stator	Model trains etc.
		Commutator and shunt wound stator	Larger models, camera lens iris and some cheap battery operated tape recorders
UNIVERSAL	240v a.c./d.c.	Commutator and series wound rotor	Domestic appliances, power drills etc.
INDUCTION (MULTIPOLE)	3Ø a.c.	Multiple of 3 stator poles. Squirrel cage rotor.	Workshop equipment lathes, bench drills etc. Film dubbing equipment
	single phase a.c.	At least 2 pairs of stator poles, one high R or fed via C Squirrel cage rotor	Tape spooling, ventilation fans. Heavy duty domestic appliances, washing machines.
INDUCTION (SHADED POLE)	single phase a.c.	Copper loop embedded in stator poles. Squirrel cage rotor	Record player. Domestic tape machines Small fans.
SYNCHRONOUS	single phase a.c.	Stator as for INDUCTION types. Salient pole armature.	Tape capstan drive. High quality record players.
		Cogged stator and armature.	Clocks

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