VARIABLE CAPACITORS IN TUNED CIRCUITS

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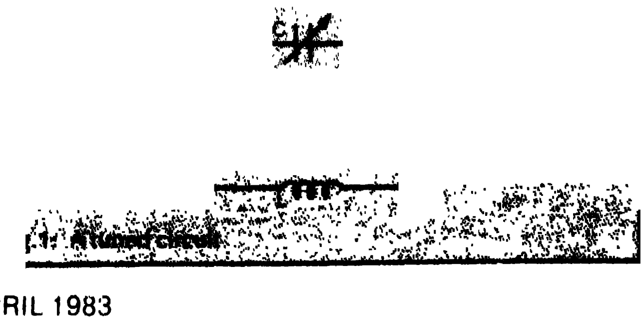
A tuned circuit is formed by a combination of a coil and a condenser. It can select a given signal frequency from a number of different frequencies. As in the case of a radio receiver, it is necessary to be able to vary the tuning so that signals of different wavelengths or frequencies may be received. This can be achieved by varying the inductance or the capacitance of the typical tuned circuit shown in Fig.1. The latter procedure, however, is simpler and is nearly always adopted. In such circuits, the longer the wavelength of the signal we wish to select, the more capacity must be put in the tuning circuit.

Capacitors and capacity

A capacitor (or condenser) is made of two metal electrodes, separated by an insulating medium, called the dielectric material.

The property of the condenser to store electrical charge is termed as the capacitance. The capacitance of a condenser depends on its various physical and electrical parameters. The capacitance is directly proportional to: (i) the area of overlap of the electrode plates, (ii) the number of pairs of such plates in parallel, and (iii) the specific inductive capacity of the insulating material



used. On the other hand, the capacitance is indirectly proportional to the distance between the plates. Capacity is usually expressed in microfarads (abbreviated as μF or mfd) or in picofarads (abbreviated as pF). A microfarad is $1/10^6$th and a picofarad is $1/10^{12}$th respectively of a Farad, which is the unit of capacitance.

There are basically two types of capacitors, viz. fixed and variable. Here we will discuss only the different forms of variable capacitors.

Variable capacitors

Variable capacitors are generally made having a fixed set of vanes while a set of moving vanes operate between the gaps of the fixed vanes. The fixed and moving vanes are mutually insulated either by air or some other dielectric material. When the vanes of the condenser are fully interleaved, we get the maximum capacitance.

Many variable condensers have an air dielectric, but others have dielectric materials like mica, polyester or other insulating materials.

The former are always more efficient because air is the most perfect dielectric material known, causing minimum energy loss. On the other hand, solid dielectrics, having a higher 'dielectric constant', require a smaller area of vanes to make a condenser of a given capacity. In addition, the vanes can be placed much nearer to obtain greater capacitance, without the least fear of a short circuit. Consequently, the physical size of a solid dielectric condenser is sizeably less than that of an air dielectric condenser of equal capacity.

Air dielectric condensers are used when precision tuning and low losses are involved. But solid dielectric condensers are suitable for compact, portable sets, where loss can be tolerated within limits.

Types of variable capacitors

The type of variable capacitor depends on the performance characteristics desired This variation in the capacitor characteristics is achieved by modifying the shape of the moving vanes. The shape of the fixed vanes is quite unimportant, provided that they are large enough to completely overlap the moving vanes when interleaved. The general types of variable capacitors are described hereafter, each having advantages for certain requirements.

Straight line capacitor: Condensers of this type have semicircular moving vanes, as shown in Fig. 2(a). As a result, the capacity increases (or decreases) at a uniform rate as the moving vanes are turned. This results in a linear relationship between the capacity of the condenser and the angular position of the dial, as shown in Fig. 2(b) In actual practice, the graph curves slightly at each end of the dial, as shown by dotted lines.

This type is suitable for applications such as reaction control (feedback control from detector stage to the tuning stage) in a wireless receiver but unsatisfactory for tuning purposes in receiver sets. This is because the wavelengths to which a coil will tune are not proportional to the capacity of the tuning condensers. Thus stations are crowded at the lower range and spaced unnecessarily at the upper range, if such a condenser is used in a radio set.

Square law capacitor: The last mentioned disadvantage caused the introduction of the 'square law' or 'straight-line wavelength' condensers. The shape of the moving

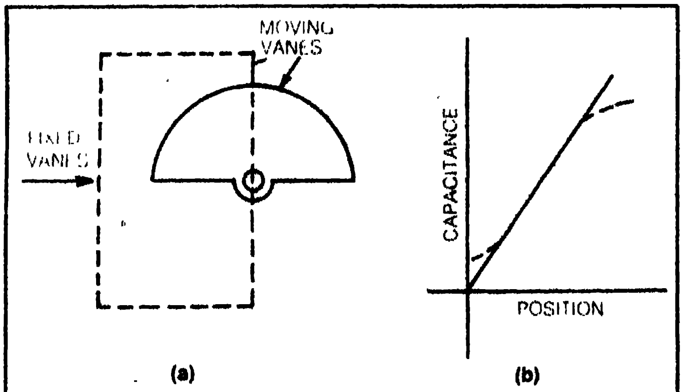


Fig.2: Straight line capacitor

vanes is such (see Fig. 3(a)), that as they are rotated, the area of overlap of the vanes is small at first and greater towards the end of rotation. This results in a linear relationship between the wavelength of the tuned circuit and the dial angular reading, as shown in Fig. 3(b).

This is very useful from the view of receiver calibration, but it still causes stations on the lower wavelengths to be more crowded than the ones on the upper side.

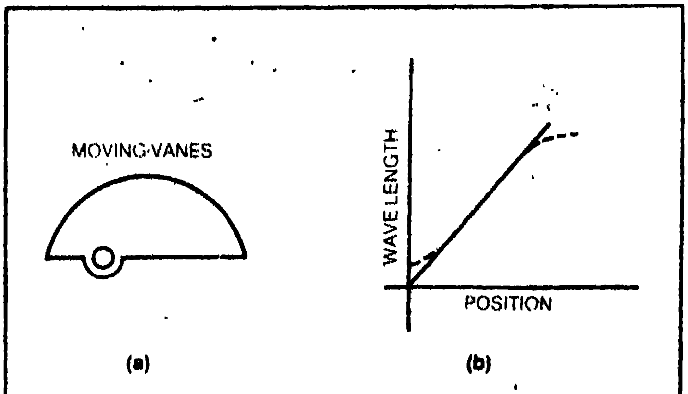


Fig.3: Square law capacitor

This is because it is the frequency, rather than the wave length, which gives the desired spacing of stations in a radio set.

Straight line frequency capacitor: We can now appreciate the value of the straight line frequency condenser. The usual shape of vanes is shown in Fig. 4(a) and is so designed that the frequency of the tuned circuit is proportional to the dial angular setting, as shown in Fig. 4(b).

For many applications, this is the most convenient, since it gives equal station separation over the whole of

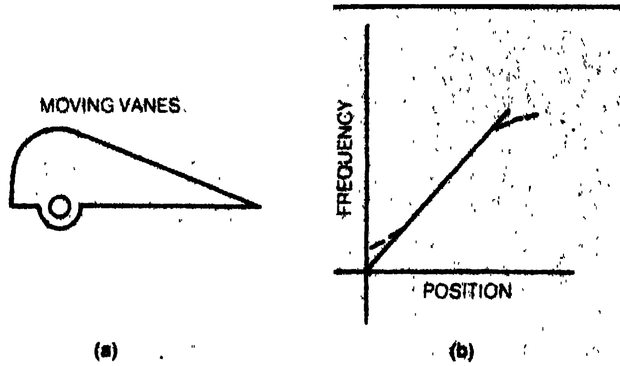


Fig.4: Straight line frequency capacitor

its scale and also permits easy calibration in terms of frequencies. However, this type of condenser is not suitable for 'ganging' (physical coupling with another variable capacitor in a radio set) because of its comparatively small capacity at low dial readings. In consequence of this, stray capacitances and trimming capacitances absolutely ruin the matching except on the higher dial readings.

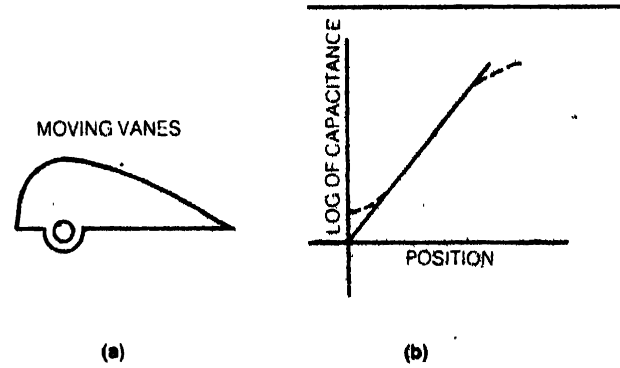


Fig.5: Log capacitor

Log capacitors: These are the best for 'ganging' purposes and their tuning characteristics lie somewhere between those of the straight line frequency and the square law capacitors. Its vane shape is shown in Fig. 5(a) and the dial reading is proportional to the logarithm of the capacity, as shown in Fig. 5(b).

Differential capacitors. These are similar to ordinary

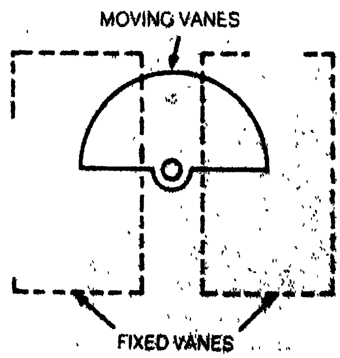


Fig.6: Differential capacitor

variable condensers except that they have two sets of fixed vanes and one set of moving vanes. The latter can mesh with either set of fixed vanes and usually are partly in mesh with both, as shown in Fig. 6. These are always of the straight line capacitance type, so that the sum of the capacitances between the moving and both sets of fixed-vanes remain constant. As the capacity is increased on one side, it is decreased on the other side at the same rate.

These are often employed for 'reaction control' purposes in radio sets.

Trimmer capacitors. These are variable capacitors of small values and range, which can be preset to a given value by suitable adjustments and are not meant for continuous variations.

Trimmers are connected in parallel with each section of 'gang' condensers, so that they can be matched to compensate for the individual stray capacitances. There are a number of different ways of making them, but the two principal methods are shown in Fig. 7(a) and (b).

In Fig. 7(a), the moving and fixed vanes are semicircular, and the moving vanes can be brought to mesh with the fixed vanes by turning the screw to the required degree, thus increasing the capacitance. In Fig. 7(b), the tightening of the insulated screw brings the springy plate closer to the fixed plate, over the mica dielectric, increasing the capacitance. The plates here are usually rectangular.

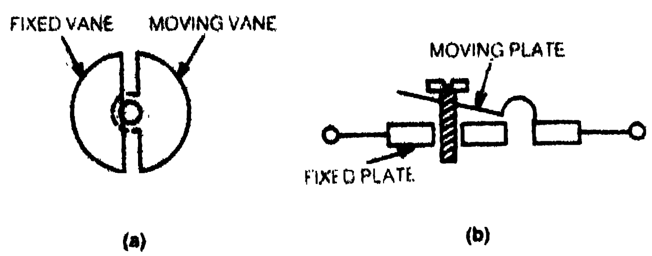


Fig.7: Trimmer capacitors

Split end-plate condenser: This is just a different method of trimming gang condensers. In this case, the end moving vane of each section is split radially and is set further away from the next fixed vane, than the others, as shown in Fig. 8. Thus the capacity of any condenser section of this end plate can be adjusted at any part of the dial by pressing the appropriate sector of the split vane towards the adjacent fixed ones. These types of 'gang' condensers can be matched with perfect accuracy over the entire tuning range.

Requirements of variable condensers

Variable capacitors are subjected to continuous adjustments, involving movement of the vanes. Thus, a rigid structure is a must for all variable capacitors so that the capacitance is not changed by bending of the vanes. The spindles should also be stiff and well mounted, pref-

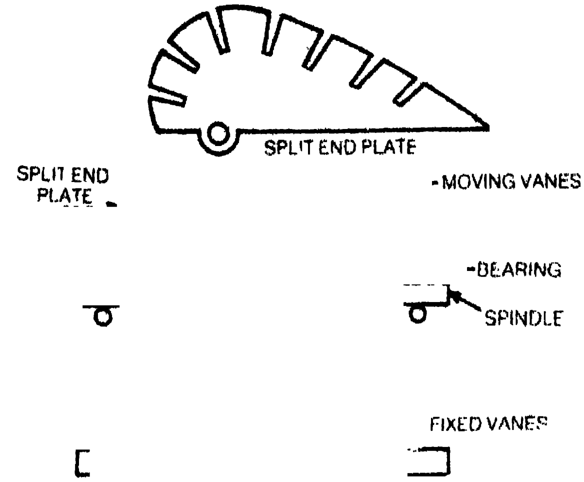


Fig.8: Split-end plate capacitor

erably with ball bearings, so that radial displacement does not take place.

A careful design is necessary so that the minimum capacity of all variable capacitors is as low as possible for any given maximum capacity. Insulation must be proper to minimise the leakage loss. And finally, the capacitor must have excellent reproduction of its capacitance at a particular setting, irrespective of the number of position changes its moving vanes has gone through. □