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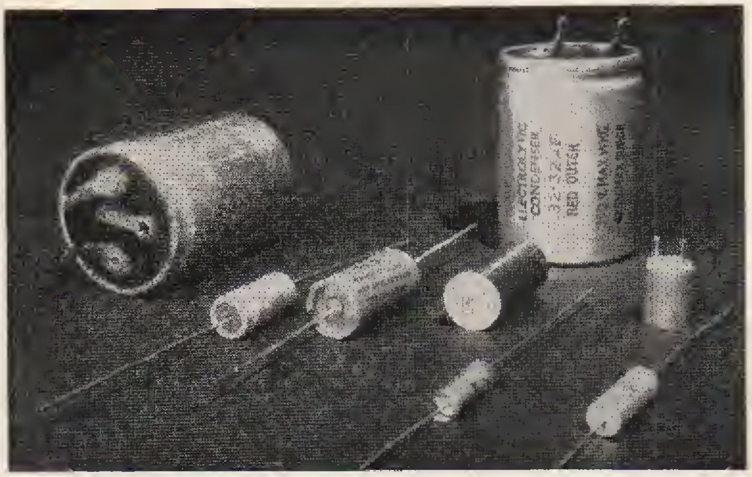
An Instructional Series for the Newcomer to Electronics



ELECTROLYTIC CAPACITORS

Here is a representative group of electrolytics. The two large components are dual units and each incorporates two separate 32μF 350V working capacitors within the one metal can. The common negative connection is the centre tag.

The smaller components with lead-out wires have the following values and voltage ratings (reading left to right): 100μF, 15V, 50μF 25V, 15μF 12V, and 60μF 10V.

A pair of plastic encased miniature capacitors specially designed for close packing on printed wiring boards are also shown. These have two pins emerging at one end. The larger one is 300μF 10V, the other 25μF 25V.

WE are all well aware of the desirability of getting a quart into a pint pot. It is now our purpose to explain how this has been achieved with capacitors.

Using any of the constructional methods described last month, we find that the component becomes very large and bulky as the value of capacitance increases. For values of say 1μF and upwards, the physical size of a "paper" capacitor is often much too great for normal applications. This question of size is most important nowadays with the continuing trend towards miniaturisation in electronic devices.

Together with this demand for smaller and more compact circuit assemblies comes the demand for very large capacitance values (several hundreds of microfarads) due mainly to the special requirements of circuits based on transistors.

The electrolytic capacitor is no newcomer to the scene but modern production techniques have advanced so tremendously that there is now little problem in getting a quart into a thimble—speaking figuratively of course! Let us now look more closely at this component.

ELECTROLYTIC CAPACITORS

Very high values of capacitance are achieved within modest volumes by replacing the normal solid dielectric with an insulating film formed by electrochemical action.

In the usual form of "dry" electrolytic capacitor construction, two electrodes of aluminium foil are separated by a paper foil which is impregnated with a chemical solution or paste. See Fig. 6.1.

When a d.c. potential is applied to the aluminium foil electrodes, a thin insulating film is formed on the surface of the electrode connected to the positive side of the supply. The large capacitance values realised are due to the extreme thinness of this film which acts as the dielectric between the two aluminium foils. This film has a high strength and can withstand voltages of up to about 600V.

The paper which carries the paste is fully conductive and therefore does not increase the effective thickness of the dielectric film in any way.

It should be noted that the so-called "dry" electrolytic is not in fact completely dry; this term is used to distinguish it from the earlier type of wet electrolytic which used a free liquid electrolyte.

Solid electrolyte aluminium foil capacitors—which are truly "dry" have been developed recently. These have a semiconductor material in place of the usual electrolyte.

ETCHED FOIL

By embossing or etching treatment, the effective surface area of the metal foils can be effectively increased and thus an even greater capacitance obtained for a given bulk. Such capacitors are known as etched foil type to distinguish them from the normal plain foil electrolytics.

The layers of aluminium foil and impregnated paper are wound into a roll and this is then sealed in a metal or cardboard case or encapsulated in a resin or plastic moulding. During the sealing process precautions are taken to prevent evaporation of the moist paste or solution. These capacitors are not completely hermetically sealed, however, as a certain amount of gas is formed inside during normal operation.

The polarity of the lead-out wires or soldering tags is clearly marked on the body of the electrolytic capacitor, and must be carefully observed in use. Reversal of these polarities will cause a breakdown of the dielectric and the capacitor will be, in all probability, ruined.

To the left of the photograph appears the circuit symbol for an electrolytic capacitor. It will be seen that the positive and negative plates are clearly distinguished.

The maintenance of the dielectric film is dependent upon the application of a d.c. polarising potential, and a small leakage current is a normal characteristic of this type of capacitor. After a long period of non-use, the film disintegrates; subsequent application of a suitable polarising voltage will cause a heavy current to flow initially, but as the dielectric film is restored, this current will fall to its normal leakage value.

The rated working voltage marked on an electrolytic capacitor is somewhat lower than the voltage applied during manufacture in order to "form" the dielectric. Certain types, designed to withstand for a short period voltages in excess of the normal rating, have in addition a surge voltage rating which is approximately the same as the forming voltage. Surge-proof capacitors of this kind are used as "reservoir" capacitors in rectifier filter circuits.

NOT FOR A.C. ALONE

The electrolytic capacitor is not suitable for circuits where only a.c. is present, but it is widely employed in circuits where an a.c. component is superimposed on a steady d.c. potential; for example, in filtering the pulsating output from power rectifiers and in de-coupling cathode bias resistors in respect of low frequency signal voltages. As the frequency of the applied a.c. is increased, dielectric losses in the film increase and the power factor becomes very large (about 15 per cent). Consequently this restricts the use of electrolytics to low frequency applications, since at r.f. they present considerable impedance. This will be discussed more fully when we deal with a.c. theory.

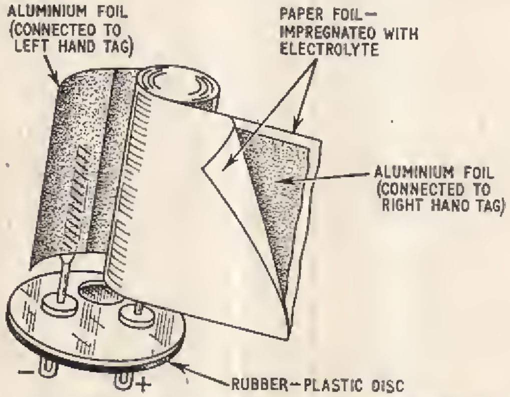


Fig. 6.1. The general form of construction of an electrolytic capacitor. The assembly is housed in either a metal or plastics case. Note that the dielectric—which consists of a thin insulating film deposited on one aluminium foil—is not actually shown in this diagram. This film is deposited by electro-chemical action during manufacture, and this particular process is referred to as "forming". It is essential to connect electrolytic capacitors according to the polarity indicated on the case. Sometimes the positive (+) tag or lead will be identified with a red mark and the negative (—) with black

The method of construction does not lend itself to fine control of capacitor values, and tolerances of −20 per cent and +50 per cent are quite usual, while tolerances of up to 100 per cent are not uncommon among certain types.

WIDE RANGE OF VALUES

There is an extensive choice of capacitance values and working voltages in the electrolytic type capacitors currently available. The physical size of the component is naturally determined by the magnitude of these two factors.

Values ranging from about 0·1μF to 1,000μF for operation at 50 volts or lower are available in either a sub-miniature or normal size class. High working voltages, such as 150, 350, 450 and 600 are provided in the normal size class of components, where the upper capacity limit is generally about 32μF; although even here smaller components are becoming more usual due to the etched foil technique.

Standard values are multiples of 8μF and combined units comprising two or three separate capacitor sections are made. In such double or treble units, a common negative connection is usually provided.

Some metal enclosed electrolytics have their outer casing connected internally to the negative electrode, while other types have their case isolated from the internal electrodes. Indication of the method adopted is printed on the side of the component, and should be noted before use.

Plastic sleeves are sometimes fitted to the smaller tubular types to allow the metal case to be insulated from chassis or from adjacent components. This is obviously not necessary in the case of plastic encapsulated types; these are very useful for close packing, for example on small printed wiring boards.

NON-POLARISED ELECTROLYTICS

Non-polarised reversible versions of the foil type of electrolytic are also manufactured. Such capacitors consist of, in effect, two separate capacitors connected in series, back to back. The resultant capacitance is normally half that of the polarised type for a given working voltage.

Electrolytic capacitors (especially those of the aluminium foil type) are more liable to be influenced by external conditions than solid dielectric capacitors, and their efficient and reliable operation is dependent upon the strict observation of a number of points.

1. Ensure that the polarity is correct before connecting up.

2. Do not exceed the maximum rated working voltage. Likewise, do not operate under conditions where the applied d.c. will be considerably less than the nominal working voltage. Either extreme condition could bring about a deterioration of the dielectric film.

3. Never connect to a pure a.c. supply.

4. Keep away from sources of heat, such as power rectifiers and large output valves.

We have now dealt with the physical nature of capacitors, and have indicated how they react to direct current (d.c.). Further discussion of the capacitor will arise when we reach the subject of alternating current (a.c.).