Radio Editors of magazines and newspapers are hereby given permission to reprint in whole or in part, with proper credit to the Aerovox Corporation, the contents of this issue of the Aerovox Research Worker.

The AEROVOX Research Worker

The Aerovox Research Worker is a monthly house organ of the Aerovox Corporation. It is published to bring to the Radio Experimenter and Engineer authoritative, first hand information on condensers and resistances for radio work.

VOL 6, NO. 7 JULY, 1934 50c per year in U.S.A. 60c per year in Canada

Electrolytic Condensers for Condenser-Start Type Motors

By the Engineering Department, Aerovox Corporation

DURING the past three years, there has come into general use a type of electrolytic condenser designed for intermittent use on alternating current. Many thousands of these condensers have been used by motor manufacturers to improve the starting characteristics of small A.C. motors. The use of these condensers has become so popular that it has appeared to be worth while devoting this issue of the Research Worker to the discussion of them. Before specifically describing these condensers designed for intermittent alternating current duty it will be worth while first to review briefly the ordinary type of electrolytic condenser designed for direct current, so that the difference between such condensers and alternating types of electrolytic condensers will be clear.

The ordinary electrolytic condenser generally used in radio receivers for filtering and by-pass purposes is designed for use on pulsating d.c. currents. These types of electrolytic condensers are made using two aluminum foils only one of which has a very thin oxide film formed electrochemically on its surface.* To properly use such a condenser it is necessary that the positive voltage from the circuit be connected to the formed plate or foil, in order to maintain this formation. If the positive side of the circuit is connected to the unformed or negative foil a relatively large current flows through the condenser in the reverse direction and rapidly deforms the formed foil.

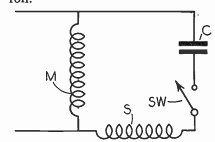

FIG. 1

In certain types of radio receivers, for example those designed for use on 110 volts d.c. precautions must be taken to prevent damage to the condenser in the event that the power lead from the receiver is connected wrongly into the light socket. To prevent damage to the condenser under such conditions it is customary to use not one formed plate but to form both of the plates. When the power lead is properly plugged into the light socket and positive voltage is applied to the positive terminal of the condenser, the condenser functions like an ordinary unit. However, if the voltage is reversed, then the film on what would normally be the unformed negative foil acts to limit the leakage current. By limiting the leakage current excess heating of the condenser which would irreparably damage it is prevented.

Condensers which are made using two formed foils are frequently referred to as double formed condensers since both plates instead of one plate are formed. Condensers for intermittent a.c. use are also this type, and the purpose of the double formation is to permit either plate to become positive and yet hold the leakage current to a low value at all times.

Condensers in which both plates are formed may be subjected to alternating current for short periods of time without damage to the condenser. If, on the other hand, the condenser is allowed to remain across, say 110 volts a.c. for a period of hours then the heating, due to the current, finally causes the condenser to become so hot as to ruin it.

The most general use of electrolytic condensers designed for intermittent a.c. duty is in connection with the starting of "split-phase" or "condenser-start" type of motors. For this reason this type of electrolytic condenser is called a "starting condenser." The

* See Vol. 4, No. 7, Oct. 1931 issue of the Research Worker.

condenser-start type motor is not a new development but its general commercial adoption was economically not practical up to about three years ago, due to the lack of suitable low cost starting condensers. The development of electrolytic starting condensers pioneered in 1932 by Aerovox Corporation made the condenser start motor an economically practical one to build. Today, such motors are very generally used with household refrigerators, oil burners, washing machines, and other devices requiring fractional horse power motors where the starting service requirements are such as to permit the use of electrolytic starting condensers.

The circuit of the motor generally used with electrolytic starting condensers is shown in Fig. 1. The motor contains two windings, one the main winding M, and the other the starting winding S. Connected in series with the starter winding across the line is the starting condenser C and a switch SW. The switch is of an automatic type which automatically opens and disconnects the condenser after the motor reaches nearly running speed. In some cases the switch is of the electromagnetic type, and in other cases it is of the centrifugal type, but in either case it is the function of the switch to maintain the starting circuit closed until the motor reaches a sufficiently high speed to continue to run and carry the load as an ordinary single phase motor.

The effect of the condenser in the starting circuit is to shift the phase of the current in the starting circuit so that for all practical purposes the motor starts as a two phase motor with the starting torque and power factor characteristics of such motors. When the motor reaches full or nearly full speed the starting circuit is automatically disconnected and the motor continues to operate as a single phase motor.

As mentioned above condenser-start type motors are frequently referred to as split-phase motors, since the effect of the condenser is to take the single phase current and to split it into two currents 90 degrees apart. If the current in the running main phase is I_1 and the current in the starting phase is I_2 then the phase relation of these two currents and the line voltage at the moment power is thrown on the motor is as shown in Fig. 2. The phase angles of the two currents are of course merely representative of the general relation existing between these two currents and the voltage.

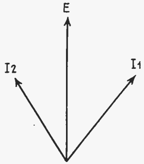

FIG. 2

The important point to be noted is that in the case of the condenser start type motor as shown in Fig. 2 the two currents are essentially 90 degrees out of phase with each other and this results in giving the motor the starting characteristics of a two phase motor.

Since the condenser is in the circuit only during the starting period which is usually a couple of seconds it is customary to rate electrolytic starting condensers in terms of the number of starts per hour. Accordingly starting condensers are normally rated for service where the number of starts per hour does not exceed twenty and each start has a duration of not more than three seconds. Under such conditions of service electrolytic starting condensers have been found to perform extremely satisfactorily on tests equivalent to many millions of start-stops of a motor.

Electrolytic starting condensers can be tested by connecting them directly across an a.c. line and measuring the current; this will determine the capacity of the condenser. If the frequency of the supply is sixty cycles the current will be equal to

$$I = \frac{.377\ CE}{1000}$$

where C is the capacity in microfarads and E is the voltage.

By transposition, the capacity in microfarads is therefore equal to

$$C = \frac{1000\ I}{.377\ C}$$

If the power factor of the condenser is also to be measured it is necessary to connect to the circuit a watt meter to read the wattage loss. Since the currents involved are usually in the order of 6 amperes and the power factor is in the order of five percent, the watt meter must be able to read in the order of 25 or 50 watts. Of course, the watt meter must also be able to handle without excess heating about 6 amperes of current.

Some users of these condensers rate them in terms of a current they pass, and the accompanying chart shows the relation between the current and the capacity of the condenser. Therefore, if a condenser is required which will pass say 5 amperes at 110 volts, the capacity can be determined from this chart and will be found to be 121 microfarads for this particular case.

The chart given on Page 3 shows graphically the relation between the capacity, the wattage loss corresponding to 10% power factor, and the current in amperes. The several curves indicate these various values at 100 volts, 110 volts, 150 volts and 220 volts 60 cycles. The curves are plotted on a basis of 10% power factor since this is the minimum guaranteed power factor, although, in general, a starting condenser will have a power factor in the order of 5%. Obviously if a testing circuit is set up and the wattage of the condenser is say 25, and the wattage for 10% power factor is 50 then the condenser has a power factor of ½ of 10% of 5%. In other words, it is simply necessary to determine the 10% wattage from the curve, and the actual wattage, and then the actual power factor bears the same relation to 10% as does the actual wattage to the wattage read from the curve.

This chart also indicates the essential circuit diagram for such a test set up. As indicated, the required units are a tapped transformer, ammeter, wattmeter and voltmeter.