when the discharge through the voltmeter is a minimum. This discharge can be held to a minimum by the use of a large capacity and a very high resistance voltmeter. The amount by which the voltage will fall during the discharge period is equal to

$$\frac{IT}{C}$$

where I is essentially constant and can be considered to be equal to the voltmeter reading divided by its resistance, T is the time of discharge and is almost a complete cycle or 1/120 of a second and C is the capacity in farads. By making I very small (i.e., using a very high resistance voltmeter) and C, very large the discharge can be held to a matter of but a couple of volts, which is negligible since we are usually measuring peak voltages in the order of 400 or 500 volts. If necessary the voltage measured might be corrected by the use of the above equation. This type of peak reading voltmeter has been checked against measurements by the cathode ray tube and by the slide back voltmeter and has been found quite accurate.

A number of measurements of peak voltages under various conditions have been made using a voltmeter of this type. In this instance the rectifier was a type 281 tube, the condenser C had a capacity of 4 mfd. and a 1000 volt

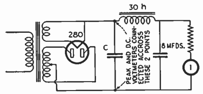

Fig. 5

rating and the voltmeter consisted of a 2 meghom wire wound resistance in series with a 500 microampere meter, giving an instrument which would read peaks up to 1000 volts.

The curves of Fig. 4 gives the results of these measurements and indicate the peak and d.c. voltages impressed across the first filter condenser with various transformer voltages and with condenser capacities of either 4 or 8 mfds. The circuit of the filter used in making these measurements is given in diagram, Fig. 5.

While actual measurement of peak voltage is always desirable the curves of Fig. 4 will enable the engineer and experimenter to determine quite accurately what peak voltages will be encountered using a particular size of filter condenser and any particular transformer voltage. While the curves only indicate the values for transformer voltages of 350 to 450 volts per anode, peak voltages obtained with transformer voltages between these values given in the curves can be obtained by simple proportion.

The number of requests to our engineering department for information on the peak voltages obtained under various conditions make us feel that these curves and the above suggestions on methods of measuring peak voltages would prove valuable to engineers. If the condensers in a radio receiver are to give satisfactory performance it is absolutely essential that they be subjected to peak voltages not in excess of their rating and it is of course desirable that the receiver be designed so that the peak voltages are normally somewhat lower than the peak rating of the condenser.

Complete Bound Volumes and Binders for The Research Worker

To those of our readers who are interested in obtaining previous issues of The Aerovox Research Worker, we have available a special loose-leaf binder containing all back numbers which in this way can be preserved for convenient reference purposes.

We have at present a limited quantity of complete issues consisting of thirty-two numbers of the Research Worker, from April 1928 to June 1931 contained in a handsome two-toned gold stamped morocco finished binder which are available for $2.50 per copy.

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Aerovox Patent Granted on Electrolyte Used in Hi-Farad Condensers

The Aerovox Wireless Corporation takes pleasure in announcing that it has been granted Patent No. 1,815,768, dated July 21, 1931 covering the special electrolyte employed in the manufacture of Hi-Farad Dry Electrolytic Condensers.

Hi-Farad Dry Electrolytic Condensers are manufactured in accordance with both this new patent and Patent No. 1,789,949 which covers the mechanical and electrical construction of these units, as well as other patents which are pending.

The features of Aerovox Hi-Farad Condensers are thoroughly protected by all claims allowed in the forementioned patents.

Aerovox Condensers for The Stenode Receiver

Another indication of the extensive popularity and dependable merit of Aerovox products is evidenced by the fact that Aerovox condensers are recommended for use in the Stenode receiver. Hi-Farad DRY Electrolytic Condensers used in the filter circuit of the power unit of this set provide maximum filtering efficiency, safe and stable operation at low cost. Aerovox non-inductive bypass and filter condensers give effective and dependable operation throughout the various circuits of the tuner unit.

Complete data and directions for building the stenode receiver is given in two books and nine full size working diagrams obtainable at the reduced price of $5.00 from the Stenode Corporation, Hempstead Gardens, L. I., N. Y.

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The Aerovox Research Worker

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A Simple Method of Measuring Condenser Capacity

By the Engineering Department, Aerovox Wireless Corporation

THE service man and radio experimenter frequently find it necessary to measure the capacity of a fixed condenser. For such work extreme accuracy is not necessary, but what is required is a method that is simple, of fair accuracy and which does not necessitate the use of many meters.

One of the commonest methods used to check condenser capacities is to connect the condenser in series with an a.c. milliameter across the 110 volt, 60 cycle line as shown in Fig. 1. Since the current is equal to the line voltage divided by the reactance of the condenser, it is possible, if we know the line voltage and the current, to calculate the capacity. The formula usually given when this method is used is

$$C = \frac{I \times 1000}{6.28\, f\, E}$$

where C is the capacity in microfarads
- I is the current in milliamperes
- f is the frequency of the supply current (25, 40 or 60 cycles)
- E is the line voltage

Since the ordinary a.c. milliameter has an effective range over which readings can accurately be made of about 5 to 1, it follows that to make it possible to measure all sizes of paper condensers which are ordinarily encountered, a number of meters are required. This is of course a disadvantage, especially as a.c. milliammeters do not form a common part of the usual equipment of the home laboratory or service shop.

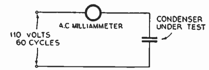

Fig. 1

Another method used for measuring capacities consists as shown in Fig. 2 of connecting and a.c. volmeter in series with the condenser under test across the a.c. line. The usual procedure when using this method is first to measure the line voltage with the voltmeter alone and then to connect the voltmeter in series with the condenser and again note the voltmeter reading. If the resistance of the voltmeter is known, its capacity can then be calculated from the following formula:

$$C = \frac{10^6}{6.28 f R \sqrt{\left(\frac{E_L}{E_V}\right)^2 - 1}}$$

where C is the capacity in microfarads
- f is the frequency
- R is the voltmeter resistance
- E_L is the line voltage
- E_V is the voltmeter reading when it is connected in series with the condenser.

If this voltmeter method is to be used it will be found necessary to use several voltmeters or a low reading voltmeter with several multiplying resistances. This is due to the fact that accurate indications will only be obtained when the reactance of the condenser being tested is reasonably large in comparison with the resistance of the voltmeter. For this reason the ordinary 150 volt a.c. voltmeter, such as is commonly used to check line voltages and which has a total resistance of about 15,000 ohms, cannot be used to measure large fixed condensers since their reactance is so small that a negligible change in voltage is produced when the condenser is connected in series with the voltmeter. For example the Weston Model 476 150 volt voltmeter when connected across the a.c. line read 117 volts. This same voltmeter when connected in series with a 2 mfd. condenser across the same line read 116 volts, a change of only 1 volt. Obviously, therefore, this voltmeter could not be used to measure condenser capacities in the order of 1 or 2 microfarads or larger.

However, by a somewhat different method we can make use of such a voltmeter to measure all sizes of paper condensers commonly used in radio receivers. A voltmeter of this type is usually an essential part of every service kit.

As indicated previously, this voltmeter cannot be used directly due to the fact that its high resistance makes it impossible to obtain accurate indications when testing condenser capacities of 1 mfd. or more. We can get around this difficulty by shunting the meter so as to lower its effective resistance. When we speak of shunting the meter, the reader probably thinks of a resistance connected across the meter terminals, but for certain reasons a resistance shunt does not prove the best type in this case. Since capacity is being measured it is

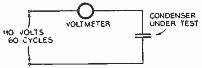

Fig. 2

much better to shunt the meter with a condenser. Not only does this make the unit more or less "direct reading" but it also simplifies the calculation of the capacity from the voltmeter readings.

Fig. 3 gives the circuit arrangement which makes it possible to use the ordinary a.c. voltmeter to measure condenser capacities from about 0.1 mfd. up to about 8 mfd. using just the single voltmeter in conjunction with a couple of shunting condensers. Not only does this unit indicate capacity but it also gives direct indication of short circuits and open circuits. The following units are required for the construction of this condenser testing instrument.

- C1—one type 307 0.5 mfd. Aerovox condenser
- C2—one type 307 2.0 mfd. Aerovox condenser
- Sw—single pole, single throw switch
- V—0-150 a.c. voltmeter
- Necessary binding posts, wire, etc.

It will be worth while to explain how this unit makes it possible to measure a wide range of capacity. In the first place it will be noted that the smallest capacity connected across the voltmeter is 0.5. mfd. obtained when the switch is open. A condenser of this capacity has a reactance at 60 cycles of approximately 5000 ohms, whereas the voltmeter has a resistance of approximately 16,000 ohms. Due to the fact that the currents through the condenser and the voltmeter are 90 degrees out of phase, the impedance of the circuit differs by but a small value from the impedance of the condenser alone. On the other hand if a resistance shunt were used in place of a condenser shunt the effective resistance of the 5000 ohm shunt in parallel with the 15000 ohm meter would be about 3700 ohms. As will be indicated later the use of a condenser shunt, which results in a much smaller change in impedance, simplifies the calculation of condenser capacity.

If two condensers are connected in series across the a.c. line the voltage divides in direct proportion to the reactances of the two condensers. Since condenser reactance is inversely proportional to capacity (the larger capacity the smaller the reactance) we can also say that the voltage divides in inverse proportion to the condenser capacities. For example if one 2 mfd. condenser and one 1 mfd. condenser are connected in series across a 100-volt line, then there will be one third of the total voltage or 33⅓ volts across the 2 mfd. condenser and two thirds of the voltage or 66⅔ volts across the 1 mfd. condenser. Therefore, the formula of the division of voltage is

$$\frac{C_1}{C_2} = \frac{E_2}{E_1}$$

and solving for C2 we have

$$C_2 = \frac{C_1 E_1}{E_2}$$

It can be seen from this formula that if we know the capacity of one condenser and the voltages across the two condensers that we can calculate very simply the capacity of the other condenser. We really don't have to measure the voltage across both condensers. If we measure the line voltage and the voltage across one of the condensers and subtract these two values we will obtain the voltage across the other condenser. As an illustration in the above example the line voltage was 100 and the voltage across the 2 mfd. condenser was 33⅓. By subtracting these two we obtain 66⅔ volts which was the voltage across the other condenser.

In the circuit of Fig. 3 we have a case of this sort. The two condensers in series are the condenser under test and the condenser shunting the voltmeter. The voltmeter reads the voltage across the shunting condenser and by short circuiting the two test terminals we can read the line voltage. Therefore, to measure capacity using this circuit we simply have to connect the two input terminals to the 110 volt line, short circuit the two test terminals and read the line voltage, then connect the condenser to be measured across the test terminals and again note the voltage. The capacity of the unknown capacity is then equal to

$$C_x = \frac{E_s \times C_s}{E_L - E_s}$$

where C_x is the capacity of the condenser being tested

C_s is the capacity of the condenser shunting the voltmeter

E_L is the line voltage

E_s is the voltage with the condenser under test connected to the test terminals.

With the switch open C_s consists only of C_1 and therefore has a capacity of 0.5 mfd. With the switch closed C_1 and C_2 are in parallel and therefore C_s has a value of 2.5 mfd. With the switch open the unit can be used to measure condenser capacities from 0.1 up to about 2.0 mfd. With the switch closed the range extends from about 0.5 mfd. to approximately 8 mfd. The range from 0.1 to 8 mfd. includes most of the condenser sizes ordinarily used in radio receivers. The unit shown schematically in Fig. 3 and described above gives, therefore, a simple method of measuring condenser capacity and requires the use of only a single meter of a type commonly found in most laboratories.

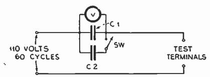

Fig. 3

Peak Voltages in Filter Circuits

Part 1

IN the design of filter circuits a most important consideration is the peak voltage across the condenser connected across the output of the rectifier. It is this condenser which is subjected to the highest direct current voltage and the highest ripple voltage. The d.c.

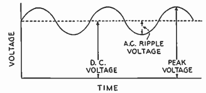

Fig. 1

voltage added to the peak value of the ripple voltage gives, as indicated in Fig. 1, the peak voltage to which the first condenser is subjected. Obviously the first condenser must have a voltage rating equal to and preferably somewhat in excess of the peak voltage to which it will be subjected in normal operation.

The peak voltages across the first condenser can be measured in a number of ways. One of the simplest is to connect a cathode ray tube across the first condenser and by measurement of the deflection of the electronic stream determine the peak voltage. While this method is simple and accurate it has the disadvantage that cathode ray tubes are not always available. A simpler method and one commonly used is to connect up a slide back voltmeter as shown in Fig. 2. By adjustment of the C bias by means of a potentiometer the grid voltage may be adjusted to that point which just cuts off plate current. Then by multiplying the grid voltage by the mu of the tube the peak voltage in the plate circuit can be determined. A precaution in using this method is that the mu of the tube at the cutoff point should be determined since it may somewhat different than the normal mu of the tube as measured on a tube bridge.

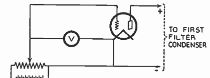

Fig. 2

A third method (described in detail in the April 1928 issue of the Research Worker) makes use of a direct reading peak voltmeter which directly indicates the peak voltage across the first condenser. The circuit of the peak voltmeter is given in Fig. 3. As will be noted this direct reading voltmeter makes use of a rectifier V in conjunction with a large fixed condenser C and a d.c. voltmeter E. If the plate of the rectifier (terminal 1) is connected to the high side of the filter circuit and terminal 2 to the low side of the filter circuit, the voltage across the filter circuit will cause a current to flow through the rectifier. Due, however, to the fact that the circuit will conduct the current in only one direction the condenser finally becomes charged to the peak value of the voltage connected across the two terminals. If no voltmeter were connected across the condenser it would remain permanently charged to the value of the peak voltage, but the voltmeter causes a slight discharge during those portions of the cycle when the voltage is less than the peak value. Obviously the meter will give most accurate indications

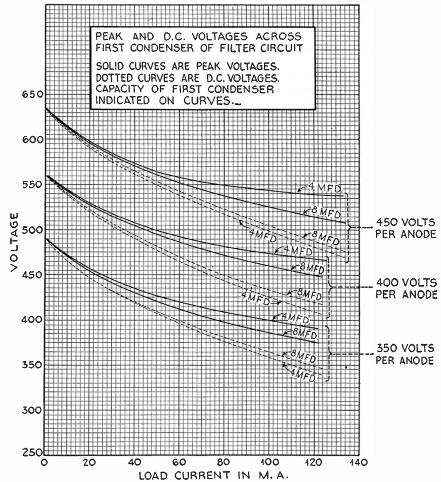

Fig. 4

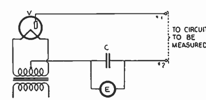

Fig. 3