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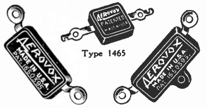
The three new midget mica condensers illustrated herewith find many applications for use in apparatus where units of lower capacities and voltage ratings of very small physical dimensions are desirable.



Type 1465

Type 1462 Type 1463

Types 1462 and 1463 condensers will stand a retest voltage of 600 volts d.c. in capacities up to .003 mfd. In capacities above .003 mfd. and up to .006 mfd. they are rated at 500 d.c. retest voltage and 250 d.c. working voltage.

Type 1465 extra small units are available in capacities up to .0005 mfds. and are rated at 500 d.c. retest voltage and 250 d.c. working voltage.

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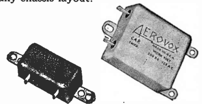

Type 260 Type 261

Condensers of this type are available in a variety of single capacities, and combinations with additional terminal lugs either on the side or top of the containers.

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The AEROVOX Research Worker

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Vol. 4 June 1931 No. 5

Measuring the Power Factor of Electrolytic Condensers

By the Engineering Department, Aerovox Wireless Corporation

IN the measurement of the power factor and capacity of electrolytic condensers certain precautions are necessary. The measurement of the capacity and power factor of a paper condenser is readily accomplished using an ordinary capacity bridge. On the bridge we actually determine the capacity and equivalent series resistances and from these values the power factor can be calculated.

In the case of electrolytic condensers we find that the power factor changes with frequency due to variations with frequency of the capacity and equivalent series resistance. Also the electrolytic condenser is designed for use only with pulsating d.c. and a polarizing voltage is therefore required to maintain the proper polarity of voltage across the condenser. This necessitates that the ordinary capacity bridge circuit be slightly altered for the testing of electrolytic condensers.

In the first place, since capacity and power factor vary with frequency, it is necessary that the condenser be measured at the frequency at which it is to be operated; in the case of filter circuits using full-wave rectification the source of tone for the bridge must be 120 cycles (assuming the condenser is to be used in a receiver designed for operation from 60 cycle supply). This immediately raises some difficulty. When a bridge is balanced at 1000 cycles, a frequency to which the ear is very sensitive, it is possible to balance quite accurately though the source of tone contains a comparatively large amount of harmonic voltage. At 120 cycles, however, even a small amount of harmonic voltage may have a disastrous effect on the accuracy of the balance. Experiments carried on in our laboratory have indicated that the presence of harmonics may cause an apparent balance to be obtained at settings which give a power factor differing by as much as 50 per cent from the true value; this applies, of course, when balancing is done by means of telephones. By the use of some type of indicating instrument in place of the telephones a more accurate balance can be obtained, but the presence of harmonics still prevents one from obtaining a really accurate null indication. The solution is obvious—a low pass filter circuit must be used between the oscillator and the bridge. The filter can be designed to pass 120 cycles and suppress all higher frequencies.

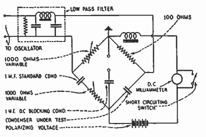

Fig. 1

To permit the application of a polarizing voltage to the condenser while it is being tested in the bridge various circuit arrangements are possible. Two of the more generally used circuits are shown in Figs. 1 and 2. Of the two, the arrangement of Fig. 1 is probably preferable since the choke, through which the d.c. voltage is supplied, is directly across the bridge and therefore has no effect on the balance. In the case of the circuit of Fig. 2 the choke does not affect the bridge balance only if the choke has a reactance very much greater than the condenser reactance. In the case of Fig. 1 a 30 henry choke is sufficient; when placed directly across the condenser as in Fig. 2 an inductance of 500 to 1000 henries is desirable.

The low pass filter should be designed to have a characteristic impedance approximately equal to the impedance of the bridge; in most cases the bridge impedance will be in the range from 100 to 500 ohms and the filter can therefore be designed to work into about 200 ohms. The proper values of inductance and capacity for use in the filter can be found as follows:

$$C = \frac{0.159}{fZ}$$

$$L = \frac{0.318Z}{f}$$

where Z is the impedance into and

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out of which the filter must work (for this work about 200 ohms is a good value.

f is the cut-off frequency in cycles per second
C is the capacity in farads at each end of the filter
L is the inductance of the choke in henries

When the bridge has been balanced the capacity and equivalent series resistance of the condenser under test can be determined from the usual Wheatstone bridge formulas. A formula for power factor can be determined by considering the phase relations as shown in Fig. 3. The power factor is the in-phase component of the voltage divided by the total voltage.

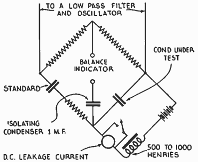

Fig. 2

$$\text{In-phase voltage} = E_r = IR$$

$$\text{Total voltage} = E_t = I\sqrt{R^2+\left(\frac{1}{\omega c}\right)^2}$$

therefore

$$\text{Power factor PF} = \frac{IR}{I\sqrt{R^2+\left(\frac{1}{\omega c}\right)^2}}$$

$$= \frac{R}{\sqrt{\frac{(R\omega c)^2+1}{(\omega c)^2}}}$$

$$= \frac{R\omega c}{\sqrt{(R\omega c)^2+1}}$$

This formula is true under all conditions. Where the power factor is very low this formula can be simplified by remembering that, for small angles, the sines of ϕ are practically the same as the tangents of ϕ. Therefore for low power factors we can say:

$$\text{Power factor} = R\omega c$$

This formula is satisfactory for determining power factors up to about 10 per cent; for larger power factors the accurate formula, equation (5), should be used. In all these formulas R is the equivalent series resistance, C is the capacity in farads and ω is 6.28 times the frequency.

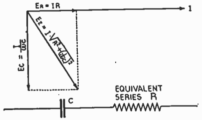

Fig. 3

A number of circuits have also been suggested for the rapid checking of the capacity of an electrolytic condenser. One of the commonest is shown in Fig. 4. The condenser under test is connected in series with a fixed paper condenser across the secondary of a step down transformer; polarizing voltage is applied as shown. The fixed paper condenser serves to prevent short circuiting the d.c. voltage through the secondary of the transformer. The readings of the a.c. milliammeter can be plotted in terms of the capacity of the condenser under test (provided the a.c. voltage is kept constant) and the d.c. leakage current can be read on the d.c. milliammeter. The impedance of the circuit in terms of the two capacities and the power factor of the electrolytic condenser is

$$Z = \frac{1}{\omega}\sqrt{\frac{PF^2}{C_e^2}+\left(\frac{C_s+C_e}{C_s\,C_e}\right)^2}$$

so that the meter readings are really a function of both the capacity and resistance of the condenser under test. But since the total impedance varies but slightly with power factor this circuit does afford a reasonably accurate check on capacity and an accurate check on d.c. leakage. It is of course intended primarily for production testing of many condensers.

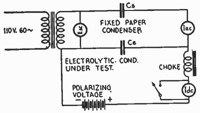

Fig. 4

A Simple Dynatron Oscillator

Whether one has a small or large radio laboratory, there is always need of a radio frequency oscillator for use in making various tests on radio circuits and receivers. Such oscillators are of course an essential part of a service man's equipment. Most r.f. oscillators use an ordinary three element tube in connection with some type of feedback circuit to make the tube oscillate. While such oscillators are quite satisfactory the frequency generated is somewhat critical with respect to plate voltage which sometimes makes it difficult to calibrate the oscillator and have it hold its calibration. An r.f. oscillator somewhat simpler in general construction and which will maintain its calibration quite accurately can be built using the dynatron circuit. The dynatron oscillator uses a screen grid tube operated at such voltages that oscillations are produced if a tuned circuit is connected in series with the plate. Whereas, oscillators using three element tubes require coils in both the plate and grid circuits to make them oscillate, the dynatron requires only a single coil, which, of course, simplifies the circuit and also makes it easier to use a plug-in coil arrangement.

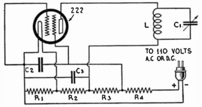

Fig. 1

The circuit of Fig. 1 shows a dynatron oscillator arranged to operate directly from the 110 volt line; the voltage may be either a.c. or d.c. In the case of d.c. voltages the polarity must be as indicated on the diagram. The necessary potentials for the filament, screen grid and plate (it will be noted in this circuit that the control grid is tied directly to the filament) are obtained by means of four resistors connected in series across the 110 volt line. Resistance R4 serves to reduce the voltage to about 60 volts for application to the screen grid. R3 further reduces the voltage for the plate circuit. The remaining two resistors function to apply to about 3.3 volts to the filament of the tube. It is of course necessary that the screen and plate circuits be bypassed to the filament and this is done by condensers C2 and C3. The following parts can be used in the construction of the oscillator.

R1—Aerovox type 992
1000-ohm resistor

R2—Aerovox type 992
150-ohm resistor

R3—Aerovox type 992
300-ohm resistor

R4—Aerovox type 992
50-ohm resistor

C2 & C3—Aerovox type 207
1-mfd. bypass condenser

If the oscillator is to cover the broadcast band then L and C1 can be any ordinary coil and condenser designed for use in a broadcast receiver. An old radio frequency transformer can be used with the primary removed.

When the oscillator is to be used for working on superheterodyne receivers, L can be replaced by a honeycomb coil that will tune to the desired frequency with the condenser C1. The oscillator can even be used to generate audio frequencies by connecting the primary of an audio transformer in the plate circuit of the tube.

By arranging the oscillator to use plug-in coils it will therefore be possible to cover any desired frequency range simply and quickly. If good coils are used the frequency generated by the oscillator will be found to be unusually stable.

The experimenter may find it necessary to try several tubes in the circuit in order to obtain one that will oscillate properly. Whether or not the tube oscillates will depend upon the value of the negative resistance and some screen grid tubes will be found to have a higher negative resistance than others and therefore prove to be poorer oscillators in the dynatron circuit.

Further Data on the Pentode and a Correction

Last month we gave some information on the problems of obtaining bias from pentode tubes, showing that due to the high sensitivity of the tube it is usually desirable that the bias be obtained from a drop across a resistor or choke in the filter circuit rather than from a resistor connected in the center tap to the filament. We also indicated that it is usually desirable that the loud speaker coupling transformer have an impedance ratio (impedance ratio is equal to the square of the turns ratio) such that the loud speaker looks like about 6000 or 8000 ohms at a frequency slightly above that at which the loud speaker resonates.

In determining the resonant period, the loud speaker should be mounted in the baffle or cabinet with which it will finally be used. If the loud speaker is then supplied with constant voltage at various frequencies and the voltage across the moving coil is measured, a curve similar in shape to that shown in Fig. 1 will be obtained. The rise at the low frequency end is the resonant point to which we have reference, and the x on the curve indicates the frequency at which the impedance should be determined and this value of impedance should be used in calculating the ratio of the coupling transformer. The curve will vary depending upon the size and shape of the baffle and it is for this reason that these measurements must be made with the speaker mounted in its baffle. The voltage across the moving coil can of course be measured by means of a vacuum tube voltmeter. Actual voltage measurements are not essential however, since the same results will be obtained by plotting frequency against the readings of the meter in the vacuum tube voltmeter circuit; due to the square law characteristic of the voltmeter, the resonant peak will be unduly emphasized, but since it is only "x" this is no disadvantage.

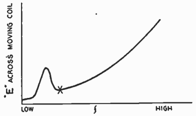

Fig. 1

In the use of the pentode there is another point which should be given attention, i.e., the actual potentials on the plate and high voltage screen under operating conditions. If both elements are supplied from the same point on the B supply system the plate potential will be somewhat lower than the screen potential due to the IR drop in the primary of the loud speaker coupling transformer. However, in a well designed transformer, the voltage drop in the primary circuit is not large enough to have an appreciable effect on the power output, and therefore it will not be necessary to make any compensations in order to maintain the same voltage on the screen as on the plate.

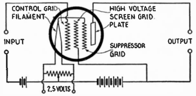

Fig. 2

Where the impedance is high in circuits employing a B supply from other than a battery source, a high capacity condenser of the proper value should be connected between the screen grid and filament, as it is desirable to keep the impedance as low as possible.

In Fig. 2 we give a diagram of the elements within the pentode, since the diagram shown in last month's (May) issue was incorrect. The high voltage screen is actually between the control grid and the suppressor grid instead of between the filament and the control grid. The element referred to as the "cathode grid" is more popularly termed the "suppressor grid." The change in the arrangement of the elements, however, does not invalidate the technical data given in the text of last month's article.