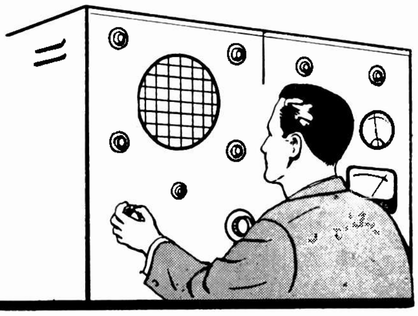
AEROVOX RESEARCH WORKER



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Basic Measurement of Capacitance

Part 2

By the Engineering Department, Aerovox Corporation

MEASUREMENT METHODS

Figures 4 to 7 show several methods of measurement. In each method, the capacitor (C) under test is charged from a constant d-c voltage source (E) and then discharged through a noninductive resistor (R). The value of the resistance will depend upon the capacitance C. It should not be too high but must be high enough to give a readily-measurable time constant, t . Also it must be high enough so that the time for the current to reach a peak is small compared to the total time. In each method, t is measured between the instant of maximum voltage (E_m) across R and the instant at which E is 37% of E_m. (See Figure 3B). The unknown capacitance then may be calculated with the aid of Equation (5), (6), or (7).

METHOD. 1. MANUAL STOP WATCH.

Although it is not always possible, or even advisable, to measure t with a manual stop watch, this is permissible in the absence of other equipment when the capacitance is very large. For example, if the capacitance is 2000 μfd and a 1000-ohm resistor is used in the test, the time constant (from Equation 4) is 2 seconds, an interval which is long enough to be measured with fair accuracy with a stop watch.

Figure 4 shows the circuit. The pushbutton switch, S, is normally closed to the top contact. This connects the capacitor to the d-c source, and C charges to voltage E. When the switch is depressed, the operator releases the stop watch at the same time and the capacitor discharges through the resistor, R. The resulting voltage drop across this resistor deflects the d-c vacuum-tube voltmeter. The latter must have a very high input resistance (at least 1000 times the resistance of R) to prevent error. Switch S is held down until the voltmeter deflection decreases to 0.37 of its initial value. At this point, the watch is stopped and the value of t read from its dial.

The most significant source of error in this method lies in the reflexes of the operator, since the watch must be stopped at the exact instance the voltage falls to $0.37E_m$.

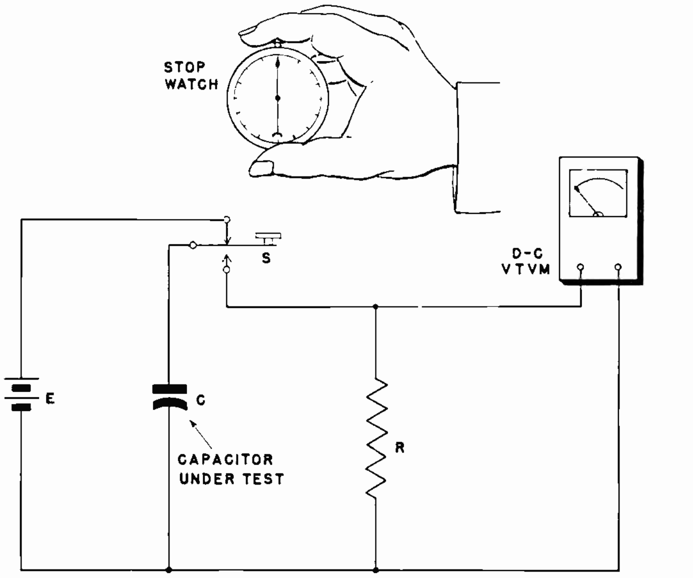
METHOD 2. ELECTRIC STOP WATCH.

In Figure 5, an electric stop watch is used. This may be a standard electric clocks — time-interval readings being taken with the sweep seconds hand. Initially, the seconds hand is set to zero (12 o'clock on the dial).

The 2-pole pushbutton switch, S_1-S_2, is normally closed against its upper contacts. This disconnects the clock from the a-c line and connects the capacitor (C) to the steady d-c voltage source (E). The capacitor accordingly charges to voltage E. When the switch is depressed, the capacitor discharges through the resistor (R), the v-t voltmeter is deflected, and the clock starts running. The switch is held down until the deflection falls to 0.37E. It is at this instant that the pushbutton is released to stop the clock with the seconds hand halted at the instantaneous time, t.

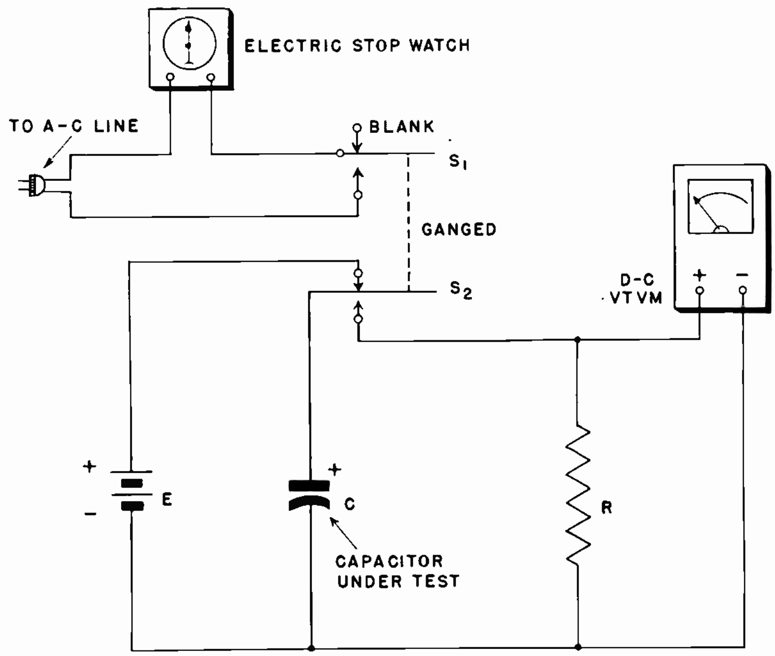
METHOD 3. RECORDER OR OSCILLIGRAPH.

A 2-channel recorder or oscillograph is required for this method. (See Figure 6A). The voltage drop across Resistor R due to the capacitor discharge current is applied to one channel, and a timing wave to the other. This gives a simultaneous recording similar to Figure 6(B). The time interval between E_m and 0.37_m may be determined by counting the timing wave peaks between these two voltage points and calculating t = n (1/f); where n is the number of peaks (Figure 6C), and f the frequency (cycles per second) of the timing wave. The time is given in seconds. If the voltage points line up with other parts of the cycles than the peaks, the measurement along the wave is made on the basis that the time of a complete cycle is 1/f. (The time of a fractional cycle is x/f, where x is the fraction.) The frequency of the timing wave must be chosen for the highest number of easily-counted cycles between the E_m and 0.37_m points. Some oscillographs, like pen-type recorders, are of the direct-inking type and deliver paper charts. Others require photographic recording.



METHOD 1

FIG. 4



METHOD 2

FIG. 5

Figure 6(A) shows the circuit. The d-c amplifier must have high input resistance. This amplifier is needed to transform the low impedance of the galvanometer element in the recorder or oscillograph. If this element were connected directly across Resistor R, it would introduce considerable loading error. In making the test, Switch S first is closed. This charges Capacitor C to voltage E and deflects the oscillograph to E_m. Next, the switch is opened. The capacitor then discharges through the resistor, and the voltage drop across R decreases in accordance with the decay of discharge current. Finally, the record is taken from the oscillograph, and voltage and time measurements made along its vertical and horizontal axes, respectively.

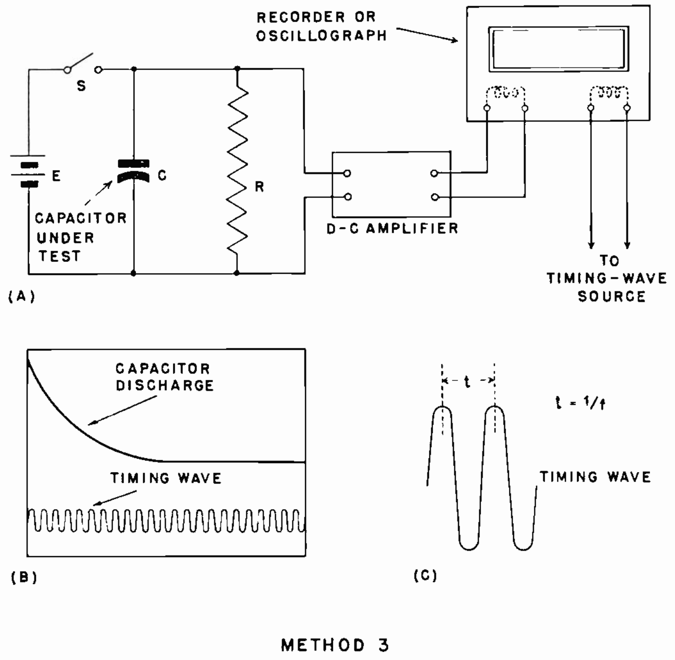


FIG. 6

METHOD 4. CALIBRATED OSCILLOSCOPE.

In this method (Fig. 7) the oscilloscope must have a horizontal axis calibrated for direct readings in seconds or milliseconds. It must also have a triggered single sweep. For best accuracy, the image should be photographed from the oscilloscope screen. The pulser delivers one pulse to trigger the single sweep of the oscilloscope each time the switch section S_1 is closed. (In some oscilloscopes, the single sweep is triggered automatically by the signal under observation, and the separate pulser is not required.)

Initially, Switch S_1-S_2 is thrown to Position 1. This charges the capacitor (C) to voltage E. Next, S_1-S_2 is thrown to Position 2. This discharges the capacitor through Resistor R, deflects the oscilloscope beam vertically, and triggers a single horizontal sweep. During the sweep across the screen, the vertical signal voltage decreases in accordance with the decay of discharge current through R. Finally, linear measurements are made vertically and horizontally on the photographed record to determine the voltage and time values.

Whereas the horizontal axis of the screen must be calibrated in time units, the vertical axis need not be voltage-calibrated, since ordinary linear measurements on the photograph will give the E_m and $0.37E_m$ points without reference to absolute voltage.

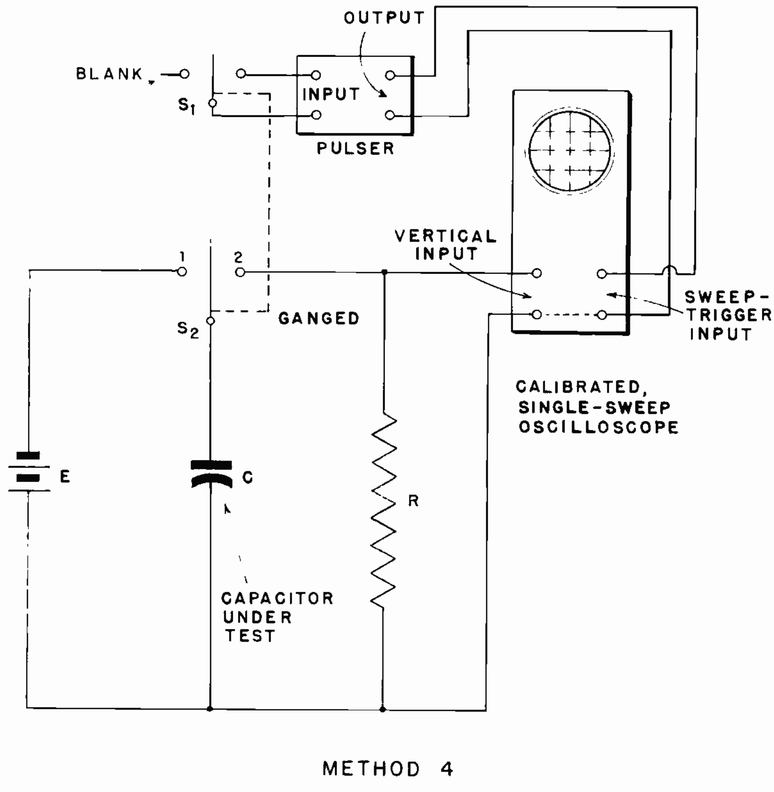


FIG. 7

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'BI-ELECTRIC'

MYLAR* PAPER BYPASS CAPACITORS

Now...2 famous dielectrics...quality kraft tissue and performance-proved mylar film...are combined to bring you a superior bypass capacitor. Aerovox "BI-ELECTRIC" units feature Aerolene impregnant and unique Polycap plastic case that is the next best thing to a metal can for humidity resistance.

The advanced construction techniques presented in "BI-ELECTRIC" capacitors offer distinct advantages over other radial lead types on the market today. The exclusive Polycap case provides a solid uniform covering that does not depend on dipped coatings that vary in thickness from end-to-end...and from capacitor to capacitor. Controlled end-fills provide sealed protection where it is needed most. Leads cannot crack end-fill... compare this with conventional dipped units. Standard capacitance tolerance on all "BI-ELECTRIC" units is ±10% making them the precision buy in a bypass capacitor.

Aerovox offers you the widest selection of bypass tubular types in the industry...molded...plastic-cased...ceramic-cased, choose the type that best suits your requirements.

TECHNICAL SPECIFICATIONS

TEMPERATURE RANGE: —30°C to +100°C

POWER FACTOR AT 25°C: will not exceed 1%

HUMIDITY TEST: meet all EIA specifications with test duration extended from 100 to 500 hours

LIFE TEST: 150% of rated voltage at 100°C for 250 hours

STANDARD TOLERANCE: ±10%

*DuPont trademark

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