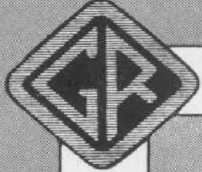


General Radio EXPERIMENTER

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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

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AN IMPROVED MEASURING CIRCUIT FOR THE SUSCEPTANCE VARIATION METHOD

● AN APPARATUS AND METHOD for measuring dielectric samples at frequencies up to 100 Mc by the susceptance variation method were described in the *Experimenter* about a year ago.* With the special holder used at that time, the two resonance voltage readings were taken at the same setting of

the standard condenser, thus eliminating the corrections that are necessary for the change in conductance of the standard condenser when the resonance readings occur at two different settings. The capacitance measurement, however, was made by changing the standard condenser, necessitating correction for the error in capacitance caused by the inductance of the condenser.

This latter correction is eliminated in an apparatus, shown in Figures 1 and 2, which was recently built for a large chemical company. In this arrangement, both resonance settings and the two settings on the sides of the resonance curve are made by means of a mi-

FIGURE 1. Panel view of the TYPE 755-AS1 Susceptance Variation Circuit.



*D. B. Sinclair, "Impedance Measurements at High Frequencies with Standard Parts," *General Radio Experimenter*, Volume XIV, No. 4, September, 1939.

chrometer drive on one of the electrodes between which the sample is clamped. This arrangement is shown clearly in Figure 2. The movable electrode is the grounded one of the pair, and its motion is measured by the dial that can be seen projecting above the panel. The electrodes are mounted above the TYPE 755-A Condenser. The massive blocks that support the electrodes serve as leads from the condenser and have a negligible inductance. The electrode faces are one inch in diameter. The screw that drives the movable electrode is $\frac{3}{4}$ inch in diameter and has 40 threads per inch. It is in contact with its nut for a length of $\frac{3}{4}$ inch, and no variation in contact resistance is noticeable, even at 130 Mc. The screw carries a 2-inch dial, calibrated to read directly in half ten-thousandths of an inch. A capacitance calibration is also supplied, which is accurate to $0.01 \mu\mu\text{f}$ or 0.25% up to $100 \mu\mu\text{f}$.

Referring to the rear view of the unit (Figure 2), the oscillator is plugged in at the left-hand terminals, and the tuning inductance at the next pair. The vacuum-tube voltmeter plugs in at the extreme right.† The binding posts just at the right of the electrodes are pro-

†TYPE 684-A Modulated Oscillator and TYPE 726-A Vacuum-Tube Voltmeter are recommended.

vided for connecting unknown impedances other than slabs of dielectric.‡ The two pairs of screws on the tops of the electrodes are provided for the same purpose. These make it possible to connect practically any kind of unknown, or to mount an additional special sample holder, if desired.

The precision-drive condenser is not necessary for measuring dielectric samples, since all capacitance readings are taken from the micrometer drive, but it provides a ready means of checking the calibration of the micrometer, which may change as a result of straining in use, and also permits condensers beyond the capacitance range of the micrometer electrode to be measured.

The procedure for measuring dielectric samples is as follows:

- (1) The sample is clamped between the electrodes and the circuit tuned to resonance by means of the precision condenser. The electrode dial reading d_r and the resonant voltage V_r are noted.
- (2) The sample is then removed, and the circuit restored to resonance by turning the electrodes together. The dial reading d'_r and the resonant voltage V'_r are observed.
- (3) The circuit is then detuned each

‡When the unknown is an inductance it must be shielded from the tuning inductance.

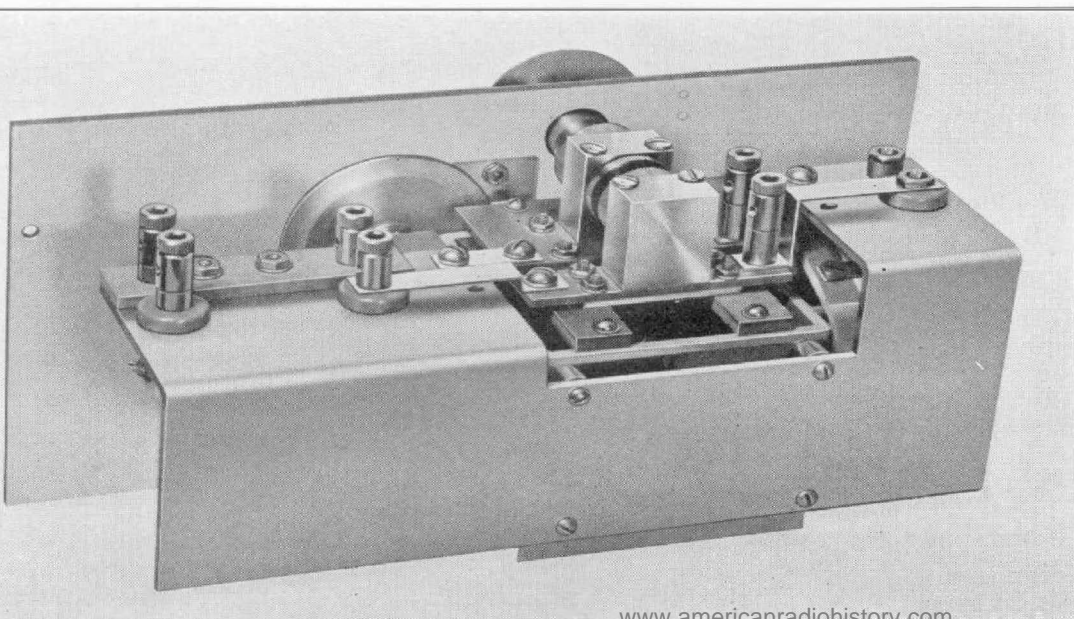


FIGURE 2. Rear view of the TYPE 755-A S1 Susceptance Variation Circuit, showing the micrometer condenser and the arrangement of terminals. The blocks that support the electrodes of the micro condenser are made massive to minimize inductance.

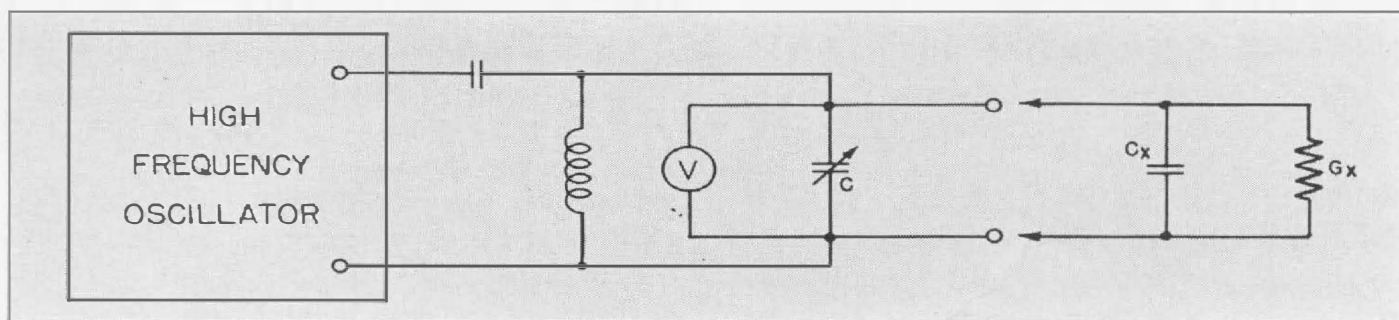


FIGURE 3. Circuit used in the TYPE 755-AS1 Susceptance Variation Circuit.

side of resonance to reduce the voltage to $0.707 V_r'$, and the corresponding dial readings d_1' and d_2' are noted.

- (4) From the calibration of the electrode dial, the equivalent capacitance values^{||} C_r , C_r' , C_1' , C_2' are determined.

The capacitance of the sample is determined by the expression

$$C = \Delta C_r + C_a$$

^{||}These are not, of course, total circuit capacitances, but merely the incremental capacitance values corresponding to the dial readings. They are used only to obtain differences.

where

$$\Delta C_r = C_r - C_r'$$

C_a = Air capacitance of sample[§]

The dielectric constant, K , is

$$K = \frac{\hat{C}}{C_a}$$

when the sample is the same size as the electrodes. Dissipation factor is calculated from the expression:

$$D_x = \frac{1}{2} \frac{\Delta C_r}{\hat{C}_x} \frac{\Delta V_r}{V_r'}$$

[§]This can be calculated from the dimensions of the electrodes: $C_a = .0885 \frac{A}{t}$, where C_a is in μf , and A and t are in centimeters.

— R. F. FIELD

MONITOR CRYSTALS FOR THE BROADCAST FREQUENCY RE-ALLOCATION

● **BROADCASTING STATIONS** whose frequencies will be changed under the re-allocation plan will need new crystals for their General Radio Frequency Monitors. Some months ago we offered to supply these at a special price of \$65 plus return of the old crystal, the offer being good until August 1, 1940. Because the date on which the re-alloca-

tion becomes effective has been extended into 1941, we are extending the time limit on this offer to March 29, 1941.

In order that a last-minute rush may be avoided, and in view of the present and prospective slowness of deliveries of raw materials, we recommend that orders be placed as early as possible.

NOTES ON THE CARE AND MAINTENANCE OF GENERAL RADIO INSTRUMENTS

● **PROPER CARE AND MAINTENANCE** are obviously necessary if optimum performance and long life are to be obtained from electrical and mechanical instruments, yet the experience of our Service Department with returned instruments indicates that most users of General Radio instruments do not follow a definite maintenance program. The fine degree of accuracy of many of our instruments is dependent in part upon the smooth operation of controls free from backlash, clean contacts, and the exclusion of dust and foreign matter.

A large part of the charge made for reconditioning instruments is for the labor of replacing parts that have not been properly cared for, cleaning contacts, lubricating moving parts, and removing foreign matter such as dust, grit, insects, bits of metal, salts from corrosion, and the like. Much of the inconvenience and expense of returning instruments for repair could be avoided if the user followed a program of periodic inspection and adjustment in his own laboratory. Of course, in many applications operating conditions are such that wear and corrosion are inevitable, but a definite maintenance program will help to minimize deterioration and failures. Although individual conditions of use will determine the details of any maintenance program, the following suggestions are offered to assist the user of General Radio equipment in any servicing he may choose to do.

Equipment used for production testing demands frequent servicing. An instrument operated occasionally may have to be serviced each time used be-

cause of the oxidation of contacts, switches, etc., presence of foreign matter, and possible moisture. Lack of lubrication and the presence of foreign matter on switches, contacts, bearings, controls, and mechanisms cause considerable difficulty even when an instrument is relatively new.

Instruments should be kept as clean as possible. A solution of half alcohol and half ether is recommended for switch and relay contacts, contact surfaces of wire-wound controls, slide wires, and mechanical contact surfaces of various types such as mouse-trap type attenuators, detent mechanisms, chain drives, gear trains, shafts, and bushings. To remove oxidation or corrosion, a fine abrasive such as crocus cloth may be used, but its use is limited to relatively large contact surfaces such as those on Variacs, attenuators, and relay contacts.

A very fine grade of sandpaper is recommended on certain types of contacts, although the residue must be removed with a fine brush for smooth operation. Fine sandpaper may be used on wire-wound controls, key switches, push switches, anti-capacity type switches, and multi-blade-contact rotary switches; also on contact buttons and relays.

Some assemblies, such as syncro-clocks, piezo-electric crystals, motors, and meters require special attention. Syncro-clocks should be carefully cleaned by one acquainted with fine mechanisms of this type. Quartz crystals should be returned to the factory. Electric motors demand the usual attention to commutator surfaces, brushes, and bearings.

Meters should not be cleaned except by one skilled in handling such fine work.

Proper lubrication is very important in the maintenance of precision instruments. Some bearing surfaces require a grease, while for others oil is best. When instruments are assembled at the factory, moving parts are lubricated with either "Lubriko,"* or a fine grade of clock oil, and the use of these lubricants is recommended in maintenance.

Lubriko has been selected because it is acid free and because it adheres to moving parts better than most lubricants. It is recommended for use on wire-wound controls, button contacts, attenuators, and the TYPE 200-B Variac. However, a very thin film should be applied, as a large quantity will cause foreign matter to collect.

For detent mechanisms, chain drives and gear trains, ball bearings, shafts, vernier drives, etc., a larger amount should be used. These moving parts require lubrication more frequently to prevent wear.

The use of a fine grade clock oil is recommended for slide wires, push-button switches, syncro-clocks, and condenser bearings. This type of lubricant should be applied in very small quantities. A thin film applied with the finger will suffice for a slide wire but this should be done frequently because of evaporation. The small gear on the shaft of the rotor of a syncro-clock requires lubrication every few months. Likewise the bearings should be oiled to insure proper operation. Condenser bearings (cone type) require occasional lubrication in small quantities.

Tubes and batteries in our equipment should be tested frequently and replaced

*Density MD, manufactured by Master Lubricants Company, Philadelphia, Pa.

if necessary. Only such types as recommended for our instruments should be used.

It is always well to inspect the wiring in an instrument. While every effort is made during manufacture to solder firmly each connection, occasionally one will break loose due to excessive vibration either in transit or in use.

Dials are lacquered and usually do not require much attention. However, the use of an oil polish will improve their appearance. For smooth operation slow-motion drives, either friction- or gear-type, must be cleaned occasionally. A fine brush and a cloth saturated with carbon tetra-chloride are satisfactory.

Air condensers require occasional attention and the dirt and lint between the plates can be removed with pipe cleaners. With calibrated condensers, care must be taken not to bend the plates. Foreign matter between terminals on a fixed condenser should be periodically removed. Otherwise, the combination of dirt and moisture will produce a low value of leakage resistance.

An oil polish may be used on wood cabinets, panels, and dust covers to improve appearances. The crackle finish can be restored to its original appearance by using an oil polish and carefully wiping afterward.

For specific instruments, these general suggestions often must be supplemented by more specific information, usually included in instruction books. Whenever additional service or maintenance instructions are needed, the Service Department will gladly supply the necessary information.

— H. H. DAWES

VARIACS IN COMBINATION

● TWO OUT-OF-THE-ORDINARY connections for Variacs have been brought to our attention by users. Both of these use the TYPE 80-A Variac Transformer in combination with TYPE 100 or TYPE 200 Variacs.

The first of these, used by Mr. Louis A. Paine, Chief Engineer of Therm Electric Meters Co., Inc., uses the Variac as a potential phase shifter for

FIGURE 1 (below). Arrangement of TYPE 100 Variac and TYPE 80 Variac Transformer for varying the potential phase in testing wattmeters.

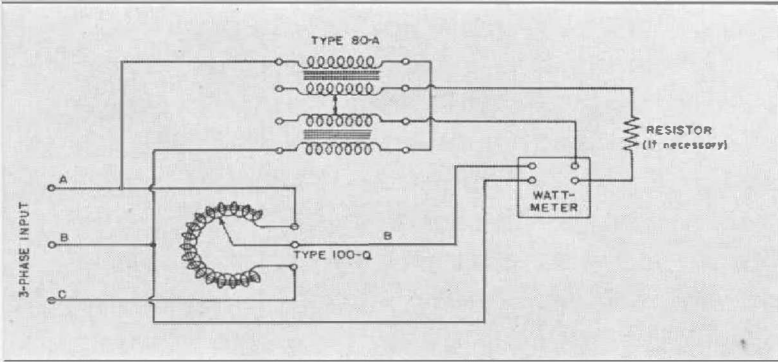


FIGURE 3 (below). By using two Variacs, the voltage can be held constant as its phase is varied.

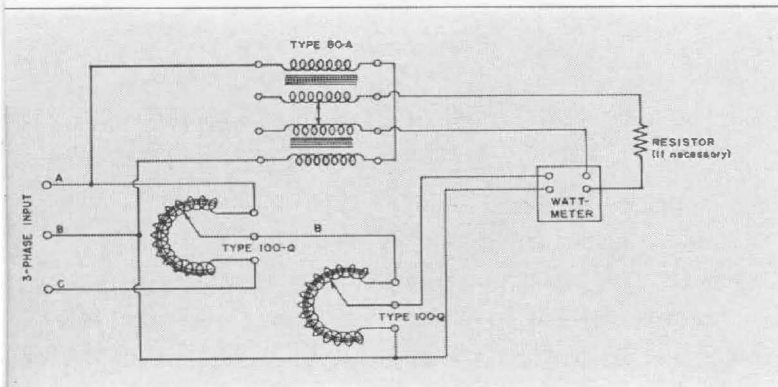


FIGURE 4 (below). Method of combining TYPE 100 Variac and TYPE 80 Variac Transformer to obtain a fine control of motor speed.

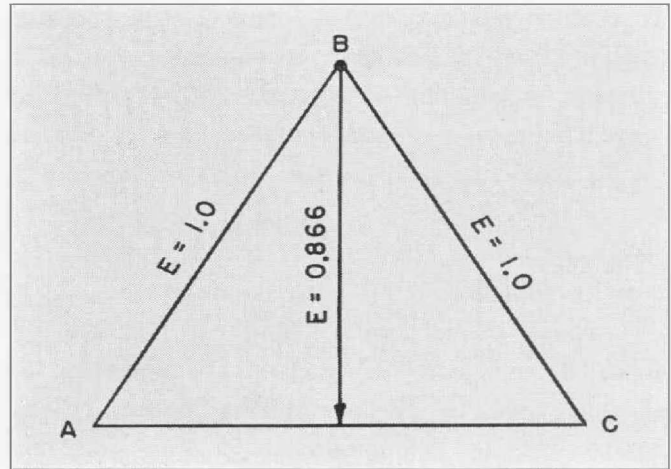
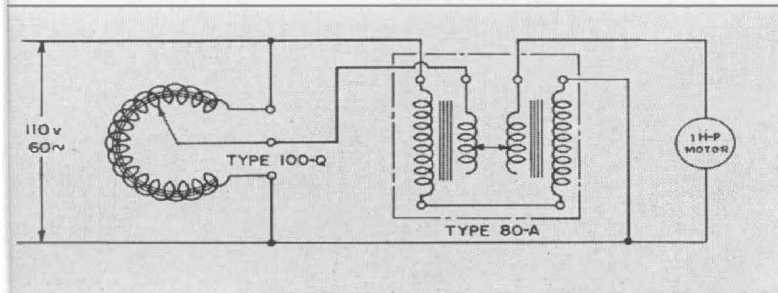


FIGURE 2.

testing wattmeters. The Variac is connected across two wires of a three-phase line. The potential coil of the wattmeter is then fed from the Variac brush and the third line wire. The current coil of the wattmeter is supplied through a TYPE 80-A Variac Transformer. Using this connection an effective phase variation of 0 to 60° is obtainable, corresponding to a power-factor variation from unity to 0.5.

The use of a single Variac to supply the potential coils has the disadvantage that a voltage variation accompanies the desired phase variation. As shown in Figure 2, the voltage varies from unity at zero phase shift to 0.866 at 30° phase shift, and back to unity at 60° shift. This voltage variation can be avoided by using a second Variac as shown in Figure 3.

The second application is furnished by Pierce Plastics of Bay City, Michigan. Here the Variacs are used for speed control on a repulsion-type motor. The circuit is shown in Figure 4. The general operating point is set by the TYPE 100 Variac and the 10-volt winding on the TYPE 80-A Variac Transformer permits a fine control of voltage around that point.

MISCELLANY

● **THE MOTION-ARRESTING PROPERTIES** of the Stroboscope are the theme of "Quicker'n a Wink," Pete Smith's latest Metro-Goldwyn-Mayer Specialty. Produced through the co-operation of Dr. Harold E. Edgerton of the Massachusetts Institute of Technology, consultant on General Radio Stroboscopes, this film features the Strobotac, the Strobolux, and the continuous-film high-speed camera (TYPE 651-A).

● **ENGINEERS** whose work involves the measurement and analysis of noise will be interested in a recent publication of the Underwriters' Laboratories, Inc., entitled "Noise in Burglary-Resistive Vaults under Normal and Attack Conditions,"* by H. D. Brailsford. This bulletin is "a report on a special investigation of the noise or sound in burglary-resistive vaults, conducted for the purpose of developing new and additional data on the requirements for burglar alarm systems operating on the sound-detection principle." The investigation, in which the General Radio Sound-Level Meter and Sound Analyzer were used, included measurements of sound-levels, frequency characteristics, and reverberation times. Methods of measurement are described in detail and an elementary explanation of the theory of sound and vibration is included.

*Bulletin of Research No. 17, July, 1940.

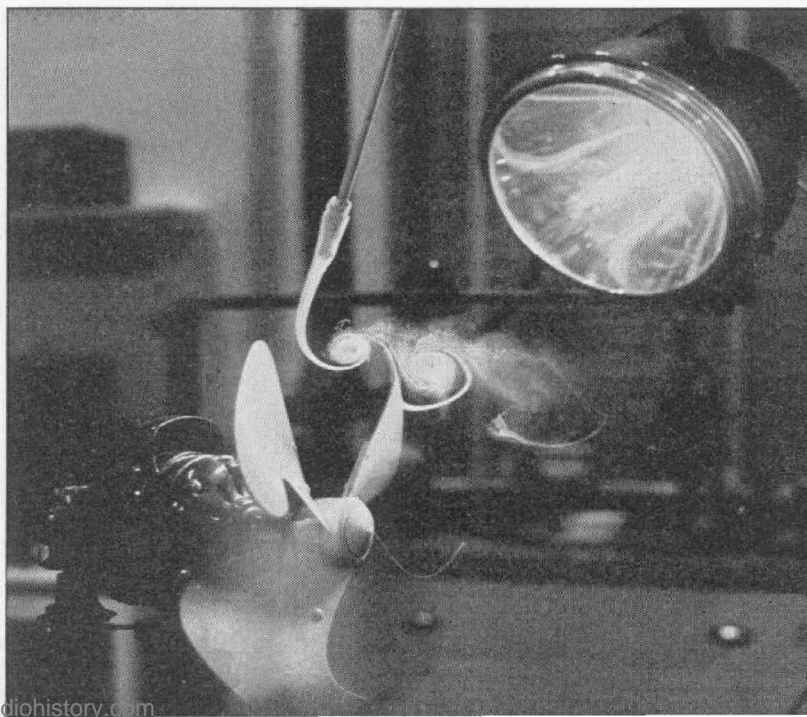
Air currents around an electric fan are shown in this photograph, which was taken with a TYPE 648-A Strobolux. This is one of the scenes from "Quicker'n a Wink." Others include a bullet shattering a light bulb, a golf ball boring its way through a telephone directory, and a hummingbird in flight.



Dr. Edgerton explains the operation of the high-speed camera to Pete Smith, Commentator of "Quicker'n a Wink." This camera will take pictures at the rate of 1500 frames per second.

● **MEASURING APPLAUSE** for Willkie and for Roosevelt is the latest job for General Radio Sound-Level Meters. Two of these instruments are being used in the *New York Journal* and *American's* movie applause poll on the two major presidential candidates. Measurements are made in movie theaters in metropolitan New York.

● **LATEST** to join our engineering staff is Ivan G. Easton, whose work will be in sales engineering. Mr. Easton re-





Dr. Harold E. Edgerton of the Massachusetts Institute of Technology demonstrates the Strobotac and Strobulux in this scene from "Quicker'n a Wink."

ceived his B.S. degree from Northeastern University in 1938. While at Northeastern and after graduation, he was employed in the General Radio standardizing laboratory, leaving to continue his engineering education at Harvard University, from which he received his M.S. degree in 1939.

● **L. E. PACKARD** of the Commercial Engineering staff is now in charge of our New York engineering office, succeeding Frederick Ireland. Mr. Ireland, after a short period at Cambridge, will be in charge of the Los Angeles office, replacing M. T. Smith, who returns to the main office at Cambridge.

THE General Radio *EXPERIMENTER* is mailed without charge each month to engineers, scientists, technicians, and others interested in communication-frequency measurement and control problems. When sending requests for subscriptions and address-change notices, please supply the following information: name, company name, company address, type of business company is engaged in, and title or position of individual.

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