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CAPACITY COMPARISON USING A CATHODE-RAY TUBE

Dr. Robert H. Cole of Harvard University presents an excellent paper in "The Review of Scientific Instruments," Volume 12, No. 6, June, 1941, describing the use of a Du Mont Cathode-ray Tube for the comparison of capacities. The original problem was to determine dielectric constants of polar liquids by means of an alternating current method with an accuracy in the order of one per cent, free in principle from errors due to conductivity.

Quantitative comparison of impedances differing in phase was made possible by the use of a simple geometrical property of the elliptical trace. The output of a high-frequency oscillator was applied to a series circuit containing the dielectric and a standard condenser (see figure 1a). The voltages across these two impedances were then applied directly to the horizontal and vertical deflection plates of a five-inch oscillotron such as the Du Mont 2511A5. If the dielectric in question has no conductivity the trace on the screen is a straight line, the slope of which depends on the ratio of the unknown and standard capacities. If the dielectric is not loss-free, the pattern of the trace observed will be an ellipse, the relative opening of which depends on the conductivity, and the ratio of the unknown and standard capacities. The author shows, however, that the slope of the ellipse for zero voltage across either the horizontal or vertical deflection plates is independent of the conductivity.

If the deflection sensitivities of the vertical and horizontal deflecting plates are equal, and if the traces produced by a voltage applied separately to the pairs of plates are perpendicular, the ratio of capacities of the unknown and of the standard is equal to cot Θ where Θ is the angle between the trace and the horizontal axis (see Figure 1b). Unfortunately, these two conditions are not to be found in the commercial cathode-ray tube, and these properties must be taken into account.

Assuming that the ratio of the vertical and horizontal deflection sensitivities

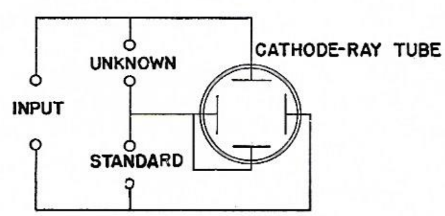

FIG. 1 (A)

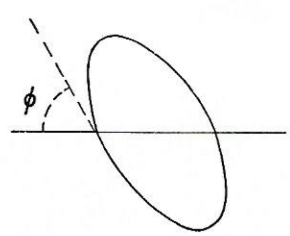

FIG. 1 (B)

is λ and the angle between the vertical and horizontal traces is $(\frac{\pi}{2} - \varphi)$ then

(1) $(a/b \cos\delta) = (\lambda\cos\varphi) \cot\Theta - \lambda\sin\varphi$

if $V_y = b \sin (wt+\delta)$ and $V_x = a \sin wt$ are the voltages across the vertical and horizontal plates. If the impedances across these plates are produced by an unknown capacity C_v and a standard capacity C_h, the quantity $a/b \cos\delta$ is equal to the ratio C_v/C_h. Hence, if the above equation is correct the unknown capacity is a function of the quantities C_h, Θ, λ, and φ

$$(2)\ C_v = \frac{(\lambda\cos\varphi) \cot\Theta - \lambda\sin\varphi}{C_h}$$

Furthermore, the determination is independent of the conductivity of the unknown (being equivalent to a conductance in parallel with the capacity of the unknown).

The validity of the equation (1) was tested experimentally by placing known capacities across the vertical and horizontal plates of the cathode-ray tube. The trace on the screen was first photographed and then projected on a ground glass screen. The reference trace is produced by short circuiting the vertical plates.

The constant λ may be determined from actual measurement of the tube deflection sensitivities and may be determined either visually with a protracter, photographically, or by using the interesting method described by Cole. His method of calibration resulted in an accuracy of the order of 0.5 percent in measuring capacities from 200 mmfd. to 1000 mmfd. over a frequency range from 50 kc to 2 mc. The principal source of error was the determination of the angle Θ. For this measurement a Bausch and Lomb tangent meter is recommended. Reading of this angle can be consistently reproduced to 0.1°, or an error 0.3 percent in the tangent for the most desirable case, 45°. At low frequencies a resistor might conveniently be used as the standard impedance, provided the effect of the residual capacity of the resistance is negligible at the low frequencies.

Stray impedances across the input, or shunt impedances from the high potential side of the unknown to ground have no effect since they shunt the entire circuit. The author suggests that this method might readily be used to determine resistance by means of the "opening" of the ellipse.

The apparent disadvantage of this method is that rather large voltages are required to produce a sizable trace on the cathode-ray tube, although in this particular case, a push pull oscillator using a single 6N7 twin triode provided adequate voltage amplification. Further than this, the circuit is not well adapted to measurement of small impedances, and rather high potentials are developed across the unknown. This method has proved a very simple and convenient one for measurements of modest accuracy.

Through the courtesy of the author, Robert H. Cole, and the publisher, The American Institute of Physics.

TYPE 215 LOW-FREQUENCY LINEAR-TIME-BASE GENERATOR

As another contribution to the art of cathode-ray oscillography, the Du Mont Laboratories are announcing the new Type 215 Low-Frequency Linear-Time-Base Generator. This unit further expands the frequency-range of the sweep oscillator which produces the linear time base along which are plotted on the screen of the cathode-ray tube the values of the phenomenon being studied, using the usual rectangular-coordinate system of graphic representation. The design and manufacture of gas discharge tubes has been improved to the extent that a conventional sweep circuit will operate with good linearity in a range from two to 50,000 cycles per second. Although this was a decided improvement over existing performance, it was felt that a limit had by no means been reached.

Many studies require sweep frequencies as low as one cycle every few seconds. The Type 215 Generator has been developed to permit these studies. With this unit used in conjunction with an oscillograph provided with a long-persistence cathode-ray tube or with photographic recording methods, new fields of investigation are opened for all forms of low frequency transient and recurrent phenomena. The frequency range of the instrument corresponds to rotating speeds of 12 rpm to 7,500 rpm, thus permitting the visual study of machinery operation at low as well as medium speeds.

DESCRIPTION

The Du Mont Type 215 Low-Frequency Linear-Time-Base Generator is a portable instrument which provides a 450 d.c. or peak to peak undistorted linear-time-base signal voltage, the frequency of which is variable from 0.2 to 125 cycles per second. This output voltage is not ordinarily linear in conventional circuits, the deviation from linearity being due partly to the natural curvature of the condenser charging characteristics, partly to a small amount of leakage in sweep condensers, and also to the inductive impedance of the power supply. This non-linear distortion is particularly noticeable at low frequencies. To compensate for it a circuit has been incorporated which feeds back to the plate of the discharge tube a voltage of such waveform as to compensate for the deviation from linearity of the output signal of the gas triode. This results in a signal of which the deviation from linearity is negligible. The adjustment of this compensation is made at the factory.

A d.c. positioning means is provided in a positioning circuit used with the direct-current signal voltage amplifier. This system eliminates the electrical backlash frequently encountered with positioning controls, since direct coupling is used and thus no charge or discharge period exists as in condenser coupled arrangements.

The output signal voltage of the generator is balanced to ground, thereby permitting symmetrical deflection of the electron beam, with resulting freedom from defocusing and trapezpoidal distortion. When this instrument is used in conjunction with the Du Mont Type 175-A Cathode-ray Oscillograph, the pattern may in effect be spread out in the direction of sweep to an extent corresponding to approximately three times full screen deflection, or 15 inches.

In conventional single-stroke sweep circuits for use in transient studies, the adjustment of controls is quite critical, and when recurrent sweep oscillations have been stopped it is necessary to position the spot off the screen manually. In the Type 215 these adjustments are accomplished simultaneously by the simple expedient of turning a switch.

Under certain conditions of operation, the trace caused by the beam during the return time may be objectionable. To eliminate this trace, signal of the proper amplitude, waveform and phase can be applied to the grid of the oscillotron to cut off the beam during its return trace. A suitable blanking signal is provided in the Type 215 Generator, with either positive or negative polarity available with a phase switch. When the switch is thrown in the positive position, the output of the blanking terminal will be positive and may therefore be amplified through a stage of amplification with a final resultant signal of the correct negative polarity.

Synchronization of the sweep-oscillator may be obtained from either an externally derived signal or from the signal amplifying circuits of the oscillograph with which it is used.

THE "BLACKOUT" PANEL

As an added refinement of the Model 208, laboratory type cathode-ray oscillograph, we are pleased to announce the availability of the "blackout panel."

Very often the oscillograph user finds that this instrument must be used under adverse lighting conditions. Of necessity, an oscillograph panel contains a number of controls, which must be adjusted from time to time even during total darkness. The "blackout panel" is provided with flourescent-phosphorescent dial and panel markings which are activated by ultra-violet light. After the activating source is removed, the phosphorescence remains and the markings and graduations continue to be visible, although with a diminishing intensity for as long as fifteen minutes to a half hour. The ordinary incandescent lamp produces sufficient ultra violet to satisfactorily activate the panel.

The fluorescent-phosphorescent pigment is an inorganic substance having a remarkable stability at all atmospheric conditions. It is non-poisonous, requires no radioactive substance and does not yellow with age. Its durability is widened by its ability to withstand a salt spray test for seventy hours without deterioration.

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