THE General Radio EXPERIMENTER

VOLUME XV NO. 3 AUGUST, 1940

ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

Also IN THIS ISSUE

DIRECT-READING WAVEMETER FOR ULTRA-HIGH FREQUENCIES

● **THE TYPE 758-A WAVEMETER** is a convenient instrument for measuring high frequencies in the laboratory, where quite frequently ease of operation is found to be more important than high accuracy. The direct-reading dial covers in a single rotation frequencies from 55 to 400 megacycles. This wide range of frequencies, which is covered without switching or changing coils, is particularly welcome in the high-frequency field where an oscillator may produce frequencies quite different from those for which the circuit was designed.

The TYPE 758-A Wavemeter is a tuned circuit instrument comprising a variable condenser and a variable inductance. The variable condenser is of the conventional straight-line frequency type. The variable inductance is obtained by sliding a silver spring, which is attached to the rotor of the condenser, along a silver strip connected to the stator. Because inductance and capacitance are varied simultaneously, a wider range of frequency is covered in a single band than when only one element is made variable.

FIGURE 1. Measuring the frequency of an ultra-high-frequency oscillator with the TYPE 758-A Wavemeter.

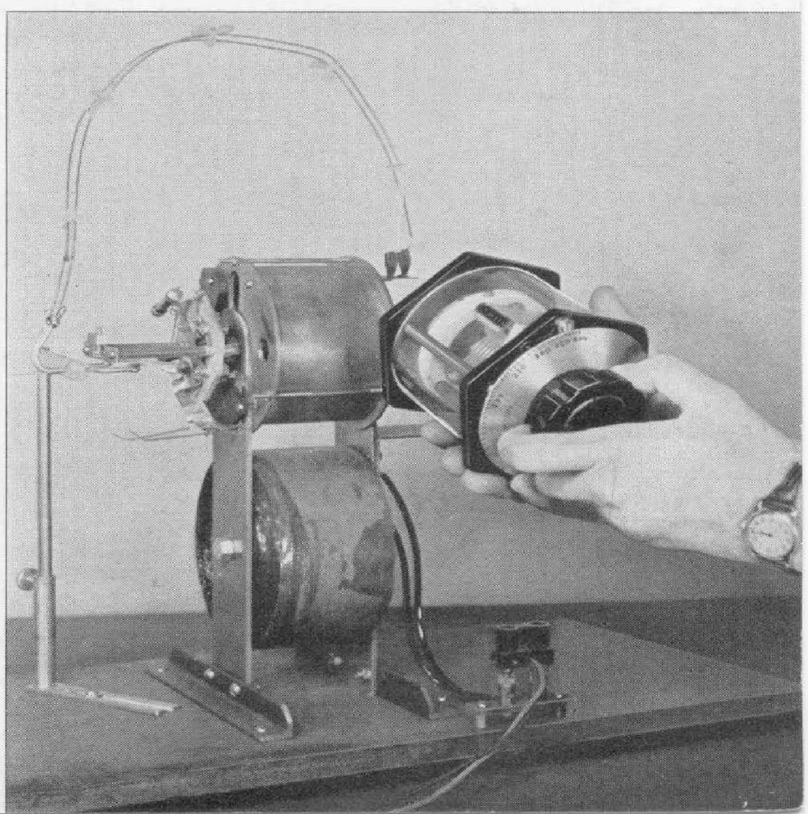


FIGURE 2. Direct-reading frequency scale of the TYPE 758-A Wavemeter.

Loosely coupled to the measuring circuit is an aperiodic indicator circuit. A flashlight lamp that will light readily with a 2-watt oscillator is used as an indicator of resonance. If the oscillator power is not sufficient to light the lamp, the wavemeter can be made to react on the oscillator and will change plate or grid current of the tube sufficiently to determine resonance.

The complete unit is mounted in a transparent but almost unbreakable case so that the indicating lamp can be observed from all directions. Since the location of condenser and coil of the wavemeter can be seen from the outside, effective coupling to an oscillator is obtained easily. The two bakelite end plates of the completed instrument are cut hexagonally so that the wavemeter can be rested in any one of six different positions.

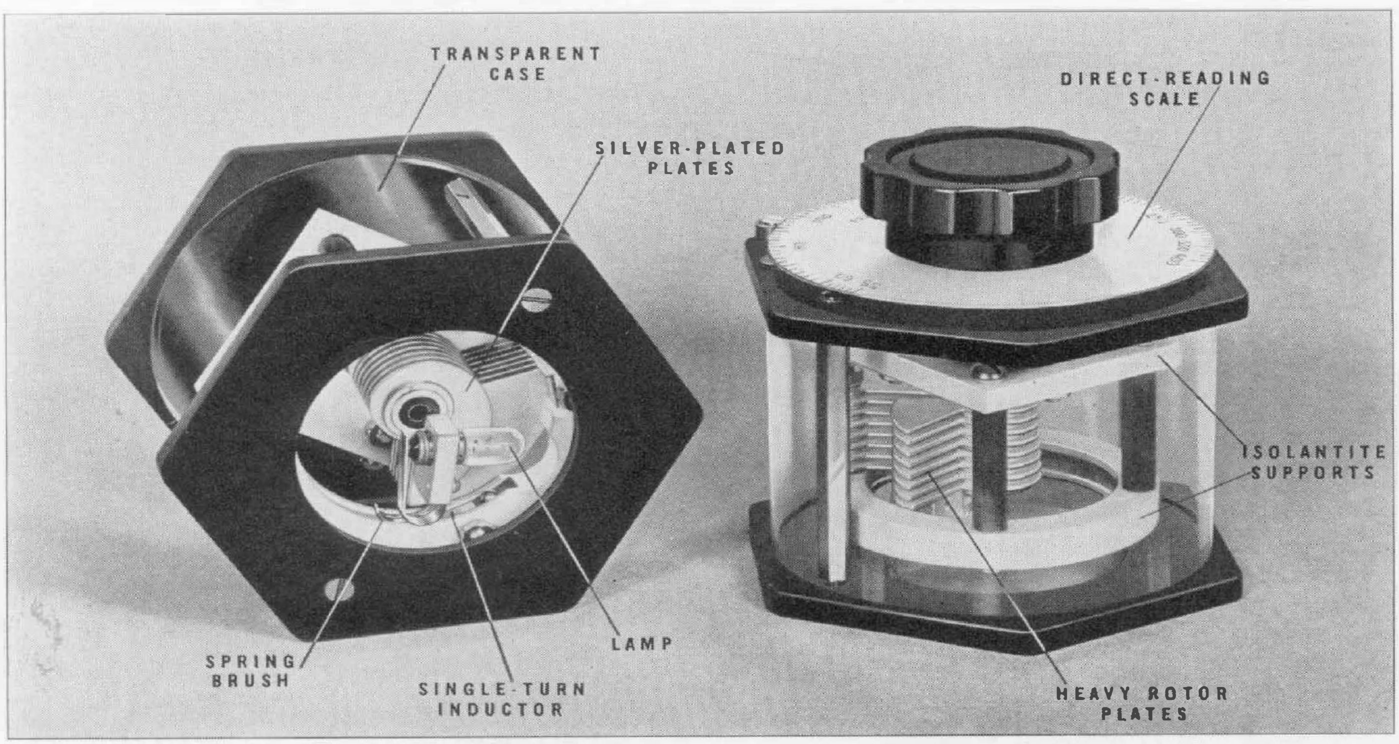
— E. KARPLUS

SPECIFICATIONS

Range: 55 to 400 Mc, direct reading.
Accuracy: 2%.
Resonance Indicator: Incandescent lamp.
Dimensions: 4¼ x 4⅞ x 4⅝ inches, over-all.
Net Weight: 1 pound, 10 ounces.

Type	*Description*	*Code Word*	*Price*
758-A	Wavemeter	WITTY	$28.00

FIGURE 3. Two views of the TYPE 758-A Wavemeter with the various parts identified.



LINE VOLTAGE CORRECTION WITH THE VARIAC

● **VOLTAGE CORRECTION** on under-voltage or over-voltage lines is a common use for Variacs. Figure 1 (a) shows the simplest connection for this purpose.

With this circuit a line whose voltage varies by ±13 per cent can be kept at its mean rated value. The rated currents, only, can be drawn from the Variac when the line voltage is at its minimum. When the line voltage is high so that the Variac is used as a step-down transformer, the flux density is higher than normal, which results in somewhat greater heating.

Figure 1 (b) illustrates a similar method, differing only in that line and output connections are reversed. The method has the advantage that the Variac always operates at its rated flux density. In using this method it is advisable always to return the brush to the neutral position (i.e., to a position over tap 4) before starting operations. If the brush is set for maximum step up, and the line voltage happens to be at its maximum, excessive no-load currents may be drawn by the Variac and it may become overheated. The rated current of the Variac may be drawn at any line voltage within the range of regulation.

Figure 2 (a) shows a circuit* using a Variac bridged across a section of a tapped autotransformer. This circuit is especially useful with line voltages higher than the rated voltage of the Variac and in cases in which it is desirable to use the full rotation of the Variac for fineness of control. Line currents up to the rated current of the Variac may be used. Figure 2 (b) is the inverse of Figure 2 (a) and has the same uses. Load currents up to the rated current of the Variac may be drawn.

Figure 3 shows circuits which are particularly useful where small line voltage variations are required and where the currents to be drawn are greater than can be supplied by any standard Variac.

In Figure 3 (a) a Variac across the

*P. K. McElroy, "Extending the Field of Application of the Variac," General Radio *Experimenter*, Volume XIV, No. 5, October, 1939.

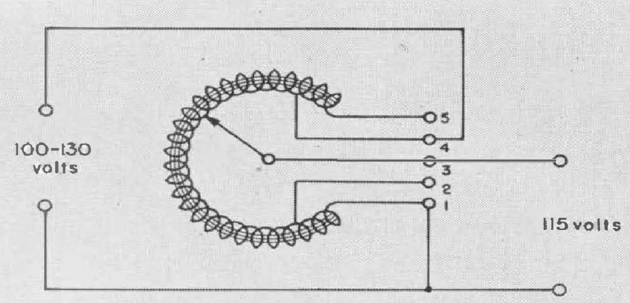


FIG. 1 (a)

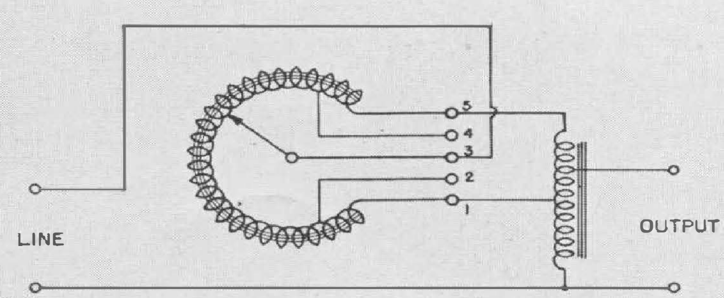


FIG. 2 (a)

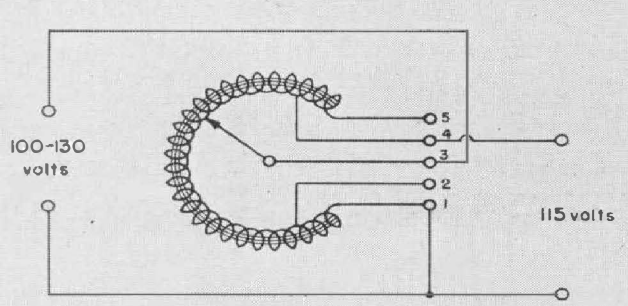


FIG. 1 (b)

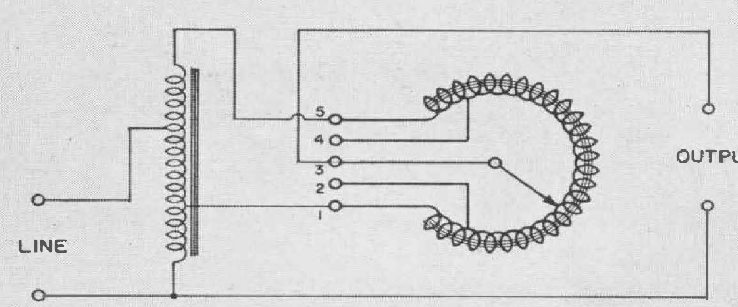


FIG. 2 (b)

line delivers a controllable voltage to the full winding of an auxiliary auto-transformer, a part of whose winding is in series with the load. With the Variac brush in the 5 position, the series voltage introduced into the output circuit by the auxiliary transformer is zero, and line and output voltages are equal. Rotation of the brush increases or reduces the output voltage by an amount depending on the turns ratio of the transformer and the position of switch S_2.

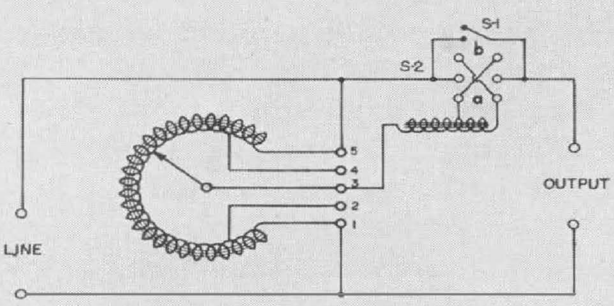


FIG. 3 (a)

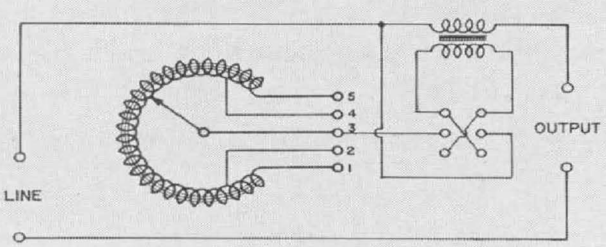


FIG. 3 (b)

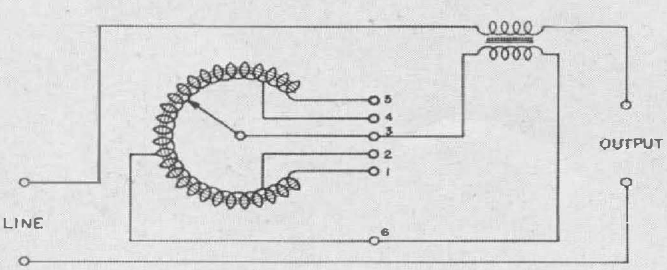


FIG. 3 (c)

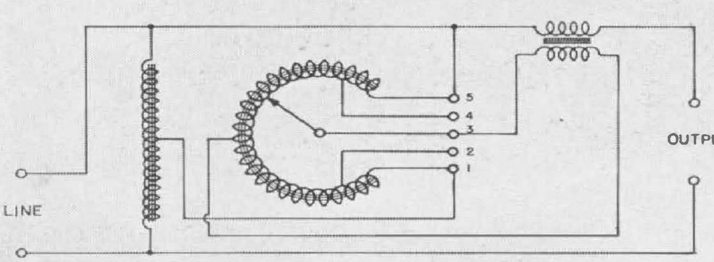


FIG. 3 (d)

Assuming that the line voltage to be compensated is at its maximum, we start with S_2 in position *a* and the brush at position 1. As the line voltage drops, the output can be held constant by rotating the brush toward position 5. This gives continuous control until the line voltage falls to normal output voltage. If the line falls below normal, switch S_1 is closed, switch S_2 is thrown to position *b* and then switch S_1 is opened. This operation changes the auxiliary transformer from a step-down to a step-up transformer without opening the output circuit. The output can now be kept at its normal value by rotating the Variac brush back toward position 5 as the line voltage falls to its minimum. Obviously, in the case of a line which is always too high or always too low, the switches may be omitted and the full range of control obtained by a single rotation of the Variac brush. Output currents up to rated current of the Variac times the turns ratio of the auxiliary transformer can be controlled.

Figure 3 (b) gives the same type of control as the circuit of Figure 3 (a). The operation and uses of this circuit are the same as for Figure 3 (a) except that the use of an inductively coupled transformer obviates the necessity of using a shorting switch to keep the output circuit closed while the reversing switch is being operated.

Figure 3 (c) gives a method by which a desired output voltage may be obtained from either a higher or a lower line without the necessity of any switching. This method requires the use of a center tap on the Variac.†

Figure 3 (d) shows an obvious extension of Figure 3 (c) which is useful in cases where the line voltage is higher than the rated voltage of any standard Variac. — S. A. BUCKINGHAM

†Center taps are provided on 230-volt models.

NEW DIALS

● **THE TWO-INCH DIAL** used on several General Radio instruments has now been made available for general sale. Two types are listed, one with 100 divisions for 360-degree rotation, and the other with 100 divisions for 180-degree rotation. Both models are drilled for a ¼-inch shaft.

A new four-inch dial with 100 divisions for 360-degree rotation is also available in both direct- and friction-drive models.

These new dials are made of nickel silver with photo-etched scales and Type 637 Knobs. All dials are insulated from the shaft. An indicator, as shown, and a drilling template are supplied with each dial.

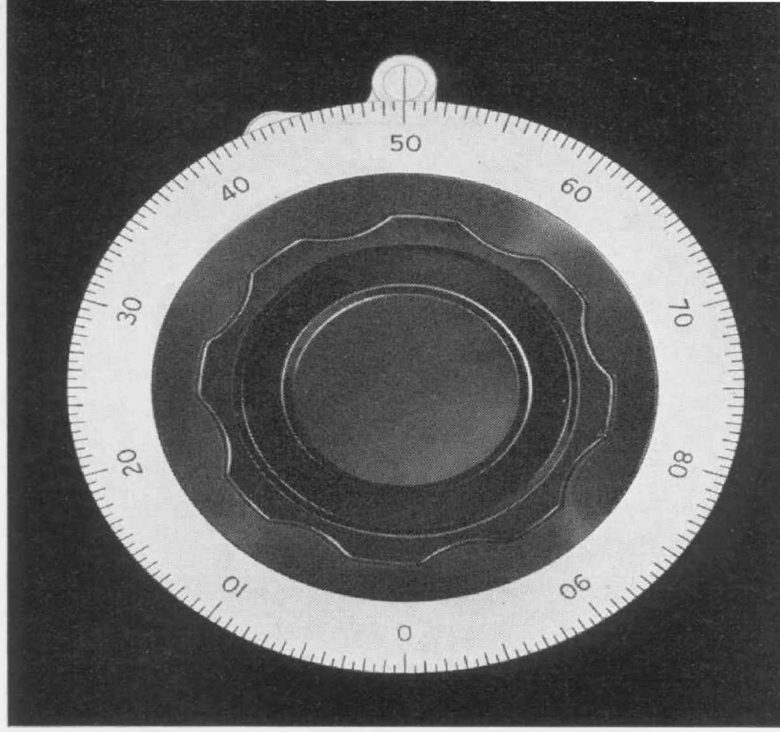
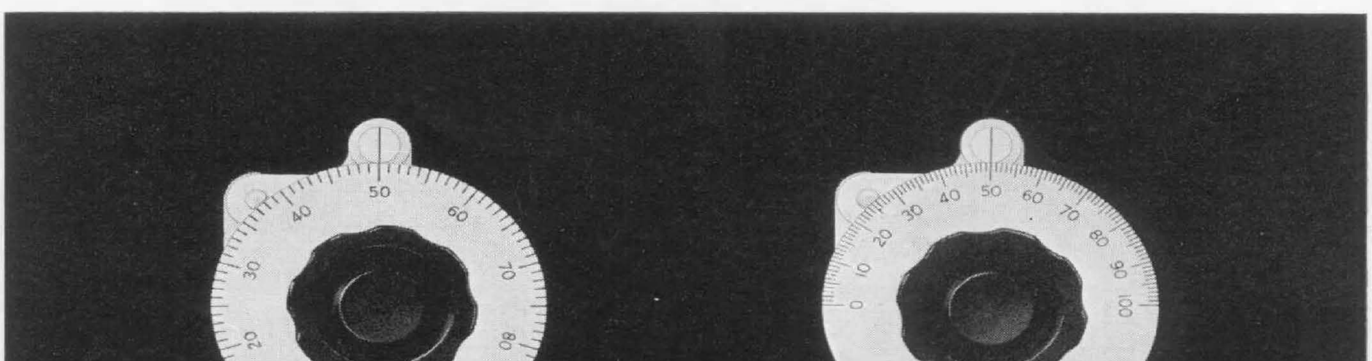


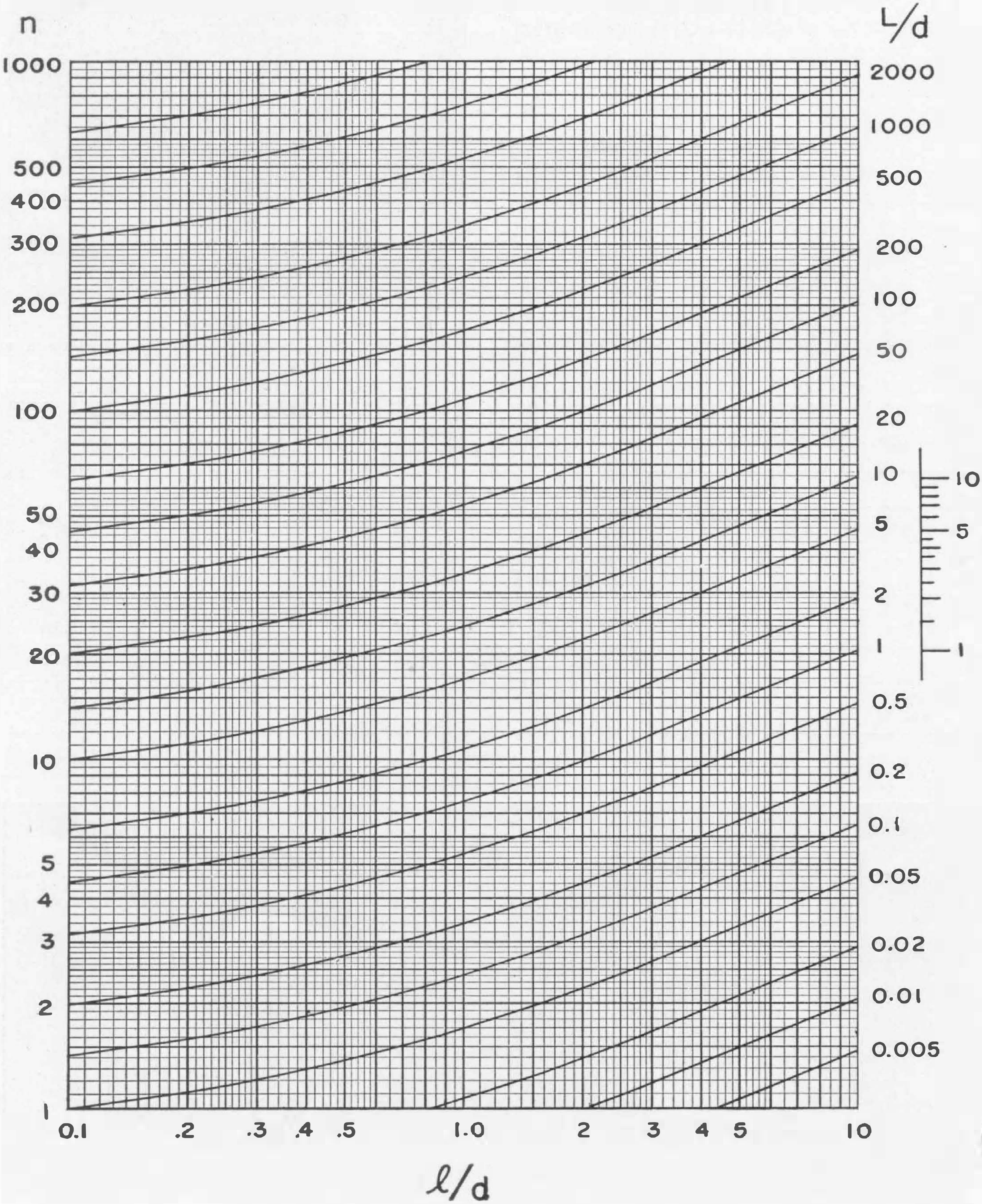
Figure 1. View of the Type 717-K or 717-L Dial. The dial is shown approximately ⅝ actual size.

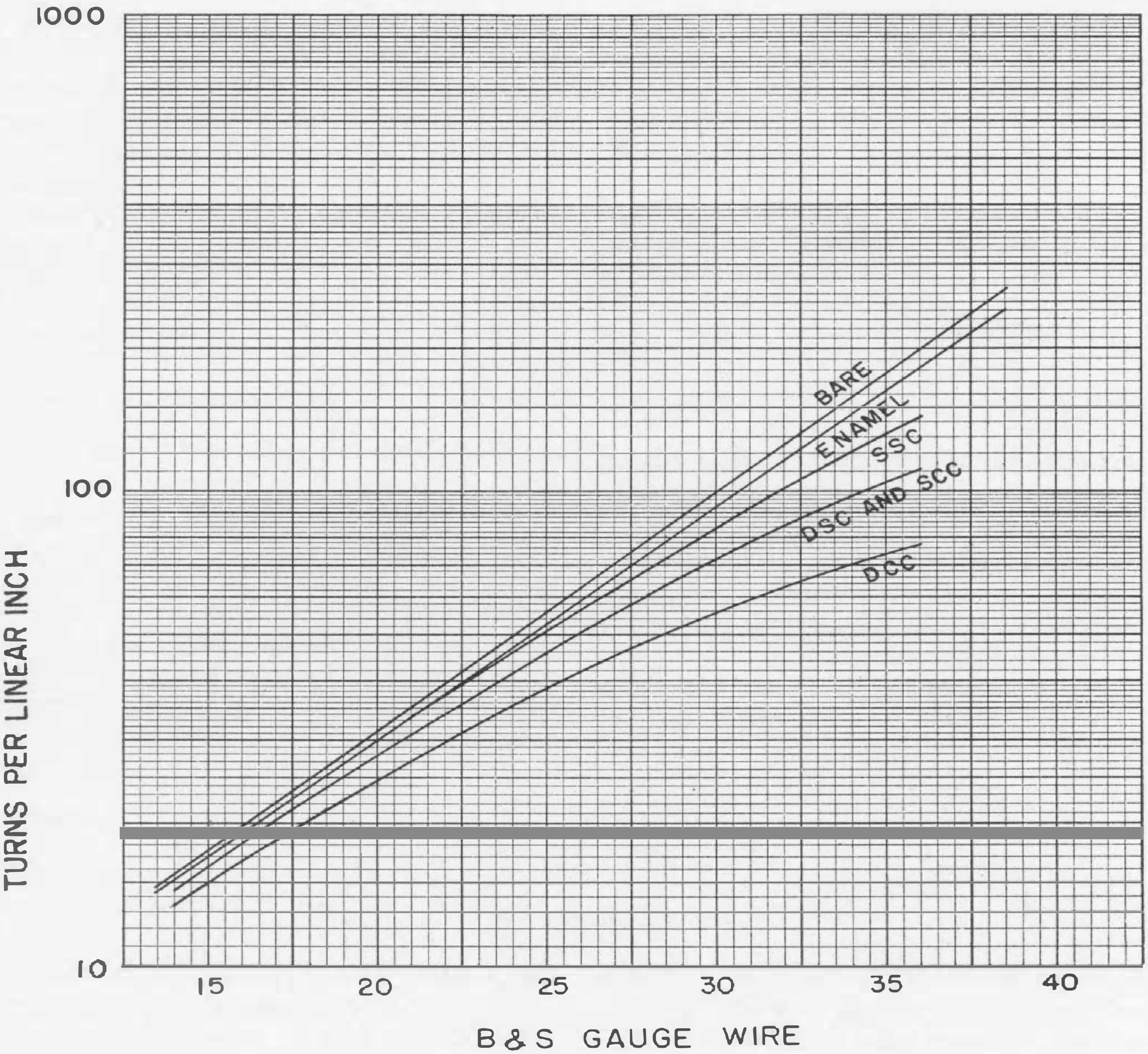
Type	*Shaft Diam.*	*Dial*		*Friction Drive Ratio*	*Net Weight*	*Code Word*	*Price*
		Arc	*Divs.*				
4-Inch Diameter — Type 703 Friction-Drive Dials							
703-K	¼"	360°	100	1 : 5	8 oz.	DIHOP	$2.00
703-L	⅜"	360°	100	1 : 5	8 oz.	DIHIP	2.00
4-Inch Diameter — Type 717 Direct-Drive Dials							
717-K	¼"	360°	100	....	5 oz.	DIHUG	1.50
717-L	⅜"	360°	100	....	5 oz.	DIKEG	1.50
2-Inch Diameter — Type 701 Direct-Drive Dials							
701-A	¼"	180°	100	....	2 oz.	DILAP	1.25
701-K	¼"	360°	100	....	2 oz.	DILUX	1.25

Figure 2. View of Type 701-K (*left*) and Type 701-A (*right*) Dials. The dials are shown approximately ⅝ actual size.



A CONVENIENT INDUCTANCE CHART FOR SINGLE-LAYER SOLENOIDS





● **ON THESE TWO PAGES** are presented charts for determining the number of turns and the size of wire to be used in order to obtain a given inductance on a given winding form.

In the left-hand chart the variables are n, the number of turns, and $\frac{l}{d}$, the ratio of winding length to winding diameter. The ratio of inductance to diameter of winding $\left(\frac{L}{d}\right)$ is used as a parameter.

The curves were computed from the expression given in Circular 74 of the U. S. Bureau of Standards,* which, using the terminology of the chart, may be written,

$$L = \frac{.02508\ n^2d^2}{l} K \qquad (1)$$

where L is the inductance in μh
K is Nagaoka's constant
and d and l are in inches.

* "Radio Instruments and Measurements," p. 252.

For a given inductance the number of turns is then,

$$n = \sqrt{\left(\frac{L}{d}\right)\left(\frac{l}{d}\right)(39.88)\left(\frac{l}{K}\right)} \quad (2)$$

This form of the expression is particularly convenient because, in designing coils, the engineer usually starts with a given coil form ($\frac{l}{d}$ known) and needs a given inductance L ($\frac{L}{d}$ easily calculated).

Since Nagaoka's constant depends on the ratio $\frac{l}{d}$, the use of this ratio for the horizontal scale makes all the curves parallel, so that, in plotting them, only one curve need be calculated. The other can be drawn from a template.

For interpolating between curves, a logarithmic scale covering one decade of $\frac{L}{d}$ is shown at the right of the chart.

The second chart is plotted from standard winding data published by wire manufacturers.

As an example of the use of these charts, consider the problem of designing a coil of 100 μh inductance on a winding form two inches in diameter, with an available winding space of two inches. The quantity $\frac{l}{d}$ is unity and $\frac{L}{d}$ is 50. Entering the chart at $\frac{L}{d} = 50$ and following down the curve to the vertical line $\frac{l}{d} = 1$, we find that n, as indicated by the left-hand vertical scale, is 54 turns.

With a winding space of two inches, this is equivalent to 27 turns per linear inch, close wound. The second chart shows that No. 18 enamel or single-silk-, No. 20 double-silk-, or single-cotton- or No. 22 double-cotton-covered wire would be used close wound. No. 25 bare wire, double spaced, could also be used.

ERRATA

● **THE FOLLOWING ERRORS** occurred in the article entitled "Substitution Measurements at Radio Frequencies," by R. F. Field, appearing in the May, 1940, issue of the *Experimenter*.

1. The values $L_C = 0.006$ μh and $R_C = 0.005\ \Omega$ apply not to the TYPE 722-N Precision Condenser as stated, but to a newly designed condenser used in the TYPE 821-A Twin-T Impedance Measuring Circuit, which will be described in a forthcoming issue of the *Experimenter*.

2. In Table I, first column, fourth line, R_L should be R_C.

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