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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

A NEW SERIES OF STANDARD INDUCTORS

Also

IN THIS ISSUE

● **HIGHLY ACCURATE STANDARDS** of resistance, capacitance, and inductance, representing the basic parameters of an electrical network, are necessarily among the major tools used in any measurement and standardizing laboratory. For many years General Radio Company has endeavored to produce such high quality standards and to improve them from time to time as dictated by enhanced knowledge and advancement in the arts of measurement and manufacturing technique. At this time a new standard inductor, known as the Type 1482, which is superior in several aspects to the long-used Type 106 Standard Inductor, is announced.

For precise work, one naturally desires an inductance standard which is insensitive to its electrical environment and ambient humidity, and which has a known temperature coefficient of minimum value. In these respects, the new Type 1482 Standard Inductors are definitely superior to the old Type 106 units.

These new inductors are symmetrically wound toroids and have thus a much higher degree of astaticism than existed in the adjacent

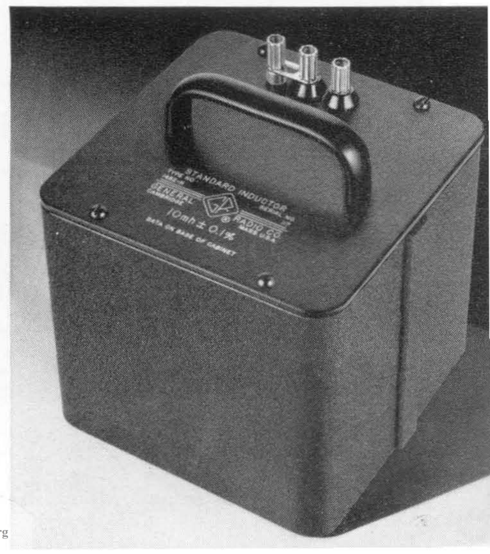
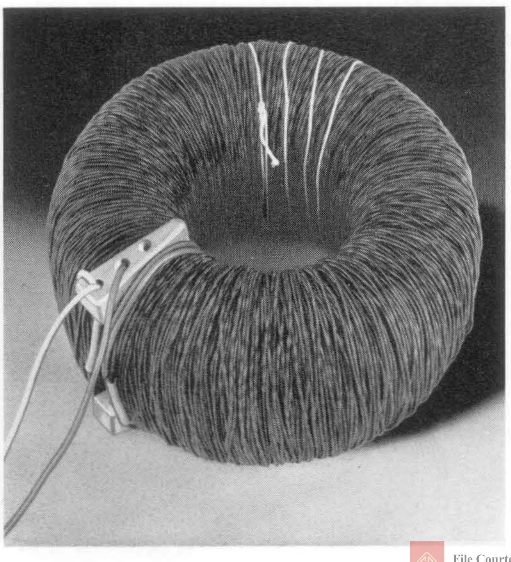


Figure 1. Panel view of the Type 1482 Standard Inductor.

pair of D-shaped coils used in the older type. They have essentially no pick-up from a moderately uniform electromagnetic field and, when energized, they produce no such field in their vicinity. Accordingly, they may be used close to each other or to other circuit components.

With no external magnetic field, these toroidal units can be housed in a metallic case and thus given an electrostatic shield with no complicated frequency correction of inductance due to eddy current reaction. Any attempted electrostatic shielding of the Type 106 Standard Inductors would have required abnormally large cases.

The Type 1482 Inductors are wound on a low thermal expansion ceramic core having an elliptical cross section to avoid sharp bends in the winding. After adjustment, they are packed in granulated cork into a cylindrical cardboard carton, together with a small amount of silica gel to insure dehydration. Having a simple geometrical construction and being uniformly supported at all points with no restraining clamps, it is expected that long-time observations will prove these "floating" inductors will have a high degree of stability. This belief is fortified by the results obtained in the accelerated aging techniques to which all of these inductors are subjected prior to final calibration. Furthermore, their temperature coefficient of inductance is definitely positive and of the order of 30 parts per million per degree C. This checks closely a theoretical value of twice the linear expansion coefficient of copper. For precise work, appropriate temperature corrections can thus be applied. This was not possible with the old Type 106 Inductors, whose thermal coefficients were indefinite both in sign and magnitude and could only be specified as less than $\pm$ 40 parts per million per degree C.



Continuing with the assembly, the cylindrical carton is supported on three wooden dowels and completely cast with a potting compound into the cubical aluminum case. These inductors are thus hermetically sealed and devoid of ambient humidity variations encountered in the older units.

The two extremities of the winding are brought out to a pair of insulated terminals. As calibrated and as ordinarily used, the LOW terminal is externally strapped to a third terminal which is grounded to the case. While so doing lowers the natural frequency of the unit slightly, it affords at the terminals a definite impedance, $R + j\omega L$, which is independent of the environs of the inductor. If desired, the ground link may be removed to afford a three-terminal ungrounded inductor.

A uniform progressive banked winding is applied around the ceramic core (single winding), avoiding overlapping at the extremities which would result in excessive distributed capacitance. Holes

Figure 2. View of the toroidal inductor before installation in cabinet.

fabricated in the core at the extremities of the winding allow the final turn to embrace either ⅓, ⅔ or all of the flux, thus permitting a finer degree of adjustment. While a toroidal winding is not, inherently, highly efficient with respect to copper loss, the maximum practical amount of copper has been used in all units to produce the highest possible low-frequency Q values. Inductors of 100 mh and less are wound of appropriate Litzendraht wire, and those of 1 mh and less are of "duplex" construction consisting of two paralleled semi-circumferential windings.

These inductors are offered in the convenient 1-2-5 unit values, which permits a precise direct comparison between them on a unity-ratio bridge. For example, the 2-unit may be compared with two 1-units in series, the 5-unit versus two 2-units plus a 1-unit in series, the 10-unit versus two 5-units in series, etc. Complete cross-checking is thus possible in a standardizing laboratory equipped with two sets of these inductors. As catalogued at the present time, inductance values extend from 100μh to 1 h inclusive. These are adjusted with a nominal limit of $\pm$ 0.1 per cent of absolute inductance except the 100-μh and 200-μh units for which the nominal limit is $\pm$ 0.25 per cent.

Additional inductors of 10h, 5h and 2h have been made and can be supplied on special order. The nominal limit for these units is $\pm$0.1 per cent.

A certificate attached to the bottom of the case gives useful data for the precise use of each individual inductor. The series inductance at 100 cycles per second and at the indicated stabilized temperature is given as obtained by direct comparison, precise to better than 0.005 per cent, with a like standard which has been certified by the National Bureau of Standards with an indicated accuracy (see table). Since this comparison measurement is at least sixfold more precise than the Bureau certification, the absolute inductance of each inductor at 100 cps is known within the limits set by the Bureau for its particular magnitude.

It is well known that effective series inductance increases with frequency owing to the existence of distributed capacitance. While insignificant at low frequencies with the smaller-valued inductors, this increase may become appreciable with the larger-valued units. For convenience, the increments to be added to the 100 cycles per second value when operating at 200 cycles per second, 500 cycles per second, and 1 kc are tabulated when they are of significant magnitude. These increments are individually computed from the equation

$$\Delta L = L_2 - L_1 = \left(\frac{f_2{}^2 - f_1{}^2}{f_r{}^2 - f_2{}^2}\right) L_1 \qquad (1)$$

which is precise up to at least 10 per cent of the natural frequency f_r. Individual values of f_r and d-c resistance at the stabilized temperature are measured and tabulated. Using the latter, together with the resistive coefficient of copper, 0.00393, more precise thermal corrections can usually be made than by the use of thermometers.

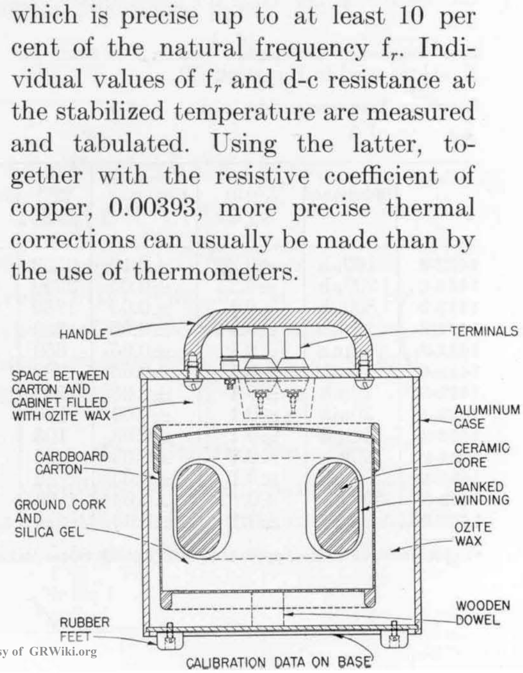


Figure 3. Cross-section drawing of the Type 1482 Standard Inductor showing details of construction and mounting.

Due to the effective thermal insulation afforded by the granulated cork, the input power should be limited to 3 watts, which produces a 20°C. temperature rise in the windings, and for precise work a limitation of 200 milliwatts, Δ T less than 1.5°C., may be taken. Corresponding current limitations may then be set in terms of resistance. These are recorded on the certificate. An auxiliary limitation of 500 volts at the terminals will rarely be encountered within a 20°C. rise in the windings.

At low frequencies, where the inductor is ordinarily used, the dissipation factor depends essentially on copper loss and is given by

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$$D = \left(\frac{R_{d\text{-}c}}{2\pi L}\right)\left(\frac{1}{f}\right) = \frac{K}{f} \qquad (2)$$

For convenience, the numerical value of the coefficient K is recorded on the calibration certificate, f being in cycles per second.

The Type 106 Inductors are now obsolete and are superseded by the new Type 1482 series. The Type 1481 series of fixed toroidal inductors, announced two years ago*, will be continued. These are much smaller in size than the Type 1482 units and, having a ferromagnetic dust core, possess higher 100-cycle Q values at the expense of a voltage coefficient of inductance and a reduced accuracy of calibration.

— Horatio W. Lamson

SPECIFICATIONS

Inductance Range: 100μh to 1 h, inclusive. Inductors of 2h, 5h, and 10h are available on special order.

Accuracy: Nominal limits of adjustment, see table. Limits of measured certificate value, see table.

D-C Resistance: See table for approximate values.

Low Frequency Dissipation Factor: See table for K values used in Equation (2).

Resonant Frequency: See table.

Maximum Input Power:
For 20°C. rise, 3 watts.
For precise work, 1.5°C. rise, 200 milliwatts.
See table for corresponding current limitations.

Mounting: Aluminum cabinet with carrying handle and rubber feet, black crackle finish. Certificate data attached to base of cabinet.

Terminals: Two insulated jack-top terminals, plus ground terminal and strap.

Dimensions: 6½" x 6½" x 8" height overall.

Weight: 11½ pounds.

Type	*Nominal Inductance*	*Nominal Limits* %	*Limits of Certificate Value* %	**Resonant Frequency* kc	**D-C Resistance* ohms	**K Values* Eq. (2)	**Maximum Milliamperes rms for* 200mw	3w	*Code Word*	*Price*
1482-B	100μh	±0.25	±0.10	3500	0.26	400	870	3400	INDUCTOTAG	**$48.00**
1482-C	200μh	±0.25	±0.05	2300	0.37	300	740	2800	INDUCTOTED	**48.00**
1482-D	500μh	±0.1	±0.05	1250	0.54	170	600	2400	INDUCTOTIM	**55.00**
1482-E	1mh	±0.1	±0.05	820	1.03	165	390	1500	INDUCTOTOP	**55.00**
1482-F	2mh	±0.1	±0.05	650	2.00	150	310	1250	INDUCTOTUB	**55.00**
1482-G	5mh	±0.1	±0.05	380	4.4	140	210	800	INDUCTOVAT	**55.00**
1482-H	10mh	±0.1	±0.03	250	8.0	127	160	600	INDUCTOVEX	**60.00**
1482-J	20mh	±0.1	±0.03	170	18	145	105	400	INDUCTOWAD	**60.00**
1482-K	50mh	±0.1	±0.03	105	46	145	66	250	INDUCTOWET	**60.00**
1482-L	100mh	±0.1	±0.03	65	90	145	47	180	INDUCTOWIG	**60.00**
1482-M	200mh	±0.1	±0.03	42	120	96	40	160	INDUCTOWOW	**60.00**
1482-N	500mh	±0.1	±0.03	26	350	110	24	100	INDUCTOYAK	**60.00**
1482-P	1h	±0.1	±0.03	16	590	94	18	70	INDUCTOYES	**60.00**

*Representative values, approximate. Actual values indicated on certificate.