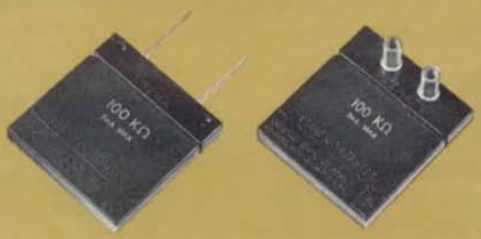
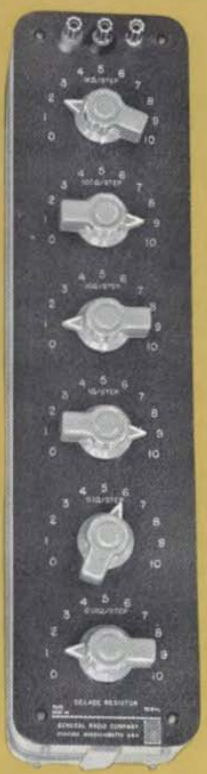
the GENERAL RADIO
experimenter

VOLUME 39 NUMBER 10 OCTOBER 1965



STABLE RESISTANCE STANDARDS

COMPACT, LOW-COST DECADES



INCREASED ACCURACY

in this issue:

RESISTANCE STANDARDS • DECADE RESISTORS • COAXIAL MICROWAVE NEWS

the GENERAL RADIO
experimenter

Published Monthly by the General Radio Company

VOLUME 39 NO 10 OCTOBER 1965

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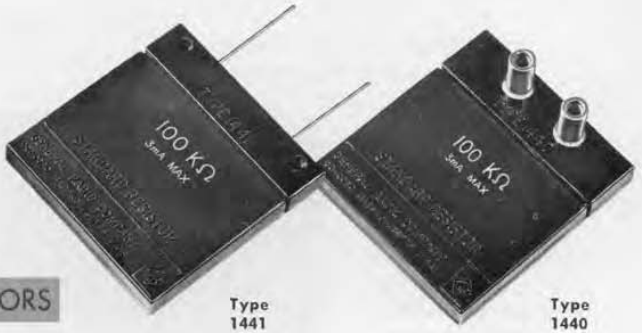
NEW STANDARD RESISTORS



Type 1441 Type 1440

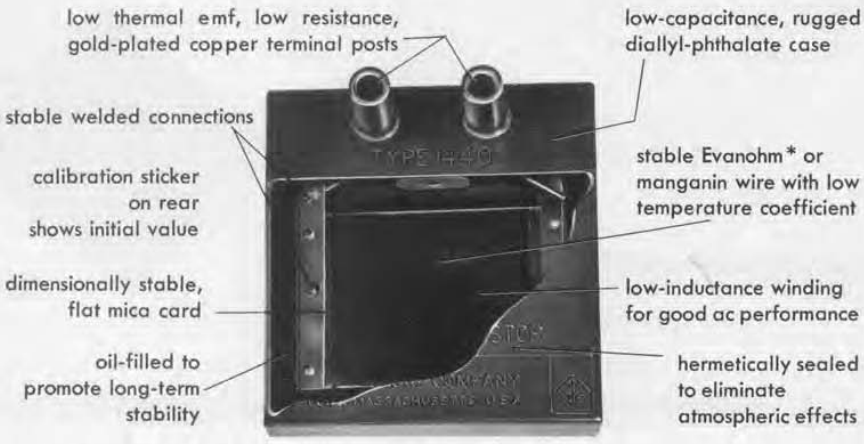
An important objective of our development program for precision resistors has been the design of a resistor unit of high stability for use both as a resistance standard and as a circuit component where ordinary commercial resistors are inadequate. Requirements for such a resistor are:

1. extreme stability
2. high accuracy (close to nominal value)
3. good frequency characteristics
4. low temperature coefficient
5. low thermal emf to copper
6. reasonable size with reasonable power rating
7. moderate price

These requirements are met in the new TYPES 1440 and 1441 Standard Resistors, shown above. These two types use identical resistance units but have different packages to suit the two distinctly different applications.

To obtain high stability, many improved techniques were necessary. First, the units are wound under low tension to avoid unnecessary stresses and wire deformation that would result in future relaxations and cause resistance drift. To do this, we had to build new winding machines with special tension-regulating devices, because no adequate machines were available. After the resistor is wound and welded to the copper terminals, it is artificially aged by repeated temperature cycling to remove stresses. Then the units are welded to the molded-in terminals on the head of the case and adjusted to value. A new abrasion adjustment technique permits extremely fine final adjustment without introducing harmful additional stresses in the wire.

After adjustment, the resistors are encased, filled with a special low-moisture oil, and sealed. All precision resistors must be sealed to avoid chemical reactions with moisture and other components of air. The more common way of sealing is to dip the resistors



* Reg. trademark of W. B. Driver Co.

Figure 1. Cutaway view of the standard resistor, showing construction.

in a rigid or semi-rigid coating. However, any such coating restricts the expansion and contraction of the wire, and stresses develop in the wire. Such coatings are always slightly porous and, if too brittle, are also subject to small cracks, which result in gradual resistance changes, particularly under humid conditions. The use of a sealed, oil-filled case removes these two causes of long-term drift.

After sealing, the units are measured and observed for at least three months and then go through a final inspection where any units that show unusual behavior are eliminated.

Table I shows the average drift for the first year. As is to be expected with wire-wound resistors, these units all show a reduced rate of drift as they age, so that drift during their second year is less.

TABLE I.

AVERAGE DRIFT FOR FIRST YEAR

1 MΩ	*100 kΩ*	*10 kΩ*	*1 kΩ*	*100 Ω*	*10 Ω*	*1 Ω*
7 ppm	6 ppm	2 ppm	3 ppm	8 ppm	8 ppm	10 ppm

Good frequency characteristics are inherent in these units because they are wound on thin mica cards. The inductance of all units is reduced because the wire forms a flat coil with low cross-sectional area. The lower-resistance units, in which inductance is more critical, use the Ayrton-Perry winding, which cancels the magnetic field to a great degree. A plastic (non-conducting) container was chosen to reduce capacitance. Our specifications include the values of residual inductances (for low-resistance values) and capacitances and approximate frequencies at which the effective series and parallel values of resistance will change by 0.1%.

The resistance wire used has a low temperature coefficient and a low thermal emf to copper. A low thermal emf is further ensured by copper terminals on the resistor itself and on the case. The units are shaped to have a relatively large surface-to-volume ratio in order to dissipate one watt without permanent change in resistance. For high-

accuracy measurements, only 0.01 watt should be used to avoid a temperature rise.

Applications

The TYPE 1440 Standard Resistor is intended for use as a laboratory or production standard for calibrating resistance measuring devices, for substitution measurements, and for incorporation in temporary measurement setups. It has gold-plated, copper, jack-top terminal posts and removable, gold-plated banana plugs, both on standard ¾-inch spacing. With the banana plug in place, there are four terminals available for making highest accuracy measurements on the low-resistance units by means of a Kelvin Bridge.

A calibration label is attached, which gives an initial calibration to ± 20 ppm against standards whose values are known typically to ±10 ppm as determined by the National Bureau of Standards. The date of calibration and a serial number are given, and room is provided for future calibration entries. The resistors can be immersed in oil without damage to this label.

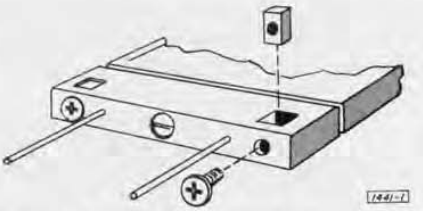


Figure 2. Type 1441 Standard Resistor can be mounted either vertically or horizontally. Hardware is furnished.

The TYPE 1441 resistors are intended for use in equipment requiring resistors of the highest stability. These units have No. 16 tinned copper leads and include hardware for vertical as well as horizontal mounting. Connection to the leads are made ½ inch from the case for calibration measurements on low-resistance units. See Figure 2.

One of the main reasons for developing these resistors was to give us a better precision resistor for use in our own precision instruments. Other equipment manufacturers will find them useful, as will anyone building his own laboratory or production measurement devices.

— W. J. BASTANIER

SPECIFICATIONS

Accuracy: ±0.01% for all units except those of 1 Ω, which are ±0.02%. This accuracy is guaranteed for our standard warranty period of two years, unless the resistor has been damaged by excessive current. Measurements on the low-resistance TYPE 1440 units should be made with a four-terminal connection and on the TYPE 1441's at ½ inch from the case. All measurements at 23°C.

Calibration Accuracy: TYPE 1440 Resistors are calibrated by comparison, to a precision of ±20 ppm, with working standards whose absolute values are known typically to ±10 ppm as determined and measured in terms of reference standards periodically measured by the National Bureau of Standards. The measured deviation from nominal value, at 23°C and 0.01 watt, is entered on the label on the reverse side of the resistor.

Stability: ±30 ppm per year.

Temperature Coefficient (Max): ±10 ppm/°C for resistances above 10 Ω; ±20 ppm/°C for 10 Ω and below.

Power Rating: 1 W. The corresponding current is indicated on the resistor and in the table below. This dissipation will cause a temperature rise of approximately 25°C and a resulting temporary resistance change due to the temperature coefficient. If this rating is exceeded, permanent changes may result.

Residual Impedances: Approximate shunt capacitance (2-terminal measurement), TYPE 1440, 2.5 pF; TYPE 1441, 1.5 pF; less for 3-terminal measurement. Typical series inductance, see price table.

Approximate Frequency Characteristic: See table.

Terminals: TYPE 1440 — gold-plated, jack-top, copper binding posts (¾-in spacing) with banana plugs that are removable and can be replaced by 6-32 screws for installation of

soldering lugs. TYPE 1441 — #16 tinned-copper-wire leads, 1⅛ in. long on 1⅛ in. spacing.

Dimensions (less terminals): Type 1440 — width 2¼, height 2½, depth ⅜ inches (58, 64, 10 mm); TYPE 1441 — width 2¼, height 2 5/16, depth ⅜ inches (58, 59, 10 mm).

Net Weight: TYPE 1440, 2 oz (60 g); TYPE 1441, 1½ oz (45 g).

Shipping Weight: TYPE 1440, 10 oz (0.3 kg); TYPE 1441, 10 oz (0.3 kg).

Resistance	*Max Current*	*Typical Inductance*	*Approx Frequency for 0.1% Resistance Change*		*Type 1440*		*Type 1441*	
			Series R	*Parallel R*	*Catalog Number*	*Price in USA*	*Catalog Number*	*Price in USA*
1 Ω	1.0 A	0.12 μH	300 kc/s	30 kc/s	1440-9601	$10.50	1441-9601	$ 6.50
10 Ω	310 mA	0.13 μH	1 Mc/s	300 kc/s	1440-9611	10.50	1441-9611	6.50
100 Ω	100 mA	0.20 μH	3 Mc/s	1 Mc/s	1440-9621	10.50	1441-9621	6.50
1 kΩ	30 mA	2.5 μH	2 Mc/s	1 Mc/s	1440-9631	10.50	1441-9631	6.50
10 kΩ	10 mA	—	200 kc/s	1 Mc/s	1440-9641	10.50	1441-9641	6.50
100 kΩ	3 mA	—	20 kc/s	100 kc/s	1440-9651	12.50	1441-9651	8.50
1 MΩ	1 mA	—	2 kc/s	10 kc/s	1440-9661	21.50	1441-9661	17.50

When ordering, please specify catalog number, type number and name, resistance value, and price. Any other resistance value between 0.1 Ω and 1 MΩ can be supplied. Please ask for a quotation.

IMPROVED SPECIFICATIONS FOR THE 1432 DECADE RESISTORS

Type 1432-T Decade Resistor

Our general program for developing improved resistors has resulted in more accurate and stable resistors for use in decade boxes as well as in the extremely stable TYPES 1440 and 1441 Standard Resistors described above. New winding, coating, heat-treating, and adjustment procedures have made possible a new two-year warranty of 0.025% for steps of 100 ohms and higher in the popular TYPE 1432 Decade Resistor and TYPE 510 Decade-Resistance Unit.

We want to emphasize that this specification is for a full two years after date of shipment. As discussed elsewhere (see page 12), we feel that this is the information that is most useful to the decade-box user who usually wants to know that his decade is better than some stated accuracy and will remain that way. We also want to point out that we feel that this new specification remains conservative. Our records show that we could have improved our specifications without actually improving the stability of the resistors and still have a reasonably low rate of returned boxes under our warranty. However, we feel that our customers have developed, over the years, a high confidence in the specifications of our

impedance standards of all types, and we want to be very careful not to destroy this confidence by specifying our units too closely. Therefore, we waited until we had made definite improvements in our resistance units to ensure that a closer tolerance would still be a conservative specification.

In the small percentage of decade resistors that have been returned because they were out of tolerance, the difficulty has often occured in the 10-ohms-per-step decade. For a number of reasons, this resistor has been a particularly awkward value to make. The new boxes use 10-ohm units of a new design that has been tested under extreme conditions and has proved to hold its specifications as well as resistors of other values.

Another important improvement in the new decades is the reduced zero resistance, which is now typically 1 milliohm per dial. This is made possible by the use of a silver overlay on the switch contact studs in all positions where the switch resistance affects either the resistance accuracy or the zero resistance. This overlay not only improves the initial zero resistance but it also is much less susceptible to long-term contamination, which was occasionally a problem with the older boxes if they were left for some time in a humid or corrosive environment. Long-term tests in a variety of gas mixtures discolored the new contacts in some cases but made negligible change in their contact resistance.

A third improvement is the use of a solid-copper alloy for the body of the binding posts. This feature is particularly important for low-level dc applications, where the thermal emf from copper wire to a binding post of another metal could result in appreciable errors. These new binding posts are gold-plated to avoid corrosion, and this also distinguishes the new decade boxes from the older models. Actually, the new switch contacts and resistor units have been in use for some time, but, officially, the new specifications apply only to units with gold-plated binding posts.

With the introduction of the new TYPE 1434 series of decade resistors (see page 8) our customers now have a choice between two series of resistance boxes. The new, less expensive units are recommended primarily for circuit design work and other applications where the utmost in accuracy is not required. We recommend the improved TYPE 1432 resistors for applications where a decade box is used as an adjustable resistance standard, or where additional accuracy in the decade could improve accuracy of a measurements system.

NEW SPECIFICATIONS

(For complete specifications, see Catalog S, pp 203 and 204.)

Long-Term Accuracy: See table at right. Our general two-year warranty applies to these tolerances unless the unit is damaged by excessive current. Tolerance shown applies to both resistance increments and total resistance after correction for zero resistance.

Zero Resistance: 1 mΩ per dial at dc; 40 mΩ per dial at 1 Mc/s; proportional to square root of frequency at all frequencies above 100 kc/s.

Resistance Per Step (ΔR) *Ohms*	*Long-Term Accuracy*
0.01	±2%
0.1	±0.5%
1	±0.15%
10	±0.05%
100	±0.025%
1000	±0.025%
10,000	±0.025%
100,000	±0.025%
1,000,000	±0.025%

Catalog Number		Total Ohms	Multiple of	No. of Dials	Price in USA
1432-9721	Type 1432-U	111.1	0.01 ohm	4	$ 98.00
1432-9711	Type 1432-K	1111	0.1	4	102.00
1432-9710	Type 1432-J	11,110	1	4	110.00
1432-9712	Type 1432-L	111,100	10	4	116.00
1432-9717	Type 1432-Q	1,111,000	100	4	127.00
1432-9720	Type 1432-T	1111.1	0.01	5	124.00
1432-9714	Type 1432-N	11,111	0.1	5	128.00
1423-9713	Type 1432-M	111,110	1	5	139.00
1432-9716	Type 1432-P	1,111,100	10	5	154.00
1432-9725	Type 1432-Y	11,111,000	100	5	229.00
1432-9723	Type 1432-W	11,111.1	0.01	6	158.00
1432-9724	Type 1432-X	111,111	0.1	6	165.00
1432-9702	Type 1432-B	1,111,110	1	6	185.00
1432-9726	Type 1432-Z	11,111,100	10	6	262.00

Type 510-B
Decade-Resistance Unit

Catalog Number		Total Resistance Ohms	Price in USA
0510-9806	Type 510-AA	0.1	$19.50
0510-9701	Type 510-A	1	15.00
0510-9702	Type 510-B	10	21.50
0510-9703	Type 510-C	100	23.50
0510-9704	Type 510-D	1000	24.00
0510-9705	Type 510-E	10,000	24.00
0510-9706	Type 510-F	100,000	27.00
0510-9707	Type 510-G	1,000,000	35.00
0510-9708	Type 510-H	10,000,000	98.00
0510-9604	Type 510-P4	Switch only	11.00
0510-9511	Type 510-P4L	Switch only	12.00

A NEW LINE OF INEXPENSIVE DECADE-RESISTANCE BOXES

As the accuracies of decade resistors increase with the state of the art it is almost inevitable that decade-box prices increase also, as a result of the additional procedures necessary to achieve this better accuracy and its required stability. However, it is apparent that many decade-box applications do not require extreme accuracy. One such application would be in the determination of resistor values in the design of electronic circuits. For this and many other uses 0.05% accuracy is sufficient, and such features as lower cost, smaller

Figure 1. *(right)* **Type 1434-QC Decade Resistor includes a continuously variable 100-ohm element (extreme right-hand dial). *(below)* The 7-dial Type 1434-G Decade Resistor can be used on the bench or in a rack. Photograph shows box with rack-mount hardware attached.**

size, and increased readability are more welcome improvements than a closer tolerance.

The new TYPE 1434 Decade Resistors were designed for these applications. They are small and light in weight for convenient use on the designer's bench, and they have a bold in-line readout that is easily interpreted. In addition to three conventional five-digit boxes, two somewhat-different models are offered. One of these, with four digits plus a 100-ohm rheostat, should be particularly useful in circuit-design work, for it has a maximum setting of over a megohm with a resolution of better than one ohm. This is adequate for simulating most resistors used in low-power transistor circuitry.

The larger, seven-dial box goes to over a megohm with 0.1-ohm steps. The panel is relay-rack height (3½ inches) and with supplied hardware forms a neat rack-mounted unit. It also has provision for rear connections so that in a relay-rack it can be wired into systems without wires visible from the panel.

The cost of these boxes is low compared with that of similar units, not because the resistors are of lower quality but because fewer resistors are used. The resistors are similar to those used in our precision boxes (see page 6) but only six units per decade are used, instead of the usual ten.

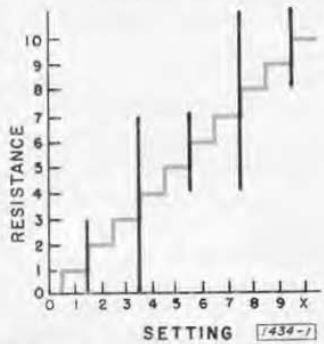


Figure 2. Limits of possible resistance jump during switching for a 1-2-4-4 combination. The system of Figure 3 avoids these jumps.

Anyone familiar with the simplest binary logic could design a decade with only four resistors, and most capacitance and inductance decades are designed this way. However, if only four components per decade are used, there has to be some switching irregularity. For example, in a series 1-2-4-4 scheme it is impossible to switch out the 1 and 2 units and switch in the 4 unit at exactly the same time. The total resistance will jump during the switching process to a value below 3 ohms or to a value above 4 ohms. The limits of possible switching jump are shown in Figure 2. Such a situation is tolerable in capacitance and inductance boxes, but in many resistance-box applications an unexpected jump in resistance value might cause damage to an electronic component. This could happen, for instance, if such a decade resistor were being used to set the bias level on a power transistor operating near its rating.

The six-resistor scheme used has none of these switching jumps and therefore acts as if ten resistors were used. Basically, the method is that of Behr and Tarpley[1], but modern switches have made the practical realization of the scheme much simpler than that of their original description in which some of the resistors had to change physical position. In this scheme six resistors are used, each with a value of two units of resistance. Five of these

[1] Behr and Tarpley, *Proceedings of the IRE*, Vol 20, 1101 (1932).

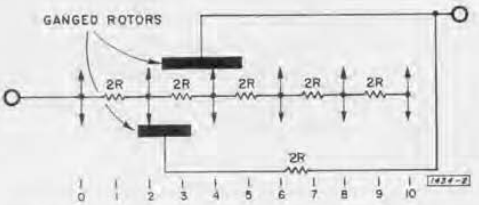


Figure 3. Diagram of the switching system used for the 6-resistor decade. Switch position shown is 3R.

are connected in series and give the even values. The sixth resistor is used to get the odd values by shunting one of the other five, as shown in Figure 3. To avoid a resistance jump the sixth resistor is put in place before it is used.

A minor limitation to this scheme is the slightly reduced maximum current specification. Because the resistor units have the same power rating as do those used in our TYPE 1432 boxes, but have twice the resistance value, the maximum current is reduced by $1/\sqrt{2}$*. We feel that this limitation is unimportant because most modern solid-state circuitry dissipates such very little power.

To ensure long life and low zero-resistance, solid-silver switch rotors and contacts are used, all switching functions are duplicated, and, in the zero position, the switching is repeated four times in parallel. While the resulting "zero resistance" specification is not so good as it is for the new TYPE 1432 Decade Resistors, which use an improved version of the TYPE 510 Decade Switch (see page 6), it is at least as good as that of former versions of this switch (2 milliohms/dial).

Decade boxes in the 1434 series are limited to those using decades with steps of 0.1 ohm to steps of 100 kilohms. Lower-resistance steps are possible, but the need for them is relatively rare, and such units are more satisfactory with the TYPE 510 switch, which is used in the TYPE 1432 Decade Resistors. One-megohm-per-step units are also less popular, and the saving in cost through the use of six resistors disappears, because the cost depends largely on the amount of wire used and would actually be higher for the six-resistor scheme, which uses a total of 12 megohms. We recommend that the TYPE 1432 Decade Resistors be used when these very-low and very-high ranges are required.

We recommend these new boxes for general use when the utmost in accuracy and low zero-resistance are not required and when the resistance range is limited to 0.1 ohm to 1 megohm. They have the important advantages of reduced size and low cost over our TYPE 1432 boxes and other similar units.

— HENRY P. HALL

* The rating of the 0.1-ohm-per-step and 1.0-ohm-per-step decades is reduced slightly more.

SPECIFICATIONS

Long-Term Accuracy: See Table 1. Our general two-year warranty applies to these tolerances unless the resistor is damaged by excessive current. Tolerance shown applies to both resistance increments and total resistance after correction for zero resistance.

Zero Resistance: Approximately 2 mΩ per dial at low frequencies except for the TYPE 1434-QC for which it is approximately 30 mΩ.

Maximum Current: See table; these values also appear on the panel of each decade box. When this maximum current is passed through a decade, the temporary change in value will be less than the accuracy specification. Currents

appreciably higher than this will cause permanent changes.

TABLE I

Total Resistance of Decade	*Resistance Per Step*	*Long-Term Accuracy**	*Max Current*
1 Ω	0.1 Ω	±2.0%	1 A
10 Ω	1.0 Ω	±0.25%	0.3 A
100 Ω	10 Ω	±0.07%	160 mA
1 kΩ	100 Ω	±0.05%	50 mA
10 kΩ	1 kΩ	±0.05%	16 mA
100 kΩ	10 kΩ	±0.05%	5 mA
1 MΩ	100 kΩ	±0.05%	1.6 mA
100-Ω Rheostat**	1 Ω/div	±1 Ω	200 mA

* At low currents and low frequencies.
** Used in TYPE 1434-QC.

Temperature Coefficient: Less than ±10 ppm/°C at room temperature, except for the low-valued units where the 0.4%/°C temperature coefficient of the zero resistance must be added.

Frequency Characteristics: Generally similar to those of the TYPE 1432 Decade Resistors.

Switches: Multiple, solid-silver-alloy switches are used to obtain low and stable zero resistance.

Terminals: Jack-top binding posts (TYPE 938-A) on standard ¾-inch spacing. A shield terminal is also provided. The TYPE 1434-G has lug connections accessible from the rear.

Mounting: All types except the TYPE 1434-G are in small cabinets for bench use. The TYPE 1434-G is also designed for bench use but, with the addition of mounting hardware, becomes a 3½-in high, 19-in relay-rack unit.

Dimensions: TYPE 1434-M, N, P, QC — width 11⅝, height 2¾, depth 4¼ inches (298, 70, 110 mm); TYPE 1434-G (bench) — width 17$\frac{5}{16}$, height 3½, depth 5 inches (442, 89, 130 mm); TYPE 1434-G (rack) — width 19, height 3½, depth behind panel, 3½ inches (485, 89, 89 mm)

Net Weight: TYPE 1434-M, N, P, QC, 3 lb (1.4 kg); TYPE 1434-G, 6 lb (2.8 kg).

Shipping Weight: TYPE 1434-M, N, P, QC, 4 lb (1.9 kg); TYPE 1434-G, 7 lb (3.2 kg).

Catalog Number	*Description*	*Total Resistance*	*Resistance Per Step*	*Number of Decades*	*Price in USA*
1434-9714	**Type 1434-N Decade Resistor**	11,111	0.1 Ω	5	**$ 99.00**
1434-9713	**Type 1434-M Decade Resistor**	111,110	1.0 Ω	5	**109.00**
1434-9716	**Type 1434-P Decade Resistor**	1,111,100	10 Ω	5	**113.00**
1434-9576	**Type 1434-QC Decade Resistor**	1,111,105	1 Ω/div	4+rheostat	**101.00**
1434-9707	**Type 1434-G Decade Resistor**	1,111,111	0.1 Ω	7	**155.00**

X IS 10

On our new TYPE 1434 Decade Resistors, as on several other of our new instruments that have a digital readout, we have adopted the convention of using an **X** to denote a 10. Thanks to the Romans, we have a couple of thousand years precedent for this use even though X-is-10-tialism is a rather modern philosophy.

This convention is most useful. For example, most decade boxes have always included a 10 setting in order to facilitate adjustments near a setting of any "round" number. Consider the number of adjustments necessary to go from 49999 to 50000 if the maximum value on each dial were 9. If the last digit went to 10, only one dial would have to be adjusted. However, if the readout is in line, as is now popular, this would result in successive readings of 49999 and 499910, which is wrong by a factor of 10. Clearly, some other symbol, such as **X**, is required to denote 10 to avoid adding the extra digit.

Some practice is required to convert numbers using the **X** into conventional numbers. We suggest that data be taken just as it appears on the readout and conversion carried out later. This not only avoids making mistakes that cannot be checked later but also records the exact dial setting, which may be important in precision work.

DECADE-RESISTOR ACCURACY SPECIFICATIONS

General Radio welcomes, and is participating in, the efforts to produce industry standards for the writing of specifications for decade boxes and related devices. In the meantime the prospective purchaser is faced with comparing the published specifications of different manufacturers and soon begins to suspect that, although the same words are being used, the meanings of the words are not necessarily the same.

Many different terms are used to express the accuracy of decade resistors. Among them are "initial accuracy," "accuracy of adjustment," "calibration accuracy," and just plain "accuracy." We have chosen the term "long-term accuracy" because we feel that this is the specification that is most informative and useful.

In most applications the user of a decade resistance box doesn't want to look at a correction chart (as he might for a single standard resistor) and then to calculate the corrected value for any setting. Also he is not particularly interested in what the accuracy was before the box was shipped to him, and the simple, unmodified term "accuracy" leads to the question of "for how long". Instead, he would like to pick up a decade box and have high confidence that it is within a given tolerance.

By the adjective "long-term" we mean two things. First, GR decade boxes, like all GR instruments, are sold under a two-year warranty. If a decade box is returned because it is outside specifications (without evidence of overload or other abuse) within two years, we will repair and readjust it at no charge*. Secondly, our experience indicates that our decade boxes will hold their specification for many more years, because wire-wound resistors almost always exhibit their greatest changes early in their life. Therefore, if the accuracy of a decade resistor is conservatively rated for a two-year warranty, it probably will be within this specification for many more years.

Obviously, the conditions of measurement have to be explained, and our wording of the specification paragraphs is an attempt to clarify these conditions.

The accuracy we refer to is the accuracy of the resistance difference between any arbitrary setting and the zero setting. It is necessary to take this difference not only because of the residual "zero resistance" of the decade box (a maximum value is specified) but also because of the resistance of any external connecting leads, which, in most cases, will be much larger. The accuracy statement also applies to each separate resistor so that the difference between any two settings on a given dial is accurate to the stated tolerance. This accuracy refers to measurements made at room temperature (23°C), at low power, and at dc or a low frequency. The effects of ambient temperature, applied power, and frequency are given elsewhere in the specification and should be added to the accuracy tolerance to obtain the tolerance under any specific condition.

* Subject to the conditions stated in our standard warranty.

14-dB (5×) ATTENUATOR

A calibrated fixed attenuator is a convenient device for accurate voltage division in measurement or test systems. In pulse work, moreover, it is important that the division be accomplished without deterioration in rise-time performance.

A recent addition to the GR874 coaxial attenuator line that very nicely meets this criterion in the TYPE 874-G14, a 14-dB unit that gives a 5× voltage division. It rounds out the line

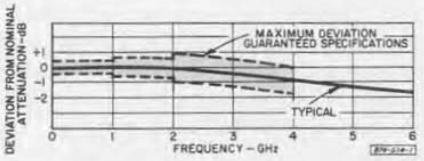


Figure 1. Attenuation vs frequency.

in the 10:1, 5:1, and 2:1 division ratios popular with oscilloscope and other pulse-equipment users.

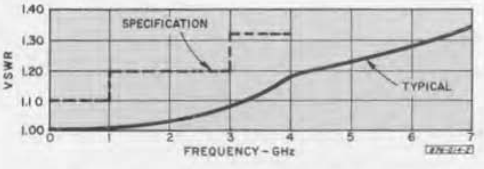
Like the familiar TYPE 874-G6 (2×) and TYPE 874-G20 (10×) Attenuators, it is a 50-ohm T-network fitted with the GR874 Coaxial Connectors. The network elements are carbon-film resistors, for superior performance in handling high-power pulses, and resistance values are held to within ±1%.

As can be seen from Figure 1, the frequency response of attenuation is quite flat. This fact, coupled with the low-VSWR obtainable through the use of the GR874 Connector (as shown in Figure 2), makes these units attractive for pulse applications all the way up to the fractional-nanosecond-rise-time category.

Another important use of attenuators is found in coaxial systems for measuring power, impedance, and VSWR. Attenuators are used to match generator and detector to the 50-ohm line impedance and to isolate the generator from the measuring circuit to prevent changes in load from reacting upon the amplitude and frequency of the generator.

— J. ZORZY

Figure 2. Voltage-standing-wave ratio vs frequency.



Catalog Number	*Description*	*Price in USA*
0874-9560	**Type 874-G14 14-dB (5X) Fixed Attenuator**	**$30.00**

U. S. Patent No. 2,548,457

TYPE 874-BBL CONNECTOR

A few years ago a locking version of the GR874 Connector, fully compatible with the nonlocking connector yet retaining the hermaphrodite feature, was introduced to provide an electrically and mechanically stable connection and to minimize leakage. While retaining all these characteristics, the TYPE 874-BBL Connector, the latest addition to the GR874 connector series, has a lower VSWR over an extended frequency range, with improved reliability and repeatability of connection.

The TYPE 874-BBL Connector, shown above, replaces the TYPE 874-BL connector for use on rigid 50-ohm air lines. Dimensionally the same, it can be distinguished by a grey (vs clear) bead support and an inner conductor with coated threads. Typical VSWR performance of the TYPE 874-BBL Connector over the 0- to 9-GHz range is shown in Figure 1.

The extended frequency range and improved performance are a direct result of two factors. First, the new polystyrene-bead support is specially compensated. The second improvement factor is the new inner-conductor locking arrangement, achieved by addition of a coating of lead-tin on the 8-32 thread of the connector inner conductor. When the connector inner conductor is threaded into the air-line inner conductor, the coating acts as a semipliable filler. It produces a very reliable electrical contact with a mechanical lock (of about 4 inch-pounds of torque) that prevents loosening of the inner-conductor joint.

Typical VSWR repeatability when the connector junction is repeatedly made and broken, for direct and 180° relative orientation of the mating connectors and extremes of relative rotational play between the mating connectors, is shown in Figure 2. Typical phase repeatability (variation in electrical length) under similar conditions is shown in Figure 3. This latter characteristic is of principal importance in phase-measuring systems, including phased-array radar systems, when disconnection and reconnection of connector junctions in the phase-information paths must be made.

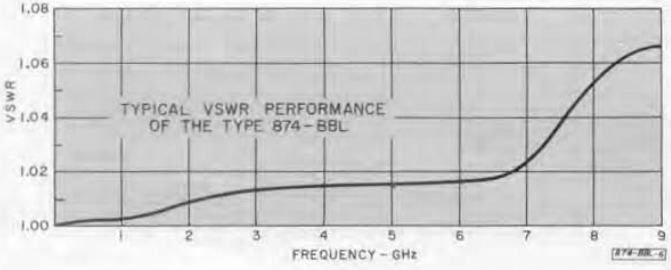


Figure 1. Plot of VSWR vs frequency for a typical mated pair of Type 874-BBL Coaxial Connectors.

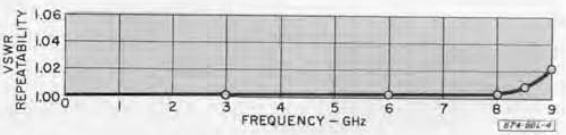


Figure 2. Repeatability, as a function of frequency, of the VSWR when the connection is repeatedly made and broken, for direct and 180° relative orientation of the connectors.

GR874 Connectors are used widely on fast-rise-time pulse equipment, including time-domain reflectometers. In those applications, where it is important that reflections from the connectors be small, the TYPE 874-BBL Connectors are recommended. Figure 4 shows a recording of a time-domain reflectometer display for a pair of TYPE 874-BBL Connectors inserted between two air-line sections that are equipped with GR900 Precision Coaxial Connectors.

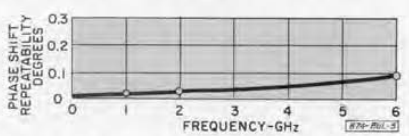


Figure 3. Phase-shift repeatability under same conditions.

Required dimensions for the air-line outer and inner conductors, for proper mounting of the connector, are shown in Figure 5. Two significant changes (vs the TYPE 874-BL) have been made in the preparation of the inner conductor. The 0.162-inch diameter step is needed to achieve the electrical performance indicated. The 0.141-inch diameter is required for proper mechanical fit between the connector inner conductor and the air-line inner conductor.

— T. E. MACKENZIE

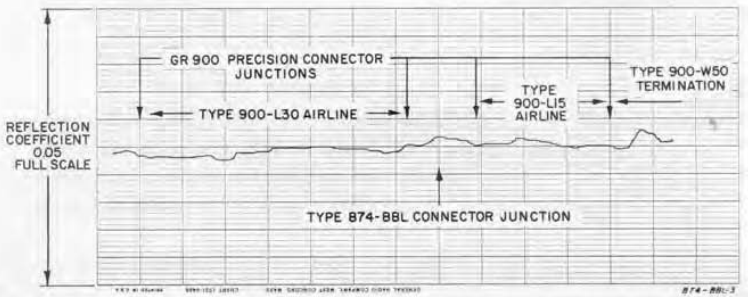


Figure 4. Time-domain reflectometer record for a pair of Type 874-BBL Coaxial Connectors inserted between two air-line sections equipped with GR900 Precision Coaxial Connectors.

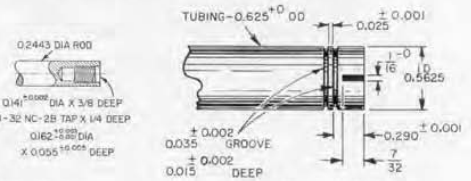


Figure 5. Installation dimensions for Type 874-BBL Coaxial Connector. Ends of pieces should be flush, within $+0 \atop -0.004$ inch. Allow minimum of 0.531 inch of unobstructed tubing to permit mounting of locking nut. All dimensions are in inches.

Catalog Number	*Description*	*Price in USA*
0874-9403	**Type 874-BBL Connector, locking**	**$3.25**

U. S. Patent No. 2,548,457

This new, 16-page, illustrated booklet describes some of many ways that the GR Variac® adjustable autotransformer is used in laboratories, factories, and educational institutions — for plastic molding, stage lighting, vacuum coating, distillation, packaging, speed control, electrical testing, and temperature control. Free on request — write for your copy today.

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