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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

A RADICALLY NEW COAXIAL CONNECTOR FOR THE LABORATORY

Also

IN THIS ISSUE

THE NEW TYPE 874 Coaxial Connector has been demonstrated to a number of engineers during the past two years both at our laboratories and at radio engineering conventions[1]. Their approval has been almost unanimous. Two important characteristics are combined in this connector, unparalleled convenience of use and excellent electrical performance. Intended for use at all frequencies from 0 to over 4500 Mc, it is applicable wherever a shielded connection is needed. The characteristic impedance is 50 ohms, and the electrical uniformity, important at ultra-high frequencies, is excellent. It is available for use in coaxial parts and systems of all kinds, such as slotted lines, stubs, attenuators, bolometers, and certain flexible cables; and on panels of instruments such as oscillators, signal generators, receivers, bridges, and amplifiers.

The unique feature of the design is that two identical TYPE 874 Connectors plug smoothly into each other without any intermediate elements, and the complication of male and female assemblies is completely avoided. A strong friction grip is made by the multiple, spring-loaded contacts, so that no locking means is required, and connections

[1]W. R. Thurston, "Coaxial Elements and Connectors." Proceedings of the National Electronics Conference, 1947, pp. 97–108.

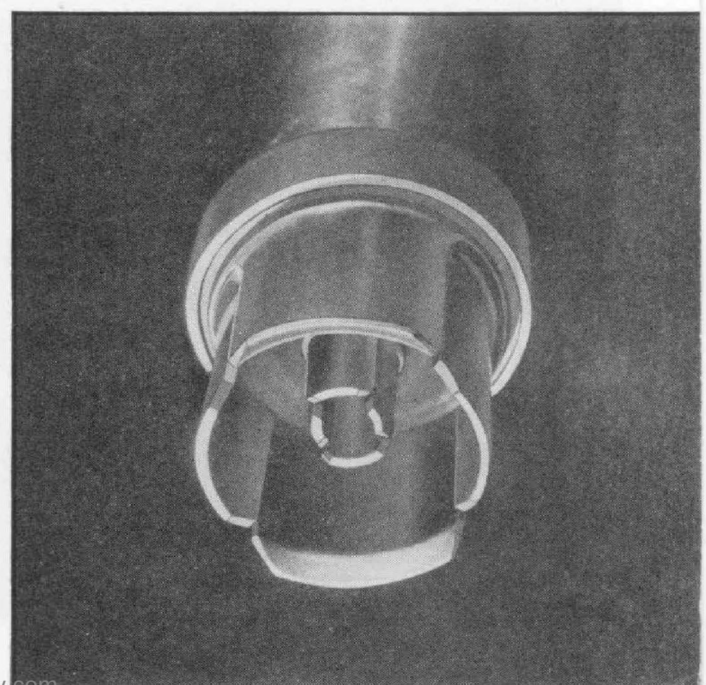


Figure 1. Type 874 Coaxial Connector (approximately 1½ times normal size).

can be made and broken very quickly and conveniently. The basic elements of the connector are an inner conductor, an outer conductor, and a supporting polystyrene bead. Figure 1 shows one of these connectors assembled at the end of a rigid, 50-ohm, air-dielectric, coaxial line. The inner and outer conductors are similar in principle; each is essentially a tube with four longitudinal slots in the end and with two opposite quadrants displaced inward. To make a joint, two connectors are plugged together so that the undisplaced quadrants of one connector overlap the displaced quadrants of the other. Figure 2 is a cross-section sketch of a joint in which the elements of one connector are shaded dark and those of the other light. The mutual overlapping referred to can be seen, as well as the resultant circularity of the joined conductors.

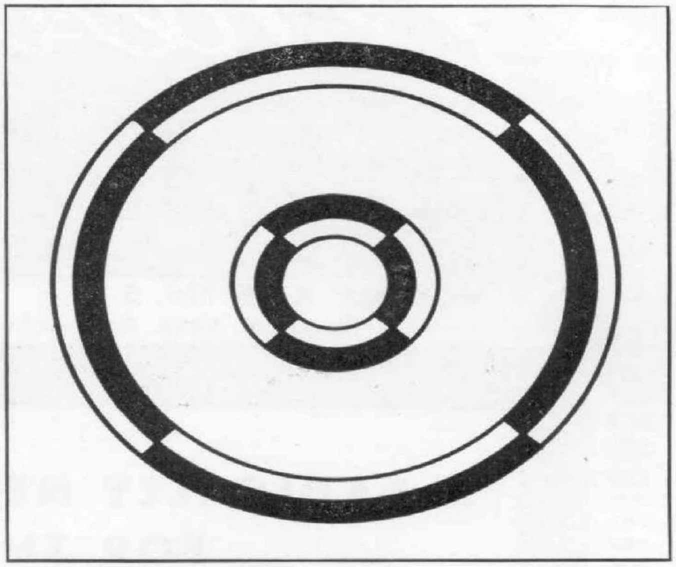
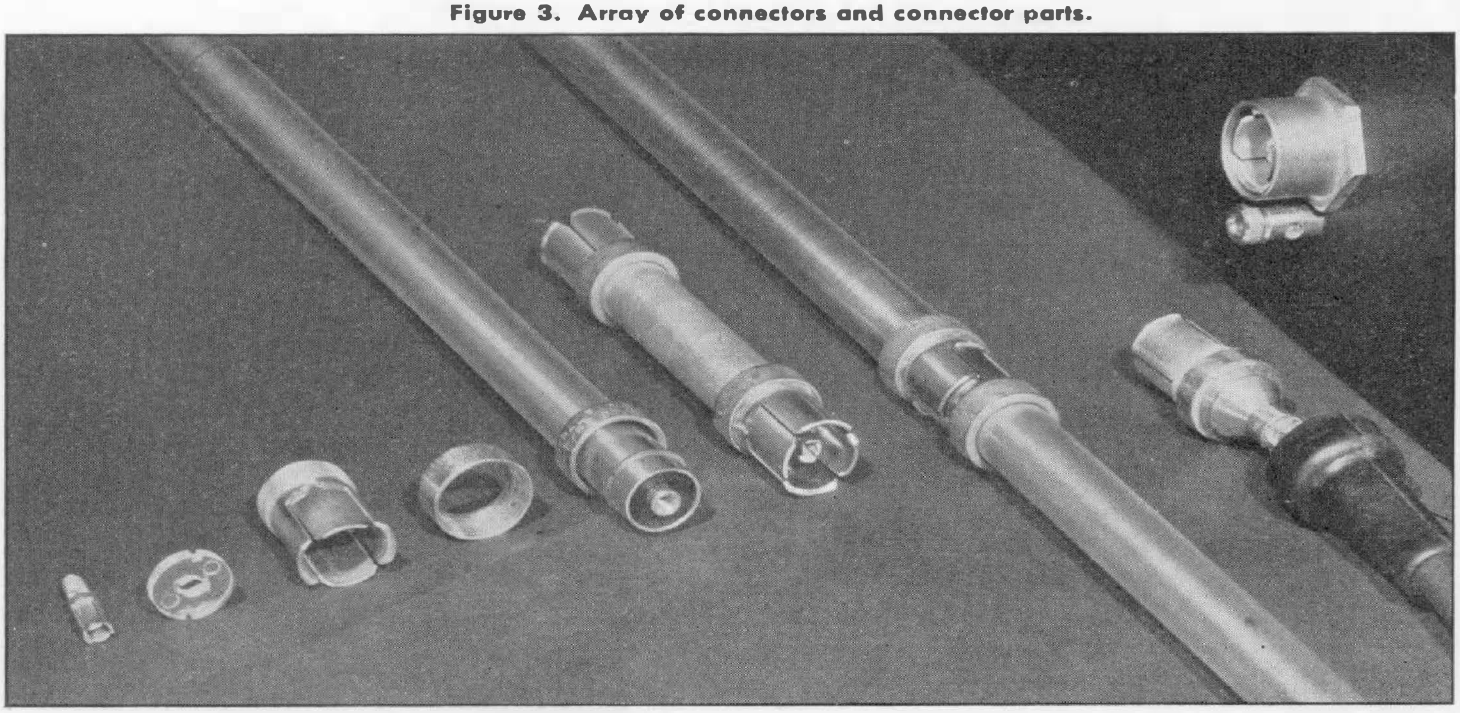


Figure 2. Cross-section sketch of overlapping joint.

Some connector parts and the basic, cable, and panel forms of the connector are shown in Figure 3. Shown at the left is the inner conductor, the polystyrene bead, the outer conductor, and the coupling nut, which holds the connector together. Next in order are a rigid, 50-ohm, air-dielectric line prepared as described in the specifications below to take a connector, two connectors assembled at the ends of a 10-cm. air line, and a connector joint between two air lines. The cable and panel forms of the connector are on the right of the figure. The cable connector is made from the basic connector elements by the addition of two tapered pieces for the cable connection and a rubber guard, and is shown in detail at the left of Figure 4. The panel connector is obtained by the addition of the panel adapter, which holds the basic connector elements on a

Figure 3. Array of connectors and connector parts.

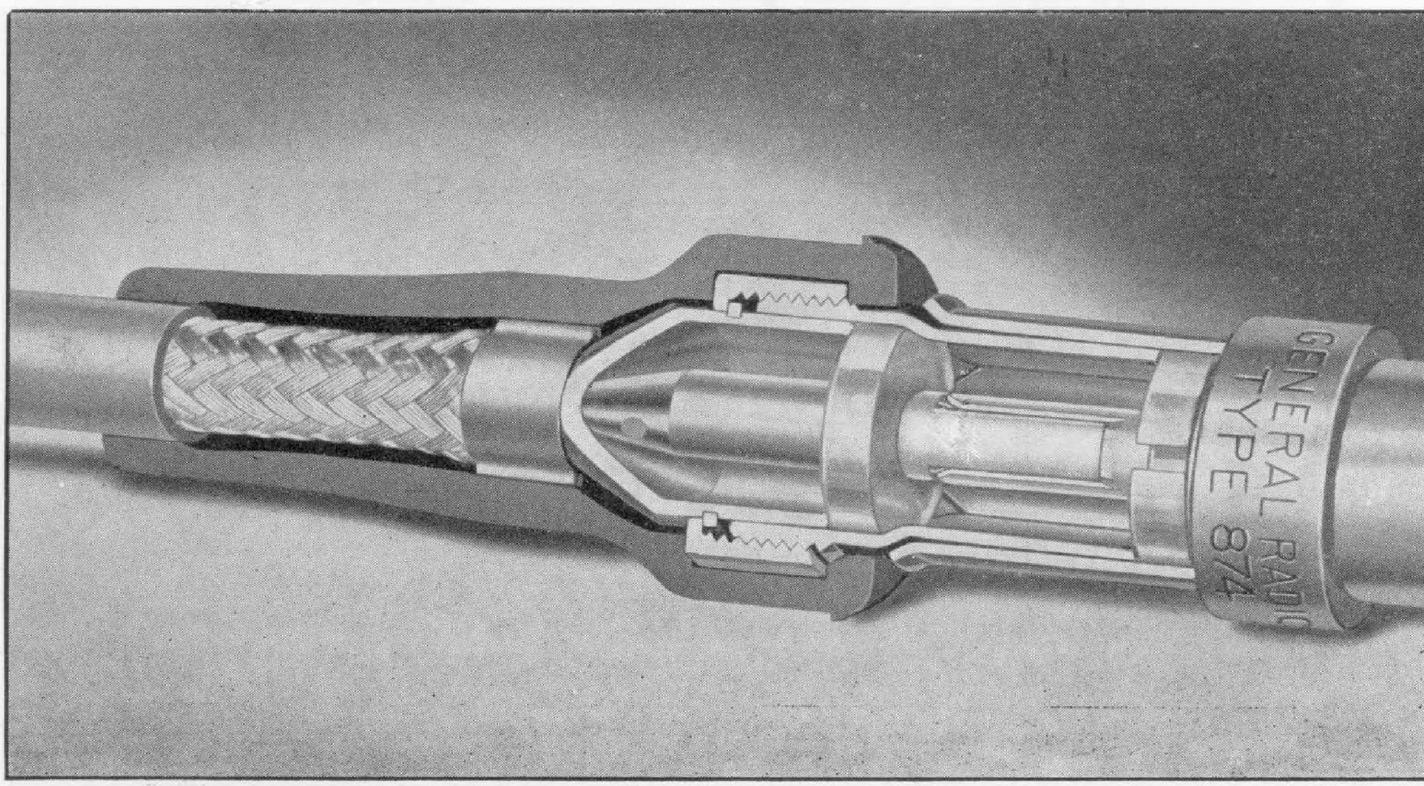


panel. The panel connector also includes two tapered pieces for a cable connection. A useful feature of the Type 874 Connector is that the axial hole in the inner conductor (see Figure 1) will receive a Type 274 Plug, the so-called "banana" type. Therefore, the addition of a binding post beside a panel connector, as shown at the right of Figure 3, makes it possible to plug a Type 274 Double-Plug Connector directly into the Type 874 Panel Connector without an adapter. This feature is particularly valuable for wide-frequency-range instruments, because at high frequencies a shielded coaxial connection is necessary, while at low frequencies an unshielded, two-wire connection is often allowable and more convenient.

One of the most interesting electrical characteristics of a coaxial connector is its performance at ultra-high frequencies, as measured by the reflections it causes in an otherwise matched line. To make reflections small, the characteristic impedance of the Type 874 Connector has been made the same at all points, and discontinuities are minimized. Figure 4 is a cut-away view of two connectors plugged together. The joint portion of the connection, at the right of the figure, can be seen to be a fairly uniform coaxial section, as also shown by Figure 2, and the effective diameter ratio of the conductors in the bead sections is so chosen as to maintain the 50-ohm impedance level. The input standing-wave ratio of a connector joint terminated by a 50-ohm matched line was measured for each of twenty separate connections made from among a group of twelve pilot-production-lot connectors over the frequency range from 1000 Mc to 4500 Mc. The solid curve of Figure 5 shows for each frequency the average of the twenty measured values of standing-wave ratio expressed in decibels[2], and the dashed curve shows for each frequency the maximum of the twenty values. The average is less than 0.3 db over the entire range. and the worst single value measured is 0.8 db for one pair of connectors at 3500 Mc. The maximum error of any single meas-

[2]Standing-wave ratio expressed in decibels = 20 $\log_{10} S$, where S is the numerical voltage-standing-wave ratio.

Figure 4. Cut-away view of basic connector joined with cable connector.



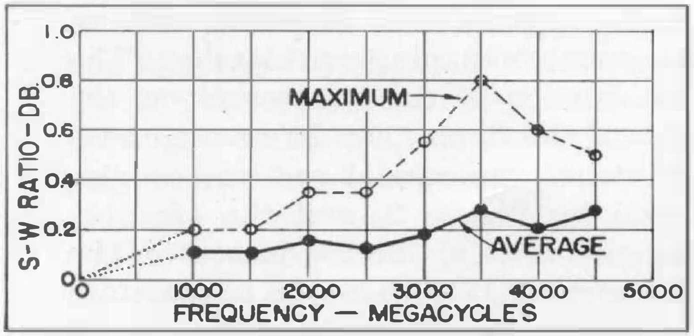


Figure 5. Type 874 Connector standing-wave ratio as a function of frequency.

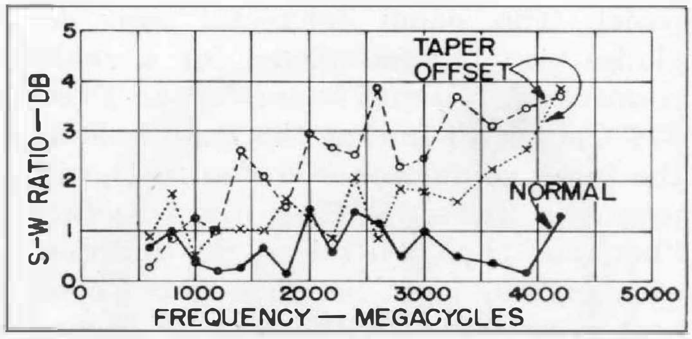
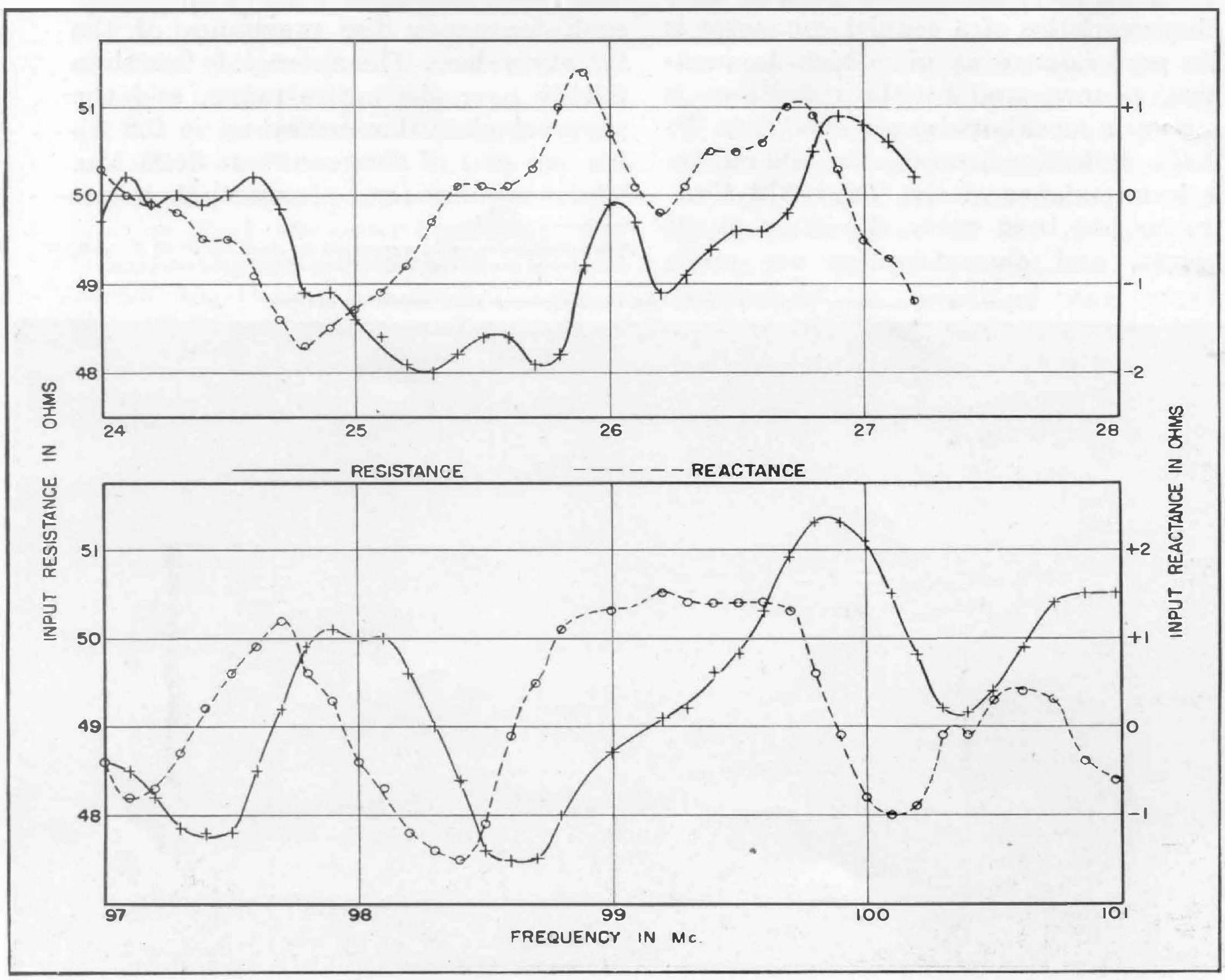


Figure 7. Input standing-wave ratio of Type 874-C Cable Connector terminated by long cable.

urement was less than ±0.2 db, except at 4500 Mc where it was ±0.3 db. These reflections are so small that they can be neglected in most measurements of moderate accuracy, and so this connector is well suited for use on ultra-high-frequency measuring equipment. External fields from the connector are so low as to be negligible in all the usual applications.

The basic connector fits a ⅝-inch O.D. tube, and the coupling nut determines the maximum diameter of 1³⁄₁₆ inch. The inner conductor is made of hardened beryllium copper and has the

Figure 6. Input impedance as a function of frequency for 2400 feet of Type 874-A2 50-ohm coaxial cable. Measurements were made on a v-h-f bridge.



necessary flexibility for receiving a banana plug as mentioned above. The outer conductor is of hard brass. The polystyrene supporting bead is molded with keyways, one of which can be seen in the right-hand bead in Figure 4, for positive alignment of the inner and outer conductors. All metal parts are finished in bright-alloy plate.

No special tools are needed to assemble these connectors.

For use with the connectors, a flexible, low-loss, coaxial cable of 50-ohm characteristic impedance is available. The TYPE 874-A2 Polyethylene Cable is designed for the high-frequency laboratory, where mechanical flexibility is a great convenience. Flexibility greater than that of other commonly used cable types of approximately the same impedance level has been achieved by using an inner conductor made up of many strands of small diameter wire and by choosing a medium over-all diameter for combining sturdiness and uniformity with flexibility. Low electrical leakage is achieved by means of two braided shields. Figure 6 shows the results of bridge measurements of input impedance of a 2400-foot length of TYPE 874-A2 Cable in the vicinity of 25 Mc and 100 Mc. With this length of cable the effects of reflections from the far end are negligible. The characteristic impedance of a flexible cable varies from point to point due to dimensional changes and produces the observed variations in input impedance with respect to frequency. The solid curve of Figure 7 shows the results of a similar cable measurement up to 4200 Mc, except that in this case a slotted line was used to measure the input standing-wave ratio of a very long cable connected to the line by means of a TYPE 874-C Cable Connector. The characteristic variation with frequency is present as at lower frequencies, and the lack of any definite trend with frequency shows that reflections caused by the connector and its tapered transition section are small compared to reflections caused by the cable itself. For comparison, the dashed and the dotted curves show the gradual trends caused by deliberate offsets of the outer taper with respect to the inner taper by distances of plus and minus 0.1 inch.

While it is planned eventually to use the TYPE 874 Connector on all new instruments requiring shielded connections, the TYPES 874-Q2 and 874-Q7 Adapters shown in Figure 8 are available for use with existing General Radio equipment.

The TYPE 874 Connector is presented as a useful element for simplifying laboratory work, with special advantages at ultra-high frequencies. A group of coaxial elements for making many kinds of ultra-high-frequency measurements, and using the TYPE 874 Connector throughout, is at present under development. At the present time the items listed below are available, and other coaxial elements will be announced later.

— W. R. THURSTON

Development of the TYPE 874 Coaxial Connector was carried out under the supervision of Eduard Karplus, who conceived the original idea of a universal connector and worked out the original design. In the development of the final design, the mechanical engineering was done by Harold M. Wilson, and the electrical engineering by William R. Thurston, author of the foregoing article.

— EDITOR.

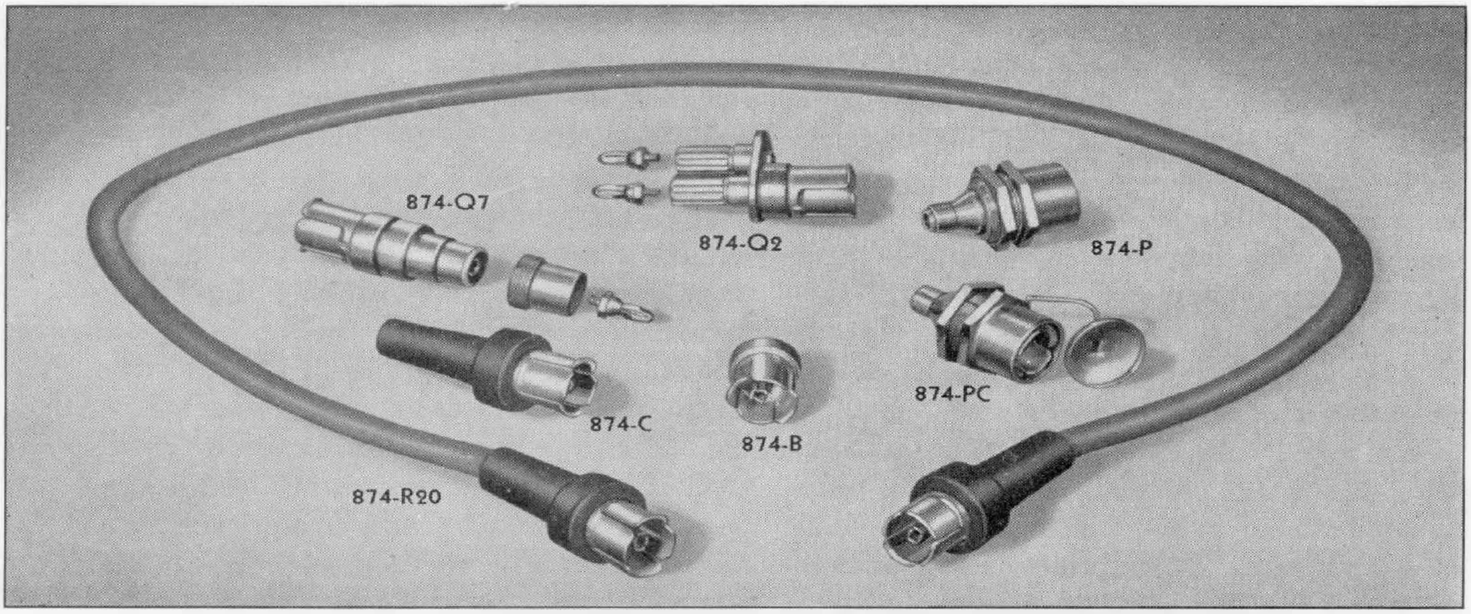


Figure 8. Coaxial connectors and parts now available.

SPECIFICATIONS

Type 874-B Basic Connector consists of inner and outer conductors, insulating bead, coupling nut, and retaining ring. This connector is designed for attachment to rigid, 50-ohm, air-dielectric, coaxial line made from ⅝″ O.D., 9⁄16″ I.D. tubing, and 0.244″ D rod. The inner conductor is to be screwed into an 8-32 tapping in the end of the rod, and the retaining ring for the coupling nut is to be snapped into a groove cut in the ⅝″ tubing.

Type 874-C Cable Connector contains the basic connector parts plus inner and outer transition pieces, a soft copper ferrule, and a rubber guard. The transition pieces are designed to attach to Type 874-A2 Polyethylene Cable and are tapered so as to maintain the 50-ohm characteristic impedance of the connector and cable throughout the change in diameters. The cable inner conductor is to be soldered to the inner transition piece, and the cable braid is attached to the outer transition piece by crimping the ferrule. The rubber guard provides a protective handle.

Type 874-P Panel Connector is similar to the cable connector, including transition pieces for Type 874-A2 Cable, except that a panel adapter, clamp ring, and nut are supplied in place of the rubber guard. The panel adapter is designed to clamp the connector in any desired orientation.

Type 874-PC Panel Connector with Cap is similar to the Type 874-P except that the panel adapter is equipped with a captive, hinged, spring cap that effectively shields the open connector when not in use.

Type 874-Q2 Adapter is designed for making the output of a coaxial system available at a pair of ¾-inch-spaced binding posts or plugs.

Type 874-Q7 Adapter is used to connect from a Type 874 Coaxial Connector to any Type 774 Coaxial Connector.

Type 874-A2 Polyethylene Cable consists of a No. 14 stranded inner conductor, separated from a double-braid tinned-copper shield by 0.244″ O.D. Polyethylene N1 insulation, and with an outer gray Plastex jacket 0.365″ O.D. The characteristic impedance is 50 ohms $\pm 5\%$, and the nominal capacitance is 32 $\mu\mu$f per foot. The attenuation at 100 Mc is about 2.6 db per 100 feet, and at 1000 Mc about 10.5 db per 100 feet.

Type 874-R20 Patch Cord consists of three feet of Type 874-A2 Polyethylene Cable with a Type 874-C on each end.

Type		*Net Weight*	*Code Word*	*Price*
874-B	**Basic Connector**	1⅔ oz.	COAXBRIDGE	**$1.50**
874-C	**Cable Connector**	1¼ oz.	COAXCABLER	**2.00**
874-P	**Panel Connector**	2¼ oz.	COAXPEGGER	**2.25**
874-PC	**Panel Connector with Cap**	2¼ oz.	COAXCAPPER	**2.75**
874-Q2	**Adapter**	2¼ oz.	COAXTIPPER	**3.00**
874-Q7	**Adapter**	2¼ oz.	COAXPASSER	**3.75**
874-A2	**Polyethylene Cable**	1½ oz./ft.	COAXCUTTER	**0.50/ft.***
874-R20	**Patch Cord**	7 oz.	COAXHATTER	**6.25**

*In lengths of 100 feet or more, $27.00/100 ft.

Type 874 Connectors are licensed under U. S. Patent No. 2,125,816; patent applied for.

VARIAC RATINGS

Important to All Present or Future Variac Users

Variac ratings are sometimes misunderstood or ignored, often with unfortunate results. Previously published material covering ratings may, perhaps, have lacked proper emphasis and clarity.

The several Variac ratings are, at first glance, confusing, yet they are all required to define exactly the limits of Variac performance. Each should be thoroughly comprehended for optimum results.

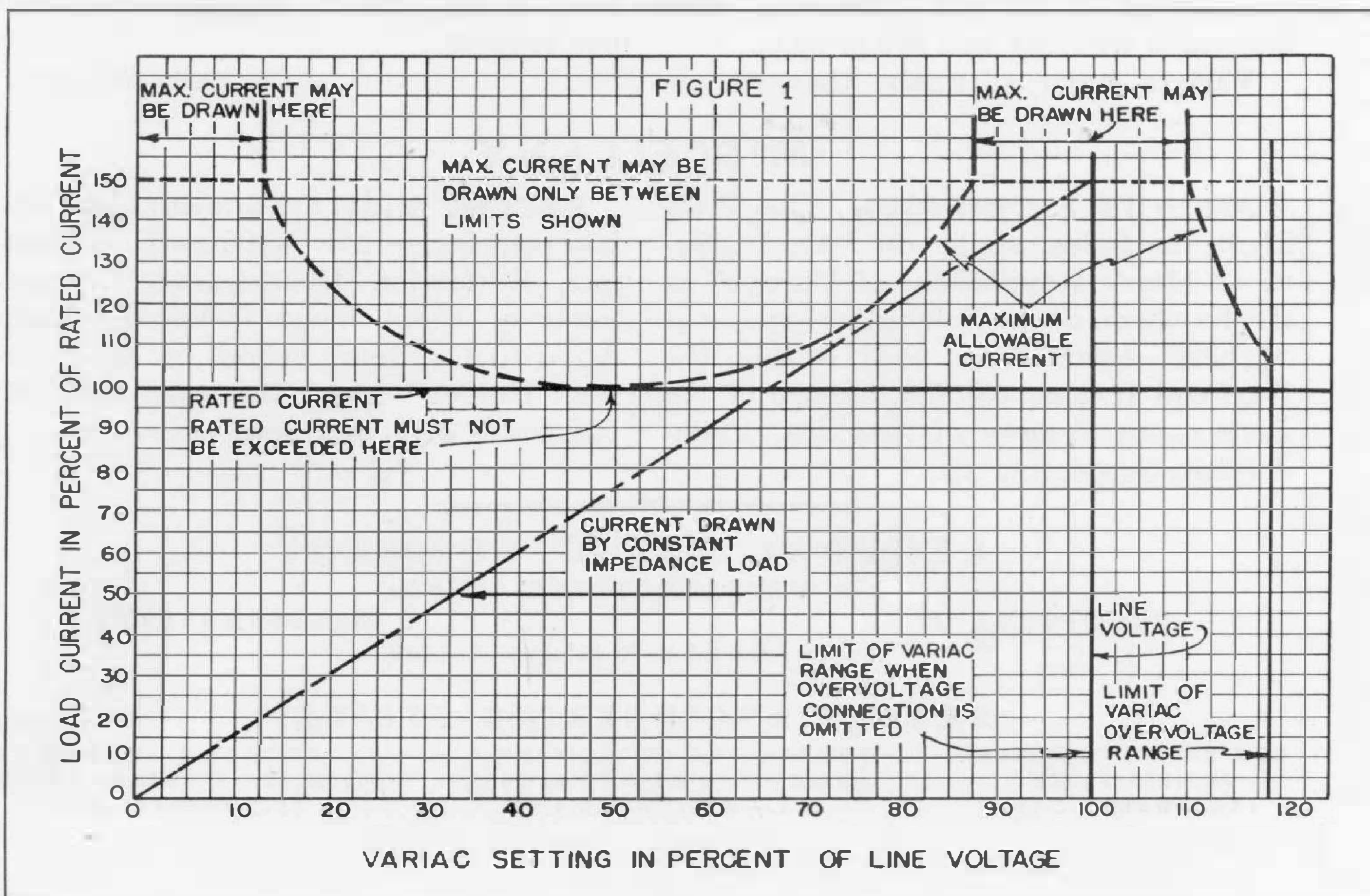
As with all continuously adjustable autotransformers, the current that may be drawn from a Variac through the brush is not constant (as in fixed transformers) but varies as a function of the Variac brush setting. Near zero and line voltages, winding heat is low and brush heat becomes the principal current limitation. At fifty and one-hundred-seventeen per cent of line voltage, winding heat is the dominant factor. Both factors operate at intermediate settings.

Figure 1 is a graphic illustration of these conditions. *The figure is typical, not specific;* 230-volt models differ from the curve shown. *Consult individual Variac instruction sheets for particulars.* The curves are:

1. Rated Current, solid line, determined by maximum winding heating. *Rated Current may be drawn at any setting.*

2. Maximum Allowable Current, dashed line, determined jointly by winding and brush heating.

3. Maximum Current, dotted line, determined by brush heat. *Maximum Current may be drawn at, or near (within approximately ten per cent of line voltage), line voltage and zero.*



In any doubtful application, play safe; keep within Rated Current at all times!

The straight dot-dash line in Figure 1, which connects the point of intersection of Maximum Current and Line Voltage with the zero-zero point, represents the current versus voltage curve of a typical load. (Technically, the curve is for a "constant impedance" load, and most Variac loads approximate this curve.) Since the line lies entirely below the Maximum Allowable Current curve, this means that a load which draws Maximum Current at line voltage can be regulated between zero and line voltage (not higher) without overloading the Variac. Variac kva ratings are derived from this concept. We believe load ratings based on other than standard line voltages are meaningless as all readily procurable electrical devices are designed for operation on these same standard voltages. Ratings are on a volt-ampere, or kilo-volt-ampere (kva), basis because it is current (amperes) that generates winding and brush heat.

Variacs have adequate thermal capacity to withstand overloads up to five times Rated Current for short periods (five seconds), as in motor-starting. Larger currents rapidly generate brush temperatures exceeding the softening temperature of the copper wire winding, with consequent damage to the wire surface beneath the brush.

Certain loads draw inrush, or surge, currents greatly beyond Variac capacities. Typically, cold incandescent lamps momentarily may draw more than fifteen times their normal, hot, operating current. To avoid such serious surges, *always set the Variac brush to zero before switching load or mains.*

Variacs are commonly used as automatic or manual line-voltage regulators. If the line-voltage fluctuation is appreciable (greater than ten per cent), load current should be limited to Rated Current to avoid overloading.

We repeat: *When in doubt, play safe; keep within Rated Current at all times!* Best of all, *use an ammeter and know you're safe!*

—Gilbert Smiley

MISCELLANY

ARTHUR E. THIESSEN, Vice-President for Sales, spoke on "An Instrument Man's Impressions of Europe" at the luncheon of the Scientific Apparatus Makers' Association, held during the National Instrument Conference of the Instrument Society of America, Philadelphia, September 10.

RECENT VISITORS to our plant and laboratories — Mr. Krishan L. Khandpur, Education Department, Government of India, New Delhi; Professor Augusto Condom, School of Engineering, University of Havana; and M. Roberto Corbo of Rome.

GENERAL RADIO COMPANY

275 MASSACHUSETTS AVENUE

CAMBRIDGE 39 MASSACHUSETTS

TELEPHONE: TRowbridge 6-4400

BRANCH ENGINEERING OFFICES

NEW YORK 6, NEW YORK
90 WEST STREET
TEL.—WORTH 2-5837

LOS ANGELES 38, CALIFORNIA
950 NORTH HIGHLAND AVENUE
TEL.—HOLLYWOOD 6201

CHICAGO 5, ILLINOIS
920 SOUTH MICHIGAN AVENUE
TEL.—WABASH 3820

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