# GR/TODAY

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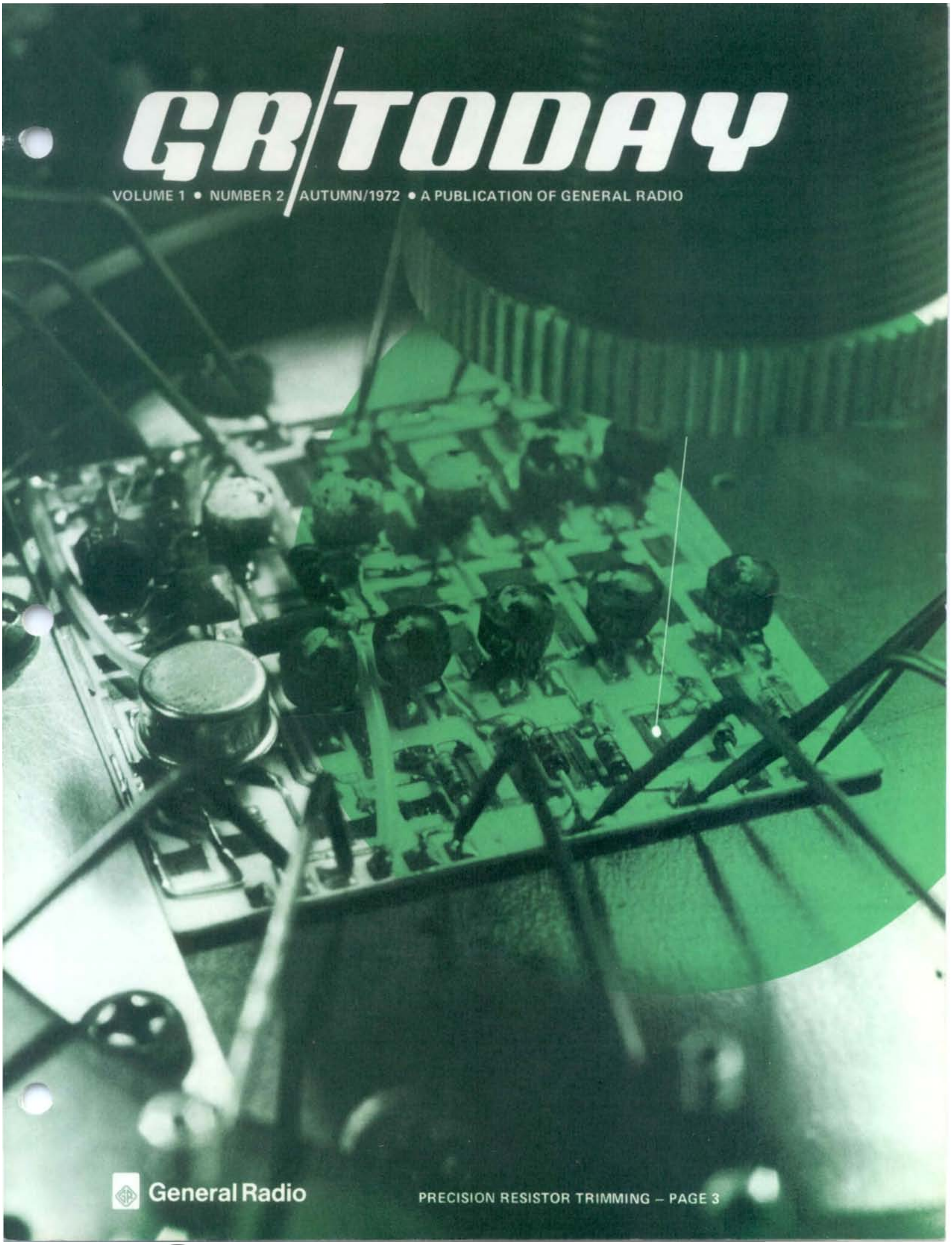


General Radio

PRECISION RESISTOR TRIMMING – PAGE 3

VOLUME 1/NUMBER 2/AUTUMN,1972

The GR/TODAY is mailed without charge to engineers, scientists, technicians, educators, and others interested in electronics. Address all correspondence to Editor, GR/TODAY, General Radio Co., 300 Baker Avenue, Concord, Mass. 01742.



*Principal contributors to the design of the 1944: Martin W. Basch, electrical design, Harold C. Jensen, mechanical design, and Paul d'Entremont, industrial design.*

# GR'S NOISE DOSIMETER EARNS I•R 100 AWARD


*The 1944 Noise-Exposure Indicator*

*Dr. Donald B. Sinclair, President of General Radio, who accepted a plaque commemorating the selection, discusses the 1944 design with Warren Kundert, Product Engineering Manager.*

*The 1944 Noise-Exposure Monitor*

GR's Type 1944 Noise Dosimeter was recently named one of 1972's most significant new technical products by Industrial Research, Inc., in their tenth annual I•R 100 competition.

The 1944, consisting of a Noise-Exposure Monitor and a companion Indicator (see GR/TODAY, Summer, 1972), was developed as a lightweight, automatic instrument to measure on-the-job employee noise exposure in compliance with the Occupational Safety and Health Act.

Winners of the 1972 I•R 100 competition were selected by a panel of distinguished scientists, including such familiar names as William P. Lear, Dr. Glenn T. Seaborg, and Dr. Wernher von Braun. The awards presentation, at Chicago's Museum of Science and Industry, marked the climax of the nation-wide observance of "National Industrial Research Week." Following the banquet, the 1944 and all the other I•R 100 selections were placed on display at the Museum.

# PRECISION RESISTOR TRIMMING

## ABRASIVES, LASERS, AND ANODIZERS

Miniaturization of electronic equipment, for both commercial and industrial purposes, is not a novel idea. Ever since Edison's first incandescent bulb, the cry has been, "Make it smaller, lighter, and cheaper." Today all these criteria are being met with hybrid circuits, and the hybrids themselves are becoming more precise (and mass produced) through the use of a variety of systems that quickly and economically adjust component values.

Hybrid circuits are more versatile than integrated circuits. First, they permit the mixing of different device types in the same circuit — something you can't do with IC's (i.e., using NPN, PNP, and MOS devices together). Second, custom IC's, when required in low volume, are prohibitively expensive, whereas similar volumes of hybrids can be economical.

Actually, the thick- and thin-film hybrids themselves may incorporate IC's, in combination with other active semiconductor devices on substrates. In turn, not only circuit wiring but resistors and, sometimes, capacitors and inductors as well, are batch-processed on the substrates. Thick films, of the order of 0.001-inch thick, are usually made with an ink or paste printed on the substrate. High-resistivity inks form resistors, high-conductivity metal-bearing inks conductors, and insulating inks the dielectrics. Similar components in thin-film circuits, only a few microinches thick, are made by evaporating and sputtering techniques. Batch-processed components, however, often require adjustment to a specific value in high-performance circuits; this is the key operation in the successful manufacture of hybrid circuits.

### THICK-FILM TRIMMING

The oldest method of component adjustment is the mechanical alteration of the resistor's shape by an abrading or scribing method.

On thick-film circuits, this is accomplished by air-abrasive trimming, in which fine particles are carried by an air stream through a fine nozzle to cut away the resistive material. In a production system, this method is combined with an automatic-positioning table and an automatic bridge to control the flow of abrasive. Large-scale systems of this type, often trimming several resistors simultaneously, have been the backbone of the thick-film circuit-production facility.

*Air-abrasive trimming cuts away excess material, adjusting the resistor's value by altering the shape of the component.*

More recently, the laser has been substituted for abrasive cutting, enabling a much finer cut without the danger of damage to surrounding areas and without the general mess of an airborne abrasive. Micronetic Systems, GR's associate in Burlington, Mass., now manufactures the computer-controlled M/S 80A Laser Trim System that trims thick- or thin-film active circuits or passive resistor networks to 0.1% accuracy at rates up to 12,000 trims per hour.

The M/S 80B Functional Trim System goes slightly beyond the capability of the M/S 80A, trimming to such parameters as ac and dc voltage and current, resistance, or frequency. An automatic substrate handler incorporates four nests that accommodate substrates up to three inches square (or other common circuit configurations). Computer control and precise beam positioning (the beam itself is about 1 mil in diameter) provide straight-line, L-shaped, serpentine, or combinations of straight-line trim patterns. A unique edge-seeking feature permits accurate location of the trim, even in the absence of accurate printing registration on the substrate. A step-and-repeat operation simplifies, speeds, and expands the probing capabilities for circuits with repetitive patterns.

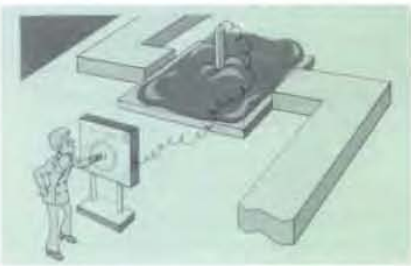
While the initial laser-system investment is much greater than that for an air-abrasive system, the greater accuracy in the control and speed of the cutting process tips the economic balance in favor of the laser for any large automated system. The M/S 80 systems can provide trims for a few tenths of a cent each, or about half the cost of an air-abrasive trim.

*Laser systems can trim to 0.1% accuracy in straight-line patterns.*

*The electrolyte is applied through a template that limits the spread of the gel to the anodizing area.*

## THIN-FILM TRIMMING

For trimming thin-film nichrome resistors, where the resistor width may be less than one mil, the air-abrasive method is generally too coarse and diamond scribing or laser trimming is often used. Tantalum thin-film resistors, however, can be adjusted by anodization, now the most widely used method for trimming this material.



*Anodization converts tantalum resistor material to a protective insulating coating with highly precise resistor adjustments as the end result.*

The anodization process, through electro-chemical action, converts tantalum-resistor material to tantalum pentoxide, an excellent insulator and an almost impervious protective coating. In this technique, resistors are first covered with an electrolyte; then a current is passed from the resistor to an electrode in the electrolyte until a monitoring bridge indicates that the resistor has been adjusted to the desired value.

A typical GR 2240 Resistance Anodize Trim System consists of an electrolyte-application station, a probing station that can contact hundreds of resistors simultaneously, multiple bridges to monitor the resistance value, multiple anodizers to adjust the resistors, and a computer to oversee the entire process. The bridge-anodizer module for the anodizing system is itself a unique device that requires some description.

## THE BRIDGE-ANODIZER MODULE

The bridge-anodizer module was developed to trim thin-film resistors at optimum speeds; it contains a bridge capable of making a measurement decision in less than 10 microseconds. To avoid high-speed mechanical switching, the module is connected to the resistor to be trimmed at the start of the trim cycle and *remains* connected through all measurement-anodize cycles until the resistor is at its final value. All anodizing is accomplished electronically, without relays. With the high-speed bridge and electronic switching, the measurement-anodize cycle is limited only by the settling time of the resistor material. For low-value resistors, measurement rates of over 100 per second are used. Anodizing typically occurs for 80% of the cycle and settling time occupies the remaining 20%; the measurement is made in the last 10 $\mu s$ of the settling time. As the final resistance value is approached, the duty cycle changes to allow additional time for settling. Special circuits detect the adequacy of this additional settling time and automatically increase the settling portion of the cycle to accomplish the desired measurement; this is particularly true for higher-valued resistors.

A single bridge module is used in a bench-top configuration to provide a total anodization capability in a small, inexpensive package. In large systems, multiple modules are used to adjust many resistors simultaneously; in a system that adjusts 450 resistors on a substrate, 30 modules trim 30 resistors simultaneously, with a crossbar switch scanning these modules through 15 positions. For 1% adjustment accuracy, typically about 45 seconds are required to trim all 450 resistors, averaging 10 resistors per second. For 0.1% accuracy, speed is greater than three resistors per second with a system accuracy of 0.05%. The same basic bridge-anodizer module can be extended from a one-at-a-time trim system to a large-scale manual system with a capacity of up to 250,000 resistors per day.

Anodized or laser-trimmed circuits are finding their way into many products where the smaller size, improved performance, and greater reliability brought about by the use of hybrid circuits are significant. (One such case is GR's 1933 Precision Sound-Level Meter and Analyzer described in the previous issue of GR/TODAY.) To make these circuits competitive with conventional etched circuits, large-scale systems have been developed to trim resistors in large quantities at a rapid pace. These systems are already producing circuits with precision-adjusted components at less cost than could be achieved through the conventional assembly of carbon resistors and other discrete components.

# MICRONETIC'S LASER-TRIM SYSTEMS TO AID IN TELEPHONE TONE-GENERATOR PRODUCTION


*Micronetic's Model 80 Laser-Trim System, being used in telephone tone-generator production.*

Microsystems International Limited of Ottawa, Canada has purchased two Laser-Trimming Systems from Micronetic Systems, Inc., a GR associate in Burlington, Mass. The systems will be applied to the production of Microsystem's ME8900-series of multi-frequency microelectronic tone generators.

The Microsystems circuits are used to produce the dual-tone dialing signals already becoming familiar to telephone users throughout North America. The tone generators are also compatible with similar systems used in other parts of the globe; this world-wide distribution will be aided by the Laser-Trim Systems's output and increased manufacturing efficiency.

The first of the Micronetic automatic, computer-controlled systems trims thin-film resistors to precise values, while the second is a functional system capable of adjusting complete circuits for specific operating parameters (i.e., ac or dc voltage, resistance, or frequency). Both systems are provided with a complete software package that features the easy-to-learn and easy-to-use Resistor-Trimming Language.

Additional information on production laser-trimming systems and the Resistor-Trimming Language is available from General Radio.

# T/D EXPANDS PRODUCT-DEVELOPMENT STAFF

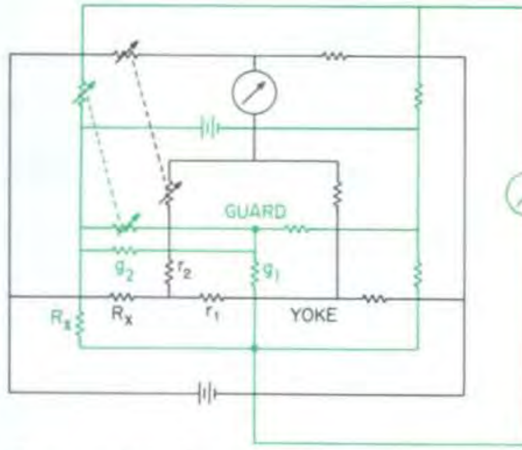
*Ago Kiss (l) and Tracy Storer team up again for T/D's signal-processing systems.*

A new team is guiding product development at Time/Data Corporation, GR's west-coast subsidiary that manufactures digital signal-analysis systems. President Leo J. Chamberlain announced that Tracy S. Storer has recently joined T/D as Vice President of Product Development and that Ago Kiss has joined the product-development staff.

Mr. Storer is responsible for engineering and software development programs; he previously managed product development for nuclear and digital signal-analysis systems and electronic counters for the Computer Division of Hewlett-Packard.

Mr. Kiss, a native of Hungary, is assisting Mr. Storer in the planning and design of advanced digital signal-processing systems for such applications as vibration testing, product noise control and reduction, and underwater acoustical studies. Mr. Kiss formerly developed signal-processing products, also for Hewlett-Packard.

*The 1666 is a new kind of low-cost manual bridge with extremely wide range and 0.01% basic accuracy.*




*The topographical duality of the 1666 bridge: $r_1$ and $r_2$ in the Kelvin circuit are series lead resistances corresponding to shunt conductances $g_1$ and $g_2$ in the Wheatstone circuit.*

# A LOW-PRICED BRIDGE WITH BOTH WHEATSTONE AND KELVIN CIRCUITS

The introduction of a new manual resistance bridge may seem an anachronism when you consider the trend toward automatic measurements and the variety of manual bridges already available. You'll find, however, that the choice of precise, wide-range instruments is much more limited than you may think. Moreover, the portability, price, and precision of a small manual bridge still make it attractive for those on-the-spot resistance measurements that are so often required.

With essential criteria in mind, GR engineers thoroughly searched the general-purpose bridge market. Satisfying these requirements, they discovered, almost seemed to necessitate the purchase of several specialized instruments.

*The criteria:*

- **Range** The bridge must have extremely wide range. Most existing bridges, however, were either four-terminal Kelvin bridges limited to low resistances or, for higher values, Wheatstone bridges that produce serious measurement errors even well above one ohm.
- **Direct-Reading Accuracy** Most small, portable bridges have 0.1% basic accuracy – not good enough for the 0.1% resistors now in common use. What we needed was a 0.01% bridge with precision components and a sensitive detector.
- **High Resolution for Comparison Measurements** The bridge must compare working resistance standards to much better than 0.01%, which requires high resolution and extreme sensitivity.
- **Ease of Calibration** We must be able to calibrate the bridge without a soldering iton and without special parts.
- **Ease and Speed of Use** Turning a row of knobs or waiting for a detector to come back on-scale after overload is annoying and frustrating to the user.

Since no available bridge existed with even a majority of these requirements, GR undertook the development of the 1666 DC Resistance Bridge. The same research that uncovered this 'hole' in the market also revealed that many potential customers have similar criteria for a manual bridge.

Our first design consideration for the 1666 was the development of a single instrument with both a Wheatstone circuit with a Wagner guard and a Kelvin double bridge to accommodate the required measurement range. Both the resistance- and conductance-measuring configurations of these circuits were required. The bridges would use the same basic parts – the diagram illustrates the duality of the circuits. These would be connected to the unknown in a slightly different way.

The critical portion of this dual design is a ganged decade that adjusts the extra Kelvin arm or the Wagner guard as the main bridge arm is balanced; the ganged decade results in almost automatic Kelvin or Wagner balances. However, while these balances may be adequate for most measurements, under extreme conditions the balance will not be satisfactory, even with perfect tracking, because of resistance *external* to the bridge. Therefore, we designed the 1666 with a "touch-up" balance to accommodate the most difficult measurements.

Our second design step involved the realization that a given detector is useful for fewer and fewer digits as the resistance range is extended upward. Was it worth adding a six-digit, 1-TΩ full-scale range if it is only good for 100% accuracy? A conductance bridge made more sense, because a six-digit, 1-μ℧ range also gives 100% at 1 TΩ without the addition of range resistors or switch positions. Besides, some people want to measure resistance and conductance. With the conductance bridge, the 1666 measures both R and G from 0.9 ohm to 1.1 MΩ. This meant seven ranges for each bridge, with the six digits extending the total range from $10^{-6}$ to $10^{12}$ Ω.

The final and, perhaps, most important step was to find an adequately sensitive detector circuit that could be included in the 1666 without doubling the price. Previous experience with the 1656 (a 0.1% RLC bridge) directed us toward FET modulators. Using the FET design, with a lot more ac gain, a low-level sinusoidal FET drive to avoid spikes, and a highly selective ac amplifier (three high-Q filters cascaded to reduce noise), we created a sensitive, but low-cost, detector. While it may not get down to Johnson noise, the detector isn't far from it, and getting closer would only cause a sharp increase in price.

This last point about cost vs performance is the essence of the 1666's design philosophy. High-precision, standards-laboratory resistance-measurement systems are expensive because, as you approach the best possible system, the cost rises sharply. By using standard, precision parts in our design, we've come up with a new kind of low-cost, portable, manual bridge that won't require top-management purchase approval.

*The result:*

- **Range** The 1666, with both Kelvin and guarded Wheatstone circuits, measures resistance or conductance with an over-all range of 1 $\mu\Omega$ to 1 p℧ (1 T$\Omega$).
- **Accuracy** GR's precision wire-wound resistors in the bridges provide a basic 0.01% instrument accuracy.
- **Resolution** A six-digit readout enables comparisons to 2 ppm at decade values of resistance.
- **Sensitivity** The 1666 has sufficient sensitivity to cover almost all of its total range with an internal bridge supply that applies less than 0.01 watt to the unknown resistor (to avoid heating effects). A simple external supply will increase sensitivity for full resolution at any value.
- **Calibration** Trim pots in each ratio arm and in the bridge-standard arm make readjustment, to an accuracy even better than 0.01%, a simple procedure when calibration is performed with a set of GR 1440 Standard Resistors.
- **Ease of Use** The adjustable decades use lever switches that you'll learn to 'play like a one-armed bandit.' The detector has three response characteristics, all of which recover quickly from overload. Moreover, the detector deflection always indicates which way to adjust the levers, no matter which bridge is in use; this means that the sensitivity control need not be adjusted during balance. Because of these features, 0.01% measurements can be made in less than 10 seconds and 1-ppm balances can be made in 20 seconds.

# ENTER THE MODULAR HIGH-PERFORMANCE SYNTHESIZER

GR's frequency synthesizers have always offered the broadest possible capability — many degrees of resolution combined with different output-frequency ranges — at prices that permit you to get just the synthesizer you need without paying for excess and unwanted performance. The newest synthesizer from GR, the 1061, goes even further with this concept by starting with a very 'basic' model and then utilizing a modular approach to expand the instrument's performance to your need.

Since many instruments are today used in automatic systems that require little or no human interface, the basic 1061 was developed for just that purpose. It has a 160-MHz range, 10-kHz resolution, non-harmonic spurs more than 80 dB below the fundamental, 100-$\mu$s programming time, 100-Hz search capability, and remote control. Its most obvious feature, however, is its front panel or, rather, its lack of one. Since manual controls have no function in automatic systems, why include them (and why pay for them, too)? Should you need them, though, a conventional, manually controlled front panel is available.

Other 1061 options accent the modular idea: Phase modulation; a choice of two reference oscillators ($2 \times 10^{-6}$ /mo or $1 \times 10^{-9}$ /day stability), and resolution down to 1 kHz, 100 Hz, 10 Hz, 1Hz, or even 0.1 Hz.

All 1061 models, regardless of the options you select, perform with better than 63-dB phase signal-to-noise ratio, over 80-dB amplitude s/n ratio, adjustable output-signal level from 0 to 20 dBm into 50 ohms, and auxiliary outputs up to 42 MHz. A search-sweep mode allows any decade (with 1-MHz steps or less) to be manually or remotely varied by a continuous control for use in resonance or bandpass studies.

*The new 1061 Synthesizers stress the concept of buying no more instruments than you need.*

# THE ELECTRET-CONDENSER MICROPHONE:

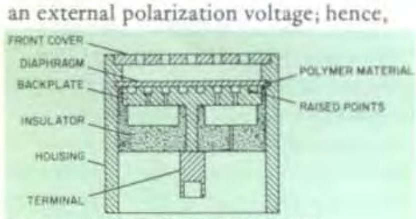
## A New Quality Microphone for Acoustical Measurements

The principle of the electret-condenser microphone has been with us for many years. Until recently, however, it was not applied to the development of instrumentation-quality microphones due to performance-limiting technical problems. The solution to those problems was actively sought because the electret microphone was known to have inherent advantages:

- Excellent sensitivity, wide dynamic range, smooth high-frequency response, and low sensitivity to shock and vibration.
- Lower cost than for other types of condenser microphones.
- A prepolarized dielectric prevents intermittent operation caused by the breakdown of the polarizing voltage under high-humidity conditions; the microphones can be used with a low-cost preamplifier.

The cross-sectional diagram reveals the construction of the electret microphone. The diaphragm consists of a polymer material in which an electrical charge is imbedded; the upper surface of the diaphragm is gold plated. Because the plated side is insulated from the backplate by the polymer material, the entire diaphragm can rest on raised points on the backplate; this configuration greatly reduces the difficult precision assembly problems associated with air-condenser microphones.

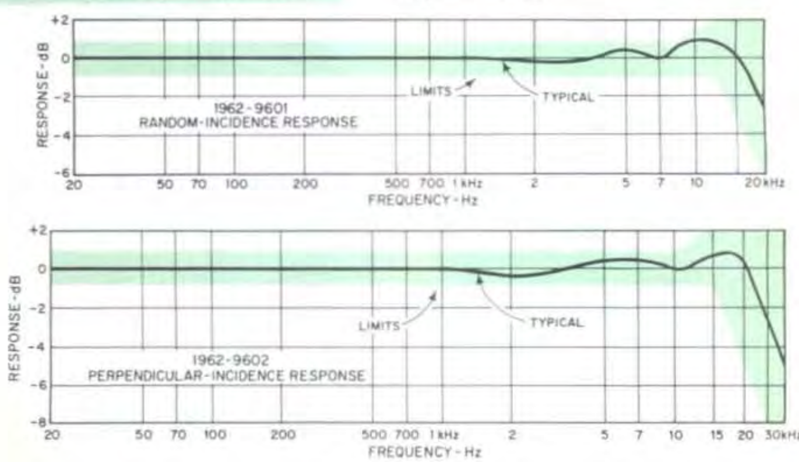
The electrical charge imbedded in the polymer eliminates the need for an external polarization voltage; hence,




*Cross-section of a typical GR electret microphone. The raised points stiffen the diaphragm to compensate for the low strength of the material. They also decrease the high-sound-level distortion to a value equal to or better than that of ordinary microphones.*

the use of the low-cost preamplifier (i.e., one that does not generate the polarizing voltage).

The principal problems preventing the development of the electret were long-term stability and temperature coefficient. After much experimentation with polymer materials and polarizing techniques, we have developed a line of stable electret microphones with a small temperature coefficient. Now available are 1-inch and ½-inch flat-perpendicular- and flat-random-incidence response versions and a ¼-inch flat-perpendicular-incidence response model.




*Typical response curves for GR's Type 1962 ½-inch Electret-Condenser Microphones.*

# EVOLUTION OF A PLUG

Just as nature's creatures adapt to an ever-changing environment so, sometimes, does a special kind of product survive, through many decades, the vagaries of the rapidly advancing field of electronics. One such product is GR's Type 274-MB Insulated Double Plug, commonly referred to in industry as the "GR plug" or the banana plug. Although the 274 itself is hardly a newsworthy item, despite its wide use for over 50 years, the number of improvements incorporated in the plug during its lifetime is.

When Melville Eastham, GR's founder, introduced the 274 in 1917, it was made of nickel silver, brass, and hard rubber and had exposed setscrews. Perhaps the most important aspect of the original model is the ¾-inch spacing between the plugs, a dimension that was adopted long ago as an industry standard for plugs of this type (and for jack-top binding posts with which the 274 mates).

Frogs and toads look alike but are, in fact, quite different; so, too, are the original and newest versions of the 274 still the same and yet different. In 1925 the original nickel silver and hard rubber gave way to phosphor bronze and phenolic. In 1927 low-loss phenolic was introduced and beryllium copper replaced phosphor bronze in 1930. Polystyrene became, in 1939, a practical substitute for phenolic. Mechanical improvements have reduced shock hazard and improved cable-strain relief; socket setscrews have replaced slotted screws to prevent splitting.

After 55 years in use, the 274 is still an important link in test-equipment set-ups. Despite constant redesign to introduce new materials and mechanical improvements, the modern version costs no more than did the 1926 version shown in the accompanying catalog excerpt from that year.

THE CHOICE OF GR RADIO EXPERTS

Type 274

## MULTI-CONNECTOR PLUG

The many uses of the Type 274 Multi-Connector Plug will be readily appreciated by radio experimenters.

One of these plugs mounted on the bakelite strip makes an excellent phone or loud-speaker plug, and any number of parallel or series connections may be made using several of these plugs.

The contact points consist of four springs which are squeezed together as the plug is inserted into the socket, thus making a perfect sliding contact.

A binding post is provided on the shank of the contact point for making external connections.

Type 274—Multi-Connector Plug Complete with jacks .............. $1.00
Dimensions 1½" x 1¾" x ½". Weight 2 oz.
Code Word: "PAPER."

## TYPE 236 BY-PASS CONDENSER

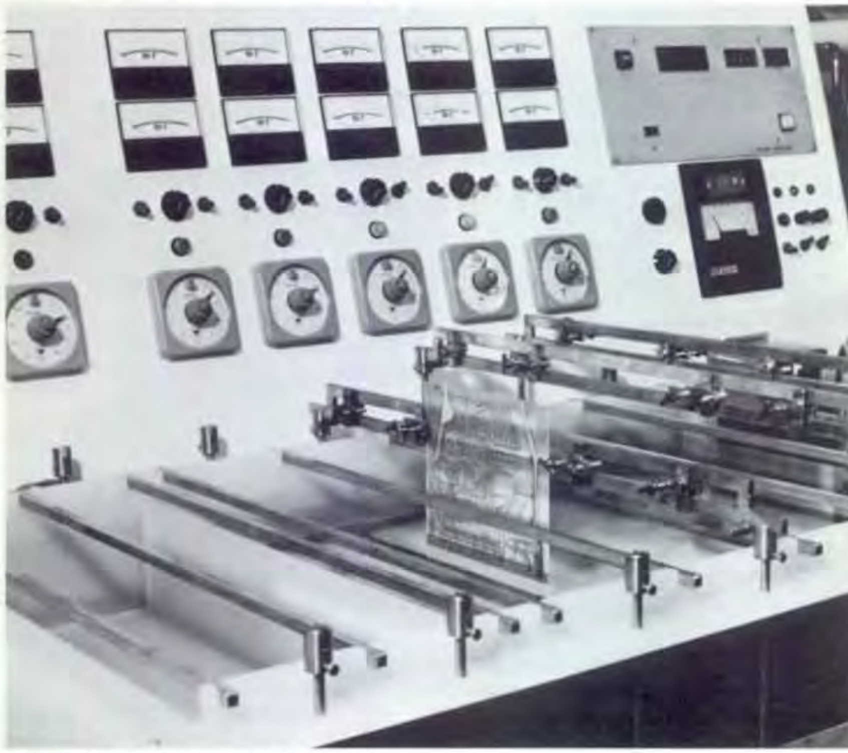
It is often advisable to by-pass portions of a radio circuit with a condenser of fairly large capacity in order to reduce the audio frequency impedance of that portion of the circuit.

A by-pass condenser across the "B" battery is particularly helpful in eliminating oscillations in the audio amplifier, due to long leads, or a high resistance in the common "B" battery.

The Type 236 Condenser is impregnated with paraffin as wound, and mounted in a substantial metal container.

Type 236—.5 M F. By-Pass Condenser .............. $1.00
Dimensions 4" x 1⅛" x 1⅛". Weight 5 oz.
Code Word: "PECAN."

# POTENTIAL $100,000 SAVINGS FROM A $600 INVESTMENT



*Over-all view of GR's new gold-plating set-up.*

Gold is where you find it or, in the case of printed circuits, where you put it. In the former case, enough is never too much; in the latter, too much can seriously affect carefully balanced profit margins while too little will introduce functional defects in the plated device.

Too much gold, as in the plating of printed-circuit boards, is usually shipped to the customer as an unnecessary and expensive bonus to him. (Underplating can be replated to bring the foil thickness up to the specified minimum.) In view of the price of gold in today's market, we carefully examined the entire plating process with an eye toward solving the real problem: Overplating.

A typical gold-plating operation takes ten minutes. At the end of the cycle an alarm notifies the operator to move his racks. Since the operator cannot always react immediately to the alarm – he may be in the middle of loading the nickel tank or transferring boards at a rinse station – he can easily, albeit unintentionally, cause a one-minute overplate. This one-minute overplate, in a ten-minute process, translates to 10% of excess gold usage which, in turn, means many lost dollars each year. A large printed-circuit job shop or captive facility will use more than 20,000 ounces of gold per year; if 10% of the gold is needlessly shipped, then in excess of $100,000 goes out the door with no chance for recovery. Excessive though it may be, this loss is considered normal for a manual plating facility. (Don't forget, too, that the $100,000 figure does not include a factor for the additional drag-out loss caused by incomplete draining over the gold tank.)

In today's technology, the way to save any or all of the excess gold, at first thought, is automation in the plating process. Total automation, however, may be prohibitively expensive, is not always adaptable to existing equipment and, perhaps, isn't really necessary. At General Radio's Bolton, Massachusetts plant, a new printed-circuit manufacturing facility is under construction. In the plating area of this facility are nickel and gold tab-plating units typical of those used throughout industry. Both deposition tanks have been additionally equipped with constant-current power supplies at each of their five bays. Also, the gold tank now includes a reset digital amp-minute meter and a function selector to reduce the current to a few mA at the end of a timed plating cycle. This gold-tank equipment, with the additions, should reduce overplate by at least half an order of magnitude.

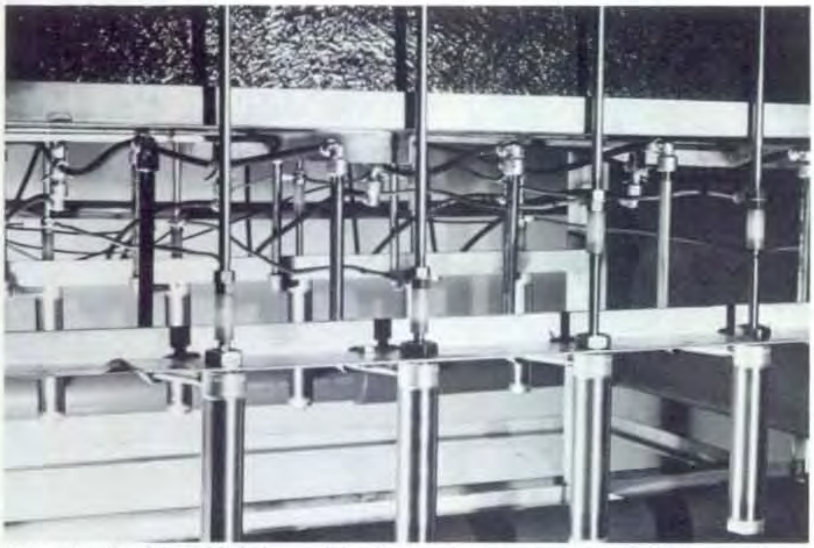
Adding a trigger mechanism to lift the work from the tank at the end of the cycle was considered next. The first such trigger mechanism proposed was a mechanical arrangement that would, when activated by a timer, move the cathode bars down two inches to immerse the boards at the start of the cycle and to lift them out of the solution at the end. The drawback to this method was the under-the-tank location of the motors, cams, and linkage required at each bay; in this position, all parts would be difficult to service and, worse, would be subject to corrosion from chemical spillage and fumes. A pneumatic system was clearly a superior power source.

A working bench model was built, using two air cylinders, one solenoid, a few fittings, and some plastic tubing at each bay. Tests run during the construction of the system indicated some final modifications: A speed control on the solenoid exhaust port and some minor changes to the fittings. With the proper pneumatic lifting mechanism beneath each bay, the model system became operational.

## How the System Works

The general plating conditions are set at the beginning of the work shift. The power supplies are, at that time, turned on and thereafter are adjusted only for required current changes. (Note that selecting the correct time and current density not only reduces overplate but also eliminates any possible problem with underplate.) The input air pressure is set to regulate the speed of the piston downstroke and the return velocity is set by an exhaust-speed control on the solenoid. Plating racks, designed by New England Plastic Coated Products, Inc., of Attleboro, Mass. for use with the lifting mechanisms, are loaded and processed through the nickel-deposition and activation cycles. At the strike bay of the gold-plating module, a rack is placed on the vertical cathode bars and a preset timer is activated. The timer energizes a solenoid that retracts the air-cylinder pistons, and the work is lowered into the strike tank. When the timer cycles out, the solenoid is de-energized, and springs in the air cylinders return the pistons to their normally extended position, lifting the work from the solution. The rack is then manually placed on the cathode bars of the adjacent gold-plating bay, and the timer at that bay is activated, although with a different immersion time.

These steps are repeated until all the plating bays are in use. As the timer at each bay cycles out, the work is automatically lifted from the tank to await further processing. The extended drain time over the tank greatly reduces gold drag-out.



*The underside of the gold-plating module, showing the interconnections of the pneumatic components; note the extended and contracted pistons.*

### Cost

No system is without its price tag but, when a seven-bay plating system can be automated for less than $600 (compared to the four- or five-figure cost of conventional automatic systems), the return on investment assumes very attractive proportions. In developing this kind of system, inexpensive as it is, remember that the entire process is only as repeatable as the timers and only as dependable as the air supply; get the best – don't attempt to save a few more pennies on these items. A properly operating semi-automatic system will no doubt find use with many precious metals in any situation where the process of selective automation is applicable.

# CHAMBERLAIN EARNS TOP TECHNICAL-PAPER AWARD

Leo J. Chamberlain, President of Time/Data Corporation, has been awarded the first LEtronix Vibraphonic Award for his paper, *A Simple Discussion of Time-Series Analysis*. The award was established by LEtronix, a manufacturer's engineering representative in the Philadelphia area, to recognize and encourage the publication of practical papers in the field of sound and vibration.

The winning paper was judged the best of those published in *Sound and Vibration* magazine during 1971. Selection was made by a special committee appointed by the Delaware Valley Chapter of the Acoustical Society of America.

*Edwin H. Toothman (l) of the Acoustical Society of America presents the first LEtronix Vibraphonic Award to Leo J. Chamberlain for the best paper published in* Sound and Vibration *magazine during 1971.*

The committee, whose members are drawn from both industry and education, considered four factors in evaluating the contending papers: Originality, technical quality, usefulness to working engineers, and over-all impact of the paper.

An engraved plaque commemorating the award was presented to Mr. Chamberlain in Buffalo, N. Y. during the April, 1972 meeting of the ASA's Technical Committee on Noise.

To secure a copy of the award-winning paper, refer to the enclosed reply card.

# COMPLETE 75-OHM COAXIAL COMPONENT LINES NOW READY

*Family portrait. A collection of many of the new 75-Ω coaxial components from GR.*

The time for complete metamorphosis seems to have finally arrived for transmission lines. Within the communications, telephone, and CATV industries, the characteristic-impedance norm is now 75 Ω, not the old familiar 50 Ω: Broad lines of general-purpose and precision coaxial elements with the 75-Ω characteristic are available from GR.

Any engineer who specifies coaxial connectors is familiar with the GR874® general-purpose and GR900® precision coaxial components; today he can have the same hermaphroditic construction, measurement repeatability and economy at 75 Ω that he's always had at 50 Ω.

**The general-purpose GR874** 75-Ω line includes connectors, adaptors, pads, attenuators, air lines, and terminations. To achieve the 75-Ω characteristic, a new inner conductor and insulating bead are used; the typical basic GR874 75-Ω connector has an SWR below 1.005 at the low end, increasing to still less than 1.015 at 2 GHz. Although specified for use from dc to 2 GHz, tests indicate excellent performance of the GR874 75-Ω line at even higher frequencies.

**The precision GR900** 75-Ω components have also been altered internally to bring them to the 75-Ω standard. The basic GR900 75-Ω connector has, like its GR874 counterpart, a very low SWR specification: $1.0015 + 0.0015 f_{GHz}$; SWR repeatability is ±0.06%.

Complete specifications on all the new 75-Ω components can be obtained from any GR office or by using the enclosed reply card.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