



THE GENERAL RADIO

# Experimenter

**REVOLUTION  
IN CAPACITOR TESTING**



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# the Experimenter

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## AUTOMATIC CAPACITOR-TESTING SYSTEMS

The inspection bottleneck was broken by GR's 1680-A Automatic Capacitance Bridge Assembly, announced in 1964. Many users who formerly tested capacitors at a rate of ten a minute at best are now testing at rates better than 120 a minute! In this issue we describe some of the complex automatic testing systems designed around this bridge and two new accessories, the 1781 Digital Limit Comparator and the 1770 Scanner System.

The increasingly demanding requirements for extreme reliability in electronic equipment, both military and commercial, have heightened the need for instruments for the rapid and accurate testing of the components that make up this equipment. General Radio has for many years manufactured instruments for component testing — impedance bridges, capacitance and inductance bridges, impedance comparators, etc — most of which were designed for use by skilled operators in a laboratory. For on-line testing of high-volume production lots, manually operated instruments are no longer adequate; automation is a must.

General Radio entered the field of automatic component testing in 1964

with the introduction of the 1680-A Automatic Capacitance Bridge Assembly.<sup>1</sup> This instrument measures the capacitance and loss of a component in a half second or less at the push of a button (or at electrical command) and presents the answer in both a digital display and an electrical output. The widespread acceptance of this device has led to a demand for complete measurement systems built around the bridge and for additional accessory instruments, some to simplify the automatic connection of components to the bridge and others to make use of the prodigious amounts of data that can now be obtained so rapidly. In addition to providing many accessory instruments, we are now prepared to provide complete measurement systems.

### MEASUREMENT SYSTEM

"System" is an often-used word whose meaning varies with context. At General Radio we define a system as a collection of instruments — of which some may be standard, some modified, some specially designed, some purchased — assembled to solve a specific measurement problem.

<sup>1</sup>R. G. Fulks, "The Automatic Capacitance Bridge," *General Radio Experimenter*, April 1965.



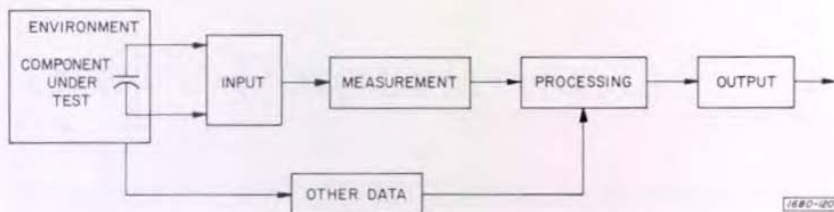


Figure 1. Block diagram of a component-testing system.

In this definition we recognize that a system is more than a group of our standard catalog instruments and a few patch cords. The grouping must be carefully thought out, both from an electrical and a mechanical standpoint. Interface problems must be identified and solved. Some instruments may have to be adapted to the requirements of the system. Others may have to be purchased or designed. Special cables, racks, and consoles may be necessary, along with special operating and maintenance instructions. In short, the system must be thoroughly engineered; the whole must be greater than the sum of the parts.

Since most of these system-design problems are beyond the inclination of many of our customers, we volunteer to do the job for them by offering custom-engineered measurement systems. Before we look at some examples of these systems, let's discuss a component-testing system in general.

#### GENERAL BLOCK DIAGRAM

Figure 1 shows a block diagram of an idealized component-testing system. The component or components are conditioned by the desired *environment* equipment, which may take the form of a temperature chamber, a vibration table, voltage-soaking equipment, etc.

The next block includes component handlers, positioners, scanners, and other *input* devices. The heart (or brains) of the system is the *measurement* equipment—in this discussion the 1680-A Capacitance Bridge. *Processing* equipment operates on the information received from the measurement equipment to put it in a more useful form. Examples of processing equipment are digital-to-analog converters, digital limit comparators, and parallel-to-serial converters. *Output* equipment includes analog recorders, digital printers, and tape and card punches. The remaining block, *other data*, includes serial-number generators, time-code generators, digital thermometers, and other devices that generate supplementary information. Such information is usually fed into the processing equipment along with the measurement data.

#### FILLING IN THE BLOCKS

##### Measurement

The measurement instrument central to the systems discussed in this article is the 1680-A Automatic Capacitance Bridge Assembly.<sup>1</sup> When a capacitor is connected to the bridge, the instrument automatically selects the proper range, achieves balance, and presents the

<sup>1</sup> *Ibid.*

measured capacitance and either dissipation factor or conductance on an in-line digital readout, complete with decimal points and units. All this information is also presented in binary-coded decimal form (1-2-4-2 BCD) for use by printers or other data-handling equipment. The entire balance operation consumes a half second or less.

Three switch-selected generator frequencies are available: 120, 400, and 1000 Hz. Capacitance range is 100 pF (full-scale) to 100  $\mu$ F at 400 and 1000 Hz (resolution is 0.01 pF) and 1  $\mu$ F (full-scale) to 1000  $\mu$ F with a 120-Hz signal. Dissipation-factor range is 0.0001 to 1.0, and the bridge will measure parallel conductance from 0.1 nanomho to 1 mho at 400 and 1000 Hz, from 1 micromho to 1.0 mho at 120 Hz.

Basic accuracy of capacitance measurement is  $\pm 0.1\%$  of reading  $\pm 0.01\%$  of full scale. Accuracy of frequencies supplied by the oscillator is  $\pm 1\%$ .

The bridge features several operating modes to accommodate a wide range of

possible applications. In the TRACK CONT mode, for example, it continuously follows variations in a capacitor under test, permitting automatic recording of the effects of temperature or other environmental conditions. In the TRACK SAMPLED mode, the bridge follows variations but yields data only on command.

In addition to measuring capacitors, this instrument can be used to measure any parameter that can be expressed in terms of an equivalent parallel capacitance and conductance. Thus parameters of dielectric materials, cables, thin-film circuits, inductors (negative capacitors), and resistors can be measured.

#### Output

There are many other ways of using the measurement results besides looking at them or writing them down. Figure 2 shows the bridge feeding data to the 1137-A Data Printer. This is the simplest means of obtaining a permanent printed record of the measurements.



Figure 2. Automatic capacitance bridge and data printer.

The 1510-A Digital-to-Graphic Recording Assembly, shown with the bridge in Figure 3, is convenient for plotting changes in the value of a given component. The digital-data output of the bridge, after conversion to an analog current (or voltage) by a high-speed digital-to-analog converter, is plotted by a graphic recorder. By selection of the proper digits for conversion, a precise zero suppression can be obtained so that very small changes in the value of a component can be easily plotted. This combination is used extensively in environmental tests on capacitors, as, for example, in the measurement of temperature coefficients.

One of the most popular means of storing data for further statistical analysis is the punched card. Through a

parallel-to-serial converter the bridge can be connected to a card punch for this purpose.

Other forms of data recording for future processing by a computer include punched tape and magnetic tape. Inquiries are invited for systems including equipment for tape recording.

Another class of output equipment operates on the component itself rather than on the measurement data. This equipment can be combined with the input equipment to sort the components into tolerance bins, for example. While General Radio provides the proper processing equipment (see below), we do not supply the mechanical handling equipment, which is readily obtainable from several manufacturers.



Figure 3. Automatic capacitance bridge and digital-to-graphic recording assembly.

### Processing

Processing equipment takes several forms. The 1136-A Digital-to-Analog Converter mentioned above is one example. Another, described more fully in the following article, is the 1781 Digital Limit Comparator, which compares the bridge reading with preset limits to determine whether a component is in or out of tolerance. Other processing (interface) instruments convert output signals from one instrument into the form required at the input of another instrument. For example, the parallel-to-serial converter mentioned above converts the parallel (all-at-once) data from the bridge into the serial (one-at-a-time) data required by a card punch. Other interface instruments change the voltage and impedance levels or the logical coding of signals from one form to another.

### Input

Input equipment is used to perform the actual connection of the terminals of the component to the terminals of the bridge. Such equipment can range all the way from the 1680-P1 Test Fixture, in which components are manually inserted, to the more sophisticated reel-type handlers and vibratory-hopper feeders.

These devices connect components to the bridge one at a time. Some applications require that components be connected in a prescribed automatic sequence and then recycled, or scanned, in the same or a different sequence. For these applications the 1770 Scanner System described on page 13 is ideal.

### Other Data

Information in addition to the measured value is often required, especially



Figure 4. An automatic capacitor-test system produced by General Radio.

when automatic output equipment is used. Identifying data, such as serial number, or data on conditions of measurement, such as temperature, time of day, or elapsed time, can be obtained from additional instruments connected into the processing equipment (through interface equipment if necessary) along with the primary measurement data.

### TYPICAL SYSTEMS

Figure 4 is a photograph of an automatic capacitor-testing system produced by General Radio for a large aerospace manufacturer. It is used for incoming inspection and quality-control testing of a broad variety of capacitors. The following components are included:

- 1) Component carrier and automatic indexer,
- 2) Bias-voltage power supply,
- 3) 1680-A Automatic Capacitance Bridge Assembly,
- 4) 1781 Digital Limit Comparator,
- 5) Serial-number generator,

Figure 5. Automatic capacitor-test system produced by General Radio for Corning Glass Works.



Photo courtesy of Corning Glass Works.

- 6) Two 1137-A Data Printers,
- 7) Interface panels,
- 8) Console.

The capacitors to be tested are loaded into the 50-component carrier stick, which is then inserted in the automatic indexer. The power supply applies bias voltage to each capacitor, and the capacitance is measured by the automatic bridge, which indicates the value and supplies the measurement data to the 1781 comparator. The comparator determines whether each capacitor is in or out of tolerance and feeds its data, along with a three-digit number from the serial-number generator, to the two printers. One printer prints the serial number and capacitance of each capacitor, the other the serial number and dissipation factor. The print-out is black for a good capacitor and red for a bad one, and it includes a digit to indicate the reason for the acceptance or rejection of the

capacitor — GO, HIGH C, LOW C, or HIGH D.

Three modes of operation are provided. The MANUAL mode allows the capacitors to be tested one at a time by means of a push button on the indexer. The AUTOMATIC mode allows all 50 capacitors to be tested. In the STOP-NO-GO mode, the capacitors are tested and stepped along automatically until an out-of-tolerance value occurs. At this point the system stops, and it stays stopped until it is manually restarted.

Figure 5 shows a system supplied to Electronic Products Division, Corning Glass Works. This system includes a stick indexer and a card punch. To satisfy the requirements of the system, a 16-character data printer and a specially designed card-punch coupler were used.

This system is used by quality-control personnel to monitor the produc-



tion of glass-dielectric capacitors. The capacitors are loaded into sticks and measured by the system. A tape printer and a card punch simultaneously record serial number, capacitance, and dissipation factor.

#### OTHER APPLICATIONS

These automatic systems can be used in the design of components for the evaluation of experimental units or for the testing and sorting of the output of a production line. They can also be employed to test purchased components in incoming-inspection or quality-assurance programs.

Capacitor testing is only one of the bridge's many applications. Atomic Energy of Canada, Limited, uses a system including a 1680-A bridge, 1136-A D/A converter, and 1521-B recorder to plot the effects of immersion in an electrolyte on the impedance of thin-film components. Another large laboratory uses similar systems in the design of inductors for telephone applications.

At General Radio we use a 1680-A bridge system to check the turns ratio of the toroidal transformers used in the bridge itself!

#### ECONOMY

Although the cost-saving advantages of automation seem obvious, the results of the installation of these automatic systems are sometimes startling. Cost analyses indicate a saving of up to 80% or more on the per-unit cost of component inspection, in spite of the higher cost of the automatic equipment with respect to manually operated equipment. Customers have told us that a 1680-A bridge can pay for itself in six weeks!

#### SUMMARY

Those who wish to automate capacitance-measuring operations can now obtain from General Radio entire systems, custom-engineered for specific applications. This systems capability is graphically summarized in Figure 6.

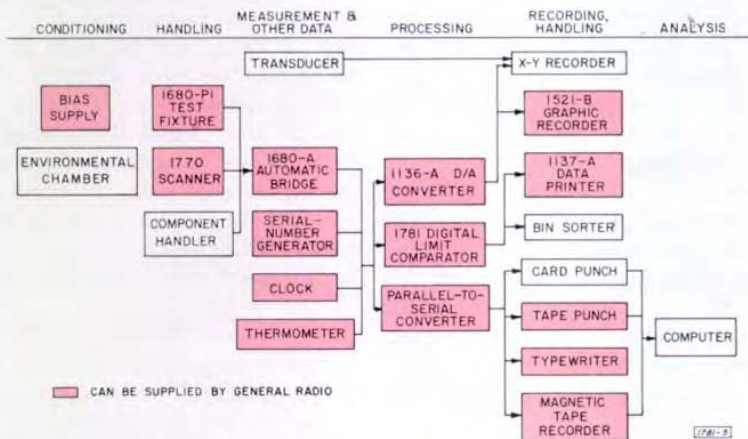


Figure 6. Chart showing instruments and devices that can be used in an automatic component-measuring system. General Radio can supply systems including those components indicated by tinted blocks.



Figure 1. GR 1781 Digital Limit Comparator shown with automatic bridge.

## DIGITAL LIMIT COMPARATOR

As mentioned in the previous article, accessory instruments are required to exploit fully the capabilities of the 1680-A Automatic Capacitance Bridge Assembly. Figure 1 shows a most useful member of this accessory family, the 1781 Digital Limit Comparator. In this instrument, measurement data from the bridge are compared with manually set limits, and the results are presented on panel lamps and in relay-contact closures at a rear-panel connector. Thus the comparator can be used not only for testing and manual sorting of components to prescribed tolerances but also, with output equipment, for automatic sorting.

### INPUT

The input to the comparator is in the form of 11 four-line BCD digits,

five for loss value (dissipation factor or conductance), five for capacitance value, and one for range code. Positive true logic is required, with the logic "1," or true, level at least 10 volts above the "0" level. Although 1-2-4-2 data are normally used, a 1-2-4-8 modification is available. Two 5-digit limits, one upper and one lower, are set for the capacitance data, an upper limit is set for the loss data, and one limit is set for the range digit. Complete comparison takes only 2.5 milliseconds.

### OUTPUT

Four front-panel lamps and corresponding internal SPDT relays provide visual and electrical indication of the comparison result. The lamps indicate GO, HIGH C, LOW C, or HIGH D/G. The relay contacts are isolated from the

instrument and from each other and are rated at 115 V, 0.1 A. A data-output connector is also provided for connecting a data printer or an additional limit comparator.

### SORTING

A 1680-A bridge and a 1781 comparator form a complete testing system by means of which an operator can manually sort capacitors into the four categories indicated by the comparator. This process can be speeded up by use of the output relay contacts to operate automatic bin sorters.

Several comparators can be connected together to sort components into several classifications. Figure 2, for example, shows three comparators connected to sort components into four tolerance groups: 1 percent, 5 percent, 10 percent, and greater than 10 percent. The measurement data digits are connected to all three comparators. After the first comparator has completed its calculation, it indicates the

result and starts the second comparator. This sequence continues until one comparator indicates GO or until all indicate NO GO. The final decision will apply power to the appropriate output circuit through the relay contacts.

A 1137-A Data Printer can be connected to the comparator to obtain a record of the results. Three printer modes are provided:

- 1) Print all measurements;
- 2) Print in-tolerance measurements only;
- 3) Print out-of-tolerance measurements only.

In addition, a color-control signal is provided to print GO measurements in black and NO GO measurements in red. A digit representing the result of the comparison is also printed.

### CIRCUIT DESCRIPTION

The 1781 Digital Limit Comparator is basically a sequential digital calculator. Comparison of the input data with preset limits is accomplished by a

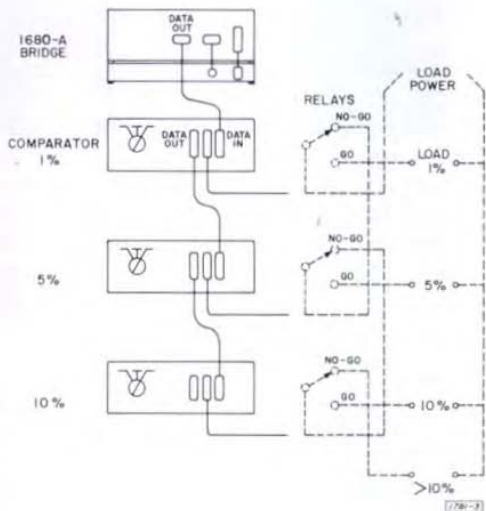


Figure 2. Diagram showing interconnection of three comparators for multiple-limit sorting. (GO-NO-GO relays shown are incorporated in comparators.)

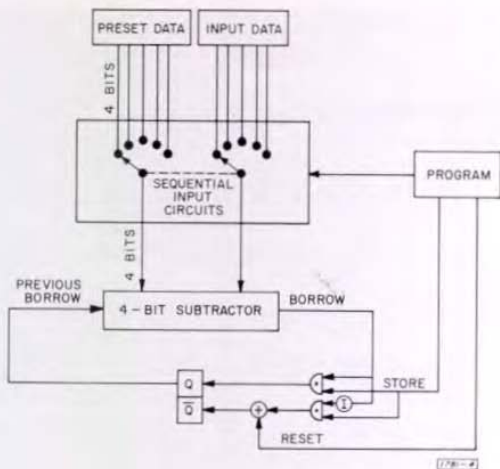


Figure 3. Simplified logic diagram illustrating comparison technique.

sequential technique in which one four-line binary-coded decimal digit is subtracted from another in a four-bit parallel subtraction circuit. In the loss comparison, for example, the measured value is subtracted from the preset limit value digit by digit, starting with the least significant digit. The simplified block diagram of Figure 3 illustrates the principle. The sequential input circuits apply each pair of digits to the four-bit subtractor (each digit is composed of four binary bits). After each subtraction, any borrow bit generated is stored and entered as a previous borrow for the next subtraction. After all five digits have been subtracted, the presence or absence of a borrow bit indicates whether the measured value is higher or lower than the preset value.

The capacitance-value comparison is performed in much the same way. The

range digit is used as the most significant digit of capacitance value. At the completion of comparison, the final borrow information is used to select the proper output relays and lamps.

This technique involves a minimum of critical circuitry and requires only 2.5 milliseconds for a complete comparison.

### CONCLUSION

Many of the advantages of an automatic bridge can be negated by an operator who misreads the indicated values or who occasionally translates measured data into incorrect decisions in handling or processing. The limit comparator, by substituting digital logic for human decision, advances the measurement system an important step nearer to elimination of human error in routine jobs.

### SPECIFICATIONS

**RANGE OF LIMIT SETTINGS:** 00000 to 99999 for both C and D.

**ACCURACY:** Same as that of data source.

**INPUT**

**Data:** 11 digits, bcd, 1-2-4-2 (1-2-4-8 optional).

**Logic Levels:**

"1" =  $V_{REF}$  (or  $V_{REF}$  to  $V_{REF}-2$  volts)

"0" =  $V_{REF}-10$  (or  $V_{REF}-8$  to  $V_{REF}-50$  volts).

**Input Resistance:** > 47 k $\Omega$  (connected to  $V_{REF}$ ).

**Maximum Source Resistance:** 100 k $\Omega$ .

**Reference Voltage:**  $\pm 50$  V with respect to chassis ground. Maximum source resistance, 1 k $\Omega$ .

**Compare Command:** Logic 1 to logic 0 transition. Minimum duration, 2.5 ms; input resistance, > 50 k $\Omega$ . Maximum source resistance, 20 k $\Omega$ .

#### OUTPUT

**Data:** Identical to input.

**Comparison Result:** ncd digit, behind 10 k $\Omega$ .

**Print Command:** Logic 1 to logic 0 transition, behind 2.2 k $\Omega$ .

**Relay Contacts:** 4 SPDT contacts, 115 V, rms, 0.1 A, rms, maximum.

#### GENERAL

**Accessories Supplied:** CAP-22 Power Cord, spare fuses, 4205-1000 Signal Cable to connect comparator to measuring instrument.

**Accessories Required:** If sorting equipment is used, 4205-1010 cable is also needed. See price table below.

**Power Required:** 105 to 125 or 210 to 250 V, 50 to 60 Hz, 10 W. (195 to 235 also available.)

**Cabinet:** Rack-bench.

**Dimensions:** Bench model, width 19, height 4, depth 16½ in (485, 105, 420 mm) over-all; rack model, width 19, height 3½, depth behind panel 16 in (485, 89, 410 mm).

**Net Weight:** 20 lb (9.5 kg).

**Shipping Weight:** 30 lb (14.0 kg).

Catalog Number	Description	Price in USA
1781-9801	Type 1781 Digital Limit Comparator, Bench Model	\$1625.00
1781-9811	Type 1781 Digital Limit Comparator, Rack Model	1625.00
4205-1010	Accessory Cable (from sorting equipment to comparator)	65.00



Figure 1. GR 1770 Scanner System.

## AUTOMATIC SCANNER SYSTEM

The 1770 Scanner System shown in Figure 1 is an automatic instrument for the sequential connection of many pairs of terminals to a single pair. Its primary purpose is to connect unknown capacitors to the 1680-A Automatic Capacitance Bridge Assembly. This bridge can detect changes in capacitance as small as 0.01 pF and, because

of its three-terminal configuration, it will ignore stray capacitance from each component terminal to ground. With other scanners, this capability cannot be used to advantage. In the 1770 Scanner System a guard arrangement connects stray capacitance (caused by long cables, for instance) from the component terminals to ground, leav-

ing less than 0.01 pF across the component itself.

### DESCRIPTION

The Scanner System is composed of two main units, the 1771 Scanner Control and the 1772 Scanner Switch. The components under test are connected to the switch unit by long cables, each consisting of 10 wires in a single shielded bundle. The switch unit is similarly connected to the control unit by a long cable. This arrangement is extremely adaptable, since the components can be separated from the switch unit, which can in turn be separated from the control unit. In environmental testing, for example, components in a test chamber can be connected to the switch unit outside the chamber by the cable bundle. The arrangement also allows expansion of the channel capacity, since several switch units can be connected to a single control unit.

### SCANNER SWITCH UNIT

The 1772 Scanner Switch accepts up to 10 plug-in reed-switch modules. Two types of switch modules are available: the 1772-P1 SPST Scanner Module and the 1772-P2 SPDT Scanner Module. Each module can accept 10 input lines and connect them sequentially to one output line. The 1772-P1 SPST module connects the input lines, one at a time, to the output line and leaves the unused lines open. The 1772-P2 SPDT module operates in the same manner except that the inactive input lines are connected to a common (ground) terminal. Figure 2 shows the use of these modules in the guarded scanning of two-terminal components. Only three of the 10 input channels are shown. Note that this connection places the stray capacitance of the inactive channels between the low output terminal and ground rather than across the output terminals. This connection is shown more clearly in Figure 3.

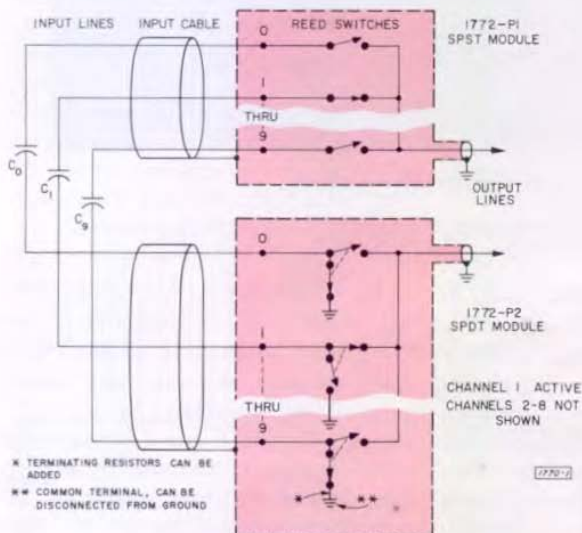


Figure 2. Simplified schematic diagram showing connections for guarded scanning of two-terminal components.

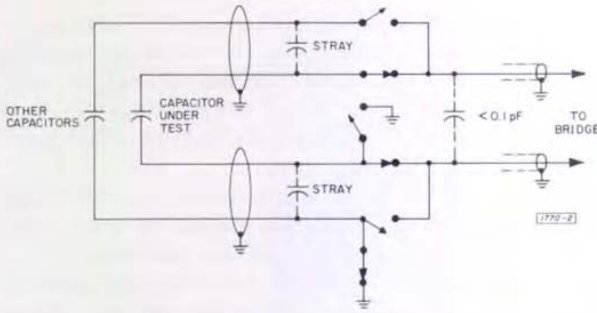


Figure 3. Simplified schematic diagram of scanner switching circuit.

Each module uses long-life reed switches capable of over 25 million operations. Total channel resistance is less than 200 milliohms.

The 1772 Scanner Switch can accept 10 modules of either type and can provide, for example, a scanning capacity of 50 two-terminal components or 100 single-terminal signal lines.

**Physical Description**

Figure 4 shows a 1770 Scanner System used with a 1680-A Automatic Capacitance Bridge Assembly. The 1772 Scanner Switch is shown at the left, housed in a 5½-inch-high relay-rack cabinet. All connections are made at the rear of the unit. The 1772-P1 and -P2 Scanner Modules plug in as shown.

Each module includes a 14-pin connector for the input lines and two parallel BNC connectors for the output lines. One BNC output connector can be used for connection to the external measuring instrument and the second to other modules. The main chassis has two connectors, one for connection to the 1771 Scanner Control and one for connection to other Scanner Switches. Two 50-foot rolls of 10-conductor shielded cable are supplied for connection to the input lines.

**SCANNER CONTROL UNIT**

The 1771 Scanner Control Unit is an all-solid-state instrument that can control up to four 1772 Scanner Switches. Its maximum capacity is 100 single or

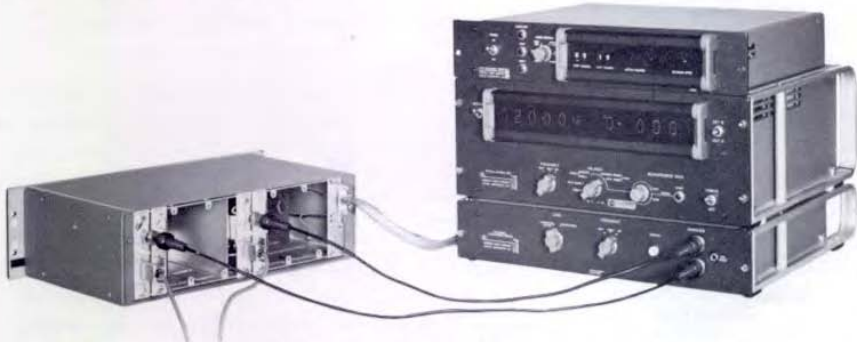


Figure 4. Scanner system connected to automatic bridge. Scanner switch is at left; control unit is above the bridge.

multiple channels. The instrument has thumb-wheel switches for channel selection and a bright in-line numerical readout of the active channel. An electrical readout is also provided, along with various other electrical inputs and outputs.

### OPERATING MODES

The thumb-wheel switches are set to the first and last channels of a desired sequence. Six modes of operation can be selected by the front-panel MODE CONTROL switch:

(1) **SINGLE STEP**, in which channel advance is initiated by manual operation of a front-panel pushbutton or by an electrical signal applied to a rear connector:

(2) **SINGLE SCAN**, in which a channel group is automatically scanned once from the first to the last channel. At the end of the sequence the first channel is ready to be activated:

(3) **CONTINUOUS SCAN**, in which a

channel group is repetitively scanned;

(4) **REPEAT**, in which the scanner remains on the first channel. A push-button or an external input is used to generate an output "measure" signal;

(5) **RANDOM ACCESS**, in which any channel can be selected by BCD contact closures applied to a rear connector;

(6) **REMOTE**, in which any mode of operation can be selected by contact closures applied to a rear connector.

### TIMING

A scanning sequence is initiated by a signal from the automatic capacitance bridge. An output delay interval, adjustable from 50 milliseconds to 2.5 seconds, is generated to allow proper operation of other equipment that may be activated by the same signal. After this delay the scanner advances one channel, and a second interval, of 10 milliseconds, allows for switch bounce time and data settling. At the end

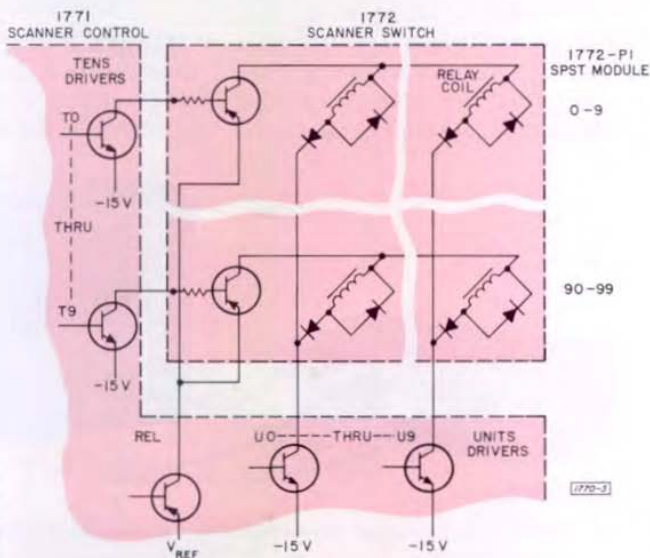


Figure 5. Simplified schematic diagram showing interconnections between control unit and switch unit.





Figure 6. Bridge-scanner system used in environmental tests on dipped-mica capacitors.

Photo courtesy of the Electro Motive Manufacturing Co., Inc.

of this interval an output signal is generated to operate the bridge. At the same time, a third interval, adjustable from 100 milliseconds to 25 seconds, is initiated. In the SINGLE SCAN or CONTINUOUS SCAN mode the scanner advances to the next channel at the end of this interval unless a signal from the bridge has caused it to advance sooner.

Front-panel terminals allow the operator to monitor the delay signals on an oscilloscope.

#### SCANNER CONTROL - SCANNER SWITCH INTERCONNECTIONS

Figure 5 shows a simplified schematic diagram of some of the interconnections between the Scanner Control Unit and the Scanner Switch Unit. Two decade counters in the Scanner Control Unit determine the active channel by means of the matrix ("crosspoint") connection shown. For example, if the tens decade is set to 0 and the units decade to 9, tens-driver transistor  $T0$  and units-driver transistor  $U9$  will be

held in saturation, connecting the coil of reed switch  $09$  between  $V_{REF}$  and the  $-15$ -volt supply. The diodes in series with the reed-switch coils allow the matrix to operate, while those in parallel with the coils prevent the surge transient from damaging the driver transistors.

The coil-return line,  $REL$ , is connected through a normally saturated transistor to  $V_{REF}$ . This transistor is cut off for the reset operation, disabling all channels.

The channel-driver transistors can supply up to 80 mA. The reed-switch coils in the 1772-P1 SPST Scanner Module require 15 mA and those in the 1772-P2 SPDT Scanner Module require 30 mA. Thus one Scanner Control Unit can drive, for example, four 100-channel single-wire Scanner Switch Units (10 1772-P1 SPST modules in each) or one 100-channel guarded-two-terminal scanner consisting of two Scanner Switch Units (10 1772-P1 SPST modules in one and 10 1772-P2 SPDT modules in the other).



Harold T. McAleer received the B.S.E.E. and M.S.E.E. degrees from the Massachusetts Institute of Technology in 1953. He was employed as a cooperative student at GR on the design of high-frequency measuring and recording instruments. After two years' service as an engineer with the U. S. Army Signal Corps at Fort Monmouth, he returned to GR as a development engineer in GR's Frequency Group, where he designed frequency counters, and associated instruments. Since early 1966 he has been responsible for the design of systems at GR. He is a registered professional-engineer and a member of the IEEE, Eta Kappa Nu, Tau Beta Pi, and Sigma Xi.



Richard F. Sette, designer of the 1781 Digital Limit Comparator and 1770 Scanner System, received the B.S.E.E. and M.S.E.E. degrees from Northeastern University in 1960 and 1962, respectively. He performed graduate research in solid-state physics at the Air Force Cambridge Research Laboratory and later served in the U. S. Army Electronics Laboratory at Fort Monmouth, where he was concerned with the testing and evaluation of integrated circuits. Since joining GR in 1964 he has been responsible for the design and development of data-processing equipment for automatic testing systems. He is a member of the IEEE and Eta Kappa Nu.

### APPLICATIONS

Figure 6 shows the 1770 Scanner System used with a 1680-A Automatic Capacitance Bridge Assembly at Electro Motive Manufacturing Company in Willimantic, Connecticut, to perform environmental-performance inspection of high-reliability dipped-mica capacitors. The capacitors are checked in an environmental chamber over a range of  $-55$  to  $+150^{\circ}\text{C}$ .

In another custom-designed measurement system, a 1770 Scanner System is used in the testing of touch-dial-telephone inductors. By use of the random-access mode, external programming equipment is used to connect a prescribed group of inductors, first for demagnetizing and then, after a known time interval, for measurement. The flexibility of the scanner system makes it ideal for this application.

The 1770 Scanner System can be used for signal-line scanning with either type of switch module. The 1772-P2 SPDT Scanner Module is constructed so that terminating resistors can be automatically connected to inactive channels (see Figure 2).

The scanner system can also be used in reverse as an output scanner, to connect a single input signal to many output terminals in sequence. In one such application, for example, two scanner switch units are operated from one control unit. One of the switch units connects input signal lines one at a time to a measuring instrument, while the other switch unit connects the output of the instrument to a multiple-channel recorder.

— HAROLD T. McALEER  
RICHARD F. SETTE

### SPECIFICATIONS

#### 1771 SCANNER CONTROL

##### INPUT

**Logic Levels** ( $V_{REF} = V_{chassis} \pm 50 \text{ V}$ ):

"1" =  $V_{REF}$  (or  $V_{REF}$  to  $V_{REF} - 2$  volts)

"0" =  $V_{REF} - 10$  (or  $V_{REF} - 8$  to  $V_{REF} - 15$  volts).

**Channel Advance:** Logic-level transition, either polarity; input resistance = 50 k $\Omega$ ; maximum source resistance = 20 k $\Omega$ .

Or, contact closure to  $V_{REF}$ ; input resist-

ance = 1.8 k $\Omega$ ; open-circuit voltage =  $V_{REF} - 15$  volts.

**Remote Control:** Start, stop, reset, skip, inhibit, random-access channel selection and mode; contact closure to  $V_{REF}$ ; input resistance = 1.8 k $\Omega$ ; open-circuit voltage =  $V_{REF} - 15$  volts.

##### OUTPUT

**Channel Identification:** BCD 1-2-4-2 (1-2-4-8 optional); output resistance = 22 k $\Omega$ .

**Measure Command:** Logic 0 to logic 1 transition behind  $0.001 \mu\text{F}$ .

**Channel-Switch Drive Current:** 80 mA.

**End of Scan:** Logic-level transition, either polarity, behind  $10 \text{ k}\Omega$ .

#### TIMING DELAYS

**Settle Delay:** 10 ms.

**Safety Delay:** Adjustable 100 ms — 25 s.

**Output Delay:** Adjustable 50 ms — 2.5 s (can be inhibited).

#### 1772 SCANNER SWITCH

**Capacity:** 10 scanner modules.

##### 1772-P1 SPST SCANNER MODULE

**Complement:** 10 SPST switch contacts, rated at 25 V, 0.1 A, maximum. Channel-drive requirement: 15 V at 15 mA.

##### 1772-P2 SPDT SCANNER MODULE

**Complement:** 10 SPDT switch contacts, rated at 25 V, 0.1 A, maximum. Channel-drive requirement: 15 V at 30 mA.

**ORDERING INFORMATION** — The 1770 Scanner System is not presently available as an "off the shelf" item. Inquiries are invited for scanner systems as described above. The price for a typical 50-channel guarded scanner is approximately \$3500.

## EXPERIMENTER on Microfilm

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film, on metal reels suitably labeled. Enlarged copies can be printed on request. All inquiries regarding this service should be directed to University Microfilms, 313 North First Street, Ann Arbor, Michigan 48106.

## INSTRUCTION MANUALS FOR THE CLASSROOM

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techniques. We are always glad to grant requests for single copies of manuals for use in the classroom. Where quantities are requested, a charge will usually be made to defray printing cost.

## ADDENDUM

In the specifications for the TYPE 1394 High-Rate Pulse Generator (July 1966 issue, page 8), the type designations 1394-A and 1394-Z appear without explanation of the distinction between them. As mentioned early in the issue, the High-Rate Pulse Generator alone is designated TYPE 1394-A; the designation 1394-Z identifies the combination of TYPE 1394-A High-Rate

Pulse Generator and TYPE 1394-P1 Pulse-Offset Control.

In the specifications for the 1525-A Data Recorder (October issue), a line of type was omitted from the *Weighting Characteristics*. The complete specification follows:

**Weighting Characteristics:** NAB and constant current for both playback amplifiers; NAB constant current, and A, B, and C weighting (standard sound-level-meter characteristic) for record channel #1. Constant current for record channel #2.

## EXPERIMENTER Editor Retires



With this issue the *Experimenter* bids farewell to Charles E. Worthen, who for over 30 years has been its Editor.

Charles Worthen joined GR in 1928, after graduating from M.I.T., and, working with J. K. Clapp, helped pioneer the first commercial primary frequency standards. In 1934 he turned his full attention to the written word; since then, as Publicity Manager and as Director of the Sales Promotion Department, he has shepherded the

*Experimenter*, catalogs, instruction manuals, handbooks, ads, and general publicity. His editorial judgment was always sound; his writing was always characterized by good taste, a style both readable and correct, and a talent for uncomplicating the complex. Perhaps more than any other individual, he has set standards for the literature of the electronics industry.

Now he retires, the better to enjoy his family, his books, some travel, and a well-earned freedom from deadlines. Our best wishes go with this man whose words were always so well chosen.

F. Van Veen, Editor

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