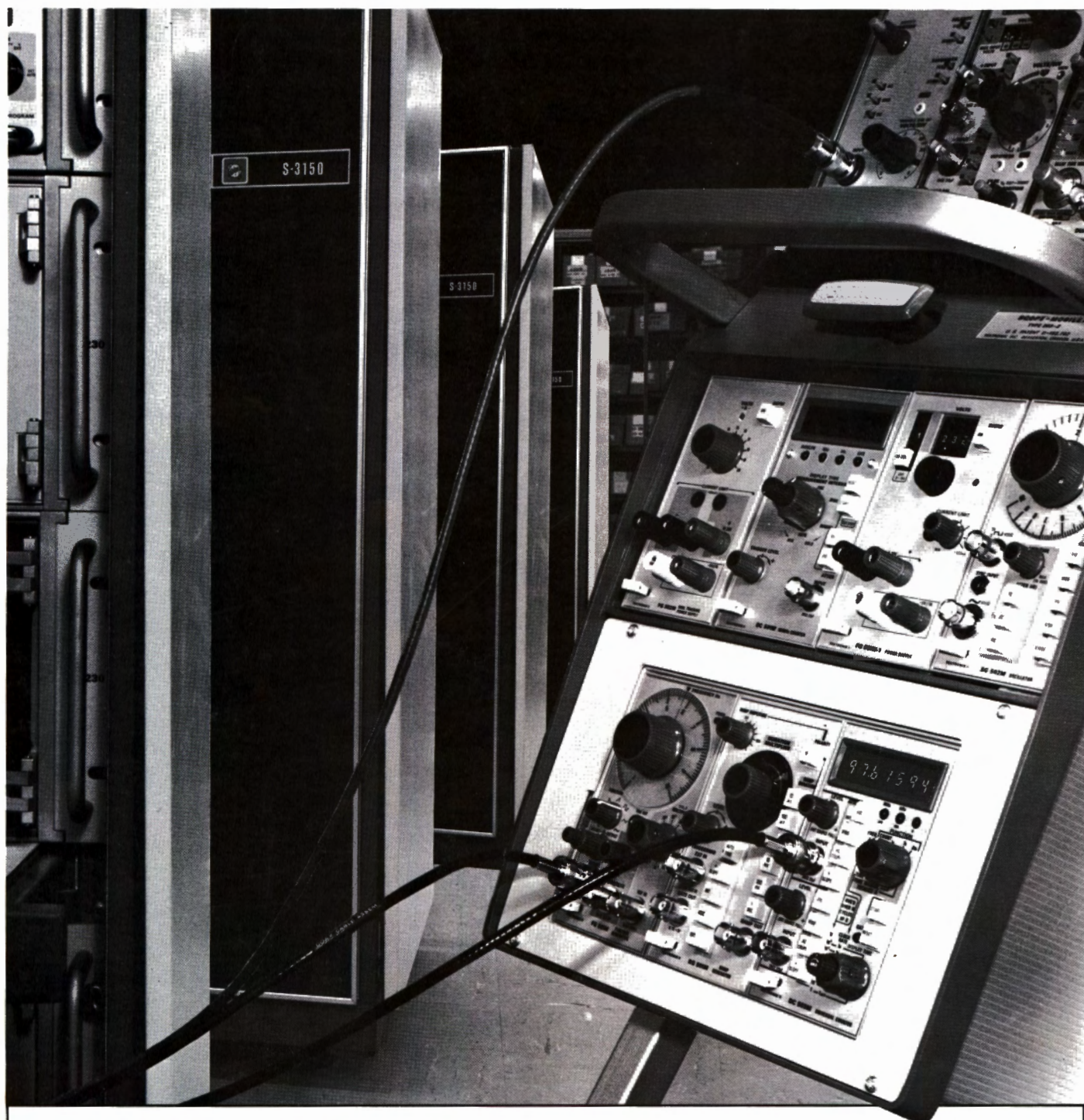




TEKSCOPE

VOLUME 4

NUMBER 3



- A NEW DIMENSION IN PLUG-IN INSTRUMENTATION
- THE 7704A—EXTENDED PERFORMANCE PLUS MODULARITY

- SEMIAUTOMATIC TESTING WITH THE CURVE TRACER
- INSTRUCTION MANUALS, A SERVICE TECHNICIAN'S BEST FRIEND

TM500 SERIES



a new dimension in plug-in instrumentation

by **Bob Ragsdale**, Program Supervisor

One of the best ways to reduce the cost of general-purpose instrumentation is to extend the measurement capability of a product through the use of plug-ins. This concept reaches a new dimension in a series of compact, low-cost, general-purpose modular instruments recently introduced by Tektronix.

The TM 500 Series is designed to meet the need for an instrumentation system that is low cost, versatile, easily updated, occupies a minimum of bench or rack space and is readily serviced.

Cover—The TM 500 Series mounted in a Scope Mobile® Cart makes a highly mobile test system as pictured here in the Systems Production area at Tektronix.

THE TM 500-SERIES ARCHITECT

The power supply represents a substantial portion of the cost of any instrument. It, more than any other single factor, imposes a practical limit on the ability to reduce an instrument's cost. The TM 500 Series offers an ideal solution to this limitation. The expensive components of the power supply: the transformer, rectifiers, filter capacitors and pass transistors are located in a mainframe that accepts plug-in units. The regulator circuits, usually consisting of one IC, are located in each plug-in. This permits the use of optimum power supply voltages for each plug-in.

The TM 503 mainframe houses and powers up to three plug-in modules, each performing a separate function. If more than three functions are needed, two TM 503's may be bolted together for rackmounting or they may be stacked vertically. The cost savings per function achieved by this approach are readily apparent.

The TM 501, a mainframe housing a single plug-in module, is available for those needing only a single function but desiring the flexibility afforded by plug-ins.

Since the intent is to make the TM 500 Series as versatile as possible, the mainframe/plug-in interface has received special attention. A number of pins are dedicated to input and output signals, with several pins available for interconnection of special systems. The pins are coded for easy identification. A system of board notches and connector barriers may be used to prevent accidental insertion of inappropriate plug-ins.

The plug-in modules currently available include function generators, power supplies, counters, a sinewave generator, pulse generator, and ramp generator, with DVM's and other plug-ins available soon.

THE PLUG-IN MODULES

FG 501 Function Generator

The FG 501 is a general-purpose instrument module with a frequency range of 0.001 Hz to 1 MHz. Output waveforms include sine, square, triangle and ramps of either polarity. An offset control with a ± 5 -volt range is provided to allow generation of \sin^2 pulses, zero-volt baseline pulses, etc.

An external VCF input allows control of frequency by means of a DC voltage. Applying a ramp waveform to this input provides sweep frequency operation. A gate input permits burst or single cycle operation. Another convenient control, the "hold" switch, can interrupt the operation of the generator in midcycle, allowing precise setup of mechanical or other low frequency systems. Release of the "hold" switch allows the generator to continue normally. Maximum output voltage of the FG 501 is 20 V peak-to-peak.

The FG 502 Function Generator is essentially identical to the FG 501 with the exception that the frequency range is 0.1 Hz to 10 MHz.

RG 501 Ramp Generator

This module is a multipurpose ramp generator capable of ramp outputs of either polarity and variable amplitude. A full complement of triggering controls enables the RG 501 to serve as a time base for a monitor oscilloscope. The amplitude and polarity controls make this unit an ideal frequency sweep accessory for the FG 501 and FG 502 function generators.

The unit produces a TTL-level gate waveform coincident with the ramp, which can be used to gate a function generator for burst or single cycle operation. The gate can also be used for Z-axis modulation of a monitor oscilloscope.

PG 501 Pulse Generator

The PG 501 is a 5-volt, 50-MHz general-purpose pulse generator with simultaneous positive and negative output pulses. Pulse rise and fall times are < 5 nanoseconds with output amplitudes separately adjustable from ≈ 0.25 to 5 volts into 50 ohms.

Calibrated and variable selection of pulse duration and period are provided, with pulse duration adjustable from < 10 ns to 0.1 second. Pulse period is adjustable in decade steps from < 20 ns to 20 ms with a 10X variable extending the period to at least 0.2 second.

A gated mode is provided in which the external trigger input is coupled to the outputs through a Schmitt circuit. This mode is particularly useful to regenerate

pulses, convert low-level pulses to high level, and other such applications.

Another useful mode is "Output Locked On". In this mode the PG 501 can be used as a power supply furnishing both positive and negative voltages. It also provides a means of setting the output pulse amplitude very accurately through the use of a digital voltmeter.

The SG 502 Oscillator

The SG 502 is a low-frequency sinewave oscillator covering the range from 10 Hz to 1 MHz. Five decade ranges and a 1-to-10 log dial permits frequency selection within 3% for all but the top range. From 100 kHz to 1 MHz the accuracy of the setting is $\pm 5\%$. The output is leveled within 0.1 dB from 10 Hz to 100 kHz and within 0.3 dB from 100 kHz to 1 MHz.

Pushbutton attenuators in 10-, 20- and 40-dB steps provide calibrated attenuation of 70 dB. A 40-dB variable attenuator extends maximum attenuation to 110 dB. Output amplitude is 2.5 volts RMS into 600 Ω or 5.0 volts RMS open circuit.

An auxiliary squarewave is also available at the front panel. The output is TTL compatible (0 to 5 volts open circuit). The squarewave switches on the 0° and 180° points of the sinewave output with rise and fall times of less than 50 ns.

The Counter Plug-Ins

Another instrument commonly found on the bench is the digital counter. The TM 500 Series includes three digital counters: the DC 501, a 100-MHz counter; the DC 502, a 550-MHz counter; and the DC 503, a 100-MHz universal counter.

All of the units feature a 7-digit stored LED display with leading zeros (those to the left of the decimal point) blanked. LED indicators are also provided for register overflow, "gate on" and units readout. On the DC 503, register overflow is indicated by a flashing display. The standard internal clock is 1 MHz with an accuracy of 1 part in 10^6 . An optional clock with 5 parts in 10^7 accuracy is available at extra cost.

Four counting times of 0.01 s, 0.1 s, 1.0 s, and 10 s are provided, with automatic switching of decimal point and kHz, MHz indicators. Automatic ranging is available on the 100-MHz unit as an option. All three units offer totalizing from 0 to 10^7 at any rate up to 100 MHz. The 550-MHz counter has selectable 1-M Ω and 50- Ω inputs. In the 1-M Ω position the unit counts directly from 10 Hz to 100 MHz. In the 50- Ω position the input is divided by 10 before counting, with a range of 50 MHz to 550 MHz.

The DC 503 Universal Counter offers six measurement functions: a frequency-counting mode, a frequency-ratio mode, three time-counting modes and an event-counting mode. It has two channels (A and B) with BNC inputs and separate trigger level, attenuator and coupling mode controls. The frequency range of channel A is 0 Hz to 100 MHz and Channel B, 0 Hz to 10 MHz.

The Power Supply Plug-Ins

There are five members in the power supply plug-in family at present. The PS 501 has two supply voltages available, a 0-20 VDC adjustable supply capable of 400 mA and a +5 VDC supply capable of 1 A.

The 0-20 VDC supply may be floated up to 350 volts and either terminal may be grounded. Current limiting is adjustable to 400 mA by means of a front panel control. A panel mounted LED signals the user when current limiting occurs. Concentric coarse and fine output controls set the output voltage to values indicated by front panel markings.

The +5 VDC supply is an auxiliary supply intended for noncritical applications such as bipolar logic, LED's, etc. Regulation is determined by an integrated circuit regulator.

The PS 501-1 module is identical to the PS 501 except that the output voltage is set and read by a ten-turn precision potentiometer with a 3-digit in-line dial, plus a range switch. The output is adjustable from 0-10 volts or 10-20 volts depending on the range switch setting. Output accuracy is essentially that of the potentiometer and is much better than can be obtained using an analog meter.

The PS 501-2 is identical to the PS 501 except that a meter with readout accuracy of 2% is provided for those preferring to monitor output voltage by this means.

The PS 502 Power Supply module is a floating dual tracking supply consisting of plus and minus supplies with a common terminal. Any one terminal may be grounded, or may be floated up to 350 VDC plus peak AC.

Each supply has a range of 10-20 volts with respect to the common terminal and a fixed current limit of 400 mA. The limit can be changed to 100 mA with an internal jumper. The dual supply can also be used as a 10-40 volt single supply. A single control sets the output of both supplies, which track each other closely.

The dual tracking supply is well suited for complementary circuits and linear IC's such as operational

amplifiers, differential amplifiers and differential comparators.

The PS 502 also contains an auxiliary 5-volt supply similar to that in the PS 501.

The PS 503 Power Supply module is a floating dual supply with many of the features of the PS 502. The main difference is that the outputs of the plus and minus supplies (relative to the common terminal) can be set independently. In addition, both outputs can be attenuated by a common control which maintains a constant ratio between the two output voltages. The common attenuator control also allows the dual supply to operate conveniently as a 0 - 40 volt supply.

SERVICEABILITY

The advantages of the plug-in concept from the standpoint of servicing are well known to industry:

Problem areas can often be quickly identified by substituting a plug-in known to be good, for a suspected unit.

Repair time is substantially shortened by easy access to circuitry and adjustments.

System down time can be kept at a minimum by use of a standby plug-in when repairs or calibration are necessary.

Add to these the commonality of design used in the TM 500-Series plug-ins that simplifies maintenance and reduces parts inventory, plus the world-wide system of service centers Tektronix provides for its customers.

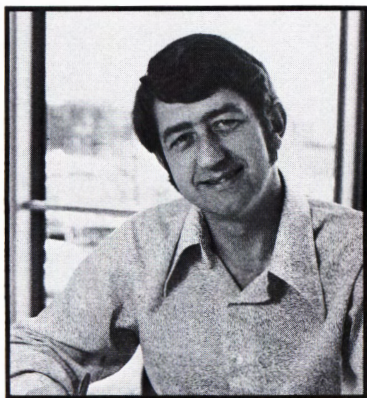
These all add up to the best in serviceability, whether you perform it, or want us to perform it for you.

SUMMARY

While the units we've been discussing cover many of the functions desired in a test system, they are but the forerunners of many other units on the way. The economies in both space and cost afforded by the plug-in concept now make it possible for you to enjoy test equipment formerly out of reach in the monolithic form. Truly a new dimension in plug-in instrumentation.

ACKNOWLEDGEMENTS

Warren Collier, as project manager, heads up the team responsible for design of the TM 500 Series. Gunther Engert and Roger Stenbock designed the mainframes and power supply plug-in modules. Steve Stanger did the sine-wave oscillator and FG 502 Function Generator, with Roger Stenbock contributing much to the FG 501. Jim Geddes designed the DC 501 and DC 502 counters and assisted Roland Crop who did the major portion of the universal counter. Rashmi Pace did the ramp generator, and Mark Walker and Michael Reiney teamed up to do the pulse generator. Mechanical design was done by Lamar Madsen, Frank Terada and Morris Wagner. Bob Ragsdale also made valuable contributions to several of the plug-in modules.

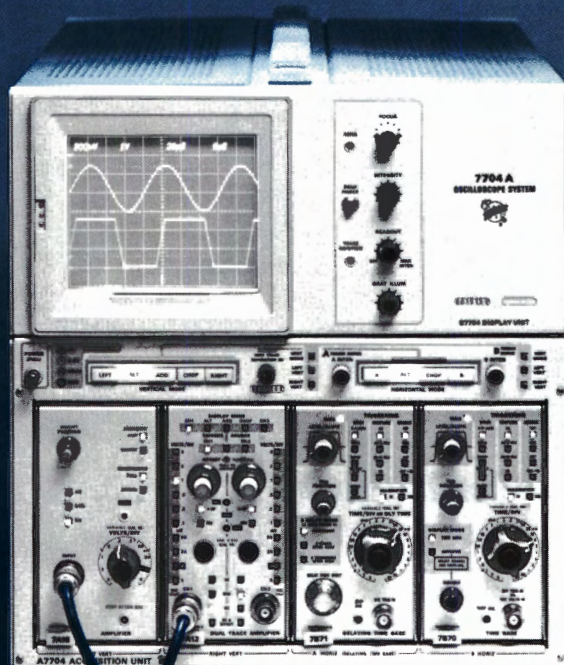


Bob Ragsdale—Bob attended the University of Washington, University of Colorado and the University of California prior to coming with Tek in 1961. He has a wide range of experience in both design and sales of general-purpose instrumentation and semiconductor automatic test equipment. Bob's favorite pastime is bicycling (he's president of the Beaverton Bicycle Club). He is also active in mountain climbing and scuba diving.

the 7704A

Extended Performance plus Modularity

With performance features proven in the TEKTRONIX 7000 Series, the new 7704A provides 250 MHz bandwidth in a new modular design.



by **Luis Navarro**, Electrical Project Leader and
Bob Shand, Mechanical Project Leader

How do you make a great oscilloscope even greater? First, you start with a performance leader like the TEKTRONIX 7704 with features such as: 150 MHz bandwidth, four plug-in flexibility, CRT READOUT, versatile trigger source selection, high-efficiency power supply, vertical and horizontal mode switching, and high writing speed CRT. To these outstanding features you add: increased bandwidth; modular construction; lighter weight; reduced spot size; and significant circuit improvements in the vertical deflection system, high-efficiency power supply, Z-axis amplifier, and high-voltage supply.

CONSIDER THE MECHANICAL

The mechanical designers of the 7704A were faced with the challenge of improving upon the proven mechanical design of the 7704. The 7704 reached a new level of usability with features such as four plug-in flexibility, compact design, easy to replace circuit boards, and user-oriented front panels. Rising to the challenge they set out to design an instrument that is easier to operate, easier to service, lighter in weight, and easier to build.

An additional goal was to further implement the "option" concept which was pioneered in the 7000 Series. This allows you to delete certain optional features to "customize" the instrument to your measurement requirements at the time of purchase while retaining the ability to add them at a later date.

The results of this mechanical design concept are shown in the finished 7704A (see Fig. 1). The 7704A configuration is modular, consisting of two main units. The A7704 Acquisition Unit contains the four plug-in compartments with the associated interface circuitry, logic board, vertical and horizontal interface, mode and trigger switching, calibrator, CRT READOUT and signal buffer modules, and the low-voltage power supply module. The D7704 Display Unit contains the CRT, vertical and horizontal amplifiers, high-voltage power supply, and the Z-axis amplifier.

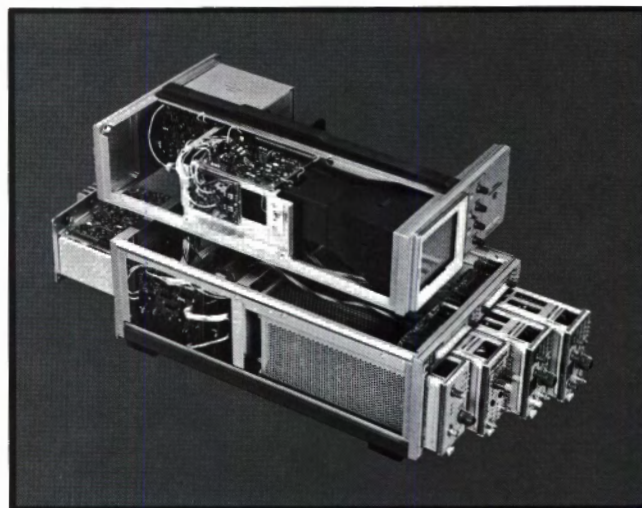


Fig. 1. 7704A uses modular design concept for system flexibility and easier service.

Separation of the two units is easy—remove the left side panel from the D7704 and disconnect one multi-pin connector. Remove four screws to loosen the latching bars which lock the two units together; then the upper unit can be lifted away. This gives complete access to components in both units for easy servicing. This concept also allows room for future system expansion.

The modular concept has been carried inside the units also. All major components are mounted on circuit boards. Cable interconnection between boards is minimized; several circuits such as the CRT READOUT and low-voltage power supply were re-designed to achieve this goal. All boards can be removed quickly due to use of quick-disconnect harmonica connectors, which group together single wires into a multiple connector, or the TEKTRONIX invented Peltola¹ coaxial connector (see Fig. 2) which provides a low cost but high performance coaxial connection.

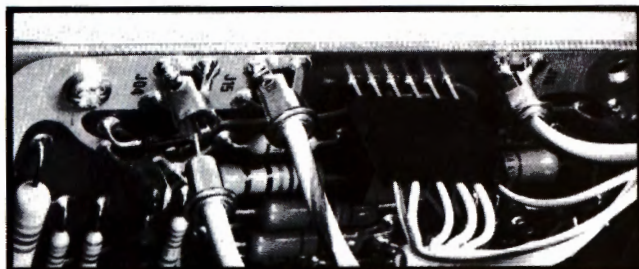


Fig. 2. Two types of quick-disconnect connectors are used: left, Peltola coaxial connector; right, harmonica connector.

Further modularity is provided by the CRT READOUT and signal buffer modules. These modules contain the input and output connectors, circuit board, and interconnecting cables required for each function. The 7704A can be ordered without CRT READOUT (Option 1) or without the signal buffer (Option 7). However, these modules can be added later with minimum expense and time simply by removing the two securing screws and cover plate. Then, install the module and connect the cables to provide expanded oscilloscope functions (see Fig. 3).

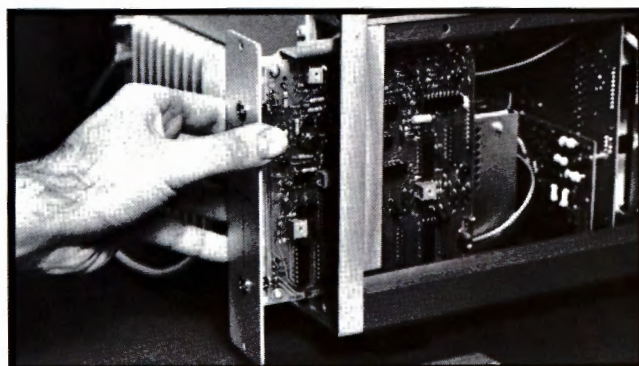


Fig. 3. Adding the CRT READOUT module.

The front panel of the 7704A has also been simplified for easier operation. Only the most used controls and connectors are placed on the front panel. Secondary functions such as the control illumination switch and the input and output connectors have been relegated to the rear panel.

Another benefit of the unique mechanical design is reduced weight—only 30 pounds (instrument without plug-ins)—a new low for laboratory oscilloscopes. This low weight rivals many portable instruments and means you can move the 7704A between benches or to a new measurement location with ease.

All of these improvements were accomplished without compromise of mechanical strength. The 7704A provides the same mechanical ruggedness which has become characteristic of the 7000 Series.

EXTEND THE PERFORMANCE

Extended performance is the key feature of the circuitry in the 7704A. The introduction of the 7000 Series, and specifically the 7704, brought new performance and versatility to oscilloscope users. Now, the 7704A brings increased bandwidth, decreased power consumption, and easier operation, all at a lower price.

Start with a High-Speed CRT

The 7704A uses the same cathode-ray tube as the 500 MHz realtime 7904.² This CRT uses a helical traveling-wave structure for the vertical deflection plates. A domed scan-expansion mesh between the deflection plate structure and the accelerating anode provides both isolation and a two-times deflection magnification. Together with a 24-kV total accelerating potential, this CRT provides small spot size, bright display, and high photographic writing speed (7 cm/ns without film fogging or 14 cm/ns with film fogging, P11 phosphor, C-51-R Camera, 10,000 speed film, and TEKTRONIX Writing Speed Enhancer). An optional CRT extends the photographic writing speed to 10.4 and 20.8 cm/ns respectively for maximum brightness and increased visibility of low repetition rate, high speed signals (Option 4—scan reduced to 8 x 10 one-half centimeter divisions).

Add an IC Vertical Amplifier

Coupled with the high-performance CRT, the vertical deflection system extends the upper bandwidth limit of the 7704A to 250 MHz (Option 9—system optimized for bandwidth). The bandwidth of the standard instrument is at least 200 MHz with minimum aberrations to provide optimum pulse response. The overall vertical deflection system uses only 2 IC's and 4 transistors versus 26 transistors in the 7704. A single, hybrid integrated circuit provides the signal channel for the vertical

output amplifier. This IC is actually comprised of 3 separate chips mounted on a 16-pin header with an integral heat sink.

A minimum of compensation adjustments are used in the vertical deflection system, consistent with good engineering practices. This means that the instrument can be re-adjusted for optimum performance if any of the transistors or IC's are replaced, without the need for costly selection of special parts.



Fig. 4. A single, hybrid IC provides the signal channel for the vertical output amplifier.

High-Efficiency Power Supply

A high-efficiency power supply similar to the type pioneered in the 7704³ is used in the 7704A. The maximum power consumption of this instrument has been reduced by 30 watts in comparison to the 7704 as a result of improvements both within the power supply and in other areas of the instrument.

An IC is used in place of eight transistors to control the operation of the inverter circuit. This IC provides better pre-regulation for the supply voltages and also takes up less space, contributing to a more compact power supply. In addition, it incorporates protection circuitry which was not previously available.

The supply is protected against excess current demand or over-voltage conditions. The IC control circuit senses the current supplied to the primary of the power transformer by the inverter circuit. If this current exceeds the normal operating level for about 15 milliseconds, the inverter circuit is shut off for about one-half second. Then, it is turned back on and the current is checked again. If the original fault is not present, the power supply continues to operate in the normal manner. However, if excess current is still being demanded, the circuit goes into a pulsed type of operation until the fault is cleared.

In a similar manner, over-voltage protection is provided by sensing the peak voltage across the primary of the power transformer. If it is too high, the inverter circuit is shut down for about one-half second. Then, it comes back on to check if the fault has been cleared; if not, the circuit goes into the pulsed mode until the fault is cleared.

Besides providing protection for the low-voltage power supply, this pulsed mode of operation also facilitates trouble location. Instead of shutting down completely or blowing fuses as with "crowbar" type protection circuits, this power supply operates in the pulsed mode if the input circuitry is working correctly. However, if the trouble is in the input or inverter circuits, pulsed mode operation will not occur.

High-Voltage Supply

The conventional method of developing and regulating the high voltage necessary for operation of the CRT is with a feedback-controlled oscillator. In the 7704A, a 20 kHz pre-regulated 216 volt peak-to-peak voltage from the low-voltage supply is the source for the high-voltage supply. Since this source voltage is pre-regulated to about 1%, a series regulator scheme can be used (see block diagram, Fig. 5). As a result, the high-voltage supply in the 7704A is more efficient while using fewer components. The high-voltage supply is built on a single circuit board to provide easy access if service is required.

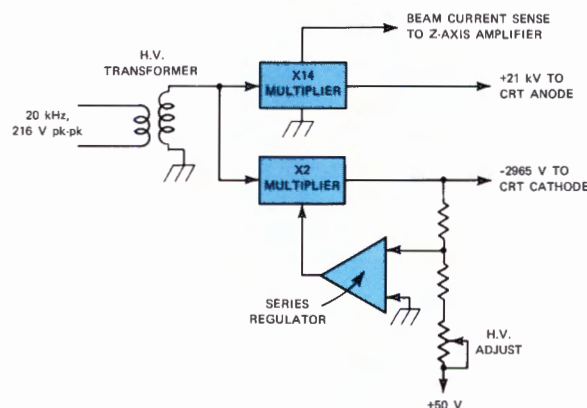


Fig. 5. Simplified block diagram of the high-voltage regulator.

Z-Axis Amplifier

The Z-axis amplifier in the 7704A provides two features which are also found on the new 485⁴—auto-focus and beam-current limiting.

Once the front-panel FOCUS control of the 7704A has been set correctly, the auto-focus circuit maintains a well-defined display regardless of differences in intensity levels, differences in sweep rates, or the mode of operation selected. This feature is of particular interest for operation in the dual or delayed-sweep modes, for photography of single-sweep displays, or when the CRT READOUT feature is used. The design of the 7704A allows individual setting of the intensity level for the portion of the display produced by each horizontal plug-in and the CRT READOUT. This intensity level is automatically switched along with the display, and as a

result, the voltage required by the CRT to maintain a well-defined display varies accordingly. The auto-focus circuit monitors the intensity drive to the CRT and produces a proportional focus-grid voltage which maintains a well-defined display.

Beam-current limiting in the 7704A allows full use of the small spot size, high accelerating potential, and fast writing speed of the CRT by automatically reducing beam current under conditions which might damage the CRT phosphor. This feature allows you to use maximum intensity for fast, single sweep or repetitive displays while providing protection for the CRT when switching to a slow sweep rate or stationary spot.

CRT READOUT


Alpha-numeric readout of measurement parameters on the CRT—a TEKTRONIX innovation which brought new dimensions and convenience to oscilloscope measurements and waveform photography—is a prominent feature of the 7704A. The CRT READOUT circuit has been mechanically re-arranged to reduce the interconnections to other circuits in the instrument. To accomplish this, the data collection IC's which assemble the information encoded by the plug-ins into the format used by this circuit, have been moved to the plug-in interface board. This arrangement also provides better data transfer to the CRT READOUT circuit. The resulting space on the readout board allows a new component layout for improved serviceability and reliability.

Time Proven Features Retained

Many of the time proven features of the 7704 appear virtually unchanged in the 7704A. For example, versatile trigger source selection. This feature allows the triggering to be selected from the plug-in unit in either vertical compartment or, when the VERTICAL MODE trigger source position is selected, the trigger signal automatically follows the displayed signal.

The simple front-panel switching, which provides unparalleled operating ease and flexibility for the 7704A, is made possible by an IC logic system. The logic circuit produces the correct control signals for other circuits in the instrument in response to the operating mode selections on both the front-panel of the 7704A and the plug-in units. A unique operating condition made possible by this circuit is a "slaved" mode which simulates dual-beam operation for most repetitive sweep applications. When the vertical is operated in the alternate mode with the horizontal in either chopped or alternate, the signal from the right vertical unit is displayed only at the sweep rate of the time base in the A horizontal compartment and the left vertical unit is displayed only at the sweep rate of the B time base unit.

The 7704A contains an accurate calibrator to use as a reference signal for checking the amplitude and timing accuracy of plug-in units as well as probe compensation. Accurate voltage output is provided on the front panel; accurate current output is available with an optional current loop adapter.

We've discussed only the major features of the new 7704A. Many other features are contained in this instrument to make measurements faster, more convenient, and more accurate. Only you can determine the real advantages and impact that four plug-in flexibility, modularity, and extended performance can bring to your measurement requirements. 

ACKNOWLEDGEMENTS

As is true of most instruments, the design of the 7704A was a team effort. Assisting Luis Navarro in the electrical design were: Bill Lukens, low- and high-voltage power supply; Jim Cavoletto, vertical amplifier; Bill Markwart, CRT READOUT. Aiding Bob Shand in the unique mechanical design were: Dave Hoskins and Bill Gordon, A7704 Acquisition Unit; Phil Lloyd, D7704 Display Unit; Dick Swanson and Larry Pearson, interconnect system. And much credit is due the electrical, mechanical, and IC support areas for their valuable assistance in this project.



Luis Navarro—Luis began his career at Tektronix in June 1966 after receiving his BSEE and MSEE degrees from the University of Nebraska. His early work was in the advanced circuit design group to develop ideas for use in various TEKTRONIX instruments. Prior to the 7704A, Luis worked on the design of the high-frequency counter IC used in the TEKTRONIX 7D14 525 MHz Digital Counter.

A native of Cuba, Luis enjoys traveling with his wife and two children and taking movies.



Bob Shand—Since Bob started with Tek 10 years ago, he has devoted his efforts to mechanical design. Among the TEKTRONIX products that he has helped to design are the R7704, 7403N, 540B and 560B Series, 549, 601, 602, and 410.

Bob is a native of the Northwest. His hours away from work are spent in family activities with his wife and four children. He is also an avid bridge player and enjoys singing.

¹Designed by Ron Petros, Electronic Design Engineer; patent applied for.

²See "A Subnanosecond Realtime Oscilloscope", TEKSCOPE, July 1971.

³See "Servicing the 7704 High-Efficiency Power Supply", TEKSCOPE, March 1971.

⁴See "A Nanosecond Portable Oscilloscope", TEKSCOPE, March 1972.

TEKNIQUE: *semiautomatic testing with the curve tracer*

by Jack Millay, Project Manager



From one-man labs, to incoming inspection groups, to the production lines of the world's largest semiconductor manufacturers, the 576 is busy making measurements on semiconductor devices. Extremely versatile and relatively low in cost, the curve tracer enjoys wide acceptance in nearly every phase of device testing.

Now a new addition to the 576, the 172 Programmable Test Fixture, greatly increases its usefulness for making repetitive measurements or tests. The 172 plugs into the 576 in place of the standard test fixture. No modifications are necessary. It can be programmed to perform up to eleven sequential tests on transistors, diodes and junction FETs without changing control settings.

The 172 is a real time saver for those who need to make several different tests on a number of devices. For example, suppose you needed to perform six tests on one hundred devices. Using just the 576 you could accomplish the task in either of two ways: (1) insert a device, perform all six tests, then insert the next device and repeat the tests; or (2) you can perform the same test on all one hundred devices, set up the next test and proceed until all six tests have been performed. The first method requires 100 insertions and 600 changes in control settings. The second method is faster, requiring 600 insertions but only 6 control setting changes.

The typical operator would spend one hour making the 600 insertions, ten minutes making the tests, plus the time needed to change the control settings.

Now consider making the same number of tests using the 172. Only 100 insertions would be needed, requiring about ten minutes. Test time would take another ten minutes, for a total of twenty minutes. There would be no control setting changes. One operator using the 172 could test the same number of devices as three operators using the fastest manual procedure.

Another important consideration is the reduction of errors. Even experienced operators make errors when repeated adjustment of control settings is required. The 172 greatly reduces this error source. Once it is programmed, an operator with little or no experience can make tests quickly and accurately.

172 MEASUREMENT CAPABILITY

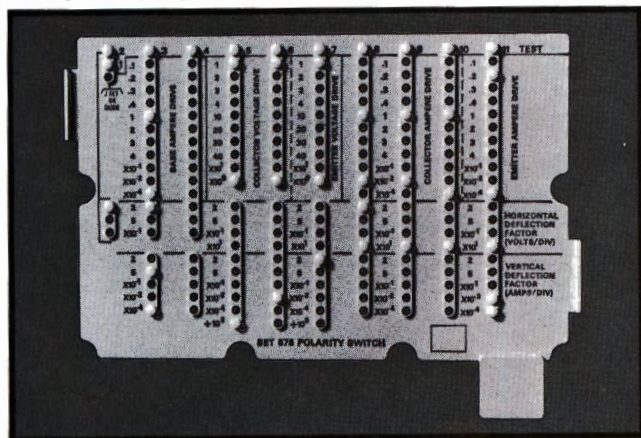
As previously mentioned the 172 will perform up to eleven sequential tests on bipolar transistors. These include three h_{FE} or $V_{CE(sat)}$ tests, one V_{BE} test and all of the normal breakdown and leakage tests. Up to four tests may be performed on junction FET's, including V_p , I_{DSS} or $R_{DS(ON)}$, I_{GSS} and BV_{GSS} . Four tests are also available for diodes including two V_F tests, I_R and V_R .

The 172 is not recommended for testing MOSFET's because of their susceptibility to damage by switching transients. However, it should be noted that the 172 safely performs tests that other automatic testers do not.

PROGRAMMING THE 172

Programming is done by inserting plastic pins into a plastic card which is then placed in the card reader section of the 172.

The pins snap into the card so they will not fall out with normal handling, yet can be easily removed to change the program. The program card is shown below.



A program card programmed to perform seven tests on a 2N3565 transistor.

The top row across the card determines which tests are to be performed. The 172 will make only those tests selected by inserting a pin; the others will be skipped. The cover of the card reader section of the 172 contains a ready reference of the tests that can be performed in each position.

In order to provide the greatest flexibility, the conditions for two of the tests for bipolars and one for FET's or diodes are controlled by the 576 front panel controls. These are tests 1 and 2 in the test sequence. The second test is a repeat of the first except the base-to-emitter voltage is displayed on the horizontal axis at a sensitivity controlled by the 172.

The large block immediately below the test selection row controls the driving current or voltage that is to be applied to the device under test. For h_{FE} or $V_{CE(sat)}$ this controls the base current drive. For leakage measurements it controls the emitter or collector voltage applied, and for breakdown tests it controls the forced breakdown current. The block just below the drive programming area controls the horizontal sensitivity of the display. On tests 3 and 4 the horizontal sensitivity programmed also determines the collector sweep

voltage applied. The bottom block of the card controls the vertical sensitivity of the display. The three holes marked " $\div 10^3$ " permit leakage current measurements down to 1 nA. The block in the lower right hand corner is used to indicate the setting for the 576 polarity switch which is not programmed by the 172.

Once the card is programmed you will find the scale factor readout on the 576 very useful to verify that the vertical and horizontal sensitivities programmed are correct. Except for tests 1 and 2 the base current readout and beta readout do not function, as more values of base current can be programmed than the readout has numbers to display.

CRT OVERLAY LIMIT CARDS

Several plastic CRT overlay limit cards for use in making GO-NO GO tests are supplied with the 172. The overlay is easily marked by placing it over the CRT graticule and marking the limits with a grease pencil or other appropriate means. A line drawn connecting the test limits in the sequence performed is a help to the operator. There are several commercially available pens that make semipermanent markings on the overlay. One very good one is Sanford's Sharpie® Number 49.

If the program includes tests 1 and 2, a 576 front panel setup chart showing the 576 control settings is very useful. If these two tests are not used, the programming card and the CRT overlay are all that are needed.

Once you have programmed several devices, programming is fast and easy. The card typically takes about ten minutes, the limit overlay about ten minutes and the 576 control setting chart about five minutes. After testing is completed, these three items are usually stored away together ready for use the next time. Additional programming cards, pins and CRT overlays are available from Tektronix at a nominal cost.



Tektronix employee Virginia Johnson makes 24,000 tests in about six hours using the 172/576 and wafer prober.

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A TYPICAL APPLICATION

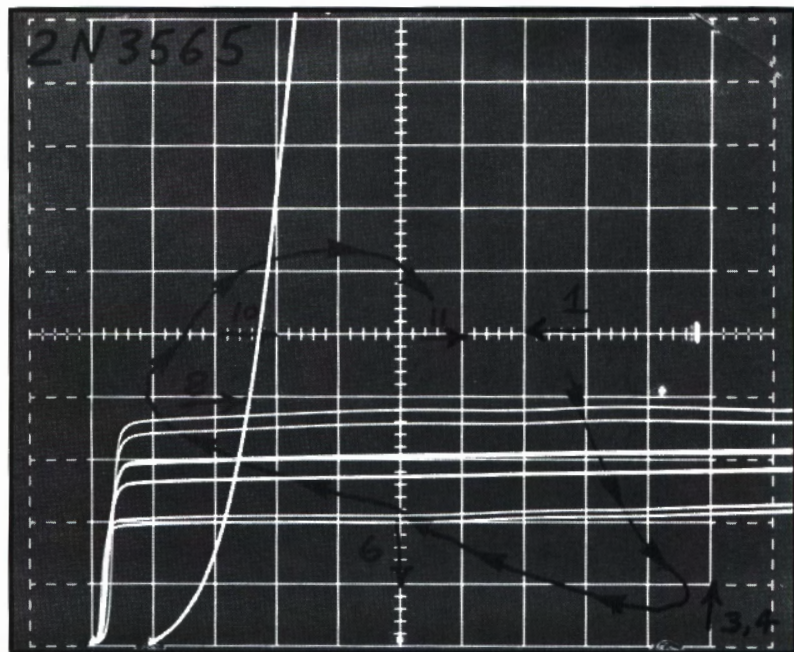
Now that we're acquainted with how the 172 functions, let's take a look at a typical series of tests performed on a device. The program card on page 11 is set up to test a 2N3565 NPN high gain silicon transistor. The tests to be performed are as shown at the bottom of the page.

Test sequences 2, 5, 7 and 9 are omitted from the program; the 172 will automatically sequence through only the tests selected with no loss of time caused by the tests to be skipped.

The test conditions for test no. 1 as set by the 576 front panel controls are:

Collector voltage drive	= Approx. 3 Volts
Base ampere drive	= 0.1 mA
Horizontal Deflection Factor	= 0.05 Volts/Div
Vertical Deflection Factor	= 0.2 Amps/Div

The photo below is a multiple exposure showing the results of each test. The black lines and figures are on the overlay and show the test limits and the sequence in which the tests were performed.



The looping on the $I_C - V_{CE}$ curves for tests 3 and 4 are caused by capacitive currents in the collector supply and in the collector to base junction of the device under test. It is particularly noticeable in testing this device because of the low value of I_C at which beta is to be measured and the high h_{FE} .

You will notice there is no measurement for test 10 in the display. This is because it is off-screen, which is often the case in GO-NO GO testing; the program is usually set up to provide optimum resolution for each test and if the device is particularly good in some characteristic, that measurement may be off-screen. If you desired to know the actual value for that test, the vertical or horizontal sensitivity could be programmed accordingly.

SUMMARY

While not intended for large scale production testing of devices, the 172 provides an ideal solution to the need for a convenient, low-cost semiautomatic test system for incoming inspection and short run applications.

AUTHOR

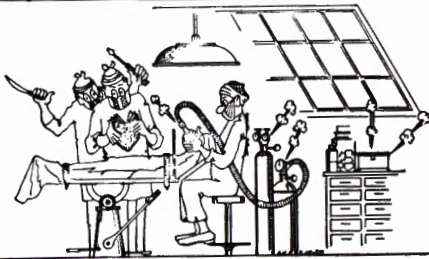
Jack Millay—Jack is familiar to many TEKSCOPE readers having authored the *Teknique* article on digital IC testing using the 576. He has been with Tektronix since 1958 and has been involved with device testing during most of his career at Tek.

A multiple exposure photo showing the test results for the 2N3565 transistor. The result for test 10 is off-screen at the right.

	Characteristic	Min.	Max.	Units	Test Conditions	
Test No. 1	Collector Saturation Voltage		0.35	Volts	$I_C = 1.0 \text{ mA}$	$I_B = 0.1 \text{ mA}$
Test No. 3	DC Current Gain	150	600		$I_C = 1.0 \text{ mA}$	$V_{CE} = 10 \text{ V}$
Test No. 4	DC Current Gain	70			$I_C = 100 \mu\text{A}$	$V_{CE} = 10 \text{ V}$
Test No. 6	Collector Cutoff Current		50	nA	$I_E = 0$	$V_{CB} = 25 \text{ V}$
Test No. 8	Collector to Emitter Sustaining Voltage	25		Volts	$I_B = 0$	$I_C = 2.0 \text{ mA}$
Test No. 10	Collector to Base Breakdown Voltage	30		Volts	$I_E = 0$	$I_C = 100 \mu\text{A}$
Test No. 11	Emitter to Base Breakdown Voltage	6.0		Volts	$I_C = 0$	$I_E = 10 \mu\text{A}$

SERVICE SCOPE

INSTRUCTION MANUALS, A SERVICE TECHNICIAN'S BEST FRIEND

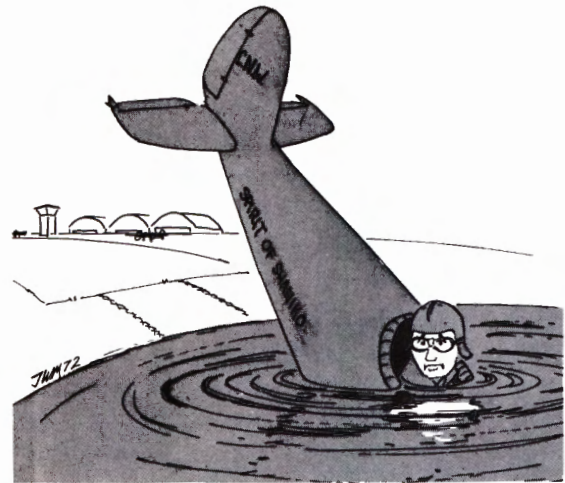


This cartoon has accompanied new TEKTRONIX instruments for many years to convey the importance of reading the instruction manual before operating an instrument. However, if you're like the majority of instrument users, you probably approach a new instrument in exactly the same way I do. Plug it in! Turn it on! Twist the knobs! Experiment! And then, when all else fails, turn to the instruction manual.

Why do we operate in this hit and miss fashion when help is only a few pages away? Probably because we're anxious to try out our new "toy" . . . see if we can "make it play". We're just "doing what comes naturally". While it may be the natural thing to do, there are some hazards to this approach. You may inadvertently damage the instrument or think it is working improperly when it isn't.

The Operating Instructions

Often when it appears that an instrument is working incorrectly, the problem is only a misadjusted or improperly used control. This type of problem is often referred to as "pilot error" and can best be cured by carefully reading and following the operating instructions in the manual.



Another common pilot error is incorrect connection to the external connectors. Although this type of error sometimes results in instrument damage, most input and output circuits on TEKTRONIX instruments are protected against overload. However, the result is always faulty operation and a lot of frustration. Once again, careful reading of the operating instructions avoids this pitfall.

The Performance Check

What do you do if the instrument doesn't work right even when operated correctly? You'll find help in the Performance Check Procedure given in the manual. This procedure is included in most TEKTRONIX instruction manuals and provides a method of checking operation of the instrument without removing the covers.

A word of caution at this point. As improvements are made in instruments, the manual is updated to reflect these changes. The manual you receive with an instrument is correct for that instrument, but may not give the correct information for an instrument received a year later. However, the reverse is not true. TEKTRONIX manuals are written as "history" manuals to correctly document previous instruments and are constantly updated to include the latest information.

To be sure that you are using correct information, check that the manual matches the serial number of the instrument being serviced.

The Calibration Procedure

If an instrument needs calibration, where better to turn than to the manual? Many times what appears to be an operational problem is an indication of the need for calibration. The manual defines the specifications which the instrument will meet, and provides information on the equipment required and the procedure to follow to return the instrument to its original performance specifications. Usually, this procedure is broken into sections and only those steps associated with the apparent trouble need to be performed. Sometimes, due to the complex nature of some instruments, the calibration procedure must be performed in the recommended sequence or in its entirety; the introduction to each calibration procedure will give you this information.

Also included as part of the introduction to most calibration procedures is a short, abridged procedure. This is intended as an index to steps in the complete procedure, or as a guide to calibration for the experienced calibrator. Only the title of the adjustment step, identification of components to be adjusted, and in some cases, the tolerance involved are given in this shortened procedure. If more information is needed, the calibrator should refer to the detailed procedure.

The Circuit Description

Many of the circuits used in TEKTRONIX instruments are complex. Since a basic understanding of the electronic circuitry in the instrument helps speed up trouble diagnosis, the instruction manual includes a circuit description or theory of operation section. Usually this section begins with a brief, general description of the instrument; then, the circuitry is discussed in detail. The depth and complexity of this discussion depends upon the instrument involved. As you read the circuit description, it helps to refer to the schematics provided in the diagrams section of the manual; the diagrams are printed on foldout pages so they can be referred to as you read the circuit description. It also helps to note where external controls and connectors are located in the circuitry. Sometimes you may find that what you thought was a problem is actually a normal operating condition.



The Maintenance Section

Thus far the manual has been used as an aid to determine if a trouble actually exists in the instrument. Now let's consider what the manual can do to help pinpoint the trouble area. Through the use of the operating instructions, calibration procedure, and circuit description sections of the manual, the defective area probably has already been identified. If more than one area is suspect, approach the problem logically. First, check the schematic to see if the suspected circuits are either interconnected or share a common signal source, control command, or power supply. If they do, begin troubleshooting in this common area. Quite often when more than one circuit is operating incorrectly, the trouble is in the power supply.

When the trouble has been isolated to a circuit or to several circuits, check the maintenance information given in the manual for assistance in locating the defective component. The maintenance procedure provides troubleshooting hints for circuits and components which are new or unique to this instrument. Also observe any cautions given in the maintenance section for maximum safety and time saving in completing the service job.

The manual provides many aids to finding the actual defective component. Typical voltages and waveforms, obtained under actual operating conditions, are given on the schematics. Although not absolute, these measurements serve as guides to correct operation and can help in isolating a defective component. Portions of the instrument located on circuit boards are enclosed by a blue line on the schematics. Photographs of the circuit boards, with the components identified by circuit number, are also provided in the manual. Using these pictures along with the schematics helps to locate individual components in the instrument. Basing diagrams for semiconductors used in the instrument are provided either in the maintenance section or on the schematic. Reference designators used to identify components and special symbols used on the diagrams are explained on the first page of the diagrams section.

The Schematics

The value of the schematics in understanding the electrical operation of the instrument has already been discussed. In circuit troubleshooting, they help to locate components and verify circuit connections. They also indicate correct component values. The schematics are usually arranged in an order which follows the normal signal flow through the instrument to facilitate signal tracing.

The Parts Lists

Another valuable section of the manual is the parts list. We use the electrical parts list along with the schematics to identify component value, tolerance and rating. Two basic formats have been used for the electrical parts lists in TEKTRONIX manuals. In the majority of the manuals, the electrical parts are grouped in categories according to the type of component (i.e., capacitors, inductors, resistors . . .). These categories are arranged in alphabetical order according to the reference designator (i.e., C, L, R . . .); the individual items are listed in numerical sequence within each category.

The second format which is used in some manuals is to list the parts by circuit boards. The parts located on a specific circuit board are grouped together and then listed in the same manner as described above. Parts not located on a circuit board are grouped under a category titled "Chassis", usually as the first items in the parts list.

A mechanical parts list is also provided in the manual. This list gives a description of the mechanical parts; exploded-view drawings accompany the list to aid in identification of the parts. Another use of the exploded-view drawings is as a guide to removal or disassembly of individual components and assemblies.

Other Helps

The manual contains many other helps for the service technician. For example, soldering and repair hints are given in the maintenance section. Specific instructions are provided for removal and repair of components or assemblies which require special procedures, and safety precautions to help you perform repairs safely.

One additional use for the manual: it's an excellent place to keep a record of calibration and repair performed on an instrument, as well as new service or troubleshooting hints you may discover.

When servicing or troubleshooting an instrument, it's important to get the job done quickly, efficiently and accurately. The instruction manual provided with your TEKTRONIX instrument was designed to help you meet this goal. We hope these few pointers will make it an even better friend.



Dale Aufrecht—We're happy to introduce to you the new Assistant Editor of TEKSCOPE. Dale joined our staff just a few weeks ago bringing ten years of writing experience with the Manuals Department of Tektronix. Included in the impressive list of manuals he has authored are the 453, 454, 7504, 7514 and the 7704.

Dale joined Tek in June of 1961, shortly after graduating from Oregon Technical Institute with an Associate Degree in Applied Science. He enjoys camping with his wife and three children during his leisure hours. He is also interested in hiking and mountain climbing and is involved in many church activities.

Our Apologies —

We inadvertently omitted the formula for trigger error at the top of the left hand column on page 10 in the March issue. It should read:

$$\% \text{ error} \propto \frac{t}{T} \times 100.$$

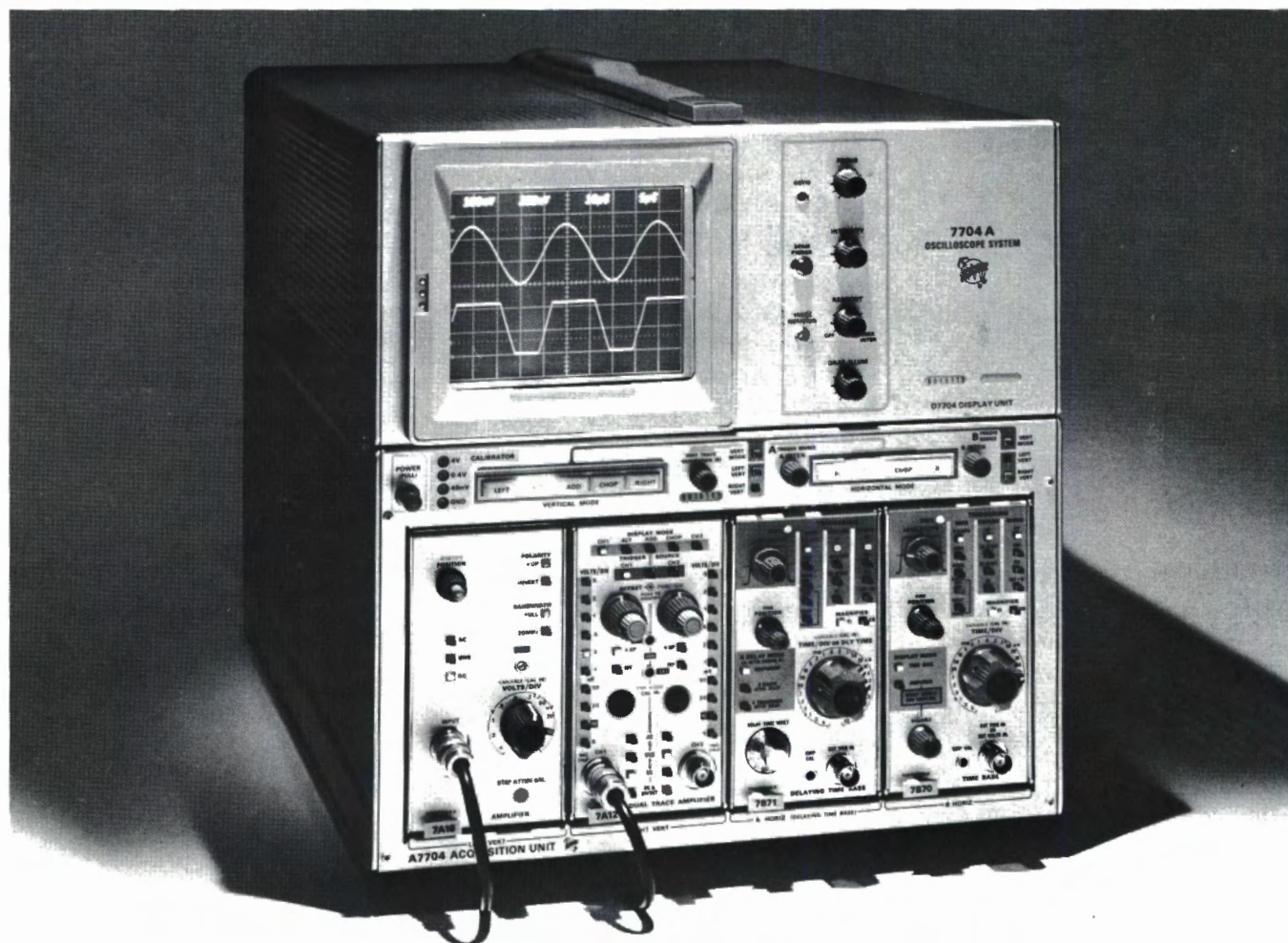


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 Editor: Gordon Allison, Ass't Editor: Dale Aufrecht, Graphic Designer: Tom Jones, Assistant: Diane Dillon.



The 7704A has

performance, modularity, pushbuttons, big screen, crt readout, versatility.

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