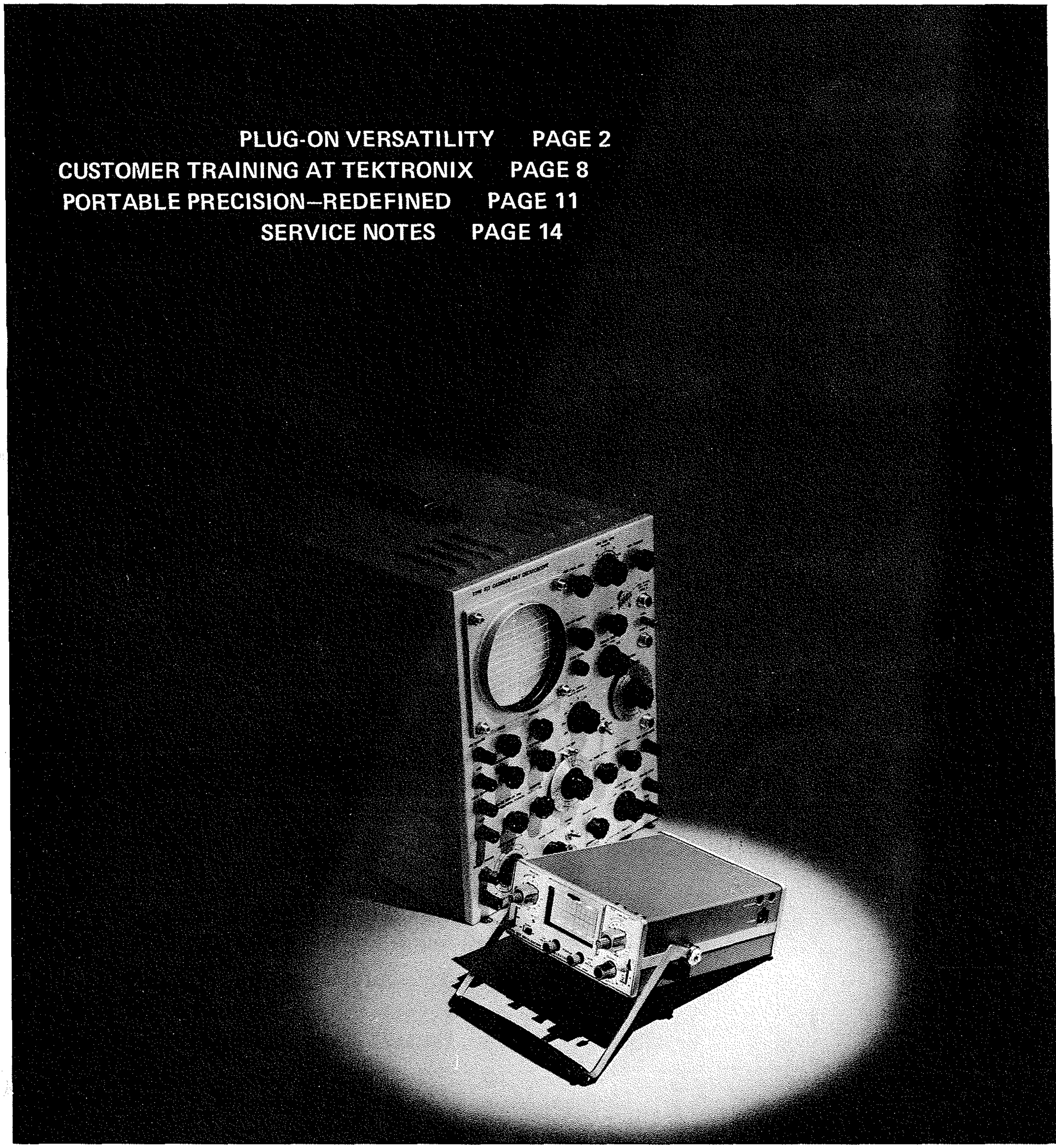
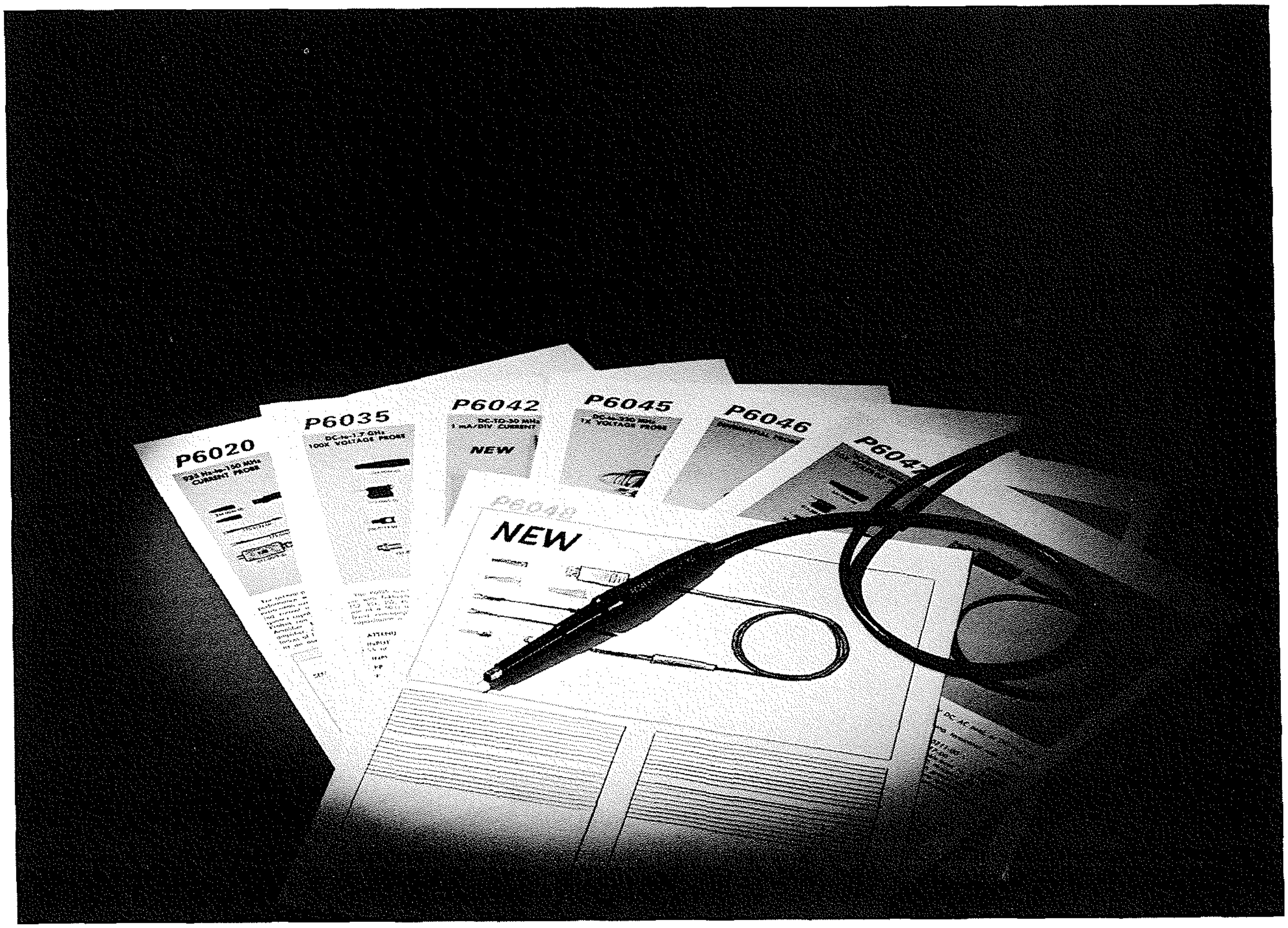
SERVICE SCOPE

NUMBER 51

AUGUST 1968





The new P6048 probe is shown next to 6 other high frequency, high performance miniature probes. Designed for use with high performance oscilloscopes, these probes illustrate the full-spectrum measurement capability currently available to the oscilloscope user. See chart on page 5 for additional details.

Plug-On Versatility

CAL HONGEL
Project Manager — Accessories Design

COVER • Tom Jones, Tektronix photographer, highlights the new SONY/TEKTRONIX Type 323. The Type 512, an instrument of similar characteristics introduced 19 years ago, is shown in the background. See story on page 11.

Introduction

Tektronix introduced the plug-in instrument concept with the introduction of the Type 530/540 series oscilloscopes in 1954. This concept developed because the interface between signal source and the cathode-ray tube is often complex and must be adaptable. Oscilloscope plug-in preamplifiers accomplished this interface nicely and so provided greater versatility at a modest price.

Since that time the plug-in concept has spread to counters, spectrum analyzers, function generators and many other instrument lines. Several years ago it became apparent that this same concept could be applied between the input vertical amplifier and the signal source, thus allowing the user more versatility.

Since that time, Tektronix has been engaged in an "across-the-measurement-spectrum" effort to develop probes that interface between the many varied signal sources and the vertical inputs of high-performance oscilloscopes. The success of this effort is best measured in the spectrum of Tektronix oscilloscope/probe performance currently available to the oscilloscope user. This concept allows general-purpose oscilloscopes to adapt to many application areas that heretofore required additional plug-ins or special-purpose oscilloscopes.

A case in point is the Tektronix Type 454 Oscilloscope and the high performance probes available for use with it. Two years ago when Tektronix introduced this instrument, two probes were announced, the P6047 passive probe and the P6045 FET probe.

High-Performance Probes

The Type P6047 passive probe provides the Type 454 with 2.4-ns performance at the probe tip and serves as an excellent general-purpose probe for most circuitry because of the 10 MΩ, 10 pF (7 pF @ 100 MHz) characteristics. The P6045 FET probe offers extra sensitivity and still maintains a low input capacitance. Since that time a number of other probes have been developed that truly provide the Type 454 with a full-spectrum measurement capability.

For example, the P6020 miniature current probe with its 200-MHz performance gives the Type 454 the ability to monitor high speed current waveshapes where the source resistance and capacitance are such that a voltage probe causes severe loading.

A high-speed differential probe and amplifier has been developed that provides wideband, high common-mode rejection ratio performance. Differential probe-tip signal processing minimizes measurement errors caused by differences in probes, cable lengths, ground paths and input attenuators. As a result, small high-speed differential signals may now be analyzed on a general-purpose oscilloscope. The P6046 Differential Probe and Amplifier provide the Type 454 with a 1 mV 70-MHz capability that significantly increases the versatility of the instrument.

The P6042 DC current probe is available for use with the Type 454 and while it does not cover the full bandwidth of the instrument, it does provide a unique DC-to-50 MHz current-measuring capability all in one probe. This is a particularly useful tool for many fast semiconductor circuits since fast switching transients, low frequency response, and DC level can all be displayed simultaneously on the same oscilloscope.

New 1 kΩ 1 pF Passive Probe

The latest member to the Tektronix family of high performance miniature probes is the P6048 passive probe system, which extends the measurement capability of the Type 454. The P6048 is a 1000 Ω low impedance passive probe utilizing 100-Ω cable. (A 50-Ω probe system, for example, with the same 10X attenuation has only 500-Ω impedance.) 100-Ω cable is used because studies indicate this is the highest impedance transmission line that has sufficient reliability yet retains small size and flexibility necessary for probe usage. Higher impedance cables do not meet the environmental requirements. Since all low impedance systems suffer from power dissipation problems, a switchable AC-coupling capaci-

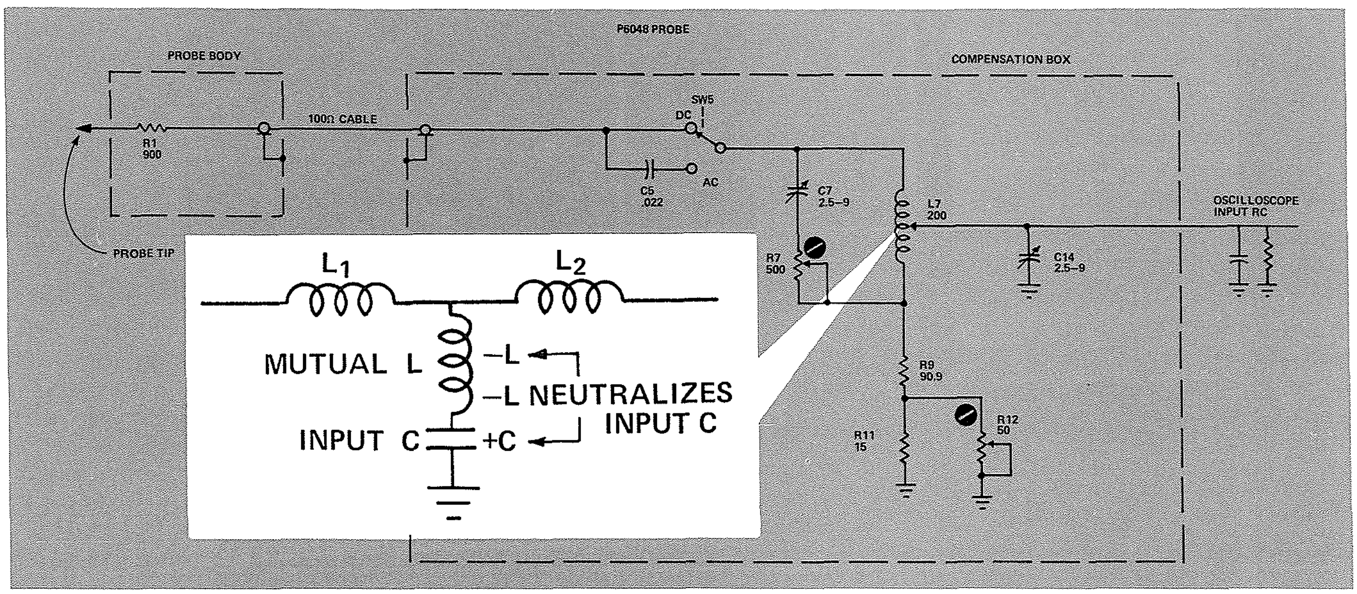


Fig 1. The termination of the P6048 probe is the key to its performance characteristics. The simplified schematic illustrates how the mutual inductance (−L) of the T-coil termination neutralizes the input capacitance (+C) of the instrument. By locating the low-impedance termination in the probe, the general-purpose aspect of the oscilloscope is retained with no sacrifice to the user.

tor is included in the termination box to extend the maximum DC input voltage from 20 V to 200 V. The P6048 design maintains the same input capacitance of less than 1 pF, *even when the probe is AC-coupled,* with a low frequency 3-dB point of 7 kHz.

Size was an important consideration in the design of the P6048 probe. For a high-speed probe to be useful, it must be small enough to probe the circuit under investigation. However, as the probe diameter decreases, the tip capacitance increases. The design of the P6048 is compromised on a 0.3-inch diameter. This allows an input capacitance of <1 pF (typically 0.8) but retains the important small size, so necessary in high-speed circuitry.

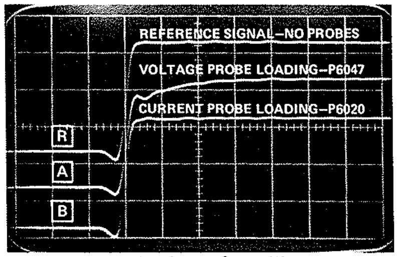


Fig 2. CRT display of oscilloscope under test. Probes are applied to deflection plate circuitry as shown in fig 4.

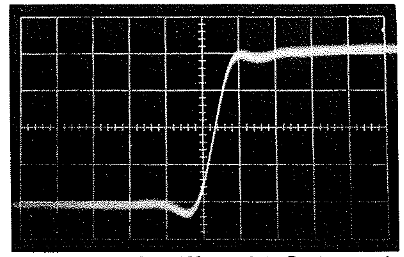


Fig 5. P6046 Differential Probe and Amplifier with Type 454 displays a 4 mV signal (5 ns/div).

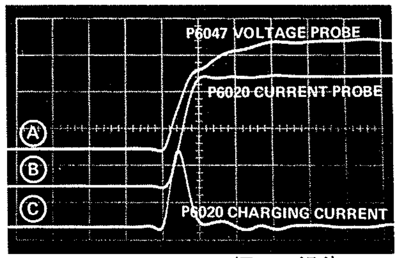


Fig 3. Test oscilloscope (Type 454).

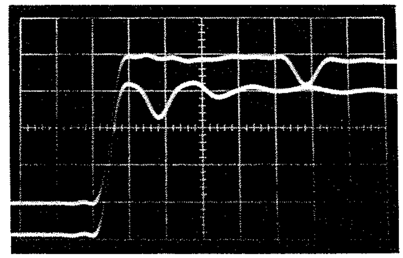


Fig 6. Inserting cable between termination and P6035 probe removes the discontinuity caused by input C from the area of interest (5 ns/div).

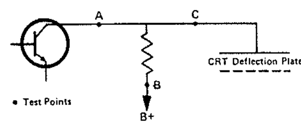


Fig 4. Measuring circuit for figs 2 and 3. Deflection plate circuitry of oscilloscope under test.

Note in fig 3 that the P6020 current waveshape Ⓑ is an accurate representation of the reference signal in fig 2 B and does not distort the reference signal R. The P6047 loads the signal severely Ⓐ and distorts the probe source as shown in fig 2 A. Additional information that only a current probe can display is the initial charging current necessary to charge the CRT capacitance Ⓒ.

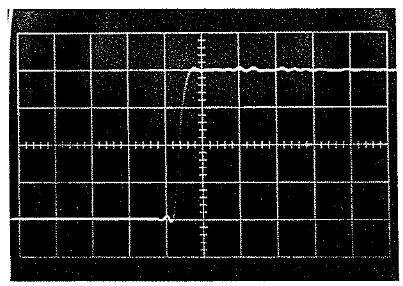


Fig 7. Response of Type 454/P6048 to fast pulse (10 ns/div).

50-Ω Systems

Another means of looking at high-speed circuits is to terminate the oscilloscope input with 50 Ω. This permits using high-speed probes such as the P6035 (5 kΩ, 0.6 pF) that work into 50 Ω and can display the 2.4-ns risetime of the Type 454. The Type 454 input characteristics will cause some reflections, but pulse measurement information is valid up to twice the length of the cable time delay used between the probe and scope. An excellent means of optimizing this viewing mode is to insert enough 50-Ω cable between the termination and the probe so the reflection occurs beyond the point of interest as shown in fig 7.

Why are Tektronix real-time oscilloscopes 1 MΩ instead of 50 Ω?

When the Tektronix Type 454 was in the design stage, there was much consideration given to the pros and cons of a 50-Ω versus a conventional 1-MΩ system. The concensus at Tektronix was although a 50-Ω system would be easier to design (1-MΩ attenuators are more complex than 50-Ω attenuators), the customer would have to accept too many compromises for a general-purpose instrument.

Since most oscilloscopes are used as a general-purpose device, a means of increasing the input resistance of a 50-Ω system is mandatory in most measuring situations. The only paths currently available to the user is an FET probe with its inherent extra cost and dynamic range considerations or a passive probe with its relatively low increase in DC resistance.

A second limiting compromise is the limited dynamic range of a 50-Ω system. Both the power ratings of the 50-Ω co nponents and the FET probe elements, all contribute to a system less tolerant of large signal swing and high DC potentials.

The third compromise is that existing general-purpose probes cannot be utilized. This limits the measurement spectrum severely as most of the probes discussed in this article could not be used.

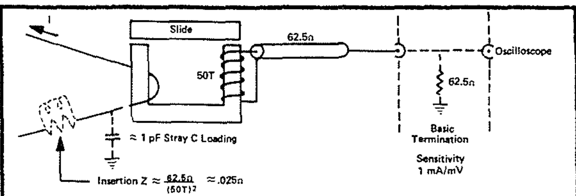
The chart on page 5 illustrates the prominent features of most popular Tektronix high-performance probes. The probe impedance diagrams will assist the user in selecting the proper probe for his measurement.

Less Than One pF, No Resistive Loading

A case where a high-speed current probe is almost a necessity is where the transistor is a very low-capacitance (0.5—2 pF), high-frequency device working into a high impedance (1—5 kΩ). A transistor with a large collector load and low capacitance presents a particularly difficult measuring circuit. A low impedance passive probe should not be used because the resistive loading could shift the operating level out of range of operation, causing clipping, limiting, or other undesirable effects. Since

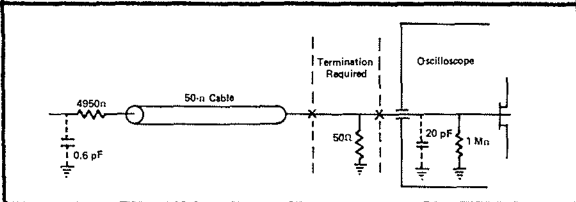
Know Your Probe Characteristics

P6020



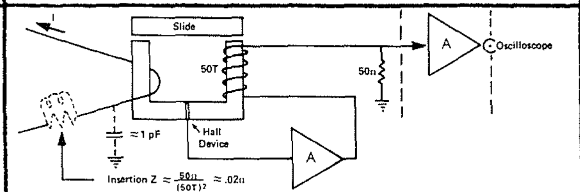
Very low source loading — less than 1 pF — no resistive loading — insertion impedance of .025Ω — elevated measurements to 500V — sensitivity 1 mA/mV — risetime 1.75 ns — 935 Hz-200 MHz bandwidth.

P6035



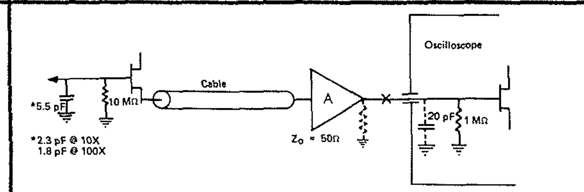
Requires oscilloscope terminated in 50Ω — very low input capacitance (.6 pF) — 50Ω cable extends length of probe and moves reflection from input C — risetime 200 ps — DC-1.7 GHz bandwidth — valid for pulse information only.

P6042



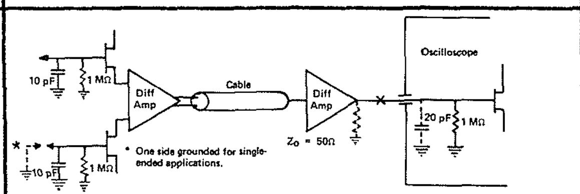
Very low source loading — both DC and AC current measurements — sensitivity 1 mA/div — 7 ns risetime — DC-50 MHz bandwidth.

P6045



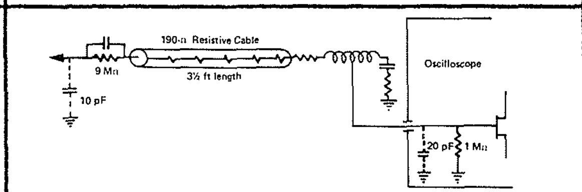
Good sensitivity (1X) — high DC resistance — low capacitance — interchangable heads: 1X 10 MΩ 5.5 pF, 10X 10 MΩ 2.3 pF, 100X 10 MΩ 1.8 pF — small size — 1.5 ns risetime — DC-230 MHz bandwidth.

P6046



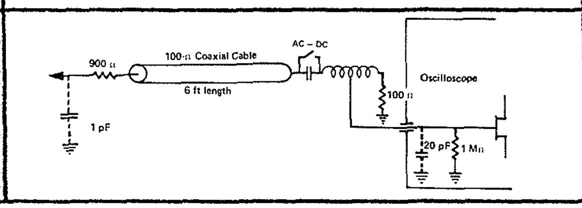
Differential wideband low-level measurements — 1000: 1 CMRR at 50 MHz — 1 mV deflection factor — probe signal paths may be matched to an unusual degree — risetime 3.5 ns — DC-100 MHz bandwidth.

P6047



Fast risetime performance into low source impedance — largest dynamic signal range — rugged — low cost — high DC resistance — least susceptible to overload — small size — 1.2 ns risetime — DC-290 MHz bandwidth.

New P6048



Very low capacitance (<1 pF) — minimum phase shift with frequency — length not critical — no capacitive loading from AC coupling capacitor — small size — loads source with 1 KΩ — low cost — 2.5 ns risetime — DC-140 MHz bandwidth.

Probing Considerations

Select the lowest impedance test point which provides a useful waveform. Although the input impedance of a probe is made as high as possible, it still will always have some finite effect on the circuit under test.

Probe loading effects can be minimized by selecting low-impedance test points. Usually, cathodes, emitters and sources should be chosen in preference to plates, collectors or drains; and inputs to high impedance dividers in preference to mid-points. Circuits with low resistive peaking or compensation often produce displays which are difficult to evaluate properly in high-speed pulse work. It's often preferable to make current measurements than to attempt an accurate evaluation of inductive circuit voltage waveforms because of the effect of the probe input capacitance.

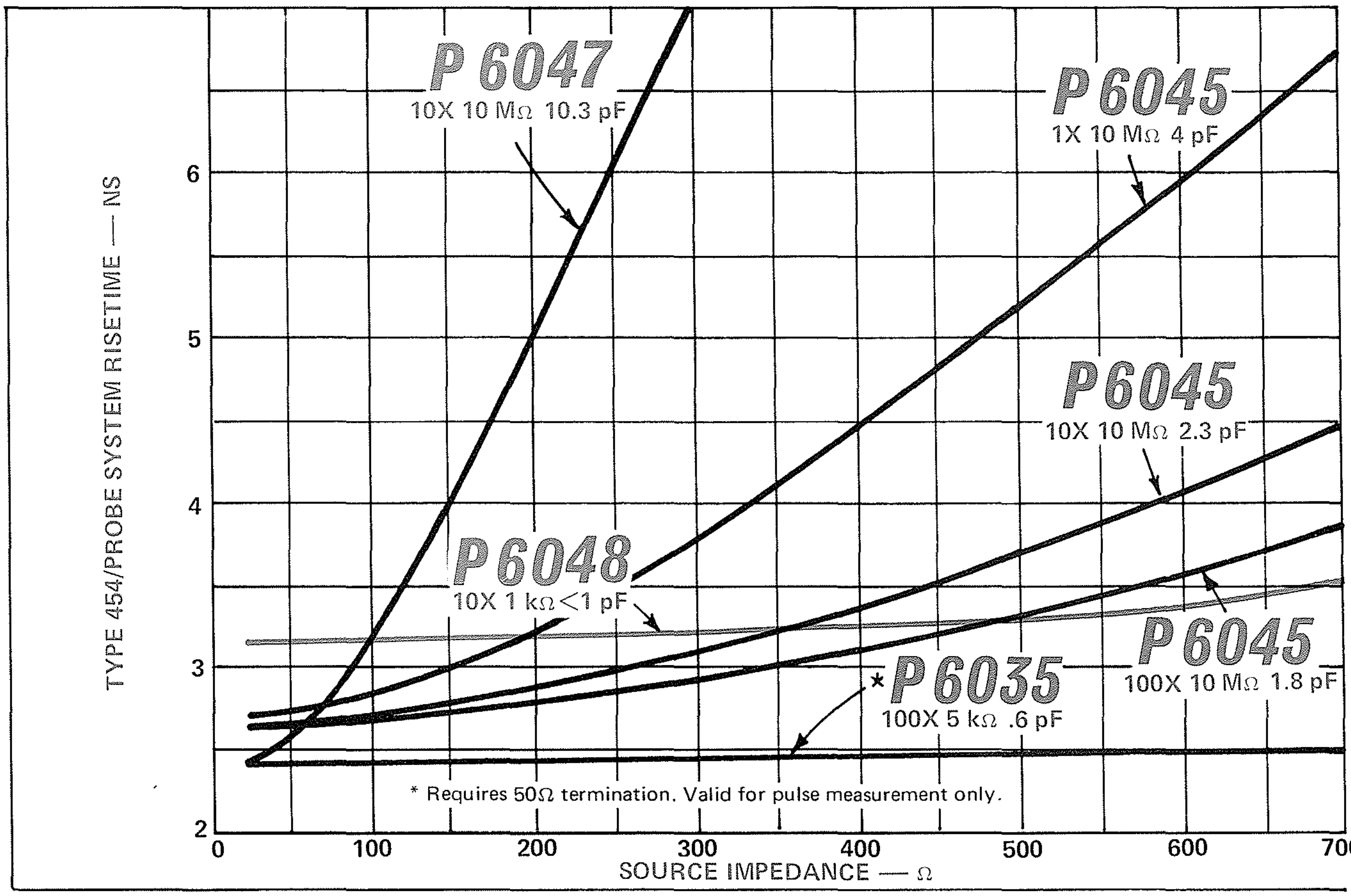
Time-delay differences must be considered, particularly in phase and time coincidence measurements, and differential applications. Low impedance probes minimize these problems and high-speed differential probes are capable of matching probe characteristics to a high degree

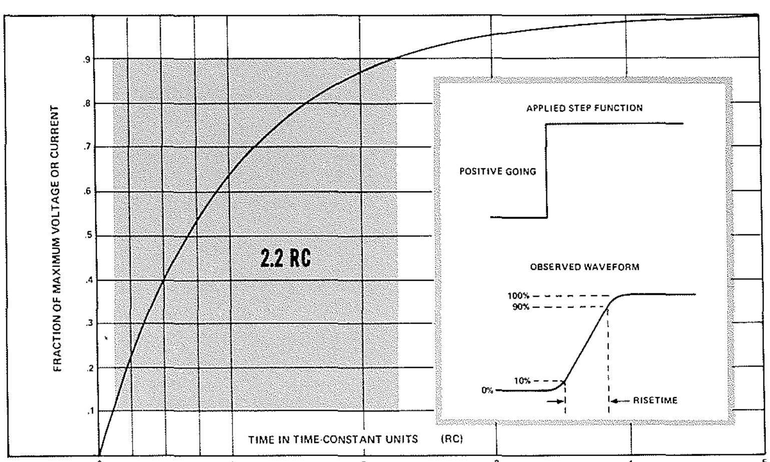
When using low impedance probes keep in mind the resistive loading of the probe. For example, if observing the 1 volt 1%, 250Ω 1% calibrator output of the Type 454 with the 1 kΩ P6048, correct calibration is indicated by a CRT display of 0.8 volts.

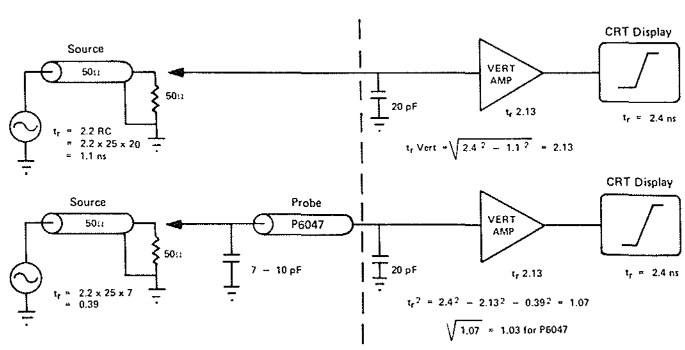
Grounding practices should always be kept in mind, particularly in high impedance probe applications. Using as short as ground path as possible (preferably coaxial adaptor or short bayonet connector) will minimize the effect of series inductance to the probe input.

And, of course, in all probes that have variable compensation adjustments, check your compensation!

Know Your Source Characteristics







Risetime is the time required for a transition from one level to another. For a more useful concept it is defined as the amount of time from 10% to 90% of the two levels. As circuit and pulse speeds increase, the physical limitation at which the risetime can change becomes significant. (It takes a finite amount of time for current to charge the capacitance in order for the change to take place.)

The diagram on the left illustrates the concept of risetime as it is applied to a universal RC curve. Note it is 2.2 RC time constants from 10% to 90% on the RC curve. Thus a fundamental limitation in the formulation of risetime is it cannot be faster than 2.2 RC.

An example of the physical limitations that 2.2 RC can have on a circuit is the risetime of the Type 454. The risetime of the Type 454 without a probe is 2.4 ns. Because the risetime of the Type 454 with the P6047 probe is also 2.4 ns, the P6047 would appear to be a 0 risetime probe. The diagrams illustrate why the 1.2-ns P6047 has this effect on the Type 454. (Although the computed risetime of the P6047 is 1.03 ns, the specified risetime is 1.2 ns).

It is necessary to find t_r vert since 2.2 RC of the source is a significant portion of the display risetime.

$$t_r \text{ display} = \sqrt{t_r \text{ vert}^2 + t_r \text{ probe}^2 + t_r \text{ source}^2}$$

$$t_r \text{ vert} = \sqrt{t_r \text{ display}^2 - t_r \text{ probe}^2 - t_r \text{ source}^2}$$

Once t_r vert is obtained, t_r probe may be found as shown below.

$$t_r \text{ probe} = \sqrt{t_r \text{ display}^2 - t_r \text{ vert}^2 - t_r \text{ source}^2}$$

Note, decreasing the amount of capacitance the source must charge from 20 pF to 7 pF decreases the source risetime limitation by a factor of ≅ 3 (1.1 ns to 0.39 ns). This then allows the addition of an extra element (the probe) with no decrease in observed risetime.

To remove, cu ong dotted line.

it is a very low-capacitance device, even the 2.3 pF of the FET probe is more than the circuit can stand.

Here a high-frequency clip-on current probe such as the P6020 is an excellent way to make the measurement. This current probe adds approximately one pF (approximately the same capacitance as the 1-kΩ probe), but there is no resistive component and the very low insertion impedance does not disturb the circuit. Further, the probe can be connected to the ground or B+ side of the load resistor, thus isolating the capacitance effect almost completely. Figs 2 and 3 show the P6020 current probe connected in this manner.

The reflection impedance of the P6020 current probe is negligible unless inserted in a low-impedance circuit (below $\approx 5\,\Omega$) or using several turns through the slot. (Additional turns are sometimes used to increase the probe sensitivity, but since the inductance varies as the square of the turns, insertion impedance quickly becomes significant.) In the case presented above, where the impedance is 5 kΩ, if you know the collector impedance, you can obtain all the information by current measurement that a voltage probe can obtain. This method almost completely eliminates probe loading as an error factor.

Source Impedance and Risetime

The chart on page 6 clearly shows the effect of source impedance on the oscilloscope display. The P6047 is the high-speed miniature probe that is included with the Type 454 oscilloscope. This particular probe is the passive 10X high impedance probe evolved to the highest state at Tektronix. Note that of all the probes on the chart, the P6047 has the fastest risetime which is 2.4-ns (including the Type 454) at 25-Ω source impedance. A 10 MΩ, 10 pF characteristic (7 pF at 100 MHz) makes it an excellent choice for 2 areas of application. The 10 MΩ resistive component minimizes DC loading and its high speed termination provides a 2.4-ns display when used with a low impedance source (50 Ω). This probe is particularly well-suited for high amplitude signals and is rated at 600 V. It is an excellent choice for a general-purpose probe.

The next curve shows the P6045 field effect probe with 1X attenuation. Its impedance characteristics are 10-MΩ input resistance with 5.5 pF input capacitance. The slope of this curve is flattened out indicating that it is more useful as source impedance increases. This probe is a unity-gain probe which allows a 10× increase in sensitivity (compared to a conventional 10X probe) with less capacitance. A design choice is available, when designing an FET probe, of low noise vs low capacitance. The designer can place an attenuator (usually 3-5X) in front of the FET and sacrifice noise performance for lower input capacitance. The P6045 does not make use of an attenuator in front of the field-effect transistor in the probe and thus excellent noise performance (<1.5 mV at 230 MHz) results. This compromise, while it results in additional tip capacitance, increases the versatility of the probe. Low capacitance performance is still available by using a 10X or 100X attenuator.

The next curve on the chart is the P6045 with its 10X attenuator offering an impedance combination of 10 MΩ and 2.3 pF. Note this curve is appreciably faster than the P6045 1X curve, keeping 3½-ns performance well out into 450-Ω source impedance. Here the usual 10X attenuation factor is present, but the capacitance is reduced to a value of 2.3 pF.

The P6045 with the 100X attenuator presents a 10 MΩ, 1.8 pF impedance to the circuit under test. Note the difference that only 0.5 pF can make in this area of measurement by comparing it to the 10X curve. We now obtain 3.5-ns operation out to nearly 600-Ω source impedance. Also, the curve is now becoming less and less reactive as indicated by the nearly straight line.

The blue line on the chart indicates the recently introduced P6048 passive low-impedance probe. This probe presents the source with 1 kΩ and less than 1 pF input capacitance. This curve is quite flat with increasing source impedance, and is very useful in high-speed circuitry where low source impedance is commonly used.

The P6035 100X probe with 50-Ω termination presents the flattest response of all. This curve is marked with an asterisk since it requires a 50-Ω termination on the front of the oscilloscope. There will be reflections due to the 20 pF input capacitance when used with a fast source, but this is still a very useful means of observing fast pulses. The reflections may be moved away from the point of interest by using additional high quality 50-Ω cable as shown on page 4.

Summary

No single probe discussed in this article is the best for all applications, but all of the probes discussed are good for specific applications. In addition, Tektronix is continually striving to develop additional probe capability to make existing instruments more versatile. It is still necessary, however, for the user to determine the characteristics of his measuring circuit as closely as possible. He may then select from the various probes available to obtain the minimum circuit loading for his measurement.

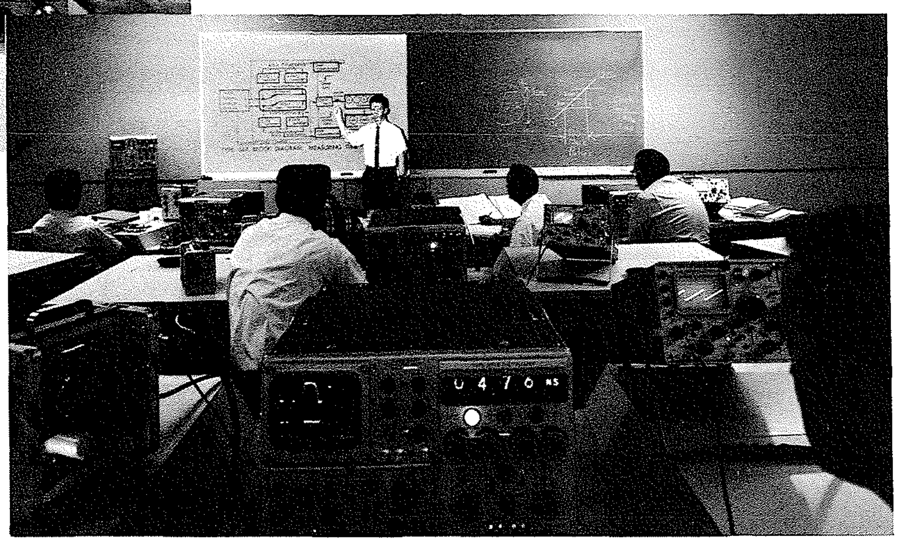
Customer Training at Tektronix

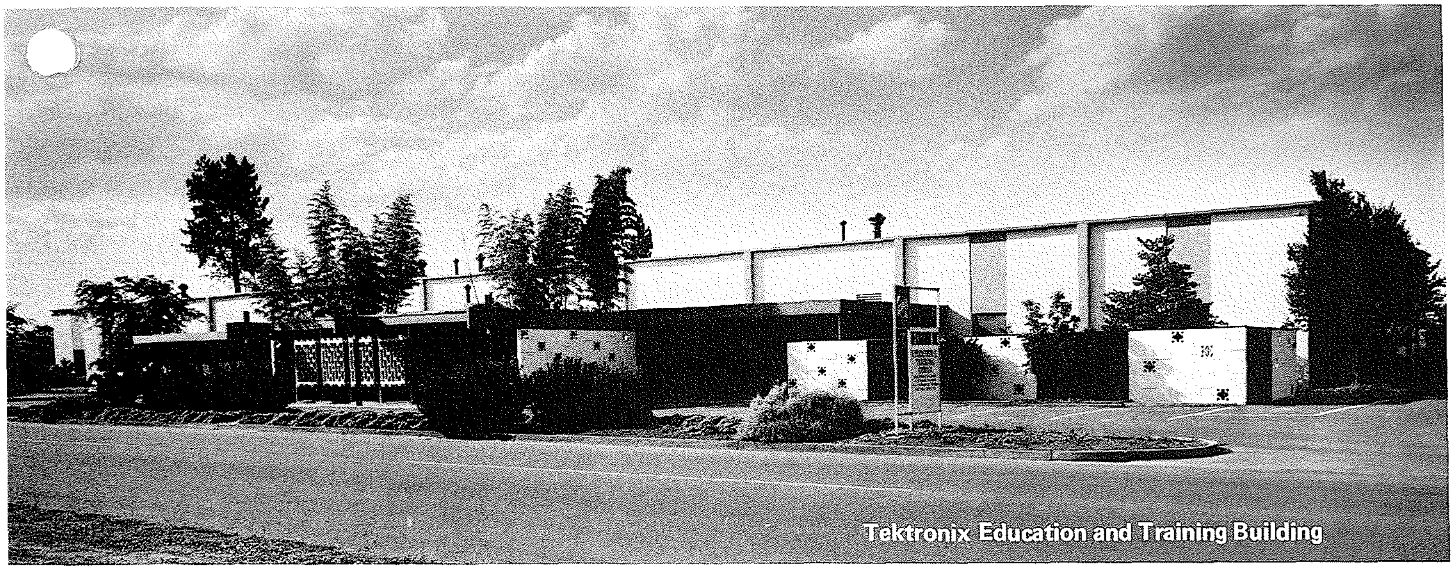
Tektronix field engineers spend a large amount of their time at customer locations teaching the proper operation and maintenance of Tektronix products. In addition, Tektronix field engineers provide local training at the field office to accommodate customers with common requirements. Oftentimes, however, there is a need for in-depth training that cannot be fully accomplished locally. To meet these needs, Tektronix has established a program of factory training which is an extension of Tektronix field engineering services. Customers who participate in this program attend classes at the Tektronix customer training center located in Tektronix Industrial Park in Beaverton, Oregon.

The diverse courses offered vary from 2-4 weeks in length. Where possible, the courses are arranged so the customer may attend 2 or even 3 different consecutive seminars.

Training at Tektronix has always had emphasis placed on the service aspect of Tektronix equipment and, therefore, circuit theory is an important portion of the curriculum. The emphasis on Tektronix training is circuit knowledge and each circuit is described and discussed thoroughly with particular attention on how the various adjustments affect circuit operation. The objective is to familiarize the customer with all the checks, measurements and adjustments necessary for a given instrument. Each phase of each course ends with a theoretical trouble-shooting period, where a group discussion is held to discuss the various problems that specific faulty components could create.

All Tektronix customer courses make extensive use of instruments. The laboratory and classroom are brought closer together with the new Tektronix-designed classrooms shown in fig 1. This unique classroom design allows the student to have a test scope, a scope under test,





and signal generating equipment, all in a classroom environment. The instructor can present theory, instrument demonstration, instrument calibration, movies, slides, etc. without changing rooms. An added benefit is, while the theory of a particular point is being made, the practical considerations may be monitored, since the scope is also present.

The first thing that the student is exposed to in the training is a detailed operator course in which particular emphasis is placed on the function of the knob. Which circuit is the variable in? What does the knob control, and how? Tektronix, throughout the curriculum, relates theory to practical considerations. Thus, when the student encounters problems in his own facility, he has a broad background from which to draw conclusions. The intent of Tektronix customer training is to have the customer trainee proficient enough to train other employees when he returns to his facility.

A staff of 6 full-time instructors ensures thorough coverage with a maximum of individual attention. Films are included in the curriculum and customers are exposed to important topics such as CRT handling, sampling, squarewaves and transmission lines. Tests are held periodically allowing the student to keep aware of his progress.

Informal "buzz" sessions are held where appropriate. For example, if the students are having the sweep circuit presented to them, the instructor might ask that all the students form into groups of two. One student then proceeds to explain the circuit under discussion to the other. If at any time he runs into any difficulty, an instructor explains the problem and he continues. This active participation in circuit analysis does a great deal toward giving the student confidence and retaining the new information.

One of the greatest potential benefits of Tektronix factory training is that it enables the trainees, upon returning from Tektronix, to instruct others in oscilloscope theory. As a result, customers who have technical training programs in their own company or are anticipating need for them in the future, often send an engineer, instructor, or maintenance training specialist to receive this training.

When a customer student successfully completes all the material and passes the final exam, he receives a certificate of completion. This certificate lists all the Tektronix products in which the student is proficient.

There is no cost for Tektronix factory training courses and course materials. The cost of transportation, lodging and meals is the customer's responsibility. Students are usually lodged in downtown Portland where numerous accommodations are available. This central location also provides excellent facilities for the students' after-class recreation. In addition, Tektronix provides a shuttle service between downtown hotels and Tektronix Industrial Park.

To qualify for this program the trainee should have adequate background as indicated below:

1. Knowledge of electronic fundamentals.
2. Experience in calibration of high quality laboratory test equipment (previous contact with Tektronix instruments is recommended).
3. Minimum score of 70% in Tektronix entrance exam.

If you are interested in the Tektronix factory training program, contact your local field engineer for course availability and assistance with lodging. The class schedule for the remainder of 1968 is shown on page 10.

TYPICAL COURSE OUTLINE

TOPIC	OBJECTIVES
Pulse System Technology	Concepts fundamental to oscilloscope technology: pulse circuit theory, RC curves, compensated dividers, risetime vs bandwidth, etc.
Semiconductor Circuit Review	Semiconductor theory of circuits extensively used in oscilloscope systems: differential amplifiers, paraphase amplifiers, emitter followers, etc.
Operators Course	Familiarize the student with instrument capabilities in sufficient detail to instruct others.
Power Supplies	Theory of power supply operation: high and low voltage supplies, regulators, accuracies, tolerances, etc.
Cathode Ray Tubes	Understand the contribution of the CRT: mechanical considerations, unblanking circuitry, etc.
Sweep Circuits	Relate timing accuracy to linear operation of horizontal sweep system: understand Miller Integrator, delaying sweep theory, etc.
Horizontal Amplifiers	Understand contribution of horizontal system to accuracy: X-Y applications.
V Amplifier and Delay Lines	Understand fundamental relationships of sensitivity, stability, bandpass/risetime, circuit theory, etc.
Plug-In Preamplifiers	Acquaint the student with most popular plug-in units, practical explanations of calibration and adjustment checks.
Calibration Instrumentation	Acquaint the student with a variety of special Tektronix instruments used in calibrating instruments: maintenance and trouble-shooting practices.
Laboratory Assignments	Provide the student with working acquaintance of all instruments concerned: discussion of proper adjustment and calibration practices.

CUSTOMER FACTORY TRAINING SCHEDULE 1968

JUL

530/540/580
1A1/82
July 29 – August 16

AUG

Spectrum Analyzer
1L20/1L30/491
August 12 – 30

LABOR DAY – SEPTEMBER 2

SEP

530/540/580
1A1/82
September 9 – 27

454/453/422
Sept 30 – Oct 18

OCT

530/540/550
1A1
October 7 – 25

544/546/547
556/1A1
Oct 14 – Nov 1

Sampling
+
Digital
Oct 28 – Nov 22

NOV

Spectrum Analyzer
1L20/1L30/491
November 4 –22

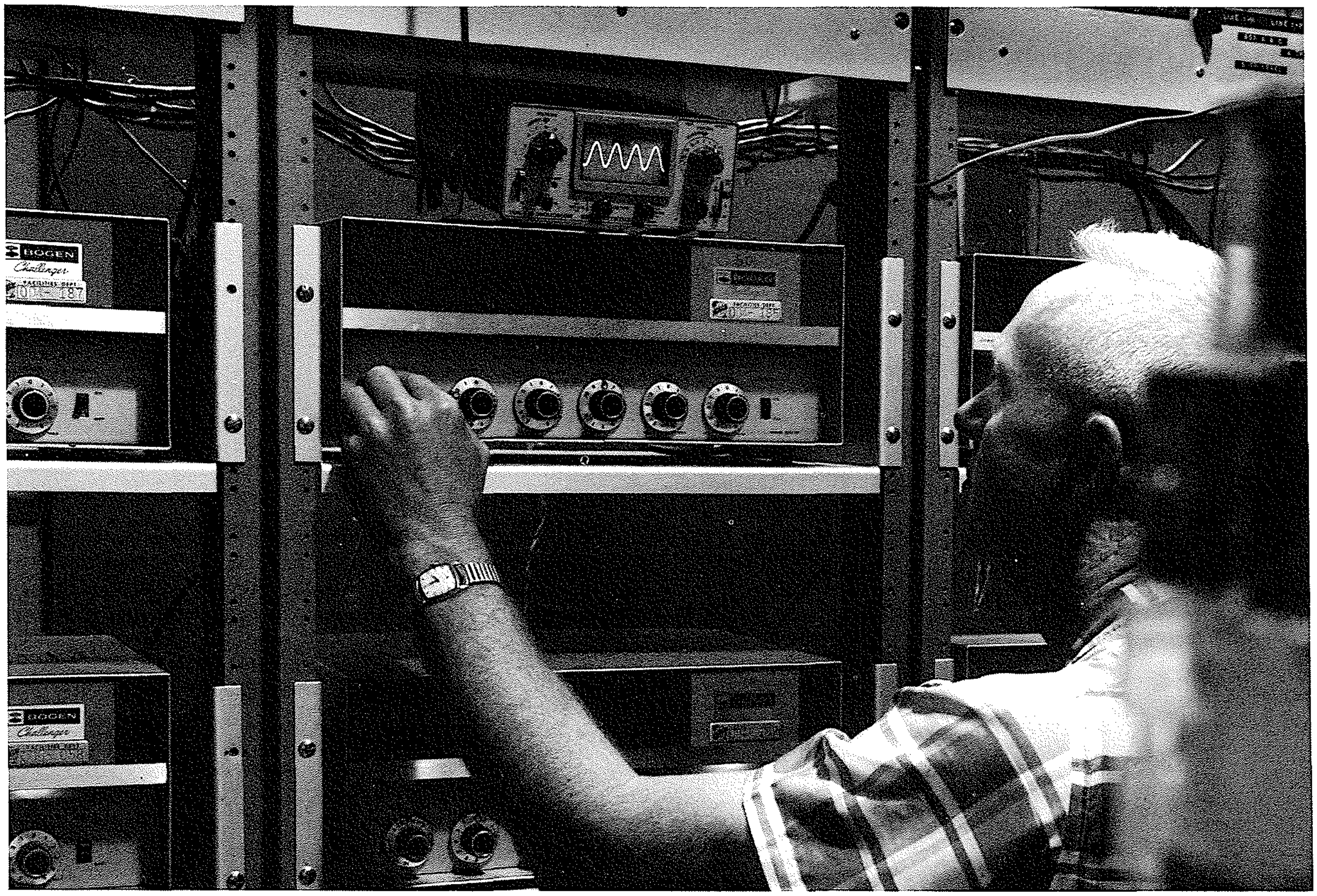
THANKSGIVING – NOVEMBER 28

DEC

530/540/580
1A1/82
December 2 – 20

568/R230
December 2 –13

CHRISTMAS HOLIDAYS



Frank Williams, Tektronix technician, checks an in-plant paging system with the Type 323.

Portable Precision-Redefined

Nearly 20 years have passed since Tektronix introduced the Type 512 DC—2 MHz oscilloscope. At the time it was introduced, in May of 1949, it was advertised as a portable precision laboratory oscilloscope. Its triggered calibrated sweeps and high-gain DC-coupled vertical amplifier (it was the first DC-coupled Tektronix oscilloscope) made it an immediate success and created new standards for oscilloscope performance.

The SONY®/TEKTRONIX® Type 323 makes an interesting contrast to the Type 512, since the electrical characteristics are somewhat similar. Although most Type 512's have long since been retired and replaced with newer Tektronix oscilloscopes, many remain in active use. A closer look at the two instruments shows very clearly the trends and progress of the electronics industry over the past 19 years.

Semiconductors have made possible tremendous savings in weight, power, dissipation, size and reliability. The 7-pound weight of the Type 323 compared with the 53 pounds of the Type 512 is dramatic evidence of this trend. Equally as impressive is the 280 watts of the Type 512 contrasted with the typical 1.6 watts of the Type 323. The overall instrument size has decreased from 4160 cubic inches to 320 cubic inches. In addition, the Type 323 is much more reliable since it is solid-state with the exception of the cathode-ray tube. The chart on page 13 shows other interesting contrasts.

Human engineering was one of the design goals that the Type 323 meets nicely. The Type 323 has only 7 front panel controls. The focus and intensity are located on top of the front panel since they are not used often. This simplifies front panel layout and minimizes accidental moving of controls.

The SONY/TEKTRONIX Type 323 contains the same high quality components and workmanship as Tektronix oscilloscopes and complements the product line nicely. Because the instrument is being marketed by Tektronix (outside of Japan and parts of Asia), it is necessary that the same support exists to ensure that Tektronix can meet the after-sale service commitment. As a result, the instrument manual, spare parts support, etc., are consistent with normal Tektronix practices. The instrument uses plug-in transistors which allow easier and quicker maintenance. In addition, consideration has been given for easy access to circuit boards.

The Type 323 may be powered AC, DC or from its self-contained battery pack. The battery charge rate (full charge or trickle charge) is selectable from the rear panel. The battery pack and charger circuitry may be removed as a unit and operated independently of the instrument. This allows the Type 323 to be powered by a second battery pack while the first is being charged. In cases where the Type 323 is operating from an AC line the battery may be charged at full rate (16 hours) even while the instrument is operating. The 16-hour charge rate ensures that the instrument may be used a full 8-hour day—yet it will be completely charged the next morning.

The Type 323 has a 3-inch CRT that uses a very low-power direct-heated cathode developed by SONY for its 4-inch television sets. The power required is 180 mW and this design contributes to the 2-second warm-up time of the Type 323.

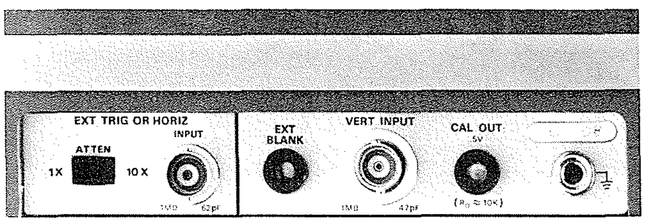


Fig 1. Input and output connections are provided on the left side panel freeing important front panel space for operating controls.

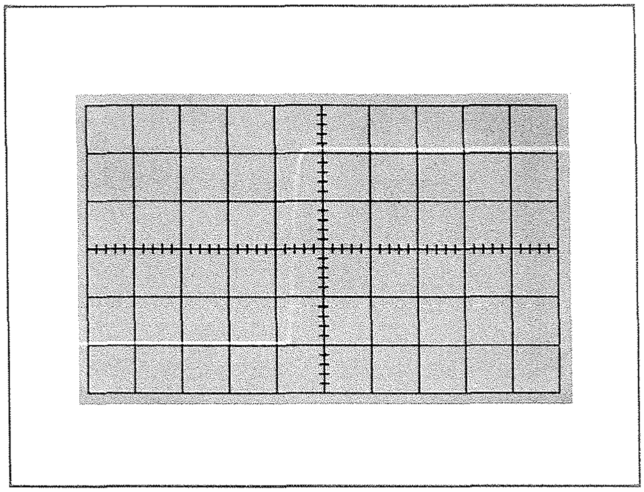


Fig 2. Response of the Type 323 to a fast-rise signal (.5 us/div).

Typical of some of the unique power-saving circuits is the vertical amplifier output stage. A power-saving circuit biases the Type 323 output amplifier at low current and senses signal frequency. When high frequency signals are present, the sensing circuit increases bias so sufficient current is available to charge and discharge the CRT capacitance. In addition, complementary connection of the output transistors (NPN and PNP) minimizes heavy current flow. The output is an exact reproduction of the input, and the technique saves considerable power at high frequencies.

The Type 323 does not have an edge-lighted graticule since power drain was a first-order design consideration. The instrument requires less power, under most operating conditions, than the graticule edge-lighting circuitry used on Tektronix oscilloscopes. As a result a black, internal, non-illuminated graticule is used.

CHARACTERISTICS	TYPE 323	TYPE 512
Weight	Less than 7 pounds	53 pounds
Power	1.6 Watts (typical)	280 Watts
Size (inches)	4-1/4" x 7-1/4" x 10-5/8"	16" x 13" x 22-7/8"
Input RC	1 MΩ 47 pF	1 MΩ 45 pF
Risetime	90 ns (high gain 130 ns)	200 ns (high gain 400 ns)
Bandwidth	DC–4 MHz (high gain DC–2.75 MHz)	DC–2 MHz (high gain DC–1 MHz)
Deflection Factor	10 mV (high gain 1 mV)	150 mV (high gain 5 mV)
Time Base	5 us/div–1 s/div (17 steps)	3 us/cm–.3 s/cm (10 steps)
Magnifier	X10 (fastest sweep .5 us/div)	X5 (fastest sweep .6 us/cm)
Differential Input	No	Yes
Vacuum Tubes	1 (CRT)	44
F. P. Controls	7	22
Environmental	Yes	No
Price	$850	$950

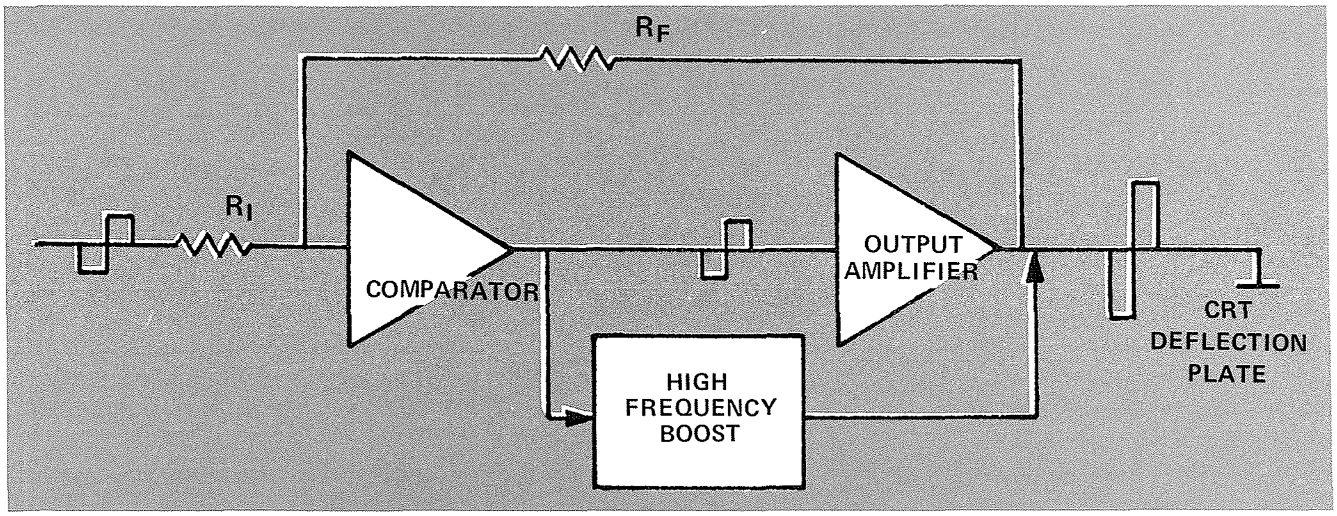


Fig 3. Type 323 vertical output amplifier diagram. The output amplifier is biased at low current to save power, so a high frequency boost circuit is used to supply the required current for high frequency operation. A feedback circuit senses the current the HF BOOST needs to supply for charging and discharging of the CRT capacitance at high frequencies. This unique circuit substantially reduces the power consumption of the Type 323.

The sweep generator provides calibrated ranges from 1 s/div to 0.5 μs/div (with an X10 magnifier). A new automatic trigger circuit is employed that minimizes front-panel space, yet provides versatile trigger operation.

The 4-MHz performance at 10 mV/div deflection factor (2.75 MHz at 1 mV/div) makes the instrument an ideal choice as a field maintenance tool. Its 11 by 8 by 4-inch dimensions and 7-lb weight enable it to go nearly anywhere. The Type 323 is designed to withstand shock, vibration, and wide variations in temperature, altitude, and humidity since SONY/TEKTRONIX engineers realize portable oscilloscopes often encounter adverse environments.

The price of the SONY/TEKTRONIX Type 323 including a P6049 10X attenuator probe with accessories is $850. Further details are included on pages 1-3 in the New Product Supplement to Tektronix Catalog 27 (1968).

SONY® TEKTRONIX®

Sony/Tektronix, a jointly-owned Japanese subsidiary located in Tokyo, Japan, was formed in November of 1964. The rapid growth of the Japanese electronics industry in the early 60's resulted in licensing discussions with several Japanese firms. The result of these discussions led to the formation of a 50-50 joint venture with SONY. Both SONY and Tektronix have cross-licensing arrangements with Sony/Tektronix.

Sony/Tektronix has responsibility for marketing of Tektronix and SONY/TEKTRONIX products in Japan and parts of Asia. The marketing of SONY/TEKTRONIX products in the U.S. and remainder of the world is handled by Tektronix, its marketing subsidiaries, and distributors.

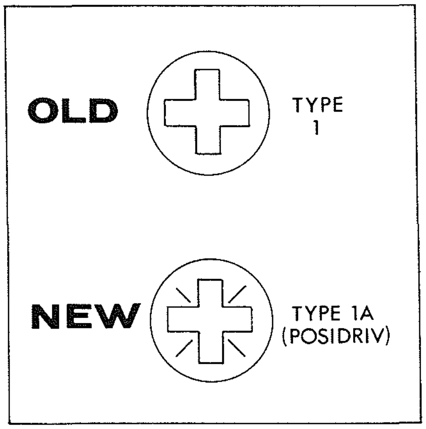
Sony/Tektronix is currently manufacturing several types of Tektronix instruments. These instruments maintain the same high Tektronix quality that is built into Tektronix domestic instruments, but are built exclusively for the Japanese market.

Sony/Tektronix was created with an engineering capability to develop new instruments. This use of the two companies' engineering talent will allow products to be developed that Tektronix or SONY would not develop alone. The Type 323 is the first instrument to be developed by Sony/Tektronix.

Service Notes

Phillips-head screws come with two kinds of slots these days, and the casual observer might never notice it! The newer type slot can be identified by four little lines on the head of each screw, located at the inside corners of the cross. See diagram at right.

The new slots permit screws to be installed with less likelihood of the screwdriver slipping in the slots (camming out) if driven with a new type Phillips screwdriver. The name for the new slot and the new screwdriver is POZIDRIV, a Phillips registered trade name.



Old Phillips screwdrivers will work in the new slots but are more apt to slip. Phillips screwdrivers having the POZIDRIV tip will not fit in the old slots unless they are the wrong (smaller) size. Because screws may be tightened harder using the POZIDRIV slot and POZIDRIV screwdrivers, they may be particularly difficult to remove without the proper tip.

The way to distinguish between an old screwdriver tip and the POZIDRIV bits is that the letters PZD appear on the POZIDRIV bits.

Transistor Troubleshooting Hints

Transistor defects usually take the form of the transistor opening, shorting or developing excessive leakage. The best means of checking a transistor for these and other defects is by using a transistor curve display instrument such as a Tektronix Type 575. If a transistor checker is not readily available, a defective transistor can be found by signal tracing, by making in-circuit voltage checks, by measuring the transistor resistances, or by substituting a known good component.

When troubleshooting with a voltmeter, measure the emitter-to-base and emitter-to-collector voltages to determine whether the voltages are consistent with normal circuit voltages. Voltages across a transistor vary with the type of device and its circuit function, but some of these voltages are predictable. The base-emitter voltage of a conducting germanium transistor is about 0.2 V and that of a silicon transistor is about 0.6 V. The collector-emitter voltage of a saturated transistor is normally 0.2 V. Because these values are small, the best way to check them is by connecting the voltmeter across the junction and using a sensitive voltmeter setting.

If values less than these are obtained, either the device is shorted or no current is flowing in the circuit. If values are in excess of the base-emitter values given, the junction is back-biased or the device is defective (open).

Values in excess of those given for emitter-collector indicate either a non-saturated device operating normally, or a defective (open) transistor. If the device is conducting voltage will be developed across resistances in series with it. If it is open, no voltage will be developed in resistances in series with it (unless current is being supplied by a parallel path).

An ohmmeter can be effectively used to check a transistor if the ohmmeter's voltage source and current are kept within safe limits. 1½ V and 2 mA are generally acceptable. Selecting the 1-k scale on most ohmmeters will automatically provide voltage and current below these values.

If the voltage and maximum output of a specific ohmmeter is in doubt, it should be checked by connecting the test leads to another multimeter before using it.

The table contains the normal values of resistance to expect when making an ohmmeter check of an otherwise unconnected transistor.

Transistor Resistance Checks

Ohmmeter Connections[1]	Resistance reading that can be expected using the R x 1 kΩ range
Emitter-Collector	High readings both ways (100 kΩ to 500 kΩ, approx).
Emitter-Base	High reading one way (200 kΩ or more). Low reading the other way (400 Ω to 3.5 kΩ, approx).
Base-Collector	High reading one way (200 kΩ or more). Low reading the other way (400 kΩ to 3.5 kΩ, approx).

[1]Test leads from the ohmmeter are first connected to the transistor and then the connections are reversed. Thus, the effects of the polarity reversal of the voltage applied from the ohmmeter to the transistor can be observed.

USED INSTRUMENTS FOR SALE

1—Type 1A2, SN 001328. Contact: Marion Paul, WFIE-TV, 1115 Mt. Auburn Road, Evansville, Indiana 47712. Telephone: (812) 425-6201.

1—Type 516, SN 154. Price: $825. 1—Type 551, SN 3247. Price: $1250. Both in very good condition. Contact: Henry L. Gorgas, Exact Electronics, 455 S.E. Second Avenue, Hillsboro, Oregon 97123. Telephone: (503) 648-6661.

1—Type 513D, SN 799. In very good condition. Contact: David Felt, Electra-Design Labs, 4406 Center Street, Omaha, Nebraska 68105. Telephone: (402) 553-4218.

1—Type 524AD, SN 2078. In good condition. Contact: Sid Chodun, 19325 West Nine Mile Road, Southfield, Michigan 48075. Telephone: (313) 353-8070.

1—Type 504, SN 002221. Price: Under $100. In good condition. Contact: Dr. Boyle, Fitzgerald Mercy Hospital, Landsdowne Avenue, Darby, Pennsylvania 19023. Telephone: 586-5020, ext. 2286.

1—Type RM15, SN 002073. Price $500. In good condition. Contact: Bob Burig, 112 Hershey Drive, McKeesport, Pennsylvania 15130. Telephone: (412) 673-4845.

1—Type P Plug-In and 2—Type P6008 Probe Sets. Contact: H. R. Greenlee, 430 Island Beach Blvd., Merritt Island, Florida 32952. Telephone: (305) 853-9542.

1—Type 81 Plug-In Adapter for 580 series, SN 5795. Price: $100. Like new. Contact: Y. J. Lubkin, 84 Beacon Hill Road, Port Washington, New York 11050. Telephone: (212) 286-4400.

1—Type 547. Price: $1,593.75. 1—Type 1A1 Dual Trace Plug-In. Price: $531.25. 1—Type 535A. Price: $1,190. 1—Type CA Plug-In. Price: $233.75. 2—Type 2022 Scope-Mobile® Carts. Price: $234. 50. Contact: F. H. Gable, 12808 Coit Road, Dallas, Texas, 75230. Telephone: 239-2611.

1—Type 500/53A. Price: $55.00. 1—Type CA. Price: $125. 1—Type 190B. Price: $150. 1—Type CRT 154-0265-00. Price: $35.00. Contact: Multisonics, Inc., Post Office Box 197, Alamo, California 94507. Telephone: (415) 837-5238.

1—Type 511AD. Price: $50. Contact: Albert Pratt, 114 West Lake View, Milwaukee, Wisconsin 53217.

1—Type 511AD DC-10 MHz. Complete good working order. Price: $195. Contact: Monroe McDonald, 4130 Shorecrest Drive, Dallas, Texas 75209. Telephone: (214) 352-1564.

1—Type 524AD with cart and 5-inch CRT. Price: $600. Used very little. Contact: Padway Aircraft Products, Inc., 11040 Olinda Street, Sun Valley, California. Telephone: 875-1740.

1—Type 545A, SN 27745; 1—Type L Plug-In, SN 9542; 1—Type 1S1 Plug-In, SN 175; 1—Type 1A1 Plug-In; and 2—Type P6006 Probes. Contact: Robert Green, Dielectric Products, Raymond, Maine. Telephone: (207) 655-4555.

1—Type 535A, SN 032925; 1—Type B Plug-In, SN 020369; 1—Type CA Plug-In, SN 065832; and 1—Type 500-53A Scope-Mobile® Cart. Complete package: $2,000. All in excellent condition. Contact: W. N. Rushworth, Purchasing Department, Quebec North Shore and Labrador Railway Company, Sept-Iles, Quebec.

1—Type 536, SN 001509; 1—Type T, SN 001707; 1—Type H, SN 003158; and 1—Type H, SN 002573. Complete package: $700. All in excellent condition. Contact: Mr. Gatecliff, Tecumseh Products, Inc., Research Laboratories, 3869 Research Park Drive, Ann Arbor, Michigan 48104. Telephone: (313) 665-9182.

1—Type 321A, SN 4337. In new condition. Contact: P. C. Miethke, 8910 Santa Monica Blvd., Los Angeles, California 90069.

1—Type 581A, SN 6059; and 1—Type 82, SN 12479. Contact: Carl Bashem, Allen Aircraft Radio, 2050 Touhy Avenue, Elk Grove Village, Illinois 60007. Telephone: (312) 437-9300.

1—Type 514D, SN 2689. In excellent condition with new CRT. Contact: B. G. Carl, 11128 Claire Avenue, Northridge, California 91324. Telephone: (213) 363-1216.

1—Type 502, SN 1221, and 1—Type 502, SN 00817. In good condition. Contact: William Brown, Applied Magnetics Corporation, 75 Robin Hill Road, Goleta, California 93017. Telephone: 964-4881, ext. 55.

1—Type 3S76, SN 3874. Contact: Dr. Charles Ladoulis, Harvard Medical School, 25 Shattuck Street, Boston, Massachusetts. Telephone: (617) 734-3300, ext. 342.

1—Type 561A/3S3/3T77/3A1/3B1/201-2. Contact: Al Nelson, Nelson Instruments, Inc., 1586 South Acoma Street, Denver, Colorado. Telephone: 733-0421.

1—Type C12 Camera with 564 Bezel. Contact: Mr. Class, Lutheran Deaconess Hospital, 2315 14th Avenue South, Minneapolis, Minnesota 55404. Telephone: (612) 721-2933, ext. 222.

1—Type 315D. In good condition. Contact: Bruce Blevins, 176 Barranca Road, Los Alamos, New Mexico 87544.

1—Type 561A/60/2B67. Price: $600. Excellent condition. Contact: Gene Harlen, 465 South 162nd, Seattle, Washington 98148. Telephone: 243-4573.

1—Type 1S1, SN 000643. Price: $975. New condition. Contact: Mr. Gagnon. Telephone: (415) 968-6220.

1—Type 515A, SN 1346. Contact: Michael J. Verrochi, Milton, Massachusetts. Telephone: (617) 698-5490. If no answer, contact: Margie Tanner, Tektronix, Inc., Waltham, Massachusetts. Telephone: (617) 894-4550.

1—Type 517, SN 769, with Scope-Mobile® Cart; 1—Type C. F. probe; and 1—Type B 170 attenuator. Price: $600. Contact: J. B. Taylor and Associates, 1520 Broadway, Oakland, California 94612. Telephone: (415) 832-4056.

1—Type 515A, SN 002588. All mods installed. Telephone: (213) 346-6075 after 6 p.m.

1—Type 310A, SN 21847. Price: $650. In very good condition. Contact: Frank A. Hayes, Red Hill Road, Middletown, New Jersey 07748. Telephone: (201) 671-0271.

1—Type 502, SN 6673. 2—Type P6017 probes. 1—Type P6000 Probe. 1—Type 500A Scope-Mobile Cart. Contact: Dennis Moore, 698 Don Juan Street, Apartment 5, Colorado Springs, Colorado 80908. Telephone: 473-0522.

1—Type 541, SN 6916. 1—Type 53/54C, SN 17265. 1—Type 53/54B, SN 9384. Contact: Carmine Iannucci, WNHC TV, 135 College Street, New Haven, Connecticut. Telephone: (203) 777-3611.

USED INSTRUMENTS WANTED

1—Type 515 or 516. Contact: Enzo Scarton, 133 East Avenue, East Rochester, New York 14445. Telephone: (716) 872-2000, ext. 23050.

1—Type 519. Contact: Oliver Osborne, 15315 South Broadway, Gardena, California 90247. Telephone: (213) 323-2443.

1—Type 515A. State price and condition. Contact: P. Shipp, Professional Instruments Ltd., Box 477, Mount Vernon, New York 10550.

1—Type 190, 190B or 191 Signal Generator. 190B preferred. Contact: Instrument Laboratories Corporation, 315 West Walton Place, Chicago, Illinois 60610. Telephone: (312) 642-0123.

1—Type 540 or 530 series, and 1—Type C Plug-In. Contact: H. R. Greenlee, 430 Island Beach Blvd., Merritt Island, Florida 32952.

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