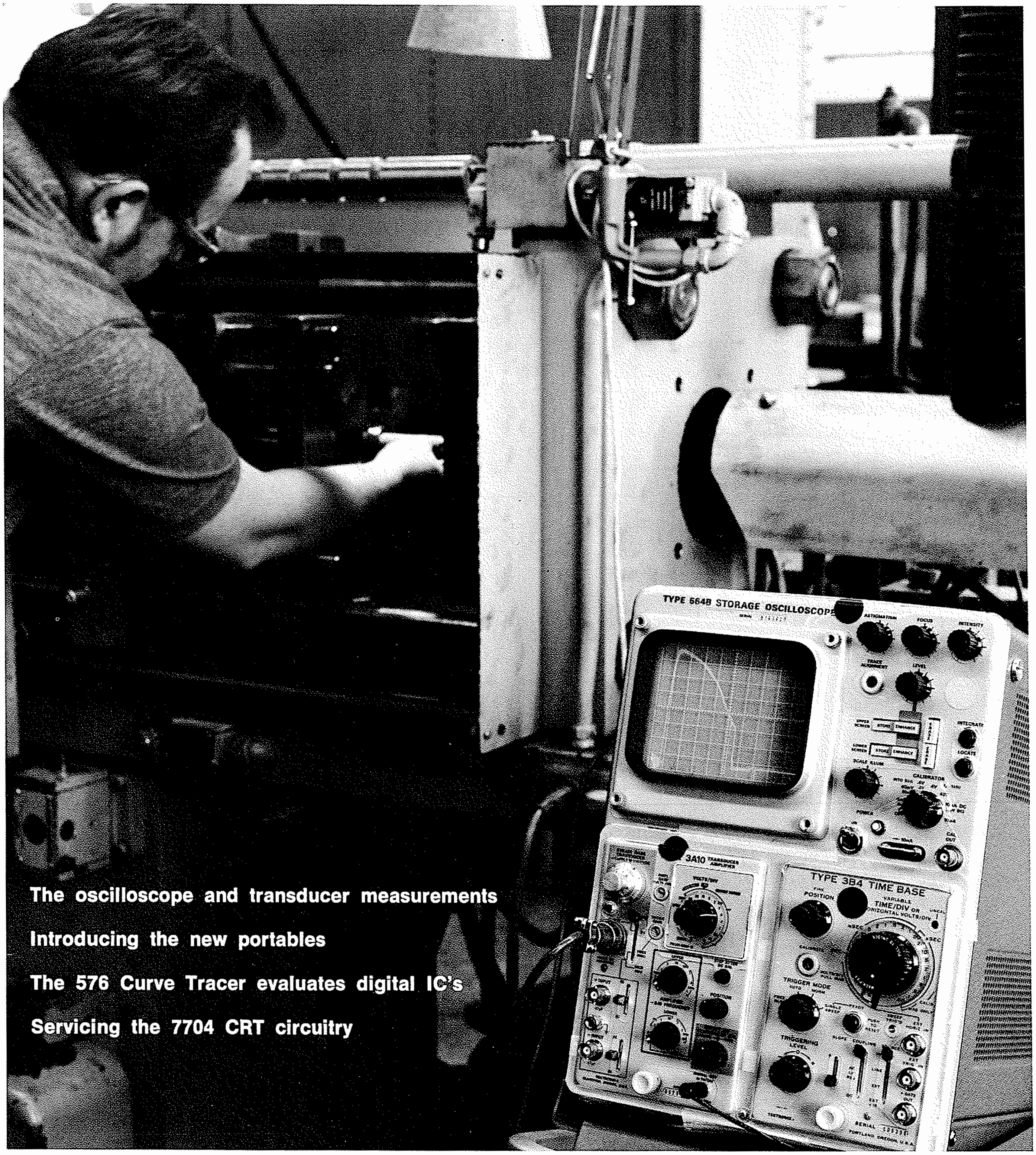
TEKTRONIX

TEKSCOPE

May 1971



The oscilloscope and transducer measurements

Introducing the new portables

The 576 Curve Tracer evaluates digital IC's

Servicing the 7704 CRT circuitry

COVER—Photo of the Beloit Injection Molding Machine in action with the process being monitored by the 3A10 transducer system.

the oscilloscope and transducer measurements

Denny Magden of Plastics adjusts the 3A10 transducer system used in monitoring injection molding of cam switch blanks.

By Ken Arthur, Staff Engineer

The fields of mechanical measurement and electrical waveform measurement have long been linked by a device called a transducer. In the context of mechanical measurements, a transducer is a device which converts some physical quantity, force, property or condition into an electrical signal. When this signal is measured, and the relationship between its parameters and those of the quantity being measured are known, the magnitude of the quantity can be calculated. Since many physical phenomena occur at frequencies beyond the range of galvanometers and chart recorders, the oscilloscope logically becomes the recognized readout device for high-frequency physical measurements. In mechanical measurements, the term "high-frequency" can be applied to any effect having a frequency component higher than one kilohertz.

Tektronix oscilloscopes having high gain differential amplifiers have been used in transducer measurements for many years. However a significant step was taken when the Type Q and 3C66 Carrier Amplifier plug-ins were introduced. With these units the transducer power supply, signal conditioner, and oscilloscope readout device were packaged in a single unit; an innovation made possible by Tektronix' revolutionary "plug-in" concept of oscilloscope design. Then came the Engine Analyzer System and the 410 Physiological Monitor. Although highly specialized in application, these instruments were designed with a "systems" approach; that is, the minimum basic components required in any transducer measurement, (the transducer itself, a signal conditioner and a readout device) were combined in an integrated system. Thus the customer was relieved of the burden of designing his own measurement system from separately purchased components—an irksome task at best, and one which many customers were ill-equipped to perform.

Now, with the introduction of the Type 3A10 Transducer Amplifier, Tektronix makes another substantial contribution to the mechanical measurement field. Along with its family of especially selected and tailored transducers, the 3A10, mounted in a 560-Series Oscilloscope, constitutes the first integrated, general-purpose transducer measurement system to appear on the mechanical measurement scene.

Design of the 3A10 was based on a survey of existing transducer instrumentation. This survey revealed a pronounced need for a transducer measurement system with the following primary characteristics:

- Ease of operation
- Functional flexibility
- Predictable system accuracy (when used with one of the system's transducers)
- Optimum sensitivity and bandwidth

The degree to which these design objectives have been met is evidenced by the number of "firsts" incorporated in the 3A10 system. Among these are:

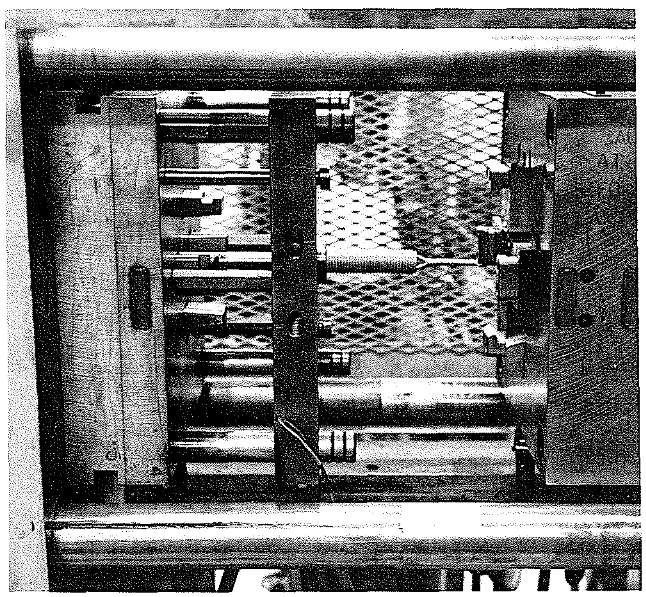
1. Snap-in attenuator scales, permitting the quantity to be read out directly in appropriate metric or U.S. system units.
2. A variable, calibrated (1 to 11 V DC) transducer power supply for strain gages, strain-gage type transducers, and other voltage-excited types.
3. Factory installed, ½ full scale calibration resistors in strain-gage type transducers, permitting transducer calibration at the push of a button and eliminating lead impedance errors.
4. Differential inputs with switchable 1 and 10 megohm input impedances, permitting the use of both piezoelectric transducers and standard oscilloscope voltage probes.
5. Separate amplifier gain control circuit for calibrating active transducers without disturbing main amplifier gain.
6. No attenuation imposed on signals below 20 mV, thereby achieving a CMRR of 100,000:1 for low amplitude signals.
7. A strain-gage adapter with a variable, precision calibration resistor, allowing compensation for variations in gage factor between different lots of gages.
8. Tektronix designed low-hum interconnecting cables to eliminate noise interference with low-amplitude transducer signals.
9. Bandwidth selection to eliminate or reduce unwanted signals, and to permit differentiation and integration of transducer signals.

The versatility of the 3A10 system stems from the fact that each of the ten transducers provided as accessories has been carefully selected, tailored or manufactured by Tektronix to take full advantage of the 3A10 Transducer Amplifier's characteristics. With these transducers, magnitudes of acceleration, force, displacement, pressure, temperature, strain, vibration velocity and vibration displacement can be measured under either static or dynamic conditions. Furthermore, the system lends itself for use with practically any transducer the customer may possess or acquire. These transducers can be incorporated in the system by following simple instructions included in the operating manual and/or the TRANSDUCER MEASUREMENTS concepts book provided as standard accessories.

The range of measurements to which the 3A10 system may be applied is virtually unlimited. Optimum utilization of the system's capabilities, of course, depends to some extent on the imagination and ingenuity of the user. At Tektronix, many of the manufacturing processes have been improved and are maintained on a day-to-day basis through the use of 3A10 systems.

PRODUCTION APPLICATION

A good example is provided by a problem recently encountered in manufacturing the cam switches which contribute substantially to the superior performance of the new 7000-Series Oscilloscopes. One of the components of these switches is a plastic "drum" having as many as 40 individual operating cams. This drum is machined from an injection-molded "blank". Because the molecular structure of this part is crystalline rather than amorphous, it must be annealed to assure permanency of dimensions. The annealing process, however, results in some shrinkage, which varies with the degree of "mold packing" or density of the molded part. Unfortunately these variations in density are not evident until the annealing process is completed. As a result, we experienced an unacceptably high reject ratio of the finished blanks.



Uniform dimensions of injection molded cam switch blank are achieved using the 3A10 Transducer Amplifier and a force transducer to control degree of mold packing.

The problem was solved through the use of the 3A10 Transducer Amplifier and a force transducer. Since the degree of mold packing varies directly with the pressure on the molten plastic during injection, the force transducer is applied to the ejector sleeve of the molding die. As the pressure of the molten plastic rises, it exerts a corresponding force against the sleeve which is in turn detected by the force transducer. Shortly after the peak pressure is attained, the cooling plastic begins to shrink, reducing the pressure on the walls of the sleeve. Once the plastic has solidified, the die is opened and the pressure drops to zero. The resulting waveform is shown in Fig. 1. Experiments soon established the desired parameters and allowable tolerances for this waveform which would result in the most economical and productive use of the molding machine and, at the same time, yield parts of consistent quality. The reject ratio fell dramatically—virtually to zero.

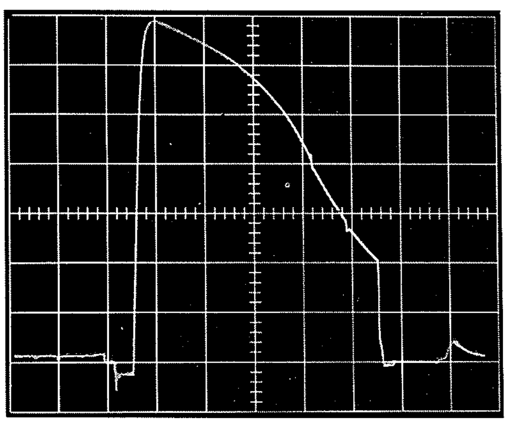


Fig. 1.
Waveform produced by force transducer during the injection molding process. Problems in the process are immediately detected by monitoring this waveform.

Other advantages were gained as bonuses. First, the operator is now able to monitor each injection by observing the oscilloscope waveform. Problems are immediately detected. Second, by connecting an X-Y chart recorder to the SIGNAL OUT jack of the 3A10, a permanent record is made available to supervisory personnel. Fig. 2 shows the record of two extended periods of operation. (The "pulses" shown on the chart are actually time-compressed versions of the waveform shown in Fig. 1.) Process problems are clearly revealed and readily identified by an examination of these records, permitting corrective measures to be taken.

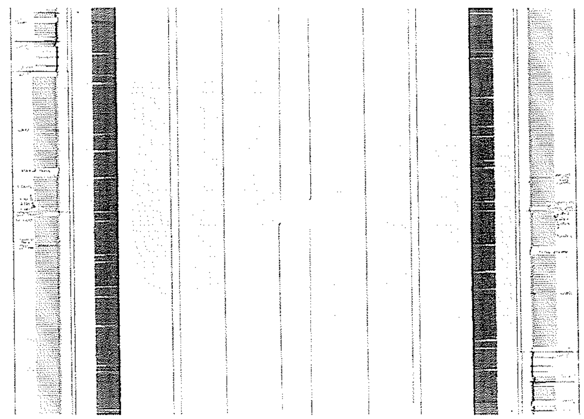
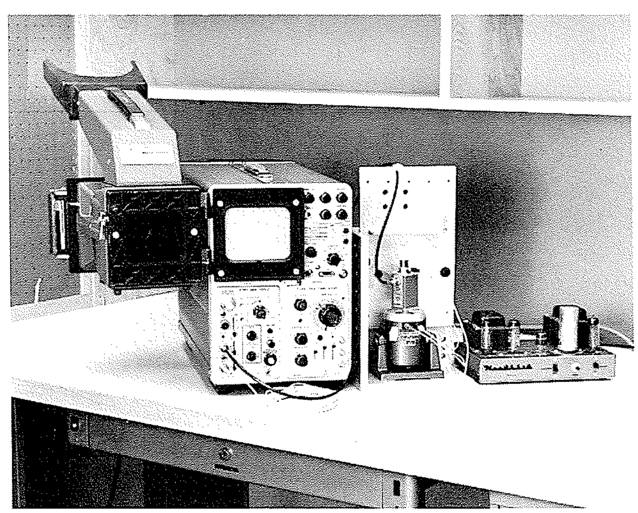


Fig. 2. Permanent chart recordings are useful in analyzing repetitive problems and for production control.

TEACHING APPLICATION

The 3A10 system has also proven its worth as a versatile training aid in the teaching of physics and even mathematics. For example, in the study of the laws of motion, it can be established through the application of mathematical procedures that velocity is the first derivative of displacement with respect to time, and acceleration the first derivative of velocity. These relationships can be demonstrated graphically by using the 3A10 system and the simple apparatus shown below. It consists of a small shake table driven by a 60-Hz squarewave voltage. The 3A10 system's vertical vibration transducer is mounted on the shake table and the accelerometer mounted on top of the vibration transducer.



Apparatus used in demonstrating the mathematical principles relating to the laws of motion.

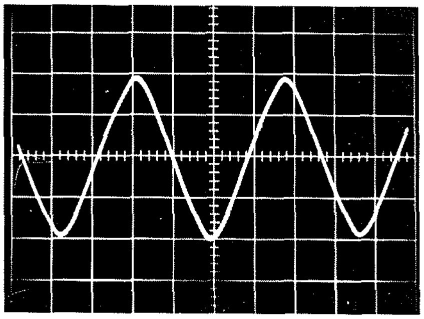


Fig. 3.
Displacement waveform from displacement output of vertical vibration transducer. Bandwidth is DC to 1 MHz.

The first step of the demonstration is to measure the vibration displacement of the table. The damping effect of the mass of the table and transducers results in a displacement which has the form of a distorted sinewave (Fig. 3). This measurement is taken with the amplifier's bandpass filter wide open (DC - 1 MHz).

Next, the lower bandpass switch is set to 10 kHz, so that the displacement signal is differentiated on the lower slope of the bandpass curve. Although this procedure attenuates the signal, the gain of the amplifier may be increased to give a clear impression of the waveform (Fig. 4). According to theory, this differential displacement signal should represent the velocity of the shake table's vibration. To test the theory, it is only necessary to transfer the connecting cable to the VELOCITY output of the vibration transducer and restore the amplifier to full bandwidth. As shown in Fig. 5, this direct measurement yields a waveform practically identical to that of the differentiated displacement waveform.

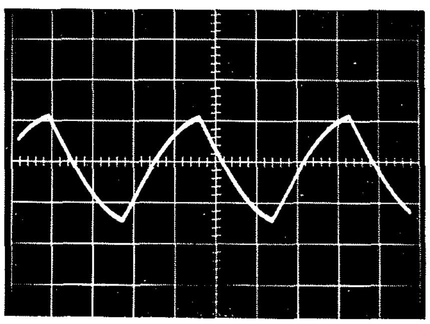


Fig. 4.
Differentiated displacement waveform. Note similarity to the velocity waveform in Fig. 5. Bandwidth is 10 kHz to 1 MHz.

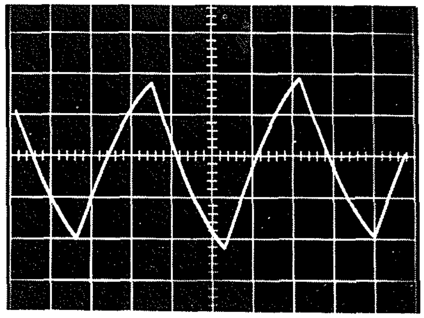


Fig. 5.
Velocity waveform from velocity output of vertical vibration transducer. Bandwidth is DC to 1 MHz.

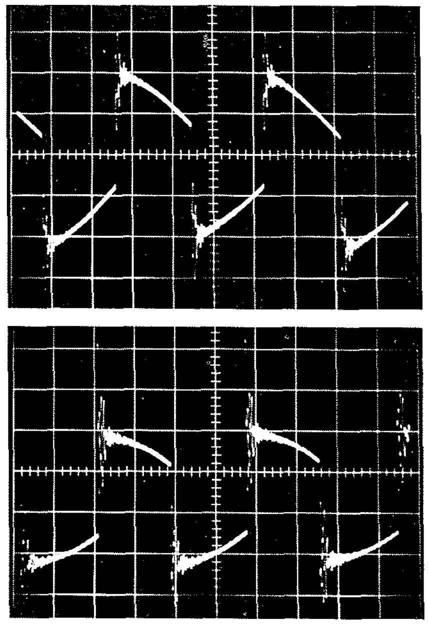
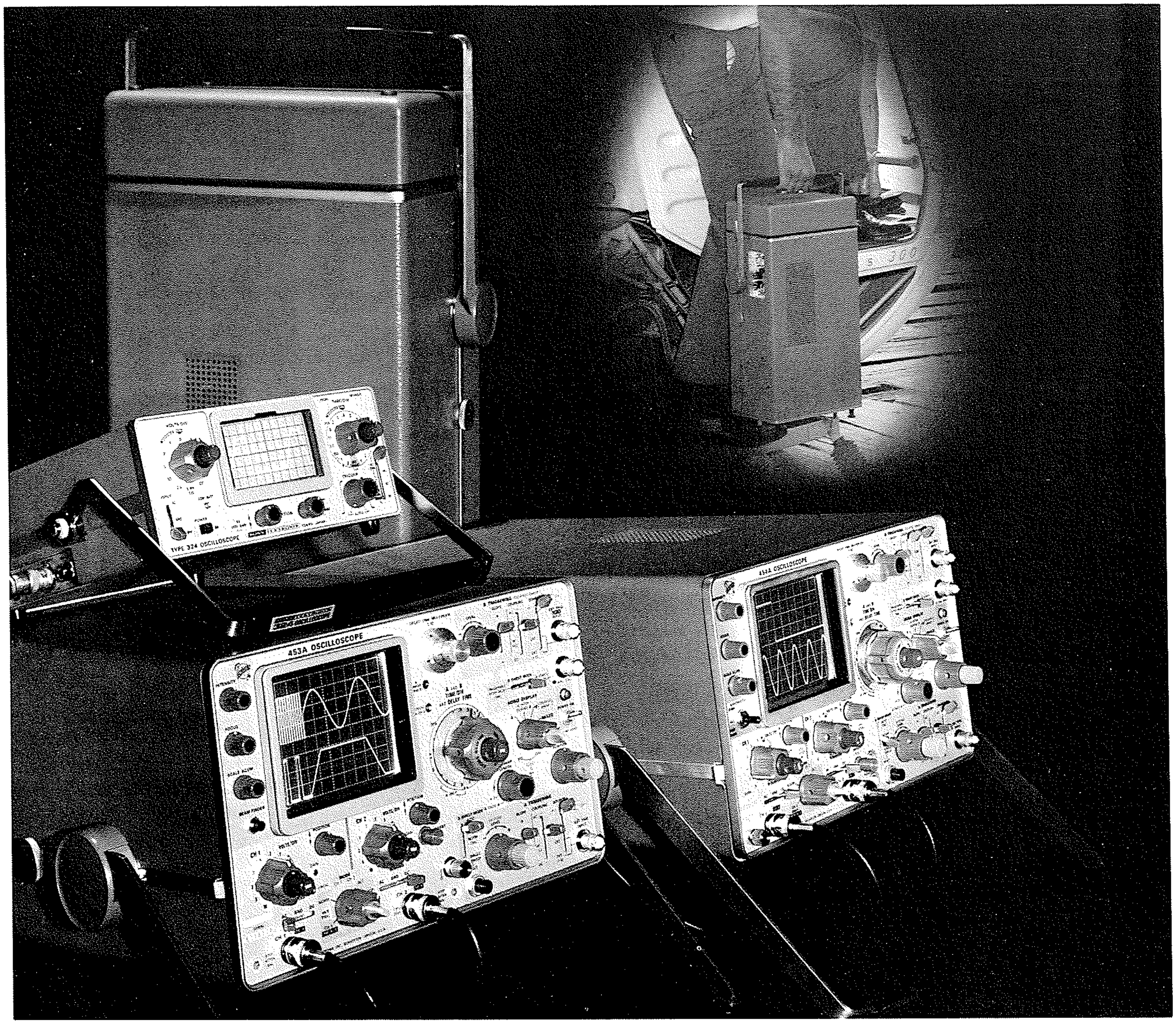


Fig. 6 & 7.
Top: Differentiated velocity waveform. Mathematically differentiating velocity should yield acceleration. Bandwidth is 10 kHz to 1 MHz.

Bottom: Acceleration waveform from accelerometer is similar to differentiated velocity waveform above, validating mathematical thesis. Bandwidth is DC to 1 MHz.

When the vibration velocity signal is differentiated and compared with the directly measured accelerometer output the resultant waveforms once again are practically identical (Fig. 6 & 7).

These two widely-divergent applications are but a small sample of the many measurements possible with the 3A10. We expect the system will find extensive application not only in the mechanical-measurement field, but also in medical research, environmental studies and other fields of endeavor.



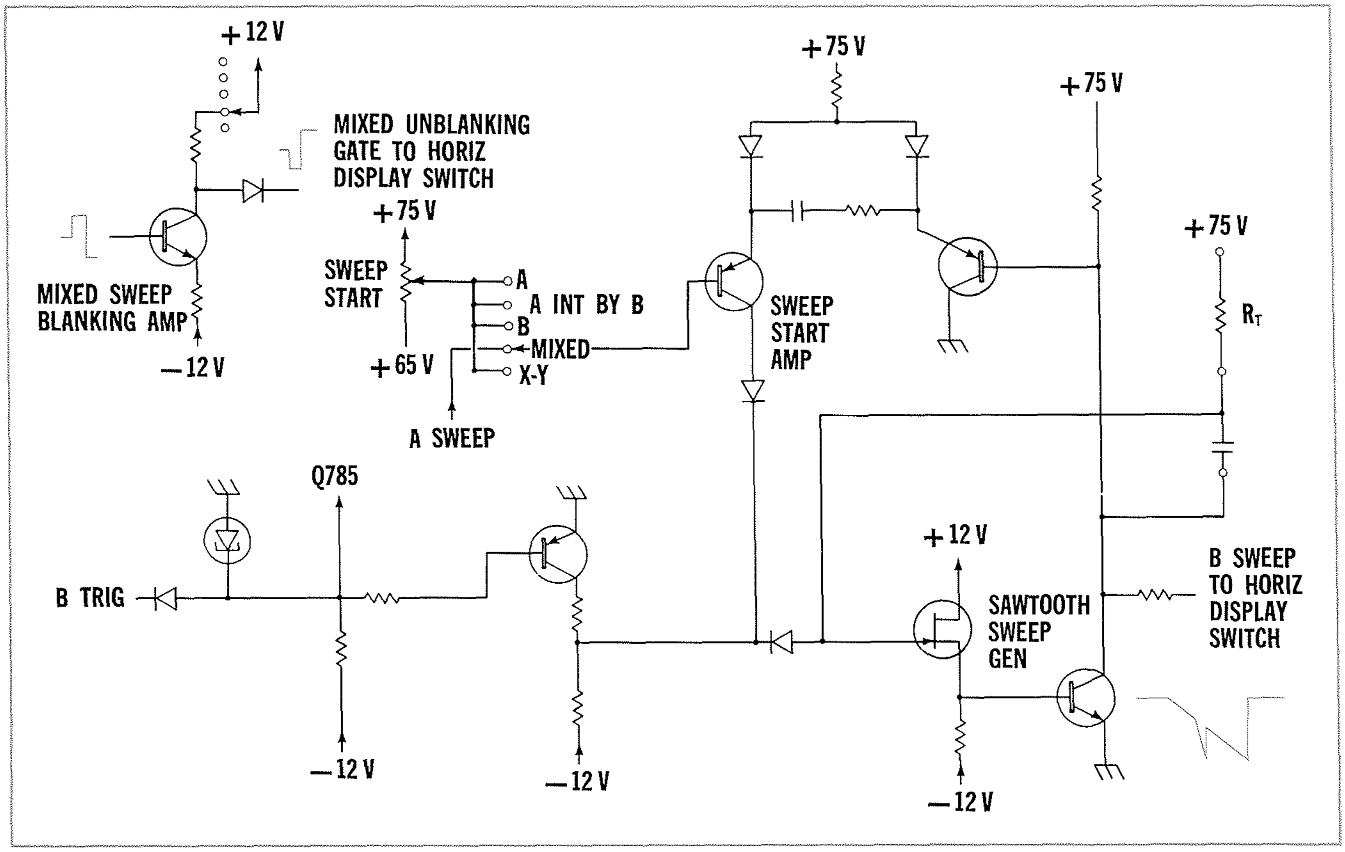
the new portables

Change for the better has always been a way of life at TEKTRONIX. New components, new techniques, new applications and sometimes problem areas, are all factors that continually bring change to our products. Often the changes are small and go unnoticed by the average user. Sometimes, however, the changes are substantial resulting, in essence, in a new product.

Two standards in the portable oscilloscope field, the 453 and 454, have recently undergone such a transformation. We now call them the 453A and 454A. A glance at the front panel reveals both instruments have big new CRTs. Screen size has been increased to 8 x 10 div providing 33% more viewing area. Accelerating potential on the 453A is raised to 14 kV giving the same bright trace as the 454A.

One thing you notice is, that in spite of the larger CRT, there seems to be more front panel space. New knob design and layout and the new color-coordinated front panels provide improved appearance and operating ease. The knobs are where you're accustomed to finding them, but there's more room to operate them.

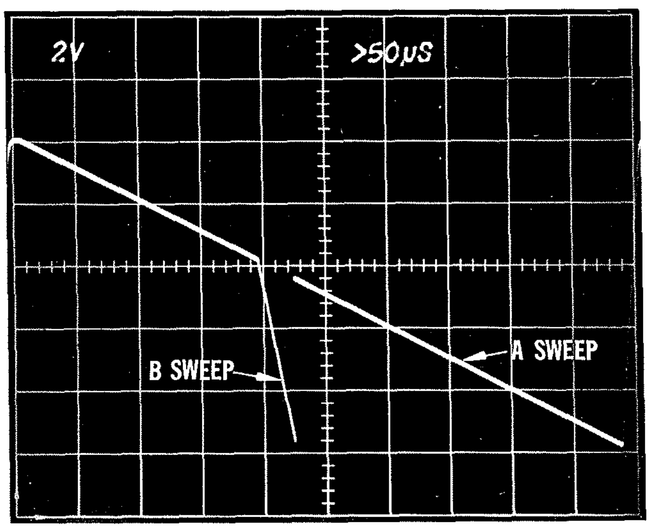
In addition to the larger CRT, improved appearance and operating ease, both instruments pack considerably more performance than their earlier counterparts. A new "mixed" sweep mode lets you view the main sweep out to the point selected by the delay time multiplier, then the delayed sweep for the remainder of the display.



Simplified partial B sweep schematic for the 453A.

The delay time is calibrated, and display repetition rate is independent of delay time. The manner in which the mixed sweep is achieved is somewhat unique. A simplified schematic of the B sweep generator is shown above. In the mixed-sweep mode, the sawtooth from A sweep generator is coupled to the start amplifier for the B sweep generator. Thus, the DC starting point of the B sweep is a direct function of the level of the A sweep. When the B sweep generator is enabled by a signal from the delay multivibrator, the B sweep starts at the point on screen reached by the A sweep. In this mode the output of the B sweep generator drives the horizontal amplifier. The output of the B sweep generator takes the form of a composite sawtooth waveform with the first and last parts occurring at a rate determined by the A sweep generator and the middle occurring at a rate determined by the B sweep generator. The A sweep unblanking turns on the beam during mixed sweep. Additional unblanking during the B sweep portion of the display is provided by the mixed sweep blanking multivibrator through the mixed sweep blanking amplifier. A signal generated by the end of B sweep drives the mixed sweep blanking amplifier to a level which blanks the remainder of A sweep.

Delay accuracy of 1.5% now extends from 50 ms/div to 0.1 μs/div, and the fastest sweep rate on the 454A is increased to 2 ns/div for better resolution of fast risetimes.

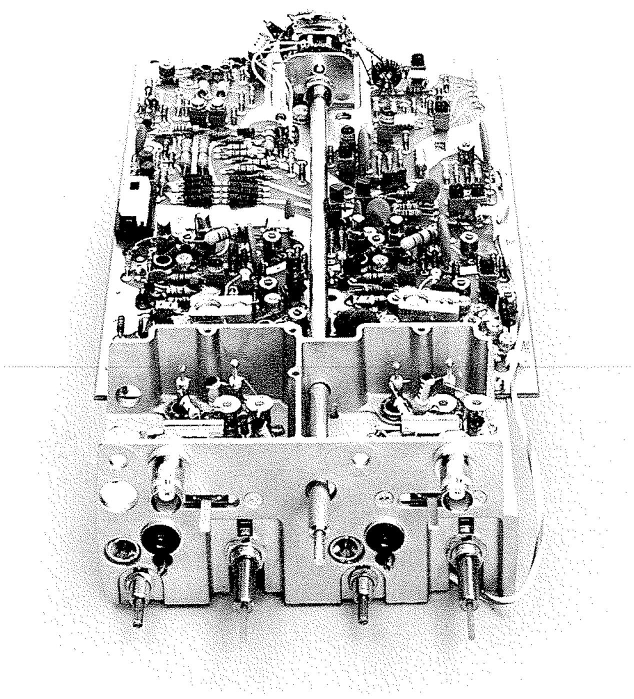


Output of the B sweep generator with Horizontal Display switch in the MIXED mode. Position of the B sweep is determined by the Delay Time Multiplier setting.

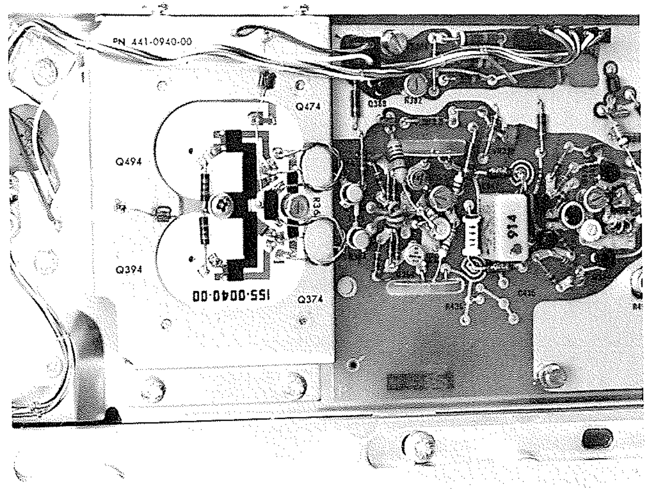
The Vertical Amplifier

The vertical amplifier in the 454A is a completely new design. FET inputs give rock-solid operation down to 2 mV/div and full 150-MHz bandwidth is available at 10 mV/div. A new delay line eliminates preshoot and a cleaner response is obtained. You will notice less effect of vertical position on amplifier response and negligible baseline shift as you switch through the attenuator positions. Crosstalk between trigger, vertical, horizontal and Z-axis signals is substantially reduced.

Complementing the new vertical amplifier system is a new, compact 10X passive probe, the P6054. The offset design of the small compensation box keeps the front panel controls clear for easy operation.



New one-piece casting provides improved shielding and rigid mounting for attenuator switches and vertical preamplifier board in the 454A.



In the 454A Vertical Output Amplifier, many of the components are an integral part of the circuit board or are a part of the thick-film etched circuitry pictured above.

Several mechanical improvements increase the ruggedness and serviceability of the 454A. The vertical attenuator switches are mounted on a one-piece casting to which the vertical amplifier printed board is attached, resulting in better shielding and stability in switch alignment. Harmonica connectors speed disconnecting and removal of etched circuit boards, and access to other areas for servicing has been improved.

A seemingly minor change will be appreciated by those of you who have to carry your instruments around. The feet on the rear form a new power cord wrap that holds the cord securely in place. No more danger of stumbling over the power cord while running for your airplane.

The 453A

Long recognized for its record of dependable maintenance-free operation, the 453 underwent somewhat fewer changes. Most noticeable is the big CRT with the bright trace.

The 14-kV accelerating potential lets you view low rep rate pulses even in adverse ambient light conditions. It, too, has a new, color-coordinated front panel, new knobs and improved layout for easier operation. The bandwidth of the vertical amplifier is increased to 60 MHz at 20 mV/div sensitivity, with 50 MHz at 10 mV/div and 40 MHz at 5 mV/div. In the horizontal section we have added the calibrated mixed sweep function and a more convenient X-Y mode. New, smaller probes and a new power cord wrap complete the major changes found in the 453A.

THE 453A-1, 453A-2, 453A-3, 453A-4

Of major importance to many customers is the addition of four new models to the 453A line. Many applications, especially in field service, require an oscilloscope which will be used exclusively to solve defined measurement problems. Once the measurement problems are defined, the oscilloscope performance characteristics needed to solve these problems are easily defined. These four new models are designed to meet these special requirements.

Since these instruments are intended for use in those applications where versatility and convenience are of secondary importance, certain 453A features have been removed to offer the user performance at a cost compatible with his needs. Features which have been removed include gate output sources, some power options, warning lights indicating uncalibrated modes, X-Y operation, scale illumination and current calibrator loops. Major differences in the models occur in the horizontal section. For example, the 453A-1 has uncalibrated delay of the delayed sweep, while the 453A-2 offers calibrated delay time. The 453A-3 has both calibrated sweep delay and mixed sweep and the 453A-4 has only a single time base. All of the instruments have vertical deflection systems identical to the 453A, except the warning lights indicating uncalibrated vertical modes have been deleted.

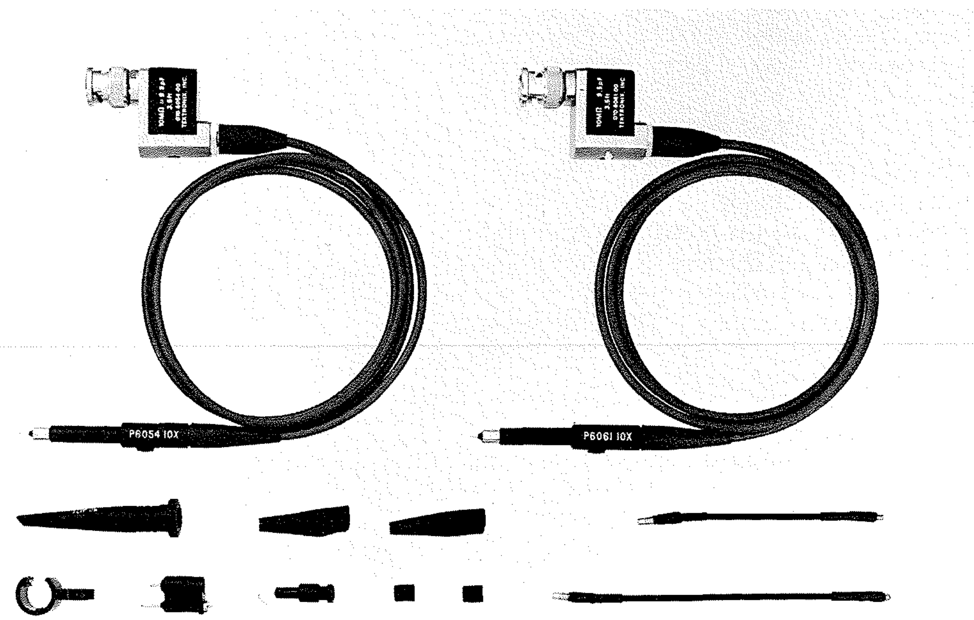
THE 324

No discussion of the new portables available from Tektronix would be complete without mentioning the 324.

Offering 10 MHz, single-channel operation in a package weighing only 8 pounds including batteries, the 324 is ideal for "on-site" maintenance applications. Up to 3 hours continuous operation is provided by an internal rechargeable power pack. The unit also operates from an external DC supply of 6.5 to 16 volts or from the AC line. Power consumption is only 8.5 watts on DC operation. An extra power pack is available to allow one power pack to charge while the other is powering the oscilloscope.

The vertical deflection factor is 10 mV/div at the full 10-MHz bandwidth and 2 mV/div at 8 MHz. Calibrated sweep rates are 1 μs/div to 0.2 s/div with a X5 magnifier extending the top of the range to 0.2 μs/div.

All of the portables are designed to withstand severe environments and include front panel covers and complete accessories.



Pictured above are two new probes developed for use with the 453A and 454A. The P6061 is designed for use with the 453A and the P6054 for use with the 454A. The probes are similar in appearance and feature small, lightweight design ideal for working with today's compact circuitry and miniature components. The offset design of the small compensation box keeps oscilloscope front panel controls clear for convenient operation. Both probes are available in 3.5-foot, 6-foot and 9-foot lengths.

TEKNIQUE:

evaluating digital IC performance using the 576 curve tracer

By Jack Millay

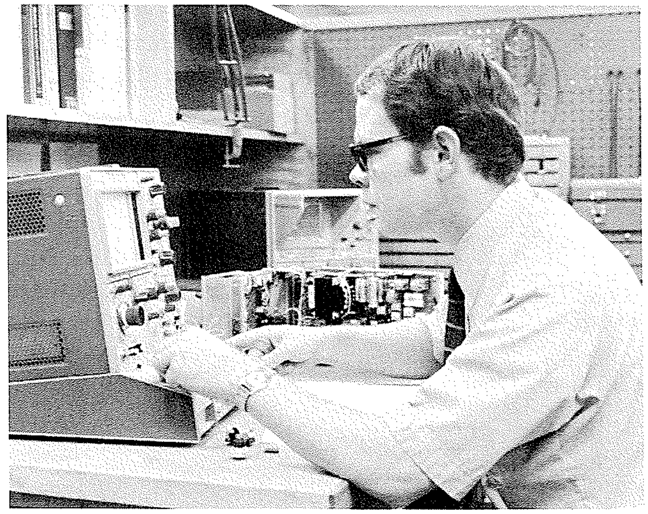
The curve tracer can be a valuable tool to circuit designers, device designers and device evaluation engineers working with integrated circuits. Most of the DC parameters of digital IC's can be displayed as a "curve" such that the point specified by the manufacturer can be verified. Because the display is a curve, much more about the device's performance can be quickly determined than with a single-point measurement. Integrated circuit input and output characteristics as well as voltage supply (V_{cc}) current can be evaluated.

Connecting the integrated circuit to the curve tracer terminals has been a problem. Now an integrated circuit adapter available from Tektronix greatly simplifies the task. The adapter plugs into the Type 576 standard test fixture. Barnes Corporation Series RD-86 sockets and contactors plug into this adapter. Sockets are available for dual-in-line, 6 through 14-lead round-pin-pattern TO packages, and flat pack. Connection to the Type 576 is performed by patch cords from the pin terminal to the 576 terminal on the adapter. The pins on the Barnes Corporation socket are so arranged that the integrated circuit pin numbers agree with the pin terminal numbering around the adapter. Some of the earlier Barnes Corporation Series RD-86 sockets and contactors were not pin compatible. Dual-in-line 14 pin and flat pack are all compatible, as are other sockets and contactors having a yellow base. The units that are now purchased from either Tektronix or Barnes Corporation are all pin compatible.

The 576 COLLECTOR SUPPLY may be used to drive the input, load the output, or drive the V_{cc} terminal. When driving the inputs or loading the outputs of an IC, the AC polarity position of the collector supply allows viewing of both current sourcing and current sinking on the same display. When displaying supply current as a function of supply voltage, usually the + polarity is used instead of AC.

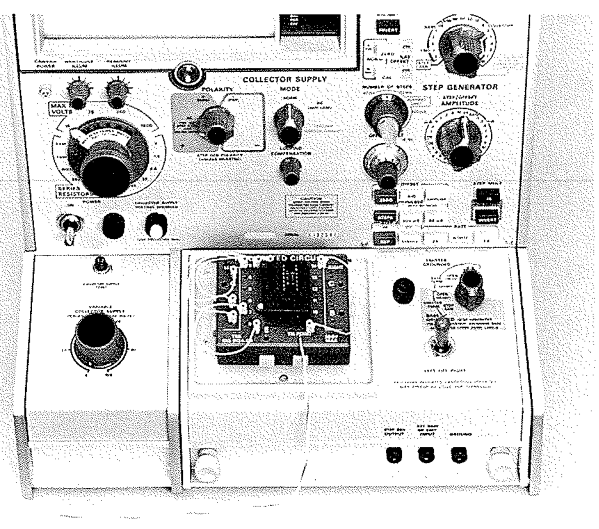
The 576 STEP GENERATOR may be used as a signal source, a power supply, or a combination of both. As a signal source it will output a voltage (or current) stairstep or a squarewave by turning the NUMBER OF STEPS control to 1. To use it as a power supply, the SINGLE STEP FAMILY button is pushed and the OFFSET MULT control is adjusted to obtain the desired voltage (or current). The CURRENT LIMIT control adjusts the limit from 20 mA to 2 A when in the voltage mode.

For many IC tests such as $I_{in}(0)$, $I_{in}(1)$, I_{os}, $I_{cc}(0)$ and $I_{cc}(1)$, the 576 COLLECTOR SUPPLY, the STEP GENERATOR and the E terminal for ground are the



Jack has been with Tek since 1958. For most of his career he has been involved with evaluation of active devices. He was manager of component evaluation for five years and is currently project manager for curve tracers.

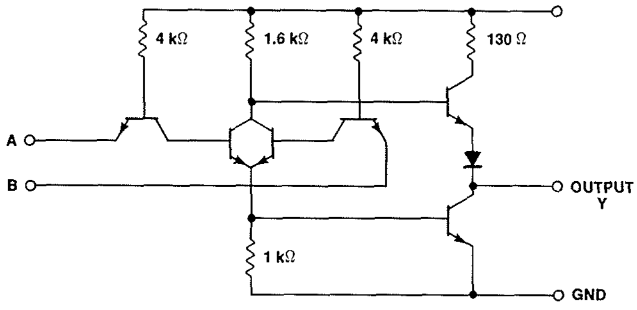
only connections needed. For some tests, such as $V_{out}(0)$, $V_{in}(1)$, $V_{out}(1)$ and $V_{in}(0)$, another voltage supply is needed. It may be connected between the GROUND connection on the front of the test fixture and the TIE POINT on the integrated circuits adapter. From the TIE POINT it can be connected with the patch cords to any pin(s) desired.



The Integrated Circuits Adapter plugs directly into the standard test fixture for the 576.

EVALUATING TTL

Following are some examples of measurements on a Texas Instruments SN7402N IC. The SN7402N is a typical example of a digital integrated circuit. Shown below is the schematic of this circuit. The measurement techniques used here can be applied to other families of circuits as well.



One of four identical sections of the SN7402N IC.

INPUT CHARACTERISTICS OF THE SN7402N

Input current of this circuit can be displayed over the full range of input voltages of interest. The STEP GENERATOR OFFSET of the 576 is used as the V_{cc} supply. The COLLECTOR SUPPLY is used to drive the input that is being evaluated. Because we want to observe both current sourcing and sinking of the input, AC collector sweep is used. Fig. 1 shows the $I_{in}(0)$ condition. The specified value of $I_{in}(0)$ may be measured on this display. It measures about -1 mA at the specified measurement point of 0.4 volts, well within the specification of -1.6 mA max. The input voltage "point" where the input voltage changes from a logical zero to a logical one can be determined by observing the sharp transition in input current. This occurs at about $+1.4$ volts. $I_{in}(1)$ may also be measured by increasing the vertical sensitivity until a reading can be obtained as shown in Fig. 2. In order to perform this measurement as the manufacturer specifies, it is also necessary to move the input not being tested, from ground to the V_{cc} supply. However, this will usually not change the measurement.

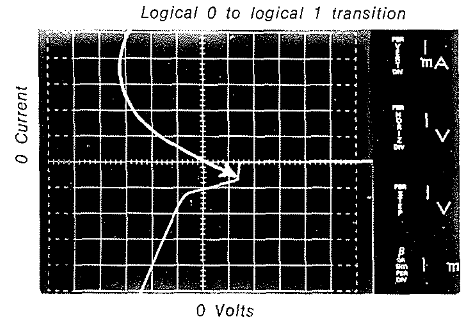


Fig. 1.
$I_{in}(0)$ condition. Step generator offset is used as V_{cc} supply. AC collector sweep drives the input being evaluated so we can observe both current sourcing and sinking.

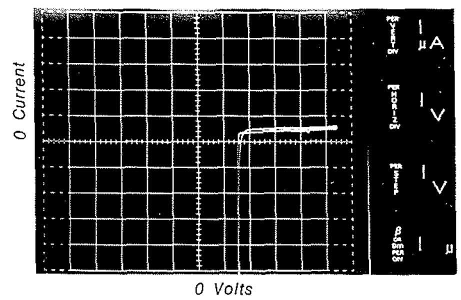
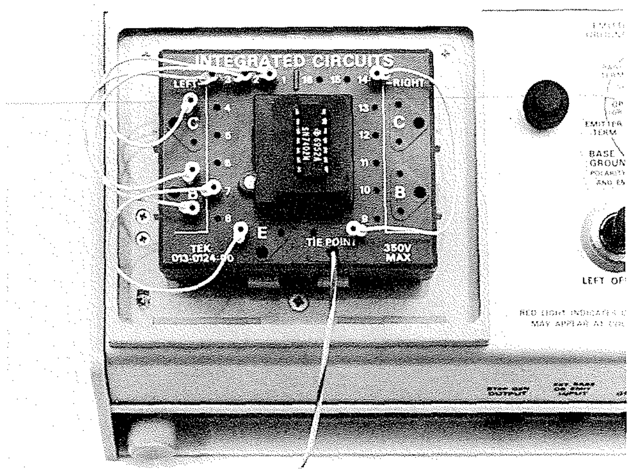


Fig. 2.
$I_{in}(1)$ condition. Same set up as in Fig. 1 with vertical sensitivity increased to permit reading of input current.



Close-up of Integrated Circuits Adapter showing pin numbering details and adapter for 14-lead dual-in-line package.

OUTPUT CHARACTERISTICS OF THE SN7402N

The ability of the output to source or sink current can also be evaluated. The STEP GENERATOR OFFSET is used to bias the input for the $V_{out}(0)$ condition. The COLLECTOR SUPPLY is used to load the output. Because we want to observe both current sourcing and sinking of the output, AC collector sweep is used. An external voltage supply is used for V_{cc}.

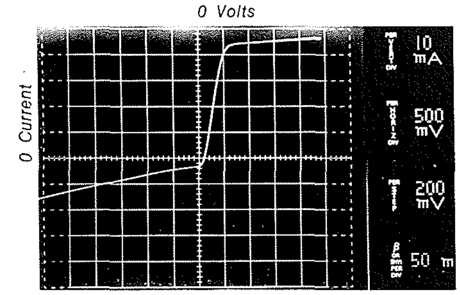


Fig. 3. $V_{out}(0)$ condition. Step generator offset is used to bias input for the $V_{out}(0)$ condition. AC collector sweep is used to load the output being evaluated. External voltage supply is used for V_{cc}.

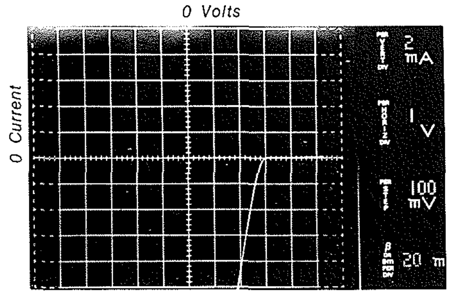


Fig. 4. $V_{out}(1)$ condition. Same set up as in Fig. 3 except the step generator offset is set to bias the input for $V_{out}(1)$ condition and the deflection factors are set accordingly.

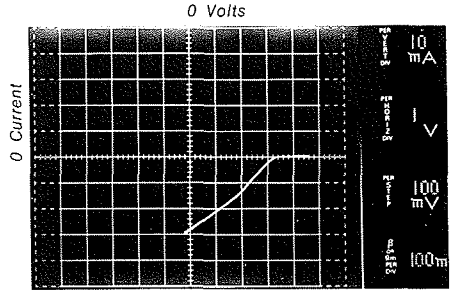


Fig. 5. Short-circuit output current, I_{os}, measured using same test set up as for $V_{out}(1)$. Vertical deflection factor is decreased to observe point at which the curve crosses the zero-voltage line.

Fig. 3 shows the $V_{out}(0)$ condition. The manufacturer's specification can be verified and actual performance measured. The device is specified able to sink 16 mA at no more than 0.4 V. From this display it is apparent that it will actually sink 35 mA at 0.4 V and will have a voltage drop of 0.25 V at the 16 mA specified. The normal fan out is specified at 10, but this particular gate could drive over 20 gates, at least as far as DC characteristics are concerned.

It can also readily be determined from the display how much current is available to drive shunt capacitance, and by knowing the amount of the capacitance, calculate the time for this current to discharge this C to the logical zero state.

Fig. 4 shows $V_{out}(1)$ of one of the SN7402N outputs along the horizontal axis as a function of output current along the vertical axis. This device is specified able to source at least 400 μA at 2.4 volts. From the curve it is apparent that it will actually source 4 mA at 2.4 volts and has a logical 1 voltage of 2.7 volts at 400 μA. Because the maximum input current $I_{in}(1)$ is specified at 40 μA, this output could drive almost 100 other worst-case inputs for a fan out of almost 100 instead of the 10 specified. However, this measurement was performed at 25°C, and when the device is operated at lower ambient temperatures, the performance for this characteristic decreases.

Short-circuit output current (I_{os}) may be measured using the same test set up as for $V_{out}(1)$ by decreasing the vertical deflection factor. The deflection factor is decreased until we can observe the point at which the curve crosses the zero-voltage line. Fig. 5 shows this characteristic. The manufacturer specifies the current to be at least —18 mA, and no more than —55 mA. This device measures —29 mA, well within specifications.

V_{cc} CHARACTERISTICS

The current required from the V_{cc} supply as a function of supply voltage and input levels can also be displayed. The COLLECTOR SUPPLY is used to drive the V_{cc} terminal. The + polarity of the supply is used as we only have to supply current (not sink). The STEP GENERATOR can be used to voltage drive the inputs from 0 volts to +5 volts by setting the AMPLITUDE control to 1 volt/step and using 5 steps. No offset is used. Fig. 6 shows this characteristic.

Only 2 curves are displayed because the zero and one-volt steps are below the level where the transition from the logical zero to the logical one takes place. The other four steps are above the transition point. $I_{cc}(0)$ measures 15.5 mA, and $I_{cc}(1)$ measures 13.6 mA, well within the manufacturer's specifications.

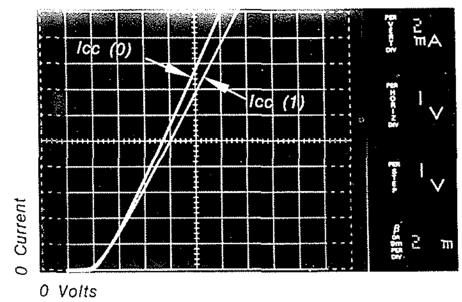


Fig. 6.
$I_{cc}(0)$ and $I_{cc}(1)$. The V_{cc} terminal is driven by the collector supply, using + polarity. The step generator drives the inputs from 0 volts to +5 volts using 1 volt/step. The outputs are open.

From the same display we can also determine the effect on V_{cc} current when V_{cc} or the input voltage is changed. Changing the input voltage has very little effect except in the logical zero to the logical one transition zone. However, a small change in V_{cc} voltage produces a relatively large change in V_{cc} current.

These examples are typical of the IC measurements that can be made using the 576. Many of these measurements can also be made on the 575 but with somewhat greater difficulty. The integrated circuits adapter will fit on the 575. However, you will need to use patch cords to connect the collector and base terminals on the right hand side of the adapter to the 575. AC collector sweep is not available on the 575 so that two displays will be needed to display both current sourcing and sinking. Also the base step supply is much more limited and cannot do some of the functions we required of the 576. This difficulty can usually be overcome by using an additional external power supply.

SERVICE SCOPE

SERVICING THE 7704 CRT CIRCUIT

By Charles Phillips, Product Service Technician
Factory Service Center

This is the second in a series of articles on servicing the 7000-Series Oscilloscopes. The March TEKSCOPE discussed servicing of the high-efficiency low-voltage power supply in the 7704.

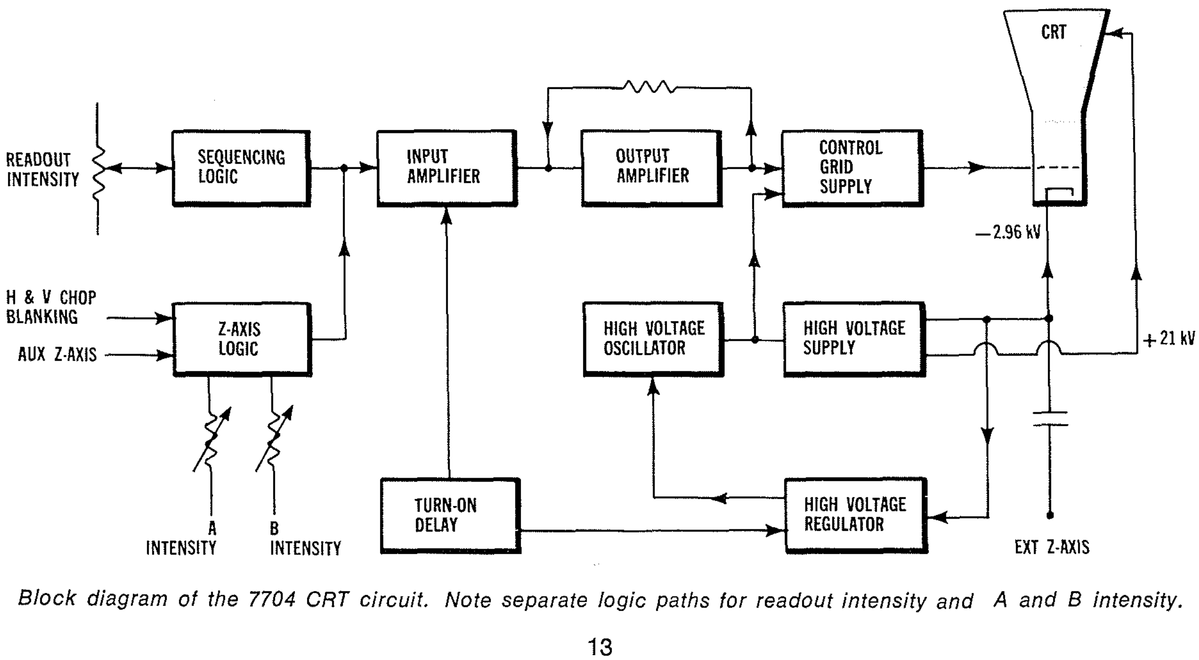
The CRT circuit in today's advanced oscilloscopes performs the same basic functions as in early day instruments. It produces the high-voltage potentials to accelerate the electron beam and provides control circuits to turn the beam on and off and to set the intensity level.

While the basic functions have not changed, the complexity of the functions has. As bandwidth and sweep rates have increased, so have accelerating potentials and the speed with which the beam must be turned on or unblanked. Multiple signals now often control the beam. Main and delayed-sweep unblanking, horizontal and vertical chopped blanking, CRT readout, and external Z-axis modulation must all be accommodated. Logic circuitry and a Z-axis amplifier provide a convenient means of processing these varied signals for control of the beam in the 7000 Series.

With the increase in complexity of the CRT circuitry arises the need for a systematic approach to servicing this portion of the circuitry. Several clues as to the probable location of a problem are available to us from the front panel. For example, there are three intensity controls on the 7704 front panel, A Intensity, B Intensity and Readout. The A and B Intensity controls are activated when plug-ins are inserted into the respective horizontal compartments. The readout is activated when a plug-in is inserted in any of the four plug-in compartments. Intensity levels set by the A and B Intensity controls pass through the Z-axis logic circuitry to the Z-axis amplifier, while the intensity level set by the Readout control goes through the sequencing logic to the Z-axis amplifier. This gives us a quick check to determine whether the problem exists in the Z-axis logic or elsewhere in the CRT circuitry.

Let's assume you have a plug-in in the A Horizontal compartment, the A Horizontal mode button depressed and the A Intensity and the Readout controls set to mid-range. You are experiencing intensity problems. Here are some symptoms and the probable causes:

1. No trace and no readout—
   a) Trace and readout off-screen—Pulling the beam finder control should bring the readout and trace on-screen.
   b) Readout locked up—Pull the readout board. If this clears the problem, U1210 on the readout board is a likely suspect.
   c) Defective Z-axis amplifier—If you have a spare Z-axis board, try replacing the entire board. If not, try replacing Q704, Q706 or Q718.



Block diagram of the 7704 CRT circuit. Note separate logic paths for readout intensity and A and B intensity.

d) Blown fuse F921—Replace the fuse located on the low-voltage regulator board. Corona discharge may cause the fuse to blow. Defective components in the high-voltage oscillator and rectifier assembly can also blow the fuse.

e) Defective CRT—See discussion on troubleshooting the —2960-volt supply. An open CRT heater or defective CRT socket can also be at fault.

2. A spot only, whose intensity is controlled by the Readout intensity control—Defective readout. Pull the readout board or replace U1210 on the readout board.

3. Readout only—

a) Trace off-screen—Pulling the beam-finder control should bring the trace on-screen.

b) Defective plug-in—Replace the plug-in. If plug-in is a time base, check to see that the controls are set to generate a trace.

c) Defective Z-axis logic—Replace U170 Z-axis logic IC.

4. Bright trace and readout but no intensity control.

a) Defective CRT.

b) Defective Z-axis logic or Z-axis amplifier.

c) Defective high-voltage circuitry.

5. Normal trace but no readout—

a) Defective readout board.

b) Defective plug-in unit.

TROUBLESHOOTING THE —2960-VOLT SUPPLY

Now let's take a closer look at some of the problems noted. First, that of no trace and no readout. We have determined that the trace is not off-screen and have pulled the readout board to eliminate it as a contributing factor. The next step is to check the —2960-volt cathode supply. This is available at a test point located in the high voltage assembly on the top right side near the rear of the instrument. A note of caution. Turn off the scope before applying or removing the meter lead to or from this test point. Corona discharge may damage some of the solid state components. If you have no voltage on this point, turn off the scope and disconnect the cable running from the CRT anode to the left side of the high voltage assembly. Lowering the swingdown chassis on the right side of the instrument gives you ready access to the anode cable connector. Touch the CRT anode lead to ground to remove the electrostatic charge on the CRT. After you have discharged the anode lead, turn the scope on. If the —2960-volt supply comes up, you have a bad CRT. If the supply still fails to come up, turn off the scope and remove the CRT base socket. This will remove any loading on the supply due to shorted elements in the CRT.

If you still do not have —2960 volts, check Q712, Q752, Q756 and Q758 on the Z-axis board. The oscillator transistors Q764 and Q766 can also be defective. If none of these units are at fault, you will need to get into the high-voltage assembly to troubleshoot further.

The simplest method to accomplish this is to lower the swing-down chassis on the right side of the instrument. Place a piece of cardboard or a tablet on the chassis as an insulator on which to lay the high-voltage assembly.

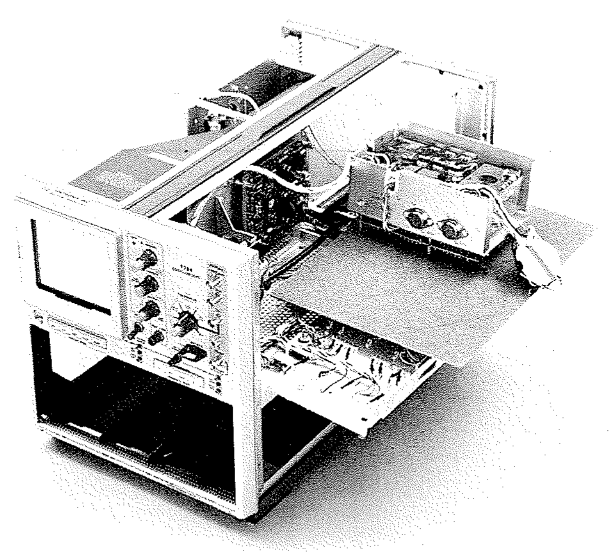
The assembly is removed by removing the seven screws holding the upper half of the back panel and the two screws holding the front of the assembly. Work the assembly around so you can lay it on the insulating material on the swing-down chassis. The brown and red leads from the trace rotation coil on some early instruments are too short to permit laying the assembly down. Just remove the Z-axis board, unplug the leads and dress them out of the way. They need not be connected to troubleshoot the supply. Reinstall the Z-axis board. Next, remove the plastic cover from the supply and locate the white-green wire running from the encapsulated assembly to the high-voltage transformer. Unsolder this lead and again check the —2960-volt supply. If it comes up, you have trouble in the encapsulated assembly and you will have to replace the entire assembly. If it is not at fault, leave the white-green wire unsoldered. This allows you to pick up the rest of the circuitry involved with the high-voltage transformer and the components around that area.

Another condition that would prevent the high-voltage oscillator from running is a shorted or leaky diode in the high-voltage secondary. We can check CR771 and CR772 by lifting their anode lead and taking a voltage reading. The anode of CR771 should read about —30 V and the anode of CR772 about —3 kV. We cannot lift CR781 to check it as this would remove the feedback to the regulator circuit. The best procedure is to replace it or substitute CR772 temporarily to determine if CR781 is defective.

Other possible causes of high voltage failure are the high-voltage transformer and filter capacitor in the secondary circuitry.

INTERMITTENT OR NOISY HIGH VOLTAGE

Another problem you may experience is an intermittent —2960-volt supply, flashes on the screen, or noisy Z-axis modulation. Principal source of this problem is the thick-film assembly containing resistors R740 through R744. On later schematics these are numbered R740A through E. The assembly is located in the high-voltage plastic housing and can be reached by lifting the circuitry from the housing.



High voltage supply removed for servicing. Insulating board between supply and swing-down gate allows unit to be operated while open for troubleshooting.

The elastic bands holding the thick-film card to the assembly are usually the culprit. The tails of the bands protruding through the circuit board sometimes come in contact with the high-voltage diodes causing a corona discharge. Clipping off these tails may cure the condition. Corona discharge also sometimes occurs between the elastic bands and the thick-film resistors. If removing the bands clears the problem, you can leave them off. If the problem is still present, replace the thick-film card. The leads to the thick film should be unsoldered at the circuit point rather than at the thick film as the card is coated with an insulating material.

NO INTENSITY CONTROL

When you have a bright trace and no control of the intensity, the first thought is to suspect the CRT. Shorted elements in the CRT will cause this. However, problems in the Z-axis amplifier can also give the same symptom. If Q724 or Q734 is defective, you will have no intensity control. A defective Q708 will cause the trace to be bright when the scope is first turned on then dim after several seconds to normal intensity.

Q732, the remaining transistor in the Z-axis amplifier, has no effect at slow or medium sweep rates. However, if you have modulation on the trace at faster sweep rates, suspect Q732. Incidentally, it's not readily apparent how to remove the heat sink from this transistor. The heat sink is in two sections; just unscrew the top from the bottom.

This covers most of the problems you may experience with the high-voltage section of the 7704. High-voltage circuitry in other 7000-Series instruments with readout is similar and can be serviced using the same techniques.

INSTRUMENTS FOR SALE

130LC Meter, $190. 115, $695. 514D, $350. S. King, 725 Little Silver Point Rd., Silvermere, Little Silver, N.J. (201) 741-3891.

3T2, 3S2, S3, 3 ft. cable ext., All $2250. R. Wagner, Wesleyan Univ., Physics Dept., Middletown, Conn. 06457. (203) 347-9411, Ext. 865.

535A with CA Plug-In. d b Electronic Enterprises, 13526 Pyramid Dr., Dallas, Texas 75234. (214) 241-2888.

535A with H Plug-In, $1000. 545A, $1250. G Plug-In, $125. Geo. Maxwell, Rescuair Corp., 9030 Owensmouth Ave., Canoga Park, Calif. 91304. (213) 882-6161.

556. Ron Seldon, Digital Development Corp., 7514 Clairemont Mesa Blvd., San Diego, Calif. 92111 (714) 278-1630.

454, Mod 163D. New condition. Palmer Agnew, 314 Front St., Owego, N.Y. 13827. (607) 687-2406.

Three new Mod 130 LC Meters. Bob Rust, (213) 889-1010, Ext. 1081.

545, CA, $550. J. R. Shapiro, 5 Lynn Dr., Englewood Cliffs, N.J. 07632 (201) 568-9287.

454, RM15, 130, 134, P6022. Three months old. Mr. Puzzuti, Aries Technology, 3475 Victor St., Santa Clara, Calif. (408) 248-9685.

Two 3A3's. B. Murray, Picker Electronics, 601 S. Bowen St., Longmont, Col. (303) 776-6190.

453, $1600. 555 w/2 D's, $1600. 585 w/81 Adapter, D Plug-In, $1500. Ed Franchuk, 1203 Opal Ave., Anaheim, Calif. 92805. (714) 546-0431.

Q Unit, $350. Never used. Vern Iverson, Possis Machine Corp., 825 Rhode Island Ave., S., Minneapolis, Mn. 55426. (612) 545-1471.

310. Norman Orr, Radio Specialists Co., 2450 W. 2nd Ave., Denver, Col. 80223. (303) 744-3461.

Two 422's. $1000 each. David Young, Interdata, Inc., 2 Crescent Pl., Oceanport, N.J. 07757. (201) 229-4040, Ext. 396.

531A, 1A2, N, L, $950. Michael Muegge, 100 Foerster St., San Francisco, Calif. 94112. (415) 931-8000, Ext. 522 or (415) 585-1625.

504, $400. 551, $1000. CA, $125. H, $125. Vince Murray, Audio Devices, 100 Research Dr., Glenbrook, Conn. (203) 324-6761.

561A/3A6/3B3 w/Probes, $1525. James Gamble, 21917 Grant Avenue, Torrance, Calif. 90503. (213) 542-2680.

453 Mod 127C, $1850. 191, $350. E. Paulaitis, 19 W. 380 Lake St., Addison, Ill. 60101. (312) 543-9260 or E. Lauer, (312) 259-6300.

453. Mike Logue, Heidelex Corp., Stuart Rd., Alpha Ind'l Park, Chemsford, Mass. 01824. (617) 256-3921.

545, $700. D, $60. K, $50. B, $45. L, $90. Time Mark Gen, 180-S2, $95. Frank Aamodt, Golden West Airlines, 4200 Campus Dr., Newport Beach, Calif. (714) 546-6570.

531, 53B, $400. Gene Mirro, P.O. Box 274, Hightstown, N.J. 08520 (609) 799-1495 after 6:00.

Two K's, $80 each. 80 w/Prb. & Atten., $80. Mr. Jordan, 1125 Greengate Rd., Fredericksburg, Va. (202) 337-7600, Ext. 711.

Will trade RM17 for 503. T. W. Moore, Mt. Holyoke College, South Hadley, Mass. 01075. (413) 536-4000.

661 w/5T3, 4S1, 51A and two P6032's. Will trade for 454. John Riccitelli or N. Bicknell, The Foxboro Co., Foxboro, Mass. (617) 543-8750.

Six 2A60's, unused. 25% discount. Harold Childers. (713) 771-5821.

512. J. C. Leifer, 328 Cree Dr., Forest Heights, Md. (301) 839-1548 or (703) 560-5000, Ext. 2773.

Sale or trade 1A1, 53/54 K, 110 Pulse Generator. Lawrence Kahn, Gamma Electronic Research Co., 6042 Rockrose Dr., Newark, Calif. 94560. Call evenings & weekends. (415) 797-2595.

317, $665. John Nicholas, Buckeye Cablevision, Inc., 1122 N. Byrne Rd., Toledo, Ohio 43607. (419) 531-5121.

575 Mod 122C, $1000. Jerry Setliff, Nuclearay, Inc., P.O. Box 9320, N.W. Station, Austin, Texas 78757. (512) 836-1120.

503, C-27. Dr. Farhang Soroosh, 1126 E. 2nd St., Casper, Wyoming 82601. (307) 234-2613.

541A, CA, $1000. Frank Cosenza, Tridair Industries, Fastener Div., 3000 W. Lomita Blvd., Torrance, Calif. 90505. (213) 530-2220.

661/4S1/5T3 and Access. Mr. Mawson, Scientific Measurement Systems, 351 New Albany Road, Moorestown, N.J. 08057. (609) 234-0200.

Will trade N for M Plug-In, Four P6010 Probes. Lloyd Hanson, Tri-State College, Engineering-Business Adm., Angola, Ind. 46703.

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561A, 564, 201-2. 565, 205-1. 1L20. Lawrence Kahn, Gamma Electronic Research Co., 6042 Rockrose Dr., Newark, Calif. 94560. Call evenings & weekends. (415) 797-2595.

564B and Engine Analyzer Accessories, including 2B67, 3A74, all accessory components. As package or separately. Henry Kovar, 11823 Porter Dr., R.R. #4, Osseo, Mn. 55369.

TEKSCOPE

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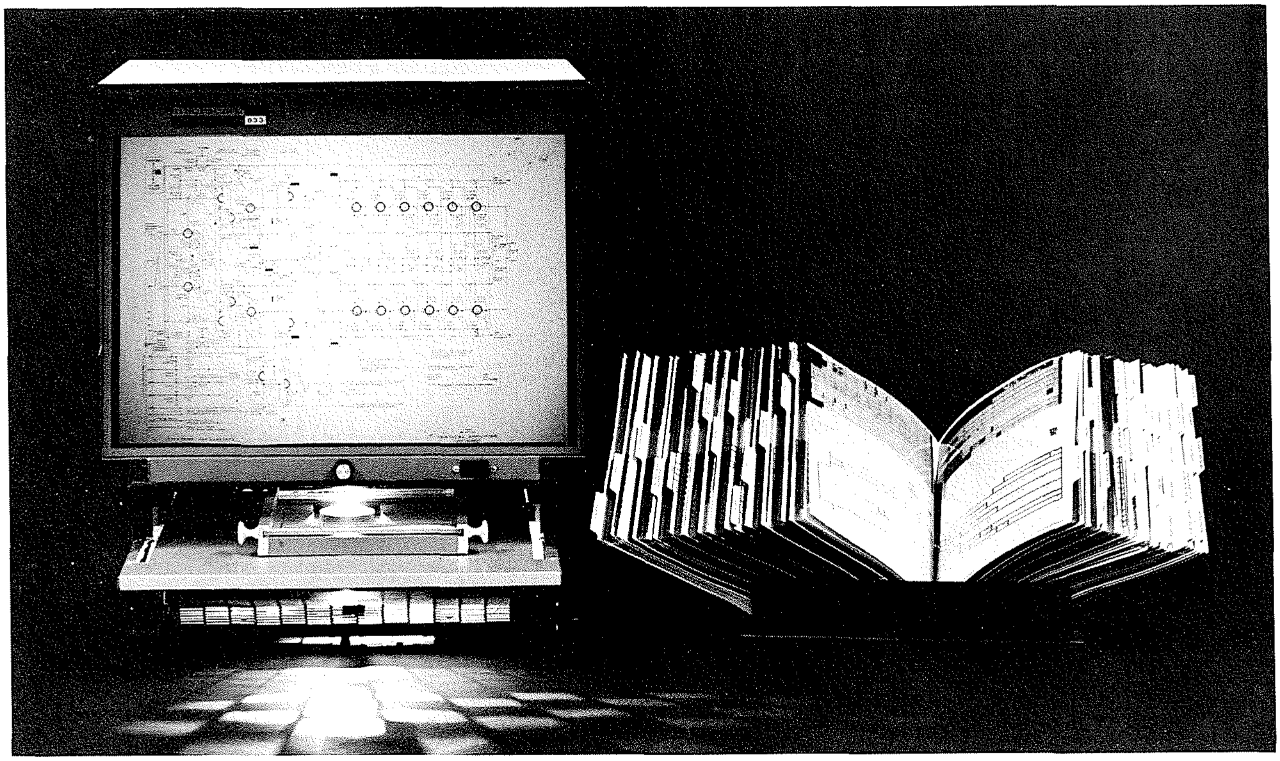

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