TEKTRONIX

INSTRUCTION MANUAL

TYPE CA PLUG-IN UNIT

DUAL-TRACE CALIBRATED PREAMP TYPE CA

INSTRUCTION MANUAL

TEKTRONIX, INC.

MANUFACTURERS OF CATHODE-RAY AND VIDEO TEST INSTRUMENTS

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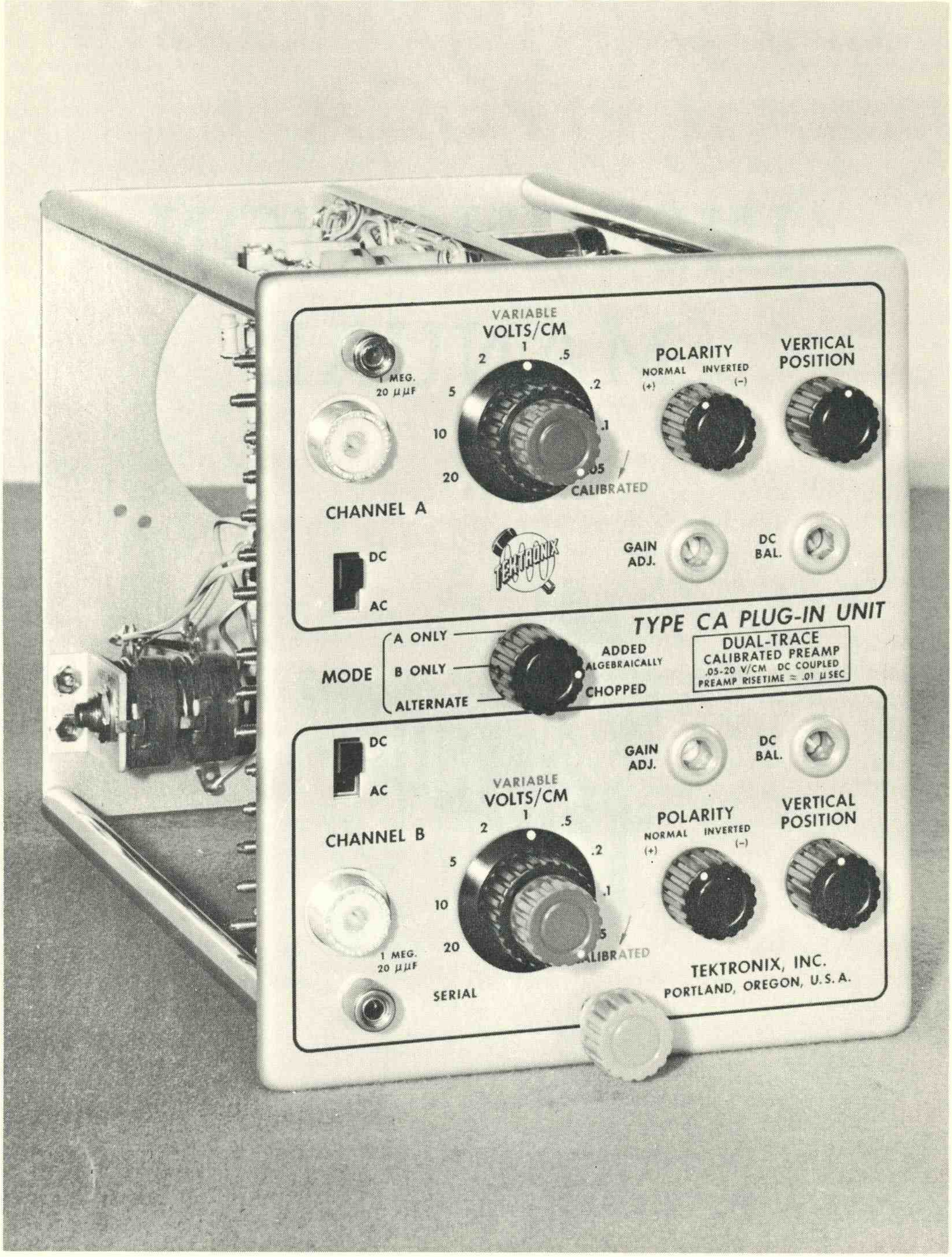
070-014 TYPE CA SERIAL NUMBER 35015



The Type CA Unit

GENERAL DESCRIPTION

GENERAL

The Type CA Unit contains two identical amplifier channels that can be electronically switched either by the oscilloscope sweep or at a free-running rate of approximately 100 kc. When amplifier switching is triggered by the oscilloscope sweep, the two signals to be compared appear on alternate sweeps. Because the sweeps are identical, and time-delay characteristics of the two amplifier channels are closely controlled, time comparisons accurate within 1 mμsec can be made.

Stationary display of two signals unrelated in frequency can be accomplished by internal triggering of the sweep alternately by the two signals. In free-running operation, switching occurs at a rate of approximately 100 kc, making it possible to view two simultaneous transients. Transients of as little as one-millisecond duration can be well delineated, with about one hundred elements in each trace. For many purposes, shorter transients can be adequately observed.

Either amplifier channel can be used separately without electronic switching, making the Type CA also useful in all single-trace applications within its frequency-response and sensitivity capabilities. Maximum flexibility is obtained by providing separate positioning, sensitivity, and polarity-inverting controls for each channel.

By placing the MODE switch in the ADDED ALGEBRAICALLY position the output of both channels may be combined, adding or subtracting according to the settings of the polarity switches.

TYPE CA SPECIFICATIONS

Operating Modes

Channel A only.

Channel B only.

Electronic switching at 100 kc (chopped).

Electronic switching on alternate sweeps.

Both channels combined at output (A±B).

Amplifier Sensitivity

Basic deflection factor—.05 v/cm, ac or dc.

Nine calibrated sensitivities—.05 v/cm to 20 v/cm, accurate within 3% when set on any one step.

Amplifier Transient Response

With Type 533, risetime 0.023 μsec., to 15 mc.

With Type 531, 535, 536, risetime 0.035 μsec., dc to 10 mc.

With Type 532, 0.07 μsec., dc to 5 mc.

With Type 541, 543, 545, risetime 0.015 μsec., dc to 24 mc.

With Type 551, risetime 0.016 μsec., dc to 22 mc.

Input Impedance

1 megohm shunted by 20 μμf; with P410 probe 10 megohms, 7.5 μμf.

Physical Characteristics

Construction—Aluminum alloy chassis. Finish—Photo-etched anodized panel. Weight—4 1/2 lbs.

FUNCTIONS OF CONTROLS AND CONNECTORS

CHANNEL A. CHANNEL B. Signal input of the A-channel or B-channel amplifier.

DC—AC. Slide switch to provide either ac or dc coupled input into the amplifiers.

VOLTS/CM. Nine-position switch used to select the calibrated vertical-deflection sensitivities.

VARIABLE. Potentiometer concentric with the VOLTS/CM switch to provide continuously variable attenuation between the calibrated sensitivities and to extend the attenuation to a sensitivity of 50 v/cm.

POLARITY. Two-position switch to provide optional in-phase or out-of-phase output.

VERTICAL POSITION. Potentiometer to provide for shifting the position of the trace vertically.

GAIN ADJ. Screwdriver adjustable potentiometer to permit the gain of the amplifier to be accurately set.

DC BAL. Screwdriver adjustable potentiometer to provide for setting the VARIABLE attenuator dc levels so the trace does not shift position when the attenuation is varied.

MODE. Five position switch to allow either amplifier to be used independently, to provide for switching the two amplifiers at an arbittary rate, to synchronize the switching with the oscilloscope's sweep, or to provide for adding the outputs of the amplifiers algebraically.

OPERATING INSTRUCTIONS

FIRST-TIME OPERATION

Plug the unit into a 540- or 530-Series Oscilloscope and turn the power on. Allow the instrument to reach operating temperature, about 2 to 3 minutes and free-run the sweep at 1 millisecond/cm. Turn the MODE switch to A ONLY and the A-channel POLARITY and AC-DC switches to NORMAL and DC respectively. Position the trace to about +2 cm with the A-channel VERTICAL POSITION control.

Turn the MODE switch to B ONLY and the B-channel POLARITY and AC-DC switches to NORMAL and DC respectively. Position the trace to about —2 cm with the B-channel VERTICAL POSITION control.

Now turn the MODE switch to CHOPPED. Two traces will appear on the crt screen. Notice that the A-channel VERTICAL POSITION control moves the upper trace and the B-channel VERTICAL POSITION control moves the lower trace. Increase the sweep speed to 100 microsecond/cm and notice that each trace is composed of many short-duration elements. The two channels are being switched at approximately 100 kc so that each channel conducts for about 5 μsec and then is cut off while the other channel conducts for an equal time.

Now turn the MODE switch to the ALTERNATE position. There are still two traces on the crt screen but the traces are no longer chopped into small bits. For each sweep cycle one channel is conducting and the other is cut off. The channels are switched at the end of each sweep cycle.

GENERAL OPERATION

Either of the two identical amplified channels can be used independently by turning the MODE switch to A ONLY or B ONLY and connecting the signal to be observed to the appropriate input. The following remarks apply equally well to either amplifier channel.

Use of Probe

The Type P410 probe, furnished with the 540-Series Oscilloscopes, is designed to preserve the transient response of this unit. This probe introduces no ringing but causes an additional frequency-response loss of less than 1 db at 24 mc. The Type P410 probe has a 10-to-1 attenuation ratio.

The Type P510A probe is not suitable for use with the Type CA Plug-In Unit and 540-Series Oscilloscope combination to observe fast-rising pulses. This probe tends to ring at about 50 mc and the wide passband of the Type CA—540-Series combination will display any ringing that may occur.

Be sure to check the adjustment of the probe when you first connect it to a plug-in unit or oscilloscope. The probe compensation is a function of the shunt input capacitance of the particular plug-in unit or oscilloscope that you use the probe with. If the compensation is incorrect the frequency response will be affected. Touch the probe tip to the calibrator output connector and display several cycles of the calibrator waveform. If the top and bottom of the displayed square wave are not flat, adjust the trimmer capacitor located either inside the probe body or inside the box at the other end of the cable to achieve correct square-wave response.

Input Coupling

It is sometimes undesirable to display the dc level of the waveform being observed. Placing the AC-DC switch in the AC position inserts a capacitor in series with the input so the dc component of the waveform is blocked and only the ac component is displayed. The low-frequency response is about 2 cps when ac coupling is used.

Output Polarity

It will be desirable to invert the displayed waveform at times, particularly when using the dual-trace feature of the Type CA. The POLARITY switch has two positions. In the NORMAL position the displayed waveform will have the same polarity as the input signal. In the INVERTED position the displayed waveform will be turned upside down; that is, a positive-going pulse will be displayed as a negative going pulse.

DC Balance Adjustment

After the plug-in unit has been in use for a period of time you will notice that the trace will change position as the VARIABLE control is rotated. This is caused by tube aging and the resultant shift in operating potentials. To correct this condition rotate the VARIABLE control back and forth and adjust the DC BAL control until the trace position is no longer affected by rotation of the VARIABLE control.

Gain Adjustment

Aging of the tubes will also affect the gain of the plug-in unit. Display a calibrator waveform of 0.2 volt peak to peak with the VOLTS/CM switch in the .05 position. Adjust the GAIN ADJ control until the displayed waveform is 4 graticule divisions in amplitude. Make sure the VARIABLE control is turned full right to the CALIBRATED position before making this adjustment.

Positioning Adjustment

The VERT POS RANGE control balances the dc output level so the full range of the front-panel positioning controls can be utilized. This control is accessible when the left side panel is removed. Center the trace in both the A ONLY and B ONLY positions of the MODE switch. Note the settings of the VERTICAL POSITION controls. .Adjust the VERT POS RANGE control so both the A-channel and B-channel VERTICAL POSITION controls are approximately centered when the displayed trace is centered.

SPECIFIC OPERATION

Generally, three types of operation will be performed using the Type CA Unit; the observation of repetitive waveforms, the observation of single, transients, and the observation of one waveform superimposed upon another. The three types of operation are fundamentally different so we will examine them in the order stated.

Repetitive Signals

Connect the two signals to be compared to the two signal inputs and turn the MODE switch to A ONLY. Set the sweep up for triggered operation and adjust the VOLTS/CM and VERTICAL POSITION controls as necessary to display the waveform. Turn the MODE switch to B ONLY and adjust the corresponding controls as necessary to display the other waveform. Now turn the MODE switch to ALTERNATE. If necessary, touch up the oscilloscope's sweep triggering controls to obtain a stable image. Both waveforms will now be displayed on the crt screen. As the control of each amplifier is independent you can position, attenuate, or invert the signals as necessary to compare their shape, relative amplitudes, etc.

Use the AC FAST triggering mode and ALTERNATE sweeps for INTernal triggering on signals having components above 10 kc. For lower-frequency signals, use the AC SLOW triggering mode. In the AC FAST position, an rc filter is inserted into the circuit allowing it to recover quickly from the dc level changes encountered with the ALTERNATE sweep. To compare the phase difference between two signals, you should trigger externally using the reference signals as the trigger signal.

Single Transients

When it is necessary to observe a single transient at two parts of a circuit another procedure must be followed. In the foregoing case, one of the signals triggers the sweep and that amplifier remains conducting for the sweep duration. At the end of the sweep the amplifiers are switched and the other signal then triggers the sweep and that amplifier remains conducting for the sweep duration. Each of the signals is being displayed every other sweep cycle. If you attempted to observe a single transient in this manner the transient will pass through whichever amplifier happens to be conducting and will trigger the sweep. This will display the transient as seen by whichever amplifier is conducting but when the amplifiers are switched at the end of that sweep there will be no further signal to trigger another sweep until the next transient occurs. The problem here is to be able to observe the transient using both amplifiers during a single sweep cycle.

Turn the MODE switch to CHOPPED. Now the two amplifiers are being switched on and off independently of any signal. The switching rate is approximately 100 kc so each amplifier is conducting for about 5 μsec and then is cut off while the other amplifier conducts for an equal length of time. In this case the sweep is being triggered by the switching waveform, particularly if the two traces are positioned very far apart, as the switching waveform is equivalent to a 100-kc square wave. It will usually be very difficult if not impossible to trigger the sweep internally from the signal so the sweep controls should be set for external triggering. Review the OPERATING INSTRUCTIONS section of the oscilloscope's instruction manual for the proper procedure for external triggering of the sweep.

Now the two signals to be observed can be connected to the two inputs and both waveforms will be displayed during one sweep cycle. Transients as short as 1 msec duration can be well delineated, with about 100 elements in each trace. As before, the independent control of each amplifier will allow you to position, attenuate, or invert the waveforms so they can be easily compared.

Algebraic Addition

In many applications, the desired signal is superimposed on an undesired signal such as line frequency hum, etc. The Algebraic Output of the Type CA unit (with the MODE switch in the ADDED ALGEBRAICALLY position) makes it possible in many cases to improve the ratio of desired to undesired signal. Connect one input to a source containing both the desired and undesired signals. Connect the remaining input to a source containing only the undesired signal. Place the MODE switch in the ADDED ALGEBRAICALLY position. Set the POLARITY switches to opposite polarities (depending upon the polarity of the desired signal). By careful adjustment, especially at low frequencies, of the VARIABLE controls and/or the GAIN ADJ. controls the amplitude of the undesired signal displayed can be reduced by a factor of 20 compared to the amplitude of the desired signal.

CIRCUIT DESCRIPTION

AMPLIFIERS

The Type CA Plug-In Unit consists of two identical amplifier channels and a channel-switching multivibrator. The following description of the amplifiers applies equally well to either channel.

Input Coupling and Attenuation

The signal to be displayed is applied to the input cathode follower V3323 (V4323) by way of the AC-DC switch and the VOLTS/CM switch. The AC-DC switch is a two-position slide switch that bypasses C3300 (C4300) in the DC position so the input is dc coupled. In the AC position of this switch the signal must pass thru C3300 (C4300) so the dc component of the signal is blocked.

The VOLTS/CM switch is a 9-position rotary switch that selects the various frequency-compensated rc attenuator sections. The sensitivity of the unit is .05 volts/cm. The input voltage is reduced by the eight individually selected attenuator sections to give nine fixed calibrated ranges.

Input Stage

The input stage consists of the cathode follower V3323 (V4323) and the cathode-coupled phase inverters V3334 and V3354 (V4334 and V4354). The control-grid dc level of V3334 (V4334) is established by the dc connection to the cathode of V3323 (V4323). The control-grid dc level of V3354 (V4354) is adjustable by means of the DC BAL control so that the dc level of the cathodes of V3334 and V3354 (V4334 and V4354) can be made equal. Any dc level difference between these two cathodes would act as a signal and cause the trace to shift position when the VARIABLE control is rotated. The VARIABLE gain control establishes the amount of cathode coupling and thus allows the stage gain to be varied over about a $2\frac{1}{2}$ to 1 range.

The GAIN ADJ control permits the basic gain of the unit to be accurately set to agree with the front-panel calibration.

Polarity and Positioning

With the POLARITY switch in the NORMAL position the displayed waveform will have the same polarity as the input signal. Placing the POLARITY switch in the INVERTED position reverses the signal-grid connection of V3364 and V3374 (V4364 and V4374) and inverts the displayed waveform. Rotation of the VERTICAL POSITION control forces one plate of the input stage toward a higher potential and the opposite plate toward a lower potential. The resulting dc level shift moves the trace vertically.

Amplifier Stage and Output CF

The signal is further amplified by V3364 and V3374 or V4364 and V4374, depending on which channel is conducting. V3364 and V4364 have a common plate load and likewise V3374 and V4374. Since one amplifier is always cut off while the other is conducting, the shunt loading effect is negligible.

V4383 is the output cathode follower that provides a low-impedance source for driving the oscilloscope's vertical amplifier. The VERT. POS. RANGE control located in the grid circuit of the output cf permits the trace to be centered vertically under no-signal conditions.

SWITCHING CIRCUIT

A Only, B Only

V3375 is a multivibrator that is controlled by the MODE switch. With the MODE switch in the A ONLY or B ONLY position the multivibrator is held in one of its two possible states by returning one grid to a positive voltage and the other grid to a negative voltage. For example, in the A ONLY position the grid of V3375A is held positive and this half of the multivibrator conducts while the grid of V3375B is held negative and this half is cut off. While V3375A is conducting the cathode is above ground which causes V3384B to conduct and in turn pulls the grid of V3393B toward ground lowering the plate voltage of V4334 and V4354. This reduced plate voltage cuts off the following stage (V4364 and V4374) and the B-channel amplifier is held in a non-conducting state. The converse is true of the A-channel amplifier. The grid of V3384A is near ground potential and with reduced plate current the plate of V3384A and consequently the grid of V3393A are permitted to become more positive providing plate voltage for V3334 and V3354 and the A-channel amplifier then conducts.

Chopped

Turning the MODE switch to the CHOPPED position returns both grids of the multivibrator to a positive voltage and the multivibrator free runs at a rate determined by the time constant of the grid circuits. The two amplifiers are alternately cut off and allowed to conduct at the free-running rate of the multivibrator.

Alternate

Turning the MODE switch to the ALTERNATE position returns both grids of the multivibrator to a negative potential and it is then bistable. At the end of each sweep cycle a negative-going trigger is generated and is coupled to the multivibrator through the Trigger Coupling Diode V3382. Each trigger causes the multivibrator to "flip" from one stable state to the other. This alternately switches the amplifiers on and off but now the switching rate is determined by the repetition rate.

Added Algebraically

Turning the MODE switch to the ADDED ALGEBRAICALLY position returns both grids of the multivibrator to —150 volts. Both sides of the multivibrator (V3375) are held sufficiently negative so that incoming triggers have no effect on the multivibrator grids. The cathodes of both halves of the multivibrator follow the grids down, driving V3384A and V3384B to cut off. With V3384A and V3384B cut off the plate voltage rises, carrying the grids of the following stage, V3393A and V3393B with it. The cathodes of V3393A and V3393B follow the grids up. Plate voltage for the input amplifier stages of both channels is supplied by the cathodes of either V3393A or V3393B. When the cathodes are up, both amplifier channels conduct equally in the absence of any signal.

Under the conditions described above signals applied to both inputs will be amplified equally by either channel. Algebraic addition of the signal occurs at the grids of the output stage, V4383. In phase input signals add, out of phase input signals subtract, at the grid of each tube if the polarity switches are at the same setting.

MAINTENANCE

PARTS ORDERING AND REPLACEMENT

Instruction Manual

A Tektronix instruction manual usually contains hand-made changes to diagrams and parts lists, and sometimes text. These changes are in general appropriate only to the instrument the manual was prepared for. These hand-made corrections show changes to the instrument that have been made after the printing of the manual.

There is a serial number on the frontispiece and on the warranty page of this manual. This is the serial number of your instrument. Be sure the manual number matches the instrument number when you order parts.

NOTE

Always include the instrument type AND SERIAL NUMBER in any correspondence regarding the instrument.

Standard Components

Tektronix will supply replacement components at current net prices. However, since most of the components are standard electronic and radio parts you can probably obtain them locally faster than we can ship them to you from the factory in Portland, Oregon. Be sure to consult the instruction manual to see what tolerances are required.

Selected Components

We specially select some of the components, whose values must fall within prescribed limits, by sorting through our regular stocks. The components so selected will have standerd RETMA color coding showing the value and tolerance of the stock they were selected from, but they will not in general be replaceable from dealer's stocks.

Checked Tubes

To obtain maximum reliability and performance we check some of the vacuum tubes in our instruments for such characteristics as microphonics, balance, transconductance, etc. We age other tubes to stabilize their characteristics. Since there are no well defined standards of tube performance we have established our own arbitrary standards and have developed equipment to do this checking. These checked tubes can be purchased through our local Field Engineering Offices or directly from the factory in Portland, Oregon.

Tektronix Manufactured Parts

Tektronix manufactures almost all of the mechanical parts and some of the components used in the instrument. If you order a mechanical part be sure to describe the part completely to prevent any unnecessary delay in filling your order. When you have any questions about mechanical parts or Tektronix manufactured components contact our nearest Field Engineering Office or write to the Field Engineering Department at the factory in Portland, Oregon.

GENERAL INFORMATION

Color Coding

We use color coded wires in the instruments to help identify the various circuits. These wires will be either a solid color or will be a solid color (including black and white) with one or more colored strips. The colored strips are "read" in the same manner as the RETMA resistor color code. In the case of multiple strips the wide stripe is read first.

Wires carrying positive regulated-power-supply voltages are white and the stripes indicate the supply voltage. For example, the +225-v supply bus will be coded red-red-brown (2-2-1) giving two significant figures and the decimal multiplier.

The negative-supply bus wires are black and the stripes indicate the supply voltage. For example, our most common negative-supply voltage is —150 v and is carried by a black wire coded brown-green-brown (1-5-1).

The mains-voltage leads to the power transformer are yellow and coded brown-brown-brown (1-1-1).

The tube heater leads are white and coded 6-1, 6-2, 6-3, etc., not to indicate that the voltages are different but to differentiate between circuits.

In other respects the color coding will vary from instrument to instrument. In general all signal-carrying leads are white and coded with a single colored stripe. In fact a few places where the number of leads exceeded the capabilities of single-strips coding we have used solid-color leads.

Soldering Precaution

The solder used on the ceramic terminals of this instrument must contain a small percentage of silver. Repeated use of ordinary tin-lead solder will dissolve the fused bond of silver that makes the solder adhere to the porcelain, especially if the soldering iron is quite hot.

Maintenance

For shops responsible for the maintenance of several Tektronix instruments, it is advisable to have a stock of solder containing about 3% silver. This type of solder is used frequently in printed circuitry and should be readily available. Or, it can be purchased directly from Tektronix in one-pound rolls (order by part number 251-514).

ADJUSTMENT PROCEDURE

The following outline is based on the adjustment procedure used in our test department here at the factory. Ordinarily, adjustment in the field will consist of touching up some of the dc level and balance controls as outlined in the OPERATING INSTRUCTIONS, but if a readjustment of the transient response is ever necessary there is a certain sequence that should be followed.

The input capacitance of the unit is accurately set to 20 $\mu\mu f$ at the factory. This insures that a properly adjusted probe can be used interchangeably with other units having 20-$\mu\mu f$ input capacitance. To preserve this feature, you will need to do one of these things: (1) use a CS-20 Input-Capacitance Standardizer, (2) calibrate a P400-Series probe against a plug-in unit known to be in correct adjustment, or (3) measure the input capacitance with a Type 130 L, C meter or with a capacitance bridge.

Peaking Coils

As preliminary adjustment, set all peaking-coil slugs so that the top of each slug is flush with the bottom turn of the winding. (As an emergency measure, these settings alone are adequate for approximately correct results.)

For complete calibration of the peaking coils, plug the Type CA unit into a 540-Series Oscilloscope known to be in correct adjustment. Have the cabinet or side panels removed. If the oscilloscope is not of recent manufacture, you will have to drill the side panel of the plug-in-preamplifier compartment within the oscilloscope, to provide access to the adjustments of the Type CA unit. A source of square waves or pulses having a risetime not longer than 3 millimicroseconds is needed. The repetition rate should preferably be 1 kc or more. It is essential that this source be terminated in accordance with the manufacturer's specifications.

Turn the MODE switch to A ONLY, the VOLTS/CM switch to 0.05, and the VARIABLE control full right to the CALIBRATED position.

The peaking coils affect the rise and leading corner of the square wave and should be adjusted for a square corner with no overshoot.

1. Adjust L3364 and L4374.
2. Adjust L3362 and L3372.
3. Adjust L3334 and L3354.

Move the square-wave source to the CHANNEL B input connector and set the B-channel controls as you previously set the A-channel controls.

1. Adjust L4362 and L4372.
2. Adjust L4334 and L4354.

If after adjustment one channel seems to have a better response than the other try a slightly different setting of L3364 and L4374, which are common to both channels, and then repeat steps 2 and 3 of the A-channel adjustment and steps 1 and 2 of the B-channel adjustment. You will have to experiment with the settings of L3364 and L4374 to find which setting will give the best balance of response.

Input Attenuators

There are two types of adjustments to be made. Each adjustment requires a Type 105, or other square-wave source having a risetime not longer than 0.025 μsec. The source must be terminated according to the manufacturer's specifications. One type of adjustment is made to compensate the attenuators so that the ac attenuation is equal to the dc attenuation. This involves a moderately short time constant. Misadjustment can be recognized as a slight rounding or overshoot at the leading corner of the square wave.

The other type of adjustment is made to get equal input capacitances at all positions of the attenuator. Misadjustment can be recognized as a downward or upward slope over about the first one-quarter of the square wave.

First compensate the A-channel attenuators. connect the probe to the CHANNEL A input connector and connect the square-wave source to the probe. Display four or five cycles of a 1-kc square wave. Set the VOLTS/CM switch to .05 and adjust C3322 for a flat top on the square wave. Remove the probe and connect the square-wave source to the input connector. Adjust the listed capacitors for a square corner on the square wave.

VOLTS/CM	Capacitor
.1	C3311C
.2	C3312C
.5	C3313C
1	C3314C
2	C3315C
5	C3316C
10	C3317C
20	C3318C

Connect the probe to the CHANNEL A input connector and connect the square-wave source to the probe. Adjust the input capacitance with the VOLTS/CM switch in the positions shown.

VOLTS/CM	Capacitor
.1	C3311B
.2	C3312B
.5	C3313B
1	C3314B
2	C3315B
5	C3316B
10	C3317B
20	C3318B

Repeat the above operations with the B-channel amplifier. Move the square-wave source to the CHANNEL B input connector with the probe in place and adjust C4322 for a flat top on the square wave. The VOLTS/CM switch should be in the .05 position. Remove the probe and compensate the attenuator.

VOLTS/CM	Capacitor
.1	C4311C
.2	C4312C
.5	C4313C
1	C4314C
2	C4315C
5	C4316C
10	C4317C
20	C4318C

Insert the probe and adjust the input capacitance.

VOLTS/CM	Capacitor
.1	C4311B
.2	C4312B
.5	C4313B
1	C4314B
2	C4315B
5	C4316B
10	C4317B
20	C4318B

PARTS LIST

For an explantion of the abbreviations used in this parts list, see the indexed sheet marked ABBREVIATIONS & WARRANTY.

Capacitors

						Tektronix Part Number
C3300	.1 μf	PTM	Fixed	600 v		285-556
C3310C	150 μμf	Cer.	Fixed	500 v	±30 μμf	281-524
C3311B	.7-3 μμf	Tub.	Var.	500 v		281-027
C3311C	.7-3 μμf	Tub.	Var.	500 v		281-027
C3311D		Selected				
C3312B	.7-3 μμf	Tub.	Var.	500 v		281-027
C3312C	.7-3 μμf	Tub.	Var.	500 v		281-027
C3312D		Selected				
C3312E	3.3 μμf	Cer.	Fixed	500 v	¼ μμf	281-534
C3313B	.7-3 μμf	Tub.	Var.	500 v		281-027
C3313C	.7-3 μμf	Tub.	Var.	500 v		281-027
C3313D		Selected				
C3313E	22 μμf	Cer.	Fixed	500 v	10%	281-511
C3314B	.7-3 μμf	Tub.	Var.	500 v		281-027
C3314C	.7-3 μμf	Tub.	Var.	500 v		281-027
C3314E	47 μμf	Cer.	Fixed	500 v	10%	281-519
C3315B	.7-3 μμf	Tub.	Var.	500 v		281-027
C3315C	.7-3 μμf	Tub.	Var.	500 v		281-027
C3315E	47 μμf	Cer.	Fixed	500 v	10%	281-519
C3315F	47 μμf	Cer.	Fixed	500 v	10%	281-519
C3316A		Selected Where Needed				
C3316B	.7-3 μμf	Tub.	Var.	500 v		281-027
C3316C	.7-3 μμf	Tub.	Var.	500 v		281-027
C3316E	250 μμf	Mica	Fixed	500 v	10%	283-539
C3317A		Selected Where Needed				
C3317B	.7-3 μμf	Tub.	Var.	500 v		281-027
C3317C	.7-3 μμf	Tub.	Var.	500 v		281-027
C3317E	500 μμf	Mica	Fixed	500 v	10%	283-541
C3318A		Selected				
C3318B	.7-3 μμf	Tub.	Var.	500 v		281-027
C3318C	.7-3 μμf	Tub.	Var.	500 v		281-027
C3318E	750 μμf	Mica	Fixed	500 v	10%	283-540
C3321	.01 μf	Cer.	Fixed	150 v	GMV	283-003
C3322	.7-3 μμf	Tub.	Var.	500 v		281-027
C3345	.005 μf	Cer.	Fixed	500 v	GMV	283-001
C3354	47 μμf	Cer.	Fixed	500 v	20%	281-518
C3374	.005 μf	Cer.	Fixed	500 v	GMV	283-001
C3375	12 μμf	Cer.	Fixed	500 v	±1.2 μμf	281-506
C3378	47 μμf	Cer.	Fixed	500 v	10%	281-519
C3385	12 μμf	Cer.	Fixed	500 v	±1.2 μμf	281-506

Capacitors *(continued)*

						Tektronix Part Number
C3388	47 μμf	Cer.	Fixed	500 v	10%	281-519
C4300	.1 μf	PTM	Fixed	600 v		285-556
C4310C	150 μμf	Cer.	Fixed	500 v	±30 μμf	281-524
C4311B	.7-3 μμf	Tub.	Var.	500 v		281-027
C4311C	.7-3 μμf	Tub.	Var.	500 v		281-027
C4311D		Selected				
C4312B	.7-3 μμf	Tub.	Var.	500 v		281-027
C4312C	.7-3 μμf	Tub.	Var.	500 v		281-027
C4312D		Selected				
C4312E	3.3 μμf	Cer.	Fixed	500 v	±¼ μμf	281-534
C4313B	.7-3 μμf	Tub.	Var.	500 v		281-027
C4313C	.7-3 μμf	Tub.	Var.	500 v		281-027
C4313D		Selected				
C4313E	22 μμf	Cer.	Fixed	500 v	10%	281-511
C4314B	.7-3 μμf	Tub.	Var.	500 v		281-027
C4314C	.7-3 μμf	Tub.	Var.	500 v		281-027
C4314E	47 μμf	Cer.	Fixed	500 v	10%	281-519
C4315A		Selected Where Needed				
C4315B	.7-3 μμf	Tub.	Var.	500 v		281-027
C4315C	.7-3 μμf	Tub.	Var.	500 v		281-027
C4315E	47 μμf	Cer.	Fixed	500 v	10%	281-519
C4315F	47 μμf	Cer.	Fixed	500 v	10%	281-519
C4316A		Selected				
C4316B	.7-3 μμf	Tub.	Var.	500 v		281-027
C4316C	.7-3 μμf	Tub.	Var.	500 v		281-027
C4316E	250 μμf	Mica	Fixed	500 v	10%	283-539
C4317A		Selected				
C4317B	.7-3 μμf	Tub.	Var.	500 v		281-027
C4317C	.7-3 μμf	Tub.	Var.	500 v		281-027
C4317E	500 μμf	Mica	Fixed		10%	283-541
C4318A		Selected				
C4318B	.7-3 μμf	Tub.	Var.	500 v		281-027
C4318C	.7-3 μμf	Tub.	Var.	500 v		281-027
C4318E	750 μμf	Mica	Fixed		10%	283-540
C4321	.01 μf	Cer.	Fixed	150 v	GMV	283-003
C4322	.7-3 μμf	Tub.	Var.	500 v		281-027
C4334	47 μμf	Cer.	Fixed	500 v	20%	281-518
C4345	.005 μf	Cer.	Fixed	500 v	GMV	283-001
C4384	.001 μf	Cer.	Fixed	500 v	GMV	283-000
C4385	.001 μf	Cer.	Fixed	500 v	GMV	283-000
C4390	.005 μf	Cer.	Fixed	500 v	GMV	283-001
C4391	.01 μf	Cer.	Fixed	500 v	GMV	283-002
C4393	.01 μf	Cer.	Fixed	500 v	GMV	283-002
C4397	.005 μf	Cer.	Fixed	500 v	GMV	283-001
C4398	.005 μf	Cer.	Fixed	500 v	GMV	283-001
C4399	.005 μf	Cer.	Fixed	500 v	GMV	283-001

Resistors

							Tektronix Part Number
R3310C	47 Ω	1/4 w	Fixed	Comp.	10%		316-470
R3310E	47 Ω	1/4 w	Fixed	Comp.	10%		316-470
R3311C	500 k	1/2 w	Fixed	Prec.	1%		309-003
R3311D	47 Ω	1/2 w	Fixed	Comp.	10%		302-470
R3311E	1 meg	1/2 w	Fixed	Prec.	1%		309-014
R3312C	750 k	1/2 w	Fixed	Prec.	1%		309-010
R3312E	333 k	1/2 w	Fixed	Prec.	1%		309-053
R3313C	900 k	1/2 w	Fixed	Prec.	1%		309-111
R3313E	111 k	1/2 w	Fixed	Prec.	1%		309-046
R3314C	950 k	1/2 w	Fixed	Prec.	1%		309-143
R3314E	52.6 k	1/2 w	Fixed	Prec.	1%		309-137
R3315C	975 k	1/2 w	Fixed	Prec.	1%		309-144
R3315E	25.6 k	1/2 w	Fixed	Prec.	1%		309-136
R3316C	990 k	1/2 w	Fixed	Prec.	1%		309-013
R3316D	10 Ω	1/2 w	Fixed	Comp.	10%		302-100
R3316E	10.1 k	1/2 w	Fixed	Prec.	1%		309-034
R3317C	995 k	1/2 w	Fixed	Prec.	1%		309-146
R3317D	10 Ω	1/2 w	Fixed	Comp.	10%		302-100
R3317E	5.03 k	1/2 w	Fixed	Prec.	1%		309-134
R3318C	997.5 k	1/2 w	Fixed	Prec.	1%		309-147
R3318D	10 Ω	1/2 w	Fixed	Comp.	10%		302-100
R3318E	2.51 k	1/2 w	Fixed	Prec.	1%		309-133
R3320	1 meg	1/2 w	Fixed	Prec.	1%		309-014
R3321	1 meg	1/4 w	Fixed	Comp.	10%		316-105
R3322	47 Ω	1/4 w	Fixed	Comp.	10%		316-470
R3323	47 Ω	1/4 w	Fixed	Comp.	10%		316-470
R3324	22 k	2 w	Fixed	Comp.	10%		306-223
R3332	27 Ω	1/2 w	Fixed	Comp.	10%		302-270
R3334	500 Ω	1/2 w	Fixed	Prec.	1%		309-250
R3337	5.6 k	1/2 w	Fixed	Prec.	1%		309-132
R3338	650 Ω	Special				VARIABLE	311-116
R3341	20 k	2 w	Var.	Comp.	20%	DC BAL.	311-018
R3343	22 k	1 w	Fixed	Comp.	10%		304-223
R3344	100 k	1/2 w	Fixed	Comp.	10%		302-104
R3345	560 Ω	1/2 w	Fixed	Comp.	10%		302-561
R3354	500 Ω	1/2 w	Fixed	Prec.	1%		309-250
R3355	8 k	5 w	Fixed	WW	5%		308-053
R3356	10 k	2 w	Var.	WW	20%	GAIN ADJ.	311-015
R3357	5.6 k	1/2 w	Fixed	Prec.	1%		309-132
R3360	150 k	1/2 w	Fixed	Comp.	10%		302-154
R3361	2x100 k	2 w	Var.	Comp.	20%	VERT. POS.	311-028
R3362	47 Ω	1/2 w	Fixed	Comp.	10%		302-470
R3364	402 Ω	1/2 w	Fixed	Prec.	1%		309-102
R3365	20 k	10 w	Fixed	WW	5%		312-591
R3366	6 k	5 w	Fixed	WW	5%		312-590
R3370	150 k	1/2 w	Fixed	Comp.	10%		302-154
R3371	3.9 k	2 w	Fixed	Comp.	10%		306-392

						Tektronix Part Number
R3372	47 Ω	½ w	Fixed	Comp.	10%	302-470
R3373	5.6 k	1 w	Fixed	Comp.	10%	304-562
R3374	30 k	½ w	Fixed	Comp.	5%	301-303
R3375	33 k	2 w	Fixed	Comp.	10%	306-333
R3376	470 Ω	½ w	Fixed	Comp.	10%	302-471
R3377	100 Ω	½ w	Fixed	Comp.	10%	302-101
R3378	160 k	½ w	Fixed	Comp.	5%	301-164
R3379	200 k	½ w	Fixed	Comp.	5%	301-204
R3380	220 k	½ w	Fixed	Comp.	10%	302-224
R3385	33 k	2 w	Fixed	Comp.	10%	306-333
R3386	470 Ω	½ w	Fixed	Comp.	10%	302-471
R3387	100 Ω	½ w	Fixed	Comp.	10%	302-101
R3388	160 k	½ w	Fixed	Comp.	5%	301-164
R3389	200 k	½ w	Fixed	Comp.	5%	301-204
R3390	220 k	½ w	Fixed	Comp.	10%	302-224
R3393	4.7 k	½ w	Fixed	Comp.	10%	302-472
R3394	4.7 k	½ w	Fixed	Comp.	10%	302-472
R3395	68 k	1 w	Fixed	Comp.	10%	304-683
R3396	12 k	½ w	Fixed	Comp.	10%	302-123
R3398	100 Ω	½ w	Fixed	Comp.	10%	302-101
R3399	100 Ω	½ w	Fixed	Comp.	10%	302-101
R4310C	47 Ω	¼ w	Fixed	Comp.	10%	316-470
R4310E	47 Ω	¼ w	Fixed	Comp.	10%	316-470
R4311C	500 k	½ w	Fixed	Prec.	1%	309-003
R4311D	47 Ω	½ w	Fixed	Comp.	10%	302-470
R4311E	1 meg	½ w	Fixed	Prec.	1%	309-014
R4312C	750 k	½ w	Fixed	Prec.	1%	309-010
R4312E	333 k	½ w	Fixed	Prec.	1%	309-053
R4313C	900 k	½ w	Fixed	Prec.	1%	309-111
R4313E	111 k	½ w	Fixed	Prec.	1%	309-046
R4314C	950 k	½ w	Fixed	Prec.	1%	309-143
R4314E	52.6 k	½ w	Fixed	Prec.	1%	309-137
R4315C	975 k	½ w	Fixed	Prec.	1%	309-144
R4315E	25.6 k	½ w	Fixed	Prec.	1%	309-136
R4316C	990 k	½ w	Fixed	Prec.	1%	309-013
R4316D	10 Ω	½ w	Fixed	Comp.	10%	302-100
R4316E	10.1 k	½ w	Fixed	Prec.	1%	309-034
R4317C	995 k	½ w	Fixed	Prec.	1%	309-146
R4317D	10 Ω	½ w	Fixed	Comp.	10%	302-100
R4317E	5.03 k	½ w	Fixed	Prec.	1%	309-134
R4318C	997.5 k	½ w	Fixed	Prec.	1%	309-147
R4318D	10 Ω	½ w	Fixed	Comp.	10%	302-100
R4318E	2.51 k	½ w	Fixed	Prec.	1%	309-133
R4320	1 meg	½ w	Fixed	Prec.	1%	309-014
R4321	1 meg	¼ w	Fixed	Comp.	10%	316-105
R4322	47 Ω	¼ w	Fixed	Comp.	10%	316-470
R4323	47 Ω	¼ w	Fixed	Comp.	10%	316-470

Resistors *(continued)*

							Tektronix Part Number
R4324	22 k	2 w	Fixed	Comp.	10%		306-223
R4332	72 Ω	½ w	Fixed	Comp.	10%		302-270
R4334	500 Ω	½ w	Fixed	Prec.	1%		309-250
R4337	5.6 k	½ w	Fixed	Prec.	1%		309-132
R4338	650 Ω	Special				VARIABLE	311-116
R4341	20 k	2 w	Var.	Comp.	20%	DC BAL.	311-018
R4343	22 k	1 w	Fixed	Comp.	10%		304-223
R4344	100 k	½ w	Fixed	Comp.	10%		302-104
R4345	560 Ω	½ w	Fixed	Comp.	10%		302-561
R4354	500 Ω	½ w	Fixed	Prec.	1%		309-250
R4355	8 k	5 w	Fixed	WW	5%		308-053
R4356	10 k	2 w	Var.	WW	20%	GAIN ADJ.	311-015
R4357	5.6 k	½ w	Fixed	Prec.	1%		309-132
R4360	150 k	½ w	Fixed	Comp.	10%		302-154
R4361	2x100 k	2 w	Var.	Comp.	20%	VERT. POS.	311-028
R4362	47 Ω	½ w	Fixed	Comp.	10%		302-470
R4365	20 k	10 w	Fixed	WW	5%		312-591
R4366	6 k	5 w	Fixed	WW	5%		312-590
R4370	150 k	½ w	Fixed	Comp.	10%		302-154
R4372	47 Ω	½ w	Fixed	Comp.	10%		302-470
R4374	402 Ω	½ w	Fixed	Prec.	1%		309-102
R4375	100 k	½ w	Fixed	Comp.	10%		302-104
R4376	2x100 k	2 w	Var.	Comp.	20%	POS. ADJ.	311-051
R4377	100 k	½ w	Fixed	Comp.	10%		302-104
R4382	1.8 k	1 w	Fixed	Comp.	10%		304-182
R4383	8.2 k	1 w	Fixed	Comp.	5%		303-822
R4384	8.2 k	1 w	Fixed	Comp.	5%		303-822
R4385	8.2 k	1 w	Fixed	Comp.	5%		303-822
R4386	8.2 k	1 w	Fixed	Comp.	5%		303-822
R4391	27 Ω	½ w	Fixed	Comp.	10%		302-270
R4393	27 Ω	½ w	Fixed	Comp.	10%		302-270
R4395	3 k	5 w	Fixed	WW	5%		308-062
R4397	15 k	2 w	Fixed	Comp.	10%		306-153

Inductors

			Tektronix Part Number
L3334	.5-1 μh	Var.	114-043
L3354	.5-1 μh	Var.	114-043
L3360	.75 μh	Fixed	108-072
L3361	.75 μh	Fixed	108-072
L3362	.9-1.6 μh	Var.	114-051
L3364	Special		114-042
L3370	.75 μh	Fixed	108-072
L3371	.75 μh	Fixed	108-072
L3372	.9-1.6 μh	Var.	114-051
L4334	.5-1 μh	Var.	114-043
L4354	.5-1 μh	Var.	114-043
L4360	.75 μh	Fixed	108-072
L4361	.75 μh	Fixed	108-072
L4362	.9-1.6 μh	Var.	114-051
L4370	.75 μh	Fixed	108-072
L4371	.75 μh	Fixed	108-072
L4372	.9-1.6 μh	Var.	114-051
L4374	Special		114-042
L4384	0.3 μh	Fixed	108-112
L4385	0.3 μh	Fixed	108-112

Switches

					wired	unwired
SW3300	single pole	single throw	slide	AC-DC		260-330
SW3310	2 wafer	9 position	rotary	VOLTS/CMA	262-407	260-146
SW3360	1 wafer	2 position	rotary	POLARITY		260-148
SW3380	1 wafer	5 position	rotary	MODE		260-244
SW4300	single pole	single throw	slide	AC-DC		260-330
SW4310	single pole	9 position	rotary	VOLTS/CMB	262-408	260-146
SW4360	1 wafer	2 position	rotary	POLARITY		260-148

Vacuum Tubes

V3323	6AK5		154-014
V3334	12AU6		154-040
V3354	12AU6		154-040
V3364 } V3374 }*	6AU6	Selected	157-059
V3375	12AT7		154-039
V3382	6AL5		154-016
V3384	12AT7		154-039
V3393	12AT7		154-039
V4323	6AK5		154-014
V4334	12AU6		154-040
V4354	12AU6		154-040
V4364 } V4374 }*	6AU6	Selected	157-059
V4383	12AT7		154-039

* Matched pair of Tubes. When you order by part number 157-059, you will receive a matched pair of tubes.

ABBREVIATIONS USED IN OUR PARTS LISTS

Cer.	ceramic	m	milli
Comp.	composition	Ω	ohm
EMC	electrolytic, metal cased	Poly.	polystyrene
EMT	electrolytic, metal tubular	Prec.	precision
f	farad	PT	paper tubular
h	henry	Tub.	tubular
k	thousands of ohms	v	working volts dc
meg	megohms	Var.	variable
μ	micro	w	watt
$\mu\mu$	micromicro	WW	wire wound
GMV	guaranteed minimum value		

ABBREVIATIONS USED IN OUR CIRCUIT DIAGRAMS

Resistance values are in ohms. The symbol k stands for thousands. A resistor marked 2.7 k has a resistance of 2,700 ohms. The symbol M stands for million. For example, a resistor marked 5.6 M has a resistance of 5.6 megohms.

Unless otherwise specified on the circuit diagram, capacitance values marked with the number 1 and numbers greater than 1 are in $\mu\mu$f. For example, a capacitor marked 3.3 would have a capacitance of 3.3 micromicrofarads. Capacitance values marked with a number less than 1 are in μf. For example, a capacitor marked .47 would have a capacitance of .47 microfarads.

Inductance values marked in mh are in millihenrys. Inductance values marked in μh are in microhenrys.

Your instrument **WARRANTY** appears on the reverse side of this sheet.

SERIAL NO. 35015

IMPORTANT

Include the INSTRUMENT TYPE and the above SERIAL NUMBER in any correspondence regarding this instrument. The above serial number must match the instrument serial number if parts are to be ordered from the manual. Your help in this will enable us to answer your questions or fill your order with the least delay possible.

TEKTRONIX

WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

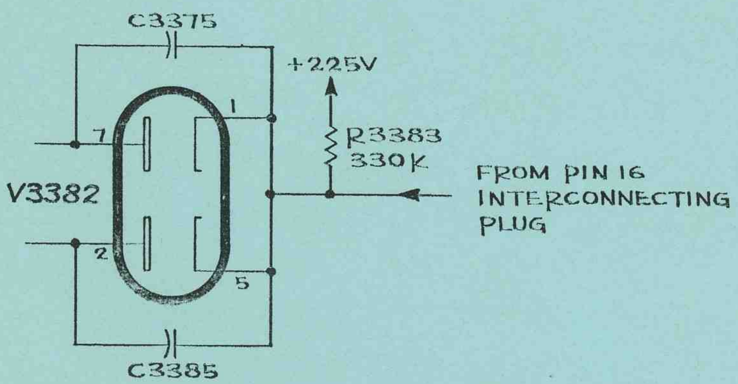
Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts and service.

Specifications and price change privileges reserved.

TYPE CA
Mod. 3786
T. S/N 34790

R3383	Add	330 k	1/4 w	Comp.	10%	316-334



PART. PREAMP DIAG.

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