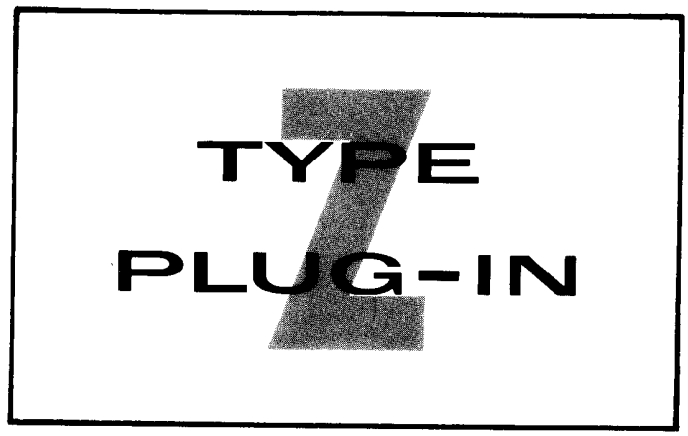
INSTRUCTION MANUAL



Tektronix, Inc.
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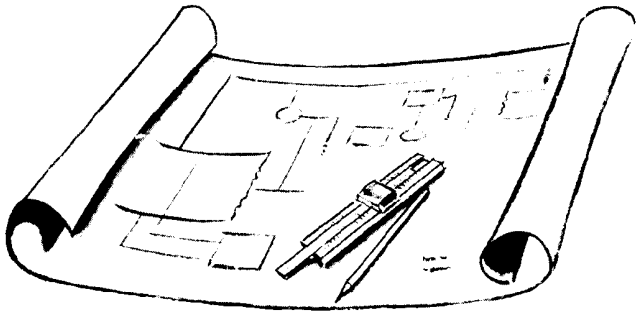
Tektronix International A. G.
Terrassenweg 1A ● Zug, Switzerland ● PH. 042-49192 ● Cable: Tekintag, Zug Switzerland ● Telex 53.574

070-251


TYPE Z PLUG-IN UNIT
CALIBRATED DIFFERENTIAL COMPARATOR
±2000 CM. DYNAMIC SCALE LENGTH
COMPARISON VOLTAGE
(Vc)
100 V
±.15%
10 V
±.5%
+
0
–
1 MEG.
24 pf
VOLTS/CM
(ATTENUATION)
DC
AC
PUSH TO
DISCONNECT
SIGNAL
A
ONLY
VAR. ATTEN.
A–Vc
DIFF.
BAL.
A–B
DIFF.
TEST
–B
ONLY
Vc–B
LINEARITY ±.05%
GAIN
ADJUST
VAR. ATTEN.
BALANCE
POSITION
SERIAL
TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.



SECTION 1

SPECIFICATIONS

General Information

The Type Z Plug-In Unit is a calibrated differential comparator preamplifier designed for use in all Tektronix Type 530-, 540-, 550-, or 580-Series Oscilloscopes. The unit may be used for three different modes of operation: (1) as a conventional plug-in preamplifier, (2) as a differential input preamplifier, or (3) as a calibrated differential comparator.

As a conventional preamplifier, the Z Unit alone has a risetime of 24 nanoseconds and a maximum sensitivity of 0.05 volt per centimeter of deflection. Table 1-1 summarizes the risetimes and bandwidths available when the Z Unit is used in combination with various types of Tektronix oscilloscopes.

TABLE 1-1

Z Unit and Type:	Risetime in Nanoseconds*	Bandwidth, —3 db, Megacycles/Second*
532	70	5
531 or 535	39	9
536	40	9
531A, 533, or 535A	35	10
541, 543, 545, 541A, 545A, 551, or 555	27	13
581 or 585**	27	13

*For signals which do not overscan the graticule.

**Type 81 Adapter must be used.

In differential input mode of operation, the dynamic range of ±100 volts allows the application of common-mode signals up to 100 volts to be applied to the unit without attenuation. The common-mode rejection ratio of 40,000 to 1 at dc or low frequencies allows measurement of differential signals less than 50 mv in amplitude on ±100-volt common-mode signals.

As a calibrated differential comparator, the Z Unit has an effective screen height of ±2000 cm at maximum sensitivity. Within the dynamic range of ±100 volts, calibrated ±DC comparison voltages can be added differentially to the input waveform to permit a maximum of 0.005% or 5 mv per mm to be accurately resolved.

Vertical Deflection Factors

0.05 to 25 volts per centimeter in nine calibrated steps; also continuously variable (uncalibrated) between steps and up to 60 volts per centimeter.

Input Impedance

1 megohm ±1% paralleled by 24 pf.

Maximum Allowable Combined DC and Peak AC Input

600 volts, ac-coupled.

Maximum Common-Mode Signal

±100 volts at 0.05 volt per centimeter. Higher voltages are permissible with larger vertical deflection factors.

Common-Mode Rejection Ratio

40,000 to 1 at 0.05 volt per centimeter with a 1-kc sine wave, lower at other sensitivities and higher frequencies.

At 0.05 volt per centimeter, a 200-volt (p-p) 1-kc common-mode signal produces less than 1 mm of vertical deflection.

Comparison Voltages Available

Three voltage ranges are provided: 0 to ±1 volt, 0 to ±10 volts, and 0 to ±100 volts. An accurate 10-turn potentiometer is used to select the comparison voltages over these ranges.

Comparison Voltage Regulator

A regulator circuit maintains comparison voltages essentially constant and independent of normal power supply voltages supplied by the oscilloscope.

Comparison Voltage Accuracy

Within 5 millivolts (0.5%) on the ±1-volt range.

Within 20 millivolts (0.2%) on the ±10-volt range.

Within 150 millivolts (0.15%) on the ±100-volt range.

Maximum Trace Shift

2 mm due to input grid or gas current.

Comparison Voltage Drift

Less than 0.1% per 100 hours operation.

Temperature compensated over normally expected temperature range. Air filter in oscilloscope should be maintained clean, particularly when using the Z Unit.

10-Turn Potentiometer Linearity

0.05%

Measurement Resolution

Resolution accuracy, at 100-volts comparison voltage—0.005%

Maximum resolution—5 millivolts per millimeter.

Transient Response and Permissible Signal Voltage Rate of Change

Rate of rise—1 volt per 6 nsec, maximum. If this rate is exceeded, grid current will flow in the input stages.

Rate of fall—1 volt in 5 nsec, maximum. If this rate is exceeded, the amplifier will momentarily cut off. If overdriven by a sufficiently fast pulse, the amplifier will "run down" linearly at the above rate.

Because of the wide dynamic amplitude capabilities of the Z Unit, transient response is a function of signal amplitude.

Mechanical Specifications

Construction—Aluminum-alloy chassis.

Front panel—Photo-etched.

Net weight—6 pounds.

Accessories

2—Instruction Manuals

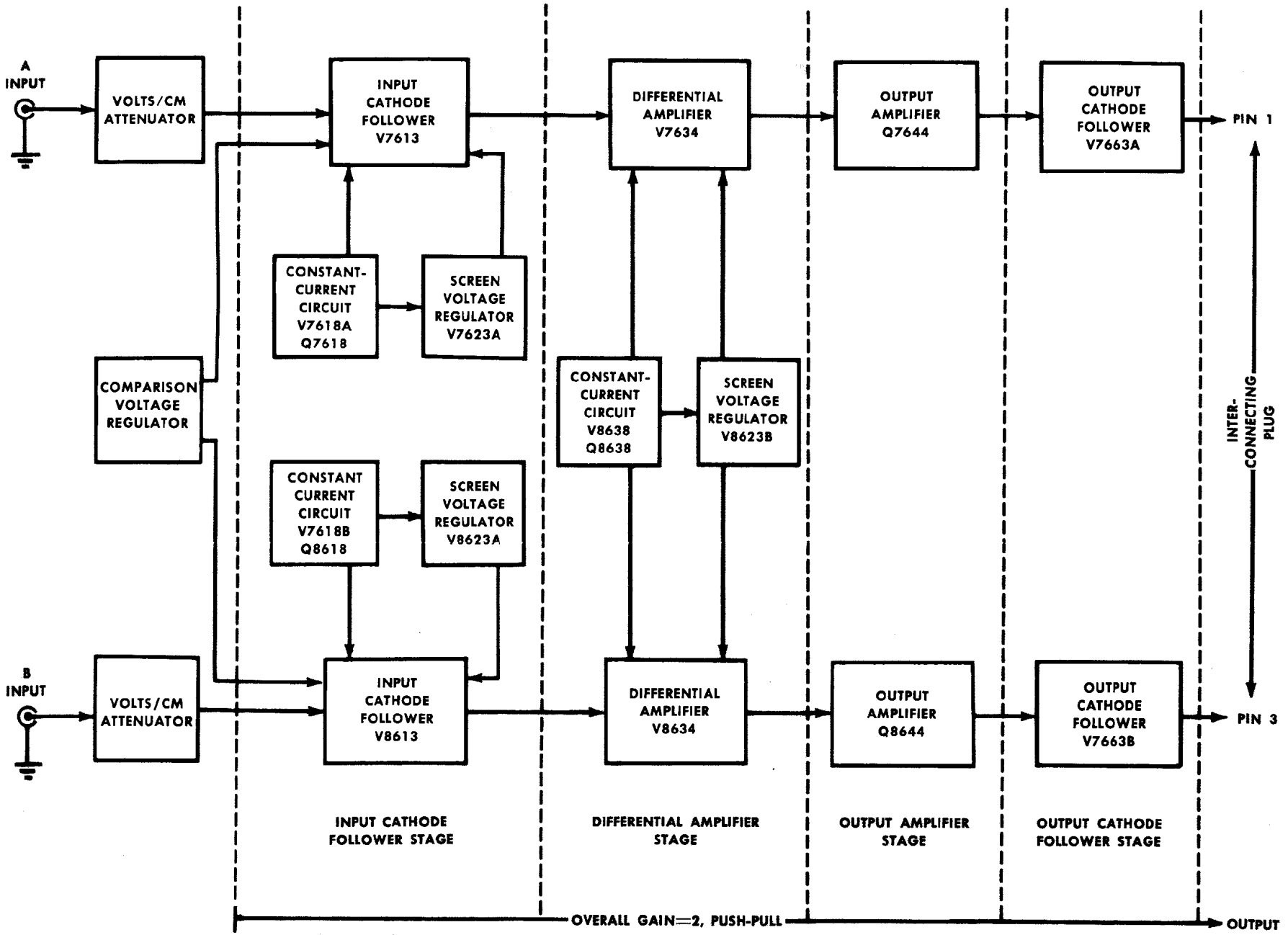
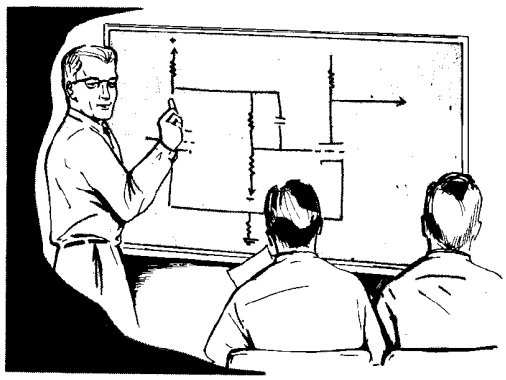


Fig. 3-1. Type Z Plug-in Unit block diagram.



SECTION 3

CIRCUIT DESCRIPTION

BLOCK DIAGRAM DESCRIPTION

Fig. 3-1 shows the block diagram for the Type Z Unit. Signals applied to A Input and B Input connectors pass through the VOLTS/CM Attenuator switches to the grids of the tubes in the Input Cathode Follower stage. The VOLTS/CM switches insert frequency-compensated attenuators into the circuit. When properly adjusted the input resistance and capacitance of the unit remains unchanged as the attenuators are inserted.

Accurate ±DC comparison voltages are obtained from the Comparison Voltage Regulator. These can be applied to the grid of either Input Cathode Follower stage by means of a Mode switch. These voltages add differentially to the signal applied to the other Input Cathode Follower when differential-comparator mode of operation is used.

The low-capacitance, high-impedance input of the Cathode Follower stage isolates the input circuitry from the amplifier stages. The Input Cathode Followers are required to handle input signal voltages as great as ±100 volts, without distorting. Special Constant-Current circuits prevent the cathode followers from cutting off or drawing grid current with large signals. Screen Voltage Regulator circuits maintain a constant voltage between the cathode and screen grid of the cathode followers. The Constant-Current and Screen-Regulator circuits permit the cathode followers to handle large signals without operating nonlinearly.

The output of the Input Cathode Followers is applied to the control grids of the Differential Amplifier stage. This stage also employs a Constant-Current circuit and a screen Voltage Regulator to permit the stage to handle large signals without distortion.

The output of the Differential Amplifier stage is applied to the bases of the transistors in the Output Amplifier stage.

Signals from the Output Amplifier stage are applied through voltage dividers to the Output Cathode Follower stage. The voltage dividers provide the proper dc operating voltages at the grids of the Output Cathode Follower stage. Output signals from this stage are then applied to the input of the oscilloscope main vertical amplifier through pins 1 and 3 of the interconnecting plug. Overall gain of the preamplifier is 2, push-pull.

You may wish to refer to the schematic diagram located near the rear of the manual and the block diagram of Fig. 3-1 during the following discussion.

DETAILED CIRCUIT DESCRIPTION

Comparison Voltage Regulator

Regulation of both the + and — comparison voltages is necessary to maintain specified voltage accuracy. This regulation system makes the comparison voltage independent of differences in regulated power supply voltages from one oscilloscope to another.

The comparison voltage is developed across V7689, a highly stable gas tube, type OG3. Because the drop across the tube is less than 100 volts, three zener diodes are placed in series to increase the reference voltage to slightly more than 100 volts. In addition to increasing the total voltage drop in the circuit, the zener diodes provide temperature compensation for V7689.

A constant-current source of 6 ma is required to maintain a constant voltage across the gas tube, V7689. For the —100-volt comparison voltage reference the 6 ma is provided by a constant-current transistor, Q8674, which operates as a common-base amplifier. The base voltage is established with respect to the —150-volt supply by zener diode D8679. Since the base-to-emitter voltage of Q8674 is essentially constant, the current through the transistor is determined and maintained constant by the voltage across resistors R8673 and R8674. By adjusting R8674, the current through V7689 is set to the specified 6 ma. Transistor Q8672, a diode-operated 2N1102, provides temperature compensation for Q8674.

For the +100-volt reference, a constant current of 6 ma is furnished by Q7674 in conjunction with zener diode D7675 and resistors R7670 and R7671. This circuit operates similar to the —100-volt reference previously explained.

As the COMPARISON VOLTAGE Polarity switch is moved from + position to — position, it is important that the load on transistors Q8674 and Q7674 remain the same. In the + and 0 positions, the current from the negative current regulator, Q8674, passes through R8670 instead of the gas tube and associated zener diodes. In the — position, the current from the positive current regulator, Q7674, passes through R8670. In calibration, the voltage at Test Point A is set equal to the voltage at Test Point B in all positions of the polarity switch, so that a constant load is always presented to Q7674 and Q8674. The voltage is then applied across the COMPARISON VOLTAGE potentiometer, R7686.

The voltage applied across potentiometer R7686 must be exactly 100 volts. Since the voltage obtained by the

drop across V7689 and the zener diodes is slightly more than 100 volts, R7684 and R7685 (if needed) reduce the potential to the exact amount required.

The precision voltage dividers consisting of R7687A and R7687B (X10), and R7687C and R7687D (X100), reduce the comparison voltage from 100 volts to either 10 volts or 1 volt by means of the COMPARISON VOLTAGE Range switch.

Input Cathode Follower Stage

Signals applied to input connectors A and B of the Type Z Unit go to the AC-DC switches which either include, or short across, the coupling capacitors. The signals then pass through the PUSH TO DISCONNECT SIGNAL switches, the VOLTS/CM switches, and the Mode switch, SW7611. The signals are then impressed upon the grids of the input cathode followers, V7613 and V8613.

The wide dynamic range of the Type Z Unit requires constant-current operation of both the Input Cathode Follower stage and the Differential Amplifier stage. Another requirement is that screen-to-cathode voltages remain constant in both stages. Transistor Q7618 is the constant-current source for both V7618A and input cathode follower V7613. This transistor operates as a common-base amplifier. Its base is held approximately 6 volts above the —150-volt supply by zener diode D8679 (see Note, below).

NOTE

When reference to the —150-volt supply is made, the actual typical voltage measurement is —144 volts at pin 9 of the interconnecting plug in all oscilloscopes using a decoupling network in the main oscilloscope.

The base-to-emitter voltage is essentially constant, the base being a few tenths of a volt more positive. With base and emitter voltages fixed, Q7618 operates at a constant current. Note that a variation in the —150-volt supply has little or no effect on the transistor bias. Thus no change occurs in either the base-to-supply drop or the base-to-emitter drop. Only the base-to-collector drop varies.

The voltage drop across zener diode D8679 sets the voltage drop between emitter and the —150-volt supply. A decrease in emitter resistance would require a greater current to establish the same fixed drop. Hence R7619 is the current control for Q7618, the constant-current source.

The collector current of Q7618 is slightly less than the emitter current, very nearly constant, and independent of the base-to-collector voltage. Such a circuit is very stable with respect to transistor parameters and temperature.

To describe the constant-current circuit of the Input Cathode Follower stage during peak operation, assume that an input voltage swing from —100 to +100 volts is applied to the grid of V7613. The cathode of V7613 and plate of V7618A follow the 200-volt swing. The cathode of V7618A varies $\frac{1}{\mu + 1}$ times the plate swing. In this circuit, the cathode swings about 1/30 of the plate swing. Therefore the grid-cathode swing of V7618A is approximately 6.6 volts. The voltage swing is now low enough for direct coupling to the collector of Q7618 whose function is to provide the constant-current source for this half of the input stage. The voltage swing of 6.6 volts is easily handled by the transistor at its operating current of approximately 8 ma.

The effect of a transistor "long-tail" in the cathode circuit of V7618A is shown in Fig. 3-2. The top curve displays the constant-current characteristics of a 2N1302 transistor when connected similar to Q7618. The lower curve displays the constant-current characteristics of V7618A with Q7618 connected in its cathode circuit to control the current. For practical purposes, no measurable change in current occurs during these voltage excursions.

The grid of V7618A returns to the zener diode D8679 through a temperature-compensating diode-connected tran-

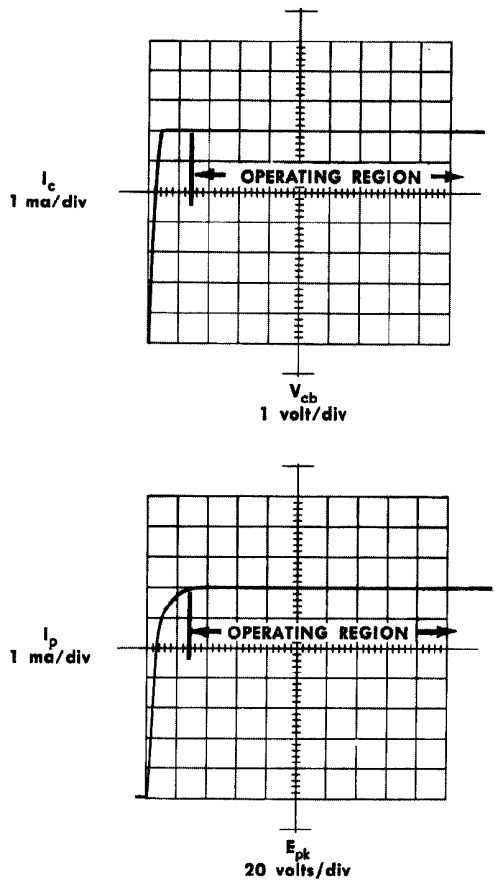


Fig. 3-2. Top: constant-current collector characteristics of 2N1302 transistor having a 1-k resistor in the emitter circuit; bottom: constant-current plate characteristics of 6DJ8 triode connected similar to V7618A. (Transistor display obtained from Tektronix Type 575 Transistor-Curve Tracer; triode display obtained from Type 570 Characteristic-Curve Tracer.)

sistor, Q8672. The bias of V7618A is the collector-to-base voltage of Q7618 plus the drop across Q8672.

The screen of the input cathode follower V7613 is connected back to its cathode through another cathode follower, V7623A, and zener diode, D7621. The screen voltage of V7613 will therefore follow variations in the cathode voltage (because it is "bootstrapped" to the cathode), approximately 105 volts above the cathode. Capacitor C7626 bypasses high-frequency components of the signal directly to the screen. C7621 and R7622 form a low-pass filter to remove zener noise from the screen of V7613.

The gain of the input CF's (V7613 and V8613 approaches unity because the impedance of the constant-current cathode "long-tail" approaches infinity, and because of the high and constant grid-screen μ. The grid-screen μ remains constant because of the constant screen-cathode potential. The most significant factor which reduces the gain of the stage below unity is the cathode-load resistors R7620, R7621, and R8621.

Slight circuit imbalances, principally in triode μ and zener diode impedance, necessitate a balance control R7620. For all practical purposes, this control, plus R7621 and R8621, form the cathode load for the input cathode followers.

Differential Amplifier Stage

Signals from the input cathode followers are applied to the grids of the Differential Amplifier stage, V7634 and V8634. The cathode circuitry of the stage consists of a constant-current circuit and a gain adjustment network. The constant-current circuit is formed by Q8638 and V8638 and is identical in principle, with one exception, to the operation of the circuits in the Input Cathode Follower stage. The exception is that one constant-current circuit supplies both tubes in this stage.

The amount of current supplied by the constant-current circuit is determined by the setting of the GAIN ADJUST control R8639. As screen-to-cathode voltage is maintained constant, R8639 controls the transconductance of V7634 and V8634, thereby controlling the gain of the stage. The control is set to provide the correct vertical deflection factors when the VAR. ATTEN. control R7633 is set fully clockwise. The VAR. ATTEN. control varies the gain of the Differential Amplifier stage by varying the cathode degeneration.

To prevent trace shift as the VAR. ATTEN. control R7633 is adjusted, the cathode potentials must remain equal. This is accomplished by proper adjustment of the VAR. ATTEN. BALANCE control R7619. Adjustment of R7619 varies the grid (and the cathode) voltage of V7634 and V8634 in opposite directions to compensate for slight differences in operating characteristics of the two tubes. Proper adjustment of R7619 will result in equal voltages at the cathodes of V7634 and V8634 for all positions of the VAR. ATTEN. controls.

As in the Input Cathode Follower stage, the screen voltage for the Differential Amplifier stage is "bootstrapped" 140 volts above the cathode. Because total cathode current, screen-to-cathode voltage, and the plate-to-screen current ratio remain constant, the plate currents of the Differential Amplifier stage respond only to differential signals.

The high-frequency response of the Differential Amplifier stage is improved by the use of series-shunt peaking in the plate circuits. This peaking is provided by L7632 and L8632.

The AMPLIFIER DC BAL. control R7640 adjusts the base voltage of Q7644 by forcing a small current through R7632. The control is used to dc balance the Output Amplifier Stage. Adjustment of R7640 forces the base of Q7644 to be at the same voltage as the base of Q8644 when no signal is applied to the unit.

Output Amplifier Stage

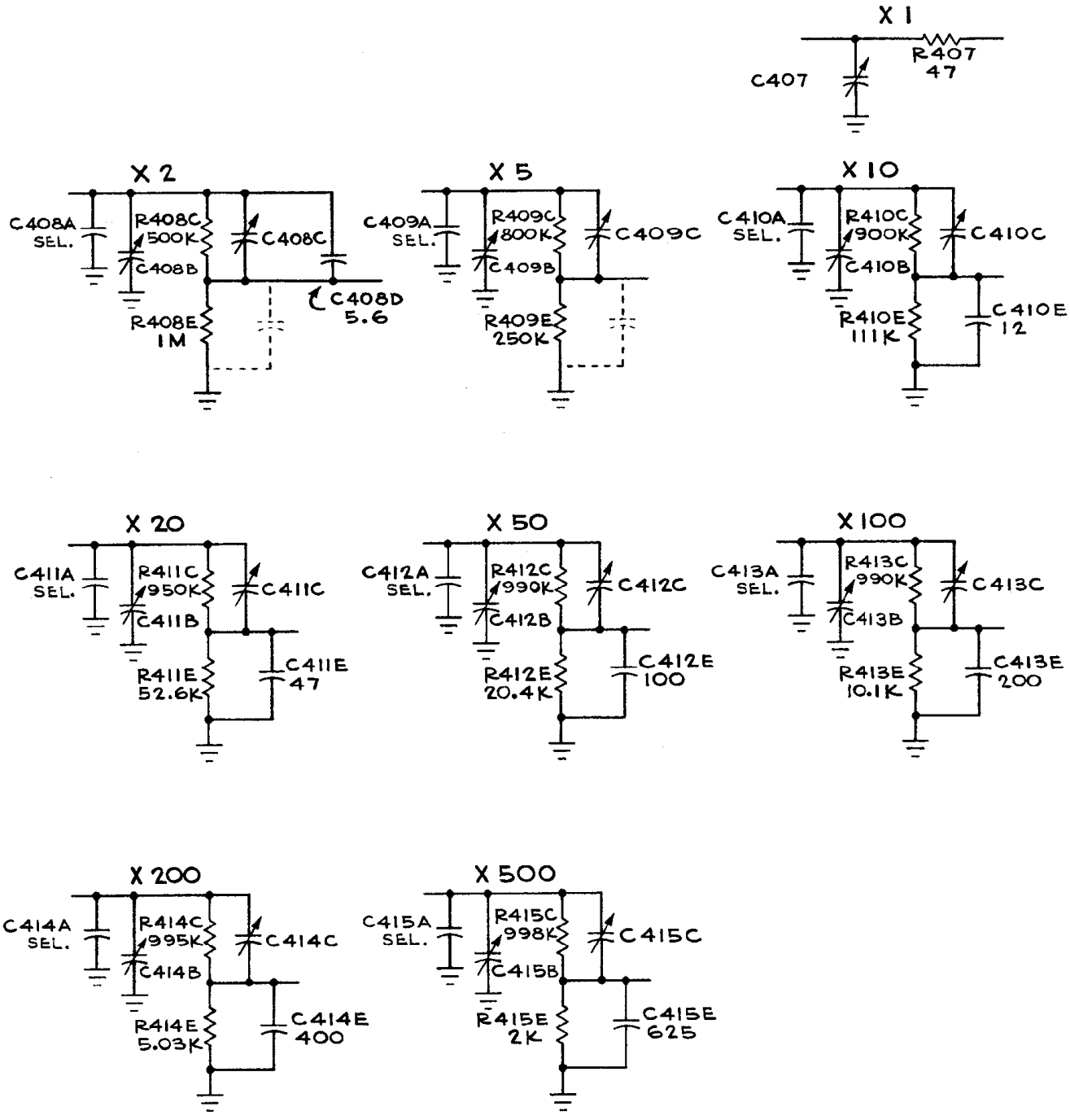
Output signals from the Differential Amplifier stage are applied to the bases of Q7644 and Q8644, the Output Amplifier stage. This stage has a gain of slightly more than two. A large common emitter resistance provides a large amount of emitter degeneration and a high degree of stability and linearity. Transistors used in this stage have an advantage over a vacuum tube stage in two respects. The dc level is lowered instead of raised, and the swing of the amplifier in the oscilloscope is limited to no more than 12 centimeters deflection on the crt screen. The latter is important since rapid recovery from very large input voltages is essential. Series-shunt peaking in the collector circuit improves the high-frequency response of the amplifier.

Output Cathode Follower Stage

Output signals from the Output Amplifier stage and positioning voltages from the POSITION control are applied to the grid circuits of the Output Cathode Followers. Compensated voltage divider networks at the input to the cathode followers lower dc levels to the proper level for driving the vertical amplifier of the oscilloscope. The dividers consist of resistors R7655 and R7656, R8655 and R8656; capacitors C7655 and C8655 compensate the attenuators for high frequencies.

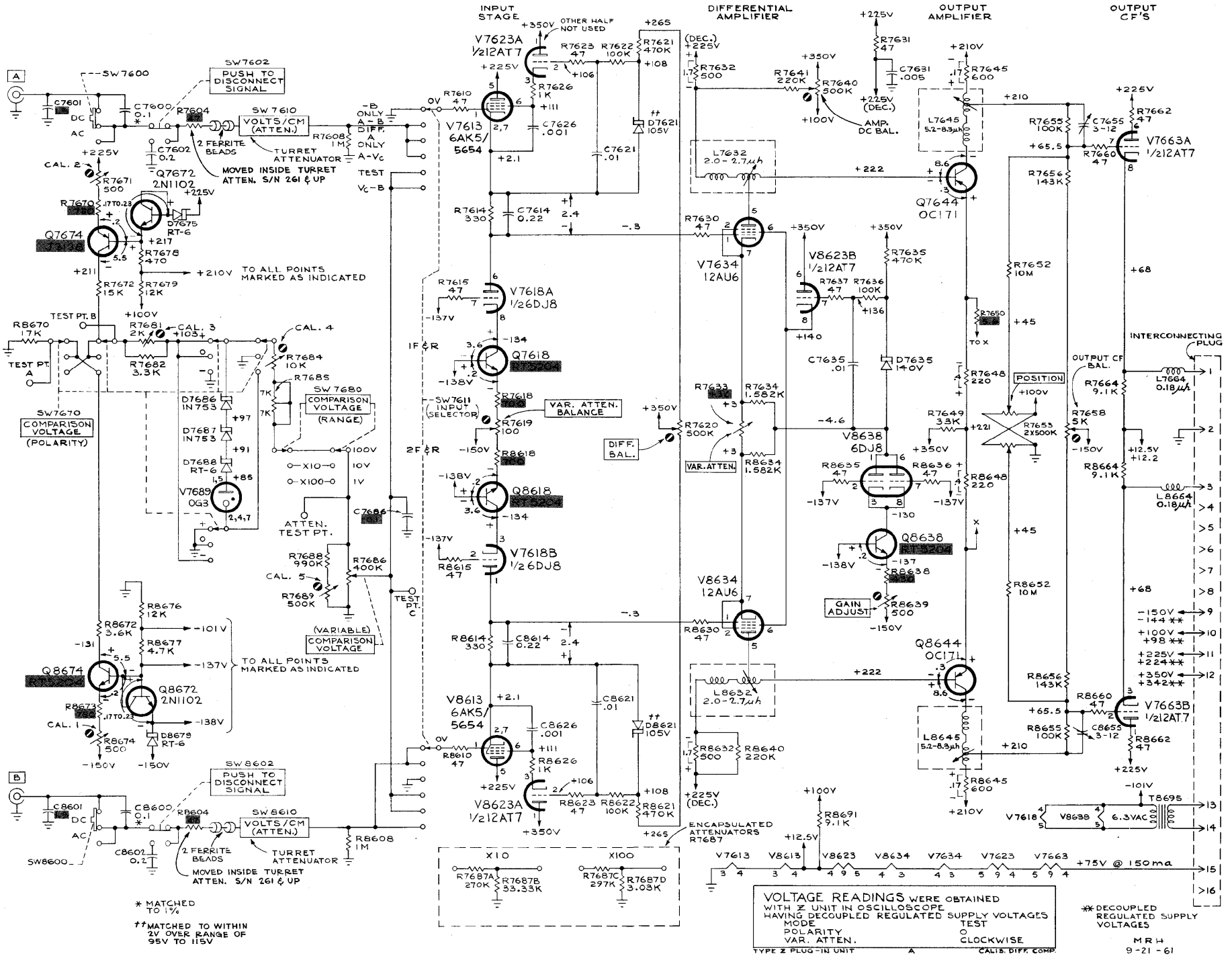
The OUTPUT CF BAL. adjustment R7658 is used to provide dc balance for the output cathode followers. This insures that the input signals to the push-pull sides of the vertical amplifier of the oscilloscope are at equal average dc potentials.

The output cathode followers provide the necessary low impedance to drive the capacitance of the interconnecting plug and the input of the oscilloscope vertical amplifier. In addition, this stage isolates the plug capacitance from the Output Amplifer stage. The signal from the Output Cathode Follower stage is applied through the interconnecting plug to the input of the oscilloscope vertical amplifier.



NOTE:-
ALL VARIABLE CAPACITORS ARE APPROX. .3 – 20 μμf.

Z TURRET ATTENUATOR


INPUT STAGE
DIFFERENTIAL AMPLIFIER
OUTPUT AMPLIFIER
OUTPUT CF'S
V7623A 1/2 12AT7
OTHER HALF NOT USED
V7613 6AK5/5654
V7618A 1/2 6DJ8
Q7618
V7618B 1/2 6DJ8
V8613 6AK5/5654
V8623A 1/2 12AT7
V7634 12AU6
V8623B 1/2 12AT7
V8638 6DJ8
V8634 12AU6
Q7644 OC171
Q8644 OC171
V7663A 1/2 12AT7
V7663B 1/2 12AT7
Q7672 2N1102
Q7674
Q8672 2N1102
Q8674
Q8618
Q8638
SW7600
SW7602 PUSH TO DISCONNECT SIGNAL
SW 7610 VOLTS/CM (ATTEN.)
SW7611 INPUT (SELECTOR)
SW7670 COMPARISON VOLTAGE (POLARITY)
SW7680 COMPARISON VOLTAGE (RANGE)
SW8602 PUSH TO DISCONNECT SIGNAL
SW8610 VOLTS/CM (ATTEN.)
SW8600
2 FERRITE BEADS
TURRET ATTENUATOR
MOVED INSIDE TURRET ATTEN. S/N 261 & UP
VAR. ATTEN. BALANCE
DIFF. BAL.
VAR. ATTEN.
GAIN ADJUST
AMP. DC BAL.
OUTPUT CF BAL.
POSITION
INTERCONNECTING PLUG
TO ALL POINTS MARKED AS INDICATED
(VARIABLE) COMPARISON VOLTAGE
ATTEN. TEST PT.
TEST PT. A
TEST PT. B
TEST PT. C
CAL. 1
CAL. 2
CAL. 3
CAL. 4
CAL. 5
ENCAPSULATED ATTENUATORS R7687
X10
X100
R7687A 270K
R7687B 33.33K
R7687C 297K
R7687D 3.03K
* MATCHED TO 1%
** MATCHED TO WITHIN 2V OVER RANGE OF 95V TO 115V
VOLTAGE READINGS WERE OBTAINED WITH Z UNIT IN OSCILLOSCOPE HAVING DECOUPLED REGULATED SUPPLY VOLTAGES
MODE TEST
POLARITY O
VAR. ATTEN. CLOCKWISE
TYPE Z PLUG-IN UNIT A CALIB. DIFF. COMP.
** DECOUPLED REGULATED SUPPLY VOLTAGES
MRH 9-21-61
TYPE Z PLUG-IN UNIT
H
CALIBRATED DIFFERENTIAL COMPARATOR