INSTRUCTION MANUAL

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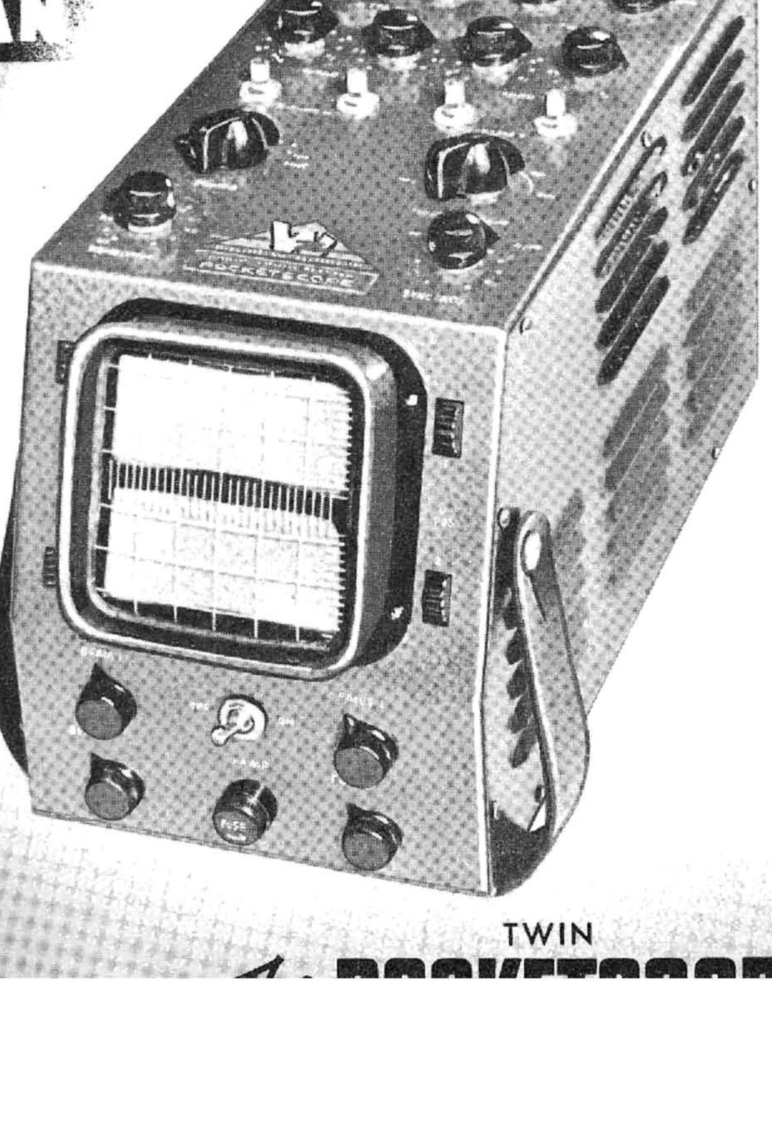
WATERMAN



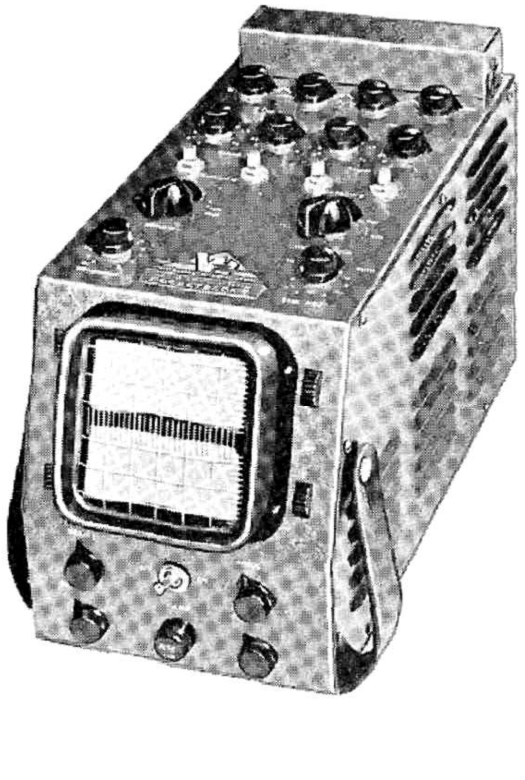
TWIN

POCKETSCOPE

WATERMAN POCKETSCOPE

MODEL **S-15-A**

INSTRUCTION BOOK



WATERMAN PRODUCTS CO., INC.

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PHONE: GArfield-6-8600 CABLE: POKETSCOPE

SECTION 1

GENERAL DESCRIPTION

The Waterman POCKETSCOPE model S–15–A is an oscilloscope containing two cathode ray tubes with independent signal inputs which permit simultaneous observation of any two voltages with respect to the same time base. Other voltages may be substituted for the time base depending upon the information desired and the ability of the operator to interpret the resultant pattern.

The cathode ray tubes are the Waterman developed 3SP1 type. Each tube screen is 1 1/2 inches high by 3 inches wide permitting great economy of space. While both tubes have equal operating potentials, each has its own beam, focus, vertical and horizontal positioning controls.

VERTICAL CHARACTERISTICS

Each vertical amplifier has a maximum sensitivity of 10 millivolts RMS (.028 volts DC) per inch and a frequency response which is flat within –2db from DC to 180KC. Its pulse rise time is equal to approximately 1.8 microseconds. In addition to the amplifiers non-frequency discriminating gain control, a compensated step attenuator permit additional attenuation of 1000, 100, 10 and 1. A fixed calibration voltage of 20 millivolts RMS at line frequency is provided as a position on the vertical attenuator.

TIME BASE

The sweep frequency is variable from 0.5 cycles to 50KC and may be operated in either the repetitive or trigger mode. Synchronization is from either internal or external sources regardless of polarity.

TIME BASE AMPLIFIER

The horizontal amplifiers have a maximum sensitivity of 1.0 volt RMS per inch and a frequency response which is flat within –2db from DC or 0 cycles to 150KC. Their pulse rise time is equal to 3.0 microseconds. Each amplifier has its own non-frequency discriminating gain control in addition to three steps of compensated attenuation 100, 10 and 1. The output of the linear time base generator is connected to either or both horizontal amplifiers by rotating their H ATT switch in the extreme counterclockwise position (SW). A fixed calibration voltage of 5 volts RMS at line frequency is provided as a position on the horizontal attenuator.

BLANKING

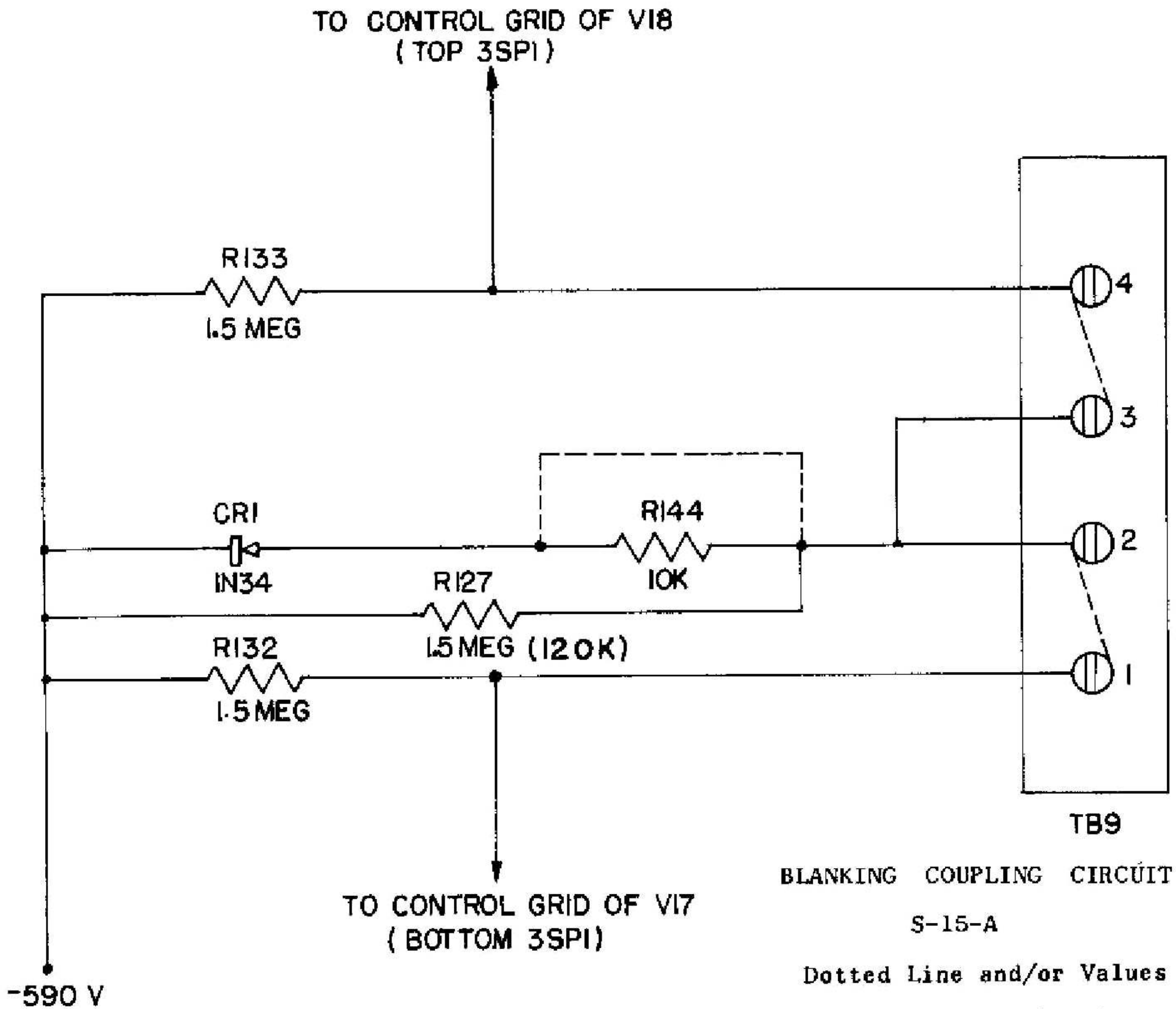
Provisions are made for connecting or disconnecting the internal blanking pulse. This thus provides a means for externally modulating the beam.

CATHODE RAY TUBE CONTROL

Individual vertical and horizontal positioning as well as beam and focus controls are provided for each cathode ray tube.

PHYSICAL CHARACTERISTICS

Convenient and functional layout of all controls and terminals permits maximum flexibility with minimum of complexity. The width is 6 inches, the depth is 12 inches and the height is 7 inches. Its weight is but 16 1/4 pounds.



BLANKING COUPLING CIRCUIT

S-15-A

Dotted Line and/or Values In ( ) Indicate Previous Circuit. This change is Effective Serial #816

SECTION II

TECHNICAL DATA

Power Supply:

Input Supply	– 105–125 volts, 60 to 400 cycles
Input Consumption	– 75 watts at 117 volts 60 cycles
Fuse Protection	– 1 amp., replaceable from the front

Operating Data:

NOTE: Each cathode ray tube has its own independent vertical and horizontal amplifiers, positioning controls, as well as its own beam and focus controls. Therefore, the information given below applies to either channel.

Vertical Amplifier: Gain max.

Deflection Sensitivity	– .01 volt RMS/inch or .028 volt DC/inch
Frequency Response	– Within –2db from 0 cycles to 180KC
Pulse Rise Time	– 1.8 microseconds
*Input Resistance and Capacity	– 1 Megohm shunted by 25 mmf
Attenuator Positions	– GND, CAL and compensated steps of 1000, 100, 10 and 1
Deflection Polarity	– + is ↑

Horizontal Amplifier – Gain max.

Deflection Sensitivity	– 1.0 volts RMS/inch or 2.8 volts DC/inch
Frequency Response	– Within –2db from 0 cycles to 150KC
Pulse Rise Time	– 3.0 microseconds
*Input Resistance and Capacity	– 1 Megohm shunted by 25mmf
Attenuator Positions	– SW (sawtooth), GND, CAL and compensated steps of 100, 10 and 1
Deflection Polarity	– + is →

*Input to both vertical and both horizontal amplifiers is direct. External DC blocking condensers must be used when required.

Linear Time Base

One sweep generator supplies signals to either or both horizontal amplifiers. This eliminates discrepancies between the two traces.

Sweep Frequency Range:	Continuously adjustable from 0.5 cycles to 50KC in five convenient steps.
Operation:	Repetitive or Trigger
Synchronization:	Internal or External in either operation regardless of polarity (internal sync from vertical amplifier #1 only)
Blanking:	Optional

Calibration

Vertical:	10 millivolts RMS at line frequency
Horizontal:	2 volts RMS at line frequency

Positioning

Independent vertical and horizontal controls for each cathode ray tube.

Stability

Normal line voltage fluctuations have little effect upon performance.

Tube Complement

Vertical Amplifier #1	12AU7	V1
	12AX7	V2
	12AX7	V3
Vertical Amplifier #2	12AU7	V4
	12AX7	V5
	12AX7	V6
Horizontal Amplifier #1	12AU7	V7
	12AX7	V8
Horizontal Amplifier #2	12AU7	V9
	12AX7	V10
Linear Time Base Generator	12AX7	V11
	12AT7	V12
	12AU7	V13
	12AU7	V14
Power Supply	6X4	V15
	1V2	V16
Cathode Ray Tube #1	3SP1	V18
Cathode Ray Tube #2	3SP1	V17

Overall Dimensions:

Height	7 inches
Width	6 inches
Depth	12 inches
Weight	16 1/4 pounds

Terminals

On top: 8 binding posts – #1 (vertical input), GND, #2 (vertical input), TEST, SYNChronizing, #2 (horizontal input), GND and #1 (horizontal input).

Back of side cover: 4 terminals for connecting or disconnecting blanking.

WARNING: High voltages are present at these terminals. Turn off power before opening side cover.

Controls – from left to right (outer amplifier controls for #1 channel
(inner controls for #2)

Top of Oscilloscope:

(#1) V ATT	– 6 position rotary switch having the following positions:
GND	– grounds amplifier input but not signal for balancing of amplifier
CAL	– applies 10 millivolts RMS at line frequency to input for calibrating amplifier gain
1000	– attenuates V INPUT signal 1000 to 1 (60db)
100	– attenuates V INPUT signal 100 to 1 (40db)
10	– attenuates V INPUT signal 10 to 1 (20db)
1	– connects V INPUT signal directly to amplifier with no attenuation
(#2) V ATT	– performs same function as its counterpart #1
(#2) H ATT	– 6 position rotary switch having the following positions:
SW	– connects output of linear time base (Sweep) Generator to horizontal amplifier

GND — grounds amplifier input but not signal for balancing of amplifier

CAL — applies 2 volts RMS at line frequency to input for calibrating amplifier gain

100 — attenuates H INPUT signal 100 to 1 (40db)

10 — attenuates H INPUT signal 10 to 1 (20db)

1 — connects H INPUT signal directly to amplifier with no attenuation.

(#1) H ATT — performs same function as its counterpart #2.

(#1) V GAIN — potentiometer for adjusting the gain of the vertical amplifier.

(#2) V GAIN — same as its counterpart above.

(#2) H GAIN — potentiometer for adjusting the gain of the horizontal amplifier.

(#1) H GAIN — same as its counterpart above.

(#1) V BALANCE — potentiometer for adjusting balance in the vertical amplifier.

(#2) V BALANCE — same as its counterpart above.

(#2) H BALANCE — potentiometer for adjusting the DC balance in the horizontal amplifier.

(#1) H BALANCE — same as its counterpart above.

SYNC SEL. — 4 position rotary switch for selecting the desired source of synchronizing voltage having the following positions: REPetitive INTernal, REPetitive EXTernal, TRIGger INTernal, TRIGger EXTernal.

RANGE — 6 position rotary switch for selecting range of sweep frequencies having the following positions: OFF, 0.5-5, 5-50, 50-500, 500-5K and 5K-50K

SYNC ADJ — potentiometer for selecting the amplitude and polarity of synchronizing voltage.

FREQUENCY — Dual potentiometer for fine control of the sweep frequency within each range.

Front of Oscilloscope:

1 V POS — Hearing aid type potentiometer for positioning the beam vertically in the upper (#1) cathode ray tube.

1 H POS — Hearing aid type potentiometer for positioning the beam horizontally in the upper (#1) cathode ray tube.

2 V POS — same as counterpart above.

2 H POS — same as counterpart above.

BEAM 1 — potentiometer for adjusting beam brightness of #1 cathode ray tube

FOCUS 1 — potentiometer for focusing the beam of #1 cathode ray tube.

BEAM 2 — same as its counterpart above.

OFF-ON — Toggle switch for applying power to the entire oscilloscope.

FOCUS 2 — same as its counterpart above.

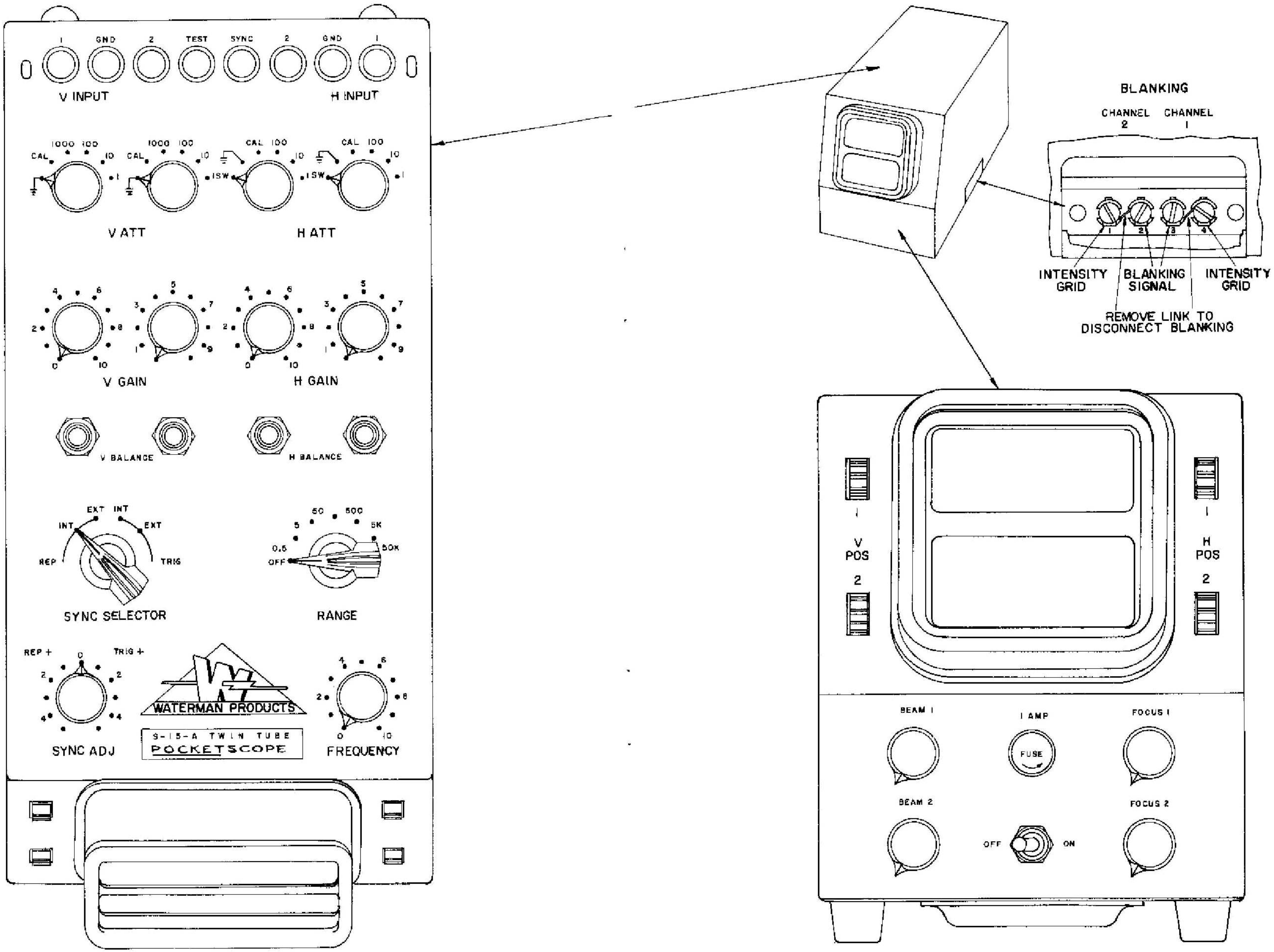
SECTION III

PRELIMINARY INSTALLATION AND ADJUSTMENT

1. The following procedure is suggested as a guide and is not to be construed as the only one possible.

CONTROL	SETTING	CONTROL	SETTING
(#1) V ATT	GND	1 V POS	Halfway
(#2) V ATT	GND	1 H POS	Halfway
(#2) H ATT	SW	2 V POS	Halfway
(#1) H ATT	SW	2 H POS	Halfway
(#1) V GAIN	CCW	BEAM 1	CCW
(#2) V GAIN	CCW	FOCUS 1	Halfway
(#2) H GAIN	Halfway	BEAM 2	CCW
(#1) H GAIN	Halfway	OFF-ON	OFF
RANGE	5-50	FOCUS 2	Halfway
SYNC ADJ	Halfway	SYNC SEL.	REP-INT
FREQUENCY	Halfway		
(#1) V BALANCE	These controls have been		
(#2) V BALANCE	set at the factory. Do not		
(#2) H BALANCE	reset them before reading		
(#1) H BALANCE	OPERATION section.		

2. Connect the oscilloscope to the power line using power cord supplied.
3. Throw OFF-ON switch to ON.
4. Advance BEAM 1 control in clockwise direction until the trace appears on the upper cathode ray tube.
5. Center this line on the screen by means of the V POS and H POS controls.
6. Adjust FOCUS and BEAM controls for desired brightness and sharpness of trace.
7. Using the (#2) counterpart, repeat 4, 5 and 6 for #2 cathode ray tube. Preliminary adjustments are now complete. Proceed to use the Oscilloscope as instructed under OPERATION.



1 GND 2 TEST SYNC 2 GND 1
V INPUT
H INPUT
V ATT
H ATT
V GAIN
H GAIN
V BALANCE
H BALANCE
SYNC SELECTOR
REP INT EXT INT EXT TRIG
RANGE
OFF 0.5 5 50 500 5K 50K
SYNC ADJ
REP + 0 TRIG +
WATERMAN PRODUCTS
S-15-A TWIN TUBE
POCKETSCOPE
FREQUENCY
BLANKING
CHANNEL 2
CHANNEL 1
INTENSITY GRID
BLANKING SIGNAL
INTENSITY GRID
REMOVE LINK TO DISCONNECT BLANKING
V POS
H POS
BEAM 1
1 AMP
FUSE
FOCUS 1
BEAM 2
FOCUS 2
OFF
ON

SECTION IV

OPERATION AND CIRCUIT

The operation of the S-15-A **POCKETSCOPE** can be more readily understood if the schematic diagram is consulted while reading the explanation below.

Basically, the S-15-A can be considered two independent oscilloscopes built into a single unit. Each oscilloscope has its own cathode ray tube, individual vertical and horizontal amplifiers in addition to provisions for modulating the intensity of each cathode ray tube trace.

The power supply is common to both oscilloscopes. This also holds true of the sweep generator. However, each horizontal amplifier has optional provision for selecting the output of this generator or an external signal.

Each Waterman Rayonic 3SP1 cathode ray tube contains all of the essential parts; a cathode for producing the electron source, a number of elements for controlling and focusing these electrons into a beam as they travel toward the luminescent screen. Before the beam strikes the screen it passes through two sets of deflection plates which are used to deflect the beam in the vertical and horizontal directions.

Individual BEAM controls are provided for varying the trace brightness. They actually vary the negative grid to cathode voltage of the 3SP1, thus regulating the amount of electrons emitted by the "gun".

Separate FOCUS controls are provided for varying the potential of the first anode. This in turn permits complete adjustment of the sharpness of the trace.

Both vertical amplifiers are identical. The tubes V1 (12AU7), V2 (12AX7) and V3 (12XA7) in the #1 amplifier have their counterpart V4 (12AU7), V5 (12AX7) and V6 (12AX7) in the #2 amplifier. This also holds true for the resistors and condensers in each circuit with the exception of R31, one end of which is connected to one plate (pin 1) of the output amplifier V3 (12AX7). This resistor is actually part of the synchronization system and will be discussed below.

The V ATT switch (S1) precedes the amplifier. It has six positions. The most counterclockwise position ⏚ grounds the grid of V1 (12AU7) through R8, a 470 ohm resistor whenever the amplifier is to be DC balanced. The second position applies .01 volt rms at line frequency to the vertical amplifier for calibrating the amplifier gain. The most clockwise positions are arranged as a 2 step attenuator of 1000 to 1, 100 to 1, 10 to 1, and a direct position which couples the input directly to the grid.

The input tube V1 is a 12AU7, with its plates tied together and is connected as a balanced bridge with each triode representing the upper slements and the cathode resistors (R9, R10 and R11) as the lower elements. R9 is a 500 ohm potentiometer which can be adjusted to equalize the voltage between the two cathodes. R12, a 5000 phm potentiometer and R13, a 300 ohm resistor in series with it are wired as the cross arm of the bridge.

Hence, any unbalance in current between the two voltage paths of the bridge (the triodes and their respective cathode resistors) will appear across this arm. When a signal is applied to the grid of the upper triode, the current in that tube will change according to the instantaneous amplitude of that signal. This changed current upsets the balance in the bridge and appears as a signal between the cathodes. The resulting signal between the two cathodes is then applied to V2, a 12AX7.

In this stage the plates have identical load resistors and the cathodes are tied together. Both grids of the 12AX7 are at the same DC level so long as no signal is applied to the input of the 12AU7. R14, a 50K potentiometer between the B^+ sides of the two plate load resistors, is adjusted until the voltages on both plates are equal. The common cathode resistor R18 is in series with a rhoestat R17 and is adjusted until the plates reach +80 volts DC. Because of the common cathode load, some inversion takes place in this stage and the amplified input signal appears on the plates as push-pull voltage.

The voltage at the plates of V2 (12AX7) appears at the grids of the output tube V3, type 12AX7. R21, R22 and R23 form a higher impedance shunting across the output of V2 (12AX7). By coupling this network back to a higher B^+ voltage through R24, the DC voltages on the two grids can be adjusted in either direction without distorting the signal voltage. This has the effect of altering the DC voltages on the plates of V3 (12AX7) without distorting the signal. In this manner vertical positioning is introduced into the amplifier.

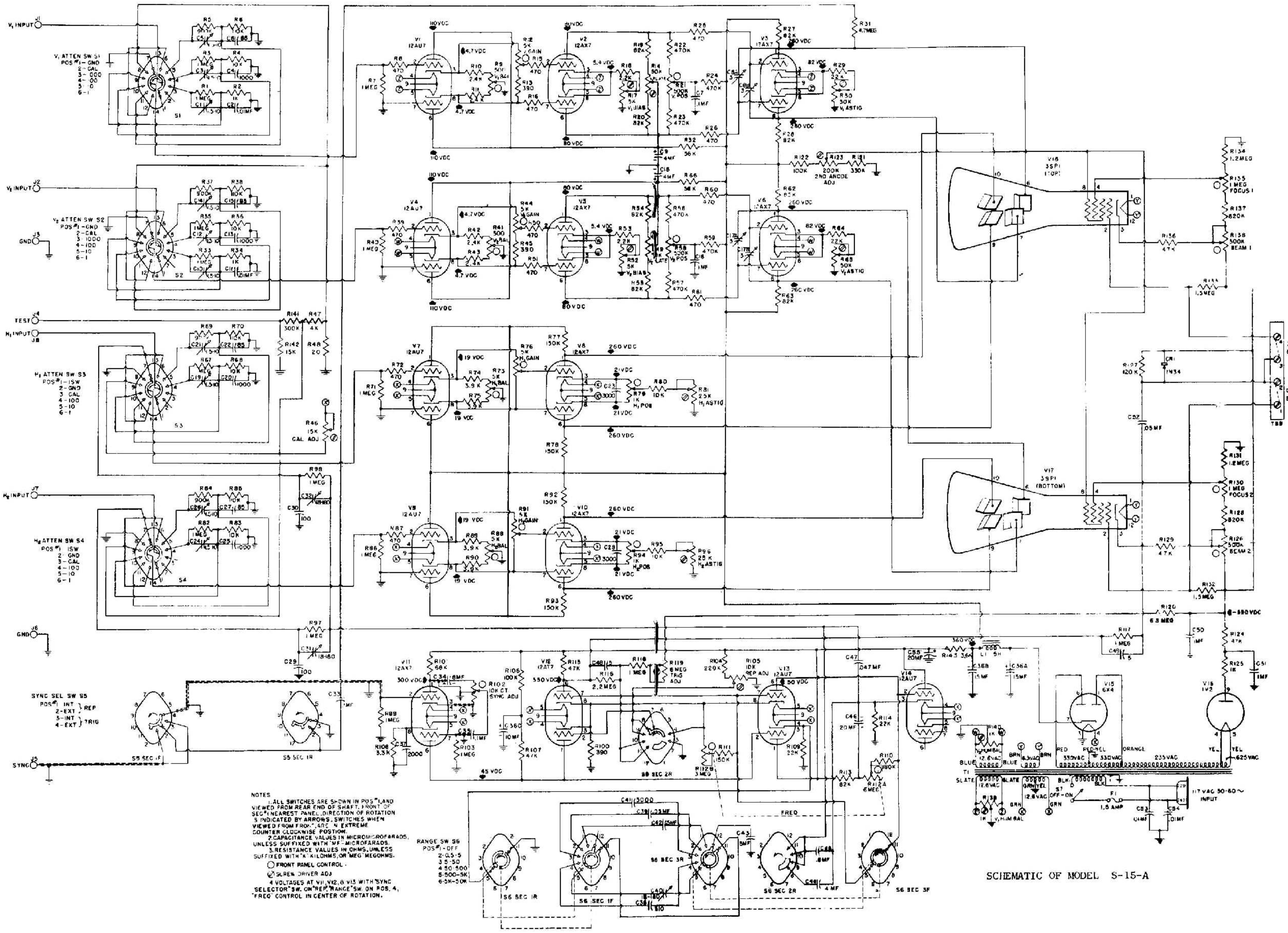
The plates of V3 (12AX7), which have equal load resistors, drive the deflection plates of V18 (3SP1) the cathode ray tube. The cathodes of V3 (12AX7) are tied to a common resistance R29 and R30. This arrangement fully inverts the signal so that the signal voltage appearing across the output plates is true push-pull.

R30 is adjusted to a point where the average DC plate voltage is equal to that of the second anode. Condenser C8A and C8B is plate-to-opposite-grid connected to improve the high frequency response of the amplifier. This description also holds true for the other vertical amplifier with the substitution of corresponding component symbols.

The horizontal amplifiers are likewise identical. V7 (12AU7) and V8 (12AX7) as well as other circuit parts have their counterparts in V9 (12AU7), V10 (12AX7), etc. Each horizontal amplifier is preceded by a H ATT switch (S3 or S4). The first (SW) position connects the output of the linear time base generator to the input of the amplifier. The second position ⏚ grounds the amplifier input through a 470 ohm resistor when it becomes necessary to DC balance it. The third position (CAL) connects 2 volts RMS at line frequency to the input for calibrating the amplifier gain.

The next two steps (100 and 10) insert compensated attenuations of 100 to 1 and 10 to 1 between the H INPUT terminal and the amplifier. The most clockwise position (1) directly connects the H INPUT terminal to the input of the amplifier.

The input tube is a 12AU7 type bridge connected. Signals are applied to one grid and appear across the cathodes just as in the vertical amplifier. R73, a 5K potentiometer, is used to balance the amplifier. The H GAIN control bridges the cathodes and feeds signal to the output tube V8 which is a 12AX7. In this tube inversion takes place. R79, a 1K potentiometer, is connected across the cathodes and is a part of the total cathode resistance. This permits horizontal positioning of the beam in the corresponding cathode ray tube. The output is push-pull and is applied across the horizontal deflection plates. This description also holds true for the other horizontal amplifier with the substitution of corresponding symbols.



SCHEMATIC OF MODEL S-15-A

The linear time base generator is common to both cathode ray tubes when their respective H ATT switches are set to SW. The generator is a multivibrator type which produces a linear sawtooth voltage in either the repetitive or trigger mode of operation.

The multivibrator proper, consists of V12 (12AT7) and V13 (12AU7), while V11 (12AX7) acts as a synchronization voltage amplifier. V14 (12AU7) is a grounded plate amplifier with a two-fold purpose. It couples a portion of the sweep output back into the multivibrator circuit through C46 to insure optimum sweep linearity and provides isolation between the horizontal amplifiers and the generator. The frequency, or writing speed, of the sweep is variable from 0.5 cycles to 50KC.

The SYNC SEL switch (S5) changes the bias applied to the multivibrator which permits it to oscillate freely or cut it off for trigger operations.

Synchronization can be from external or internal sources. It is to be noted that in either INT TRIG or INT-REP position the signal voltage is attenuated down from the vertical output of channel 1 only through R31.

In V11 (12AX7), the synchronization amplifier, one triode is so connected that R102, the SYNC adj. selects the polarity of synchronization as well as the amplitude. The other triode amplifies the signal and couples it to the multivibrator.

The BEAM and FOCUS potentiometers are located beside the face of screen of the cathode ray tube which they control. The 2nd ANODE ADJ is for setting the voltage of the 2nd anodes equal to the means voltage of the deflection plates.

When the unit is shipped from the factory wire jumpers are connected between terminals 1-2 and 3-4 located on TB9 behind the little door on the right hand side of the instrument. This connects a blanking pulse from the sweep generator to the cathode ray tube grid. This dims the beam during the return time of each sweep of the horizontal. When these jumpers are removed external signals can be applied to either grid.

WARNING: The voltage at these terminals is approximately −600 volts and the grid resistor is 1.5 megohms. If a DC blocking condenser is desired when applying external signals it must be chosen with these features in mind.

The power transformer T1 supplies all the necessary voltages for operating the unit. V15 is a type 6X4 tube for supplying the B^+. The negative supply utilizes a IV2 half wave rectifier.

The power switch S7 applies the line voltage to T1. The fuse F1, which is replaceable from the front, provides overall protection.

AMPLIFIER BALANCING

Since checking and adjusting the amplifier balance consumes little time, this operation should be checked each time the oscilloscope is turned ON.

Control Setting: V and H ATT to ⏚ V and H GAIN to minimum (CCW); V and H POS to center beam on cathode ray tube screen.

Procedure: After a few minutes warm up, advance the corresponding GAIN control in clockwise direction and note any movement of the beam from this position. Rotate the corresponding BALANCE control, located just in front of the GAIN control, until the spot returns to the original position. When the BALANCE control is properly set, turning the GAIN will not move the spot more than 1/16 of an inch. In most cases the balance can be adjusted so that no movement of the spot is observed.

CALIBRATION TECHNIQUES

Internal Calibration Voltages

Connect the input voltage to either V ATT terminal and turn the H ATT control to ⏚ (or vice versa). Then any AC input signal voltage will appear as a straight vertical line, whose length is proportional to the input voltage. DC input voltages will appear as a spot displacement which is proportional to the DC input voltage. The difference in trace length and input sensitivities between the vertical and horizontal axis permit a judicious choice of any given voltage. (Larger voltage through the H INPUT, lower voltages through the V INPUT.)

Fixed Scale Method

Both vertical calibration voltages are equal to 10 millivolts RMS at line frequency. The horizontal calibration signals are equal to 2 volts RMS at line frequency.

Since a calibration voltage is available by rotating the ATT switch to CAL, it is possible to select a setting of the GAIN control so that the calibration voltage is equal to a given deflection. Any fraction or multiple thereof is then easily interpolated.

If the vertical calibration deflection is set equal to one inch, signal inputs causing one inch deflection will equal 10V RMS when the V ATT is set to 1000, 1V RMS when the V ATT is set to 100, etc. Half inch deflection will equal 5V RMS, .5V RMS respectively. This technique is also applicable to H inputs, keeping in mind that the calibration voltage is equal to 2V RMS.

Variable Scale Method

Adjust the GAIN and ATT controls so that the incoming signal causes a conveniently usable amount of deflection. Using the graph screen supplied with the **POCKETSCOPE** note the number of scale divisions occupied by this signal. For DC signals note number of divisions of spot displacement. (There are 10 such divisions per inch on the graph screen.)

Rotate the ATT switch to CAL and note the number of divisions occupied by the calibration voltage. Use the following formula to calculate the signal voltage.

A. Signal in millivolts RMS $= \frac{DS}{DC} \times 10 \times$ V ATT

B. Signal in volts RMS $= \frac{DS}{DC} \times .01 \times$ V ATT

C. Signal in volts RMS $= \frac{DS}{DC} \times 2 \times$ H ATT

Where:

DS = amplitude of signal in scale divisions
DC = amplitude of calibration voltage in scale divisions

To measure AC peak to peak or DC voltages directly, substitute:

28 for 10 in	(A)
.028 for .01 in	(B)
5.6 for 2 in	(C)

External Calibration Voltages

Any known external voltage may be substituted for the internal calibration voltages. Again either the fixed or variable scale methods may be employed.

There is, however, a calibrating technique peculiar to DC coupled oscilloscopes.

The DC coupled amplifiers permit the observation of the AC component of a complex wave in relation to its DC level. By adjusting the GAIN control to calibrate the amplifiers sensitivity, as described under the fixed scale method above; the AC swings with respect to the DC may be viewed.

For example, in observing the behavior of the plate voltage in a simple resistance coupled amplifier, it is possible to move the trace to a line at the bottom or left hand side of the cathode ray tube screen when the ATT is at and the GAIN to minimum. This will, therefore, represent zero voltage - or ground. The B^+ is connected to the input terminal and the ATT and GAIN are adjusted until the trace moves to a position near the other extreme of the screen. The plate voltage is connected to the oscilloscope (in place of the B^+) without disturbing the ATT and GAIN setting. The plate signal will be displayed in true relation to ground and B^+. Thus, it is possible to view the plate waveform and more readily understand any distortion or inconistencies.

The same technique can be employed by viewing signals in any circuit. Other potentials can be substituted for either B^+, ground or both depending upon the particular limits desired to be viewed.

NOTE: IF AC VOLTAGES ARE TO BE VIEWED WITHOUT THE DC COMPONENT AN EXTERNAL BLOCKING CONDENSER IS REQUIRED. SIMPLY CONNECT THE CONDENSER (.1 mf or larger) BETWEEN THE INPUT TERMINAL TO BE USED AND THE SIGNAL SOURCE.

SECTION V

MAINTENANCE

Access to the equipment inside may be obtained by removing the screws which hold the side plates to the cabinet.

Under ordinary usage, the life of the tubes is consistent with that obtained in other applications. However, due to the DC amplifiers used, it is necessary to balance the unit whenever the tubes in either horizontal or vertical amplifiers are changed. Instructions for this are given below under Balancing.

The determining factor in life of the Waterman Rayonic 3SP1 Cathode Ray tubes is deterioration of their luminescent screens. It is, therefore, advisable not to leave a bright concentrated spot on the screen. The approach to the limit of useful life is indicated by the inability to obtain satisfactory focus and by the screen becoming streaked and spotted.

The Schematic Diagram and the Replacement Parts List gives the value of all parts, so that resistance and continuity checks can be readily made. A table of tube voltage as well as a tube location chart are listed at the end of this section.

The Blanking Coupling Circuit shown in the small diagram differs from the schematic diagram in that the value of R127 has been changed to 1.5 megohm and resistor R144, 10K, is inserted between the terminals 2 and 3 of TB9 and the diode IN34. The S-15-A **POCKETSCOPES** beginning with serial number 816 are wired accordingly. Instruments bearing previous serial numbers are as per the main schematic diagram. In a few instruments bearing early serial numbers, though wired as per the main schematic, the value of R127 is 1.5 megohm.

It is recommended that R144, 10K, be inserted as shown and the value of R127 changed to 1.5 meg, to prolong the life of the crystal, and insure better blanking.

From time to time it may become necessary to make adjustments to the oscilloscope. Usually these adjustments must be checked after the replacement or repair of parts. Below are listed the explanation and procedure for all the adjustments. By necessity, the setting of the basic controls such as OFF-ON, BEAM, FOCUS, etc., have been omitted.

Again these directions and comments apply to both channels of the oscilloscope.

ASTIGMATIC ADJUSTMENTS

If the beam becomes defocused as it approaches the edge of the screen, the output plate voltage of the related amplifier requires resetting. The mean voltage of the deflection plates which are directly connected to the output amplifier plates, must equal the second anode voltage.

Control Setting

V and H ATT to ⏚ V and H GAIN to minimum (CCW); V and H POS to approximate mechanical center. BALANCE to proper adjust as per Section IV.

Procedure

Remove both side plates and the cover plate from under side of the oscilloscope. Connect a DC voltmeter between the center arm of the 2nd ANODE ADJ (R123) control, which is accessible from the right hand side of the unit, until the voltage reads +260 volts. Measure voltage of the output amplifier plates (pins 1 and 6 of V3 for V channel #1 and pins 1 and 6 of V6 for V channel #2; pins 1 and 6 of V8 for H channel #1 and pins 1 and 6 of V10 for H channel #2) and adjust each POS control located along side the cathode ray tube until the corresponding plate voltages are equal to each other. Adjust the corresponding ASTIG control (see schematic), which is accessible from the under side of the unit, until the voltage at these plates equals +260 volts.

HUM BALANCE: Because of the high sensitivity of the vertical amplifier, slight hum levels in the first stage could appear on the cathode ray screen. Therefore, provisions are made to balance out any such hum by carefully selecting the center voltage of each filament winding.

Control Setting: V ATT controls to ⏚V GAIN controls to maximum (CW); H ATT controls to SW; H GAIN for 2 1/2 inch trace; RANGE to 5-50; FREQ for approx. 20 cycles sweep.

Procedure: Adjust appropriate HUM control (see schematic diagram) located on under side of unit for minimum hum signal on the cathode ray tube screen.

POSITIONING RANGE: When the setting of either V POS control is noticeably different from its mechanical center setting, positioning has become more limited in one direction that the other. This is corrected by the following method.

Control Setting: V and H ATT controls to ⏚V and H GAIN controls to minimum (CCW); V and H POS controls to approximately mechanical center.

Procedure: Rotate the appropriate V PLATE control until the spot returns to the center of the cathode ray tube screen. If difficulty is encountered in the horizontal positioning the tubes should be changed.

VERTICAL BIAS: The gain and voltages of the vertical output amplifier are to a great extent controlled by the voltage at the grids. Because of DC coupling this is the voltage appearing at the plates of the preceding stage (V2 or V5).

Control Setting: V and H ATT controls to ⏚V and H GAIN controls to minimum (CCW); V and H POS controls to center spot on screen of the cathode ray tube.

Procedure: Use a DC voltmeter to compare both plate voltages to ground. Reset each V POS control until these plates are equal. Now adjust the corresponding BIAS control located on the under side of the unit until the plates are at +80 volts.

REPETITIVE SWEEP ADJUSTMENT: Since the sweep generator is basically a multivibrator in which the bias is set to permit repetitive or trigger operation; it is necessary to select the optimum bias voltage for repetitive operation.

Control Setting: V_1 ATT control to CAL; V_1 GAIN control for approximately one inch deflection; H_1 ATT control to SW; H_1 GAIN control for approximately two inches of deflection; SYNC SEL control to REP-INT; RANGE control to 50-500; SYNC ADJ control in clockwise direction from "O"; FREQ for one cycle on screen.

Procedure: Adjust REP ADJ control (R105) located on the under side of the unit for optimum between maximum horizontal amplitude and minimum distortion of the right hand portion of the pattern.

TRIGGER SWEEP ADJUSTMENTS:

Control Setting: V_1 ATT to CAL; V_1 GAIN to maximum (CW); H_1 ATT to SW; H_1 GAIN approximately half-way; SYNC SEL to TRIG-INT; RANGE to 0.5-5; SYNC ADJ to "O"; FREQ to "5".

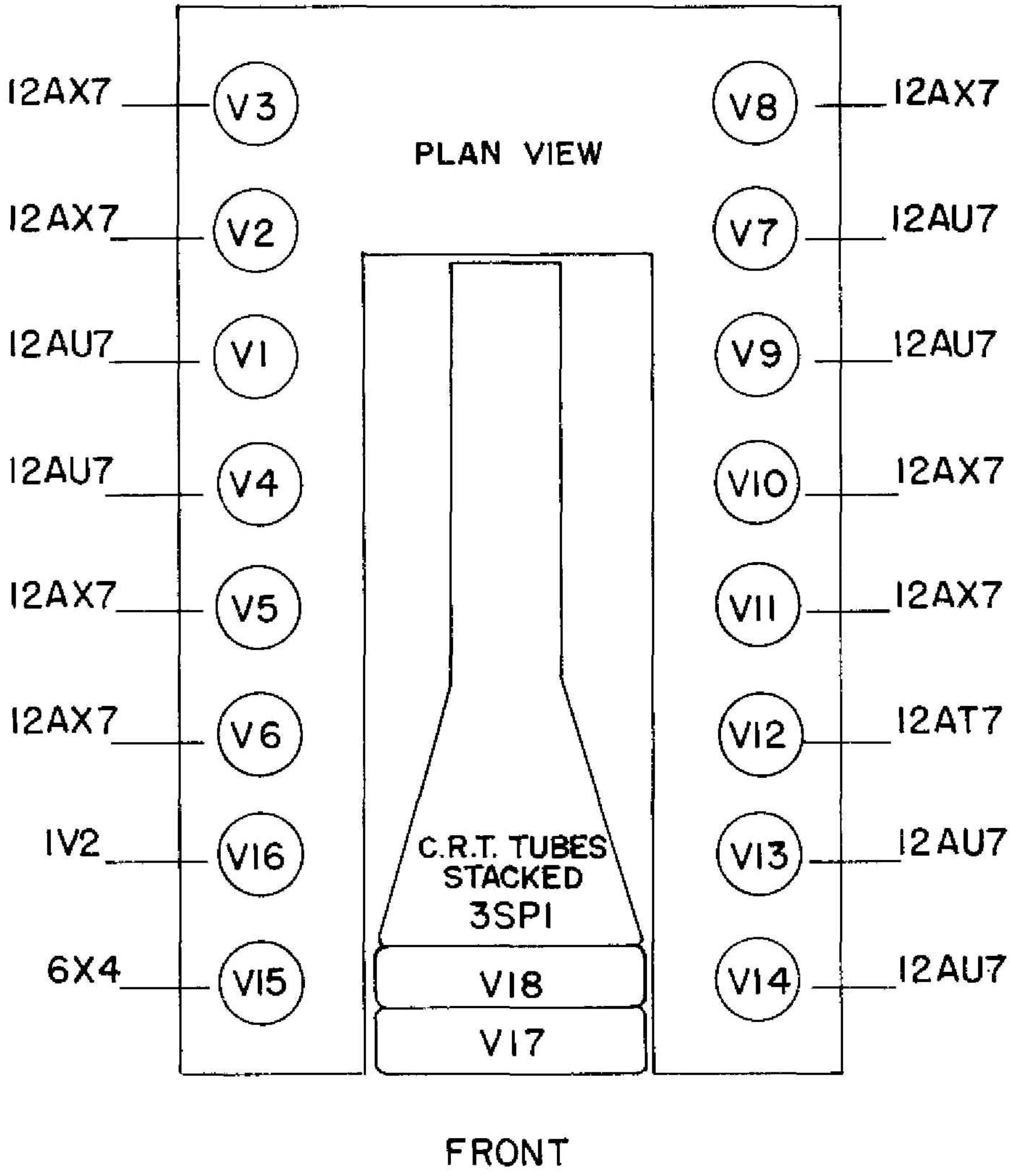
Procedure: Adjust TRIG ADJ (R119) until sweep generator no longer puts out a signal. However, rotating SYNC ADJ in either direction from "O" should "fire" sweep generator. Repeat with RANGE to 5-50 and repeat again with RANGE set to 50-500.

CALIBRATION VOLTAGE: On rare occasions it may become necessary to readjust the CAL voltage.

Control Setting: V ATT controls to appropriate setting (see Procedure) V GAIN to maximum (CW); H ATT to

Procedure: From a known source connect 10 volts rms (V ATT at 1000) or 1 volt rms (V ATT at 100) etc. to the V_1 INPUT and Adjust V_1 GAIN for a convenient trace length, carefully noting total deflection. Turn V ATT to CAL and adjust the calibration potentiometer (R46) located back of right hand side plate until the deflection is equal to the previous. All CAL voltages are now adjusted since R46 is in series with all the calibration network.

For convenience in trouble shooting, a table of tube voltages, a tube location chart, and list of replacement parts are included.



TUBE LOCATIONS

S - 15 - A

S-15-A

Tube No.	Tube Type	Pin 1	2	3	4	5	6	7	8	9	10	11	12
V1	12AU7	110	0	4.7	6.3AC	6.3AC	110	0	4.7	*			
V2	12ZX7	80	4.7	5.4	6.3AC	6.3AC	80	4.7	5.4	*			
V3	12ZX7	260	80	82	6.3AC	6.3AC	260	80	82	*			
V4	12AU7	110	0	4.7	6.3AC	6.3AC	110	0	4.7	*			
V5	12AX7	80	4.7	5.4	6.3AC	6.3AC	80	4.7	5.4	*			
V6	12AX7	260	80	82	6.3AC	6.3AC	260	80	82	*			
V7	12AU7	360	0	19	6.3AC	6.3AC	360	0	19	0			
V8	12ZX7	260	19	21	6.3AC	6.3AC	260	19	21	0			
V9	12AU7	360	0	19	6.3AC	6.3AC	360	0	19	0			
V10	12AX7	260	19	21	6.3AC	6.3AC	260	19	21	0			
**V11	12AX7	300	0	3.2	6.3AC	6.3AC	45	−0.3	0.6	0			
**V12	12AT7	55	0.03	0.6	6.3AC	6.3AC	330	−26	0.6	0			
**V13	12AU7	300	55	78	6.3AC	6.3AC	70	−27	0.6	0			
**V14	12AU7	300	70	86	6.3AC	6.3AC	—	—	----	0			
V15	6X4	330AC		0	6.3AC		330AC	350AC					
V16	1V2				565AC #.625AC	565AC				−680			
V17	3SP1	##6.3AC	−590	260	−350		260	260	250	260	260		##6.3AC
V18	3SP1	##6.3AC	−590	260	−350		260	260	250	260	260		##6.3AC

* Voltage depends on setting of #1 HUM BAL (R139) or #2 HUM BAL (R140)

** SYNC SEL to INT-REP; RANGE to 50-500; FREQUENCY to 5; SYNC ADJ to "O"

\# Voltage across filaments — pins 4 and 5

\## Voltage across filaments — pins 1 and 12

SECTION VI

S-15-A REPLACEMENT PARTS LIST

INSIST UPON FACTORY-TESTED PARTS ON ALL ITEMS MARKED WITH ASTERISK. ALL OTHER STANDARD PARTS MAY BE MORE READILY PURCHASED FROM YOUR REGULAR SOURCES.

SYMBOL	DESCRIPTION	PART NUMBER
C1, 3, 5, 10, 12, 14, 19, 21, 24, 26	Capacitor, 1.5-10 mmf, adjustable ceramic tubular.....	CZB-002-001
C2, C11	Capacitor, .01 mf, 200V, metal, paper tubular.........	CPM-001-001
C4, C13, C20, C25	Capacitor, 001 mf, 400V, metal, paper tubular	CPM-001-004
C6, C15, C22, C27	Capacitor, 85 mmf, 500V, mica CM15...............	CMA-771-850
C7, C16	Capacitor, .1 mf, 400V, paper tubular................	CPB-003-007
C8, C17	Capacitor, Dual neutralizer	CZB-001-A01*
C9, C18	Capacitor, 4 mf, 250V, electrolytic tubular	CDB-003-008
C23, C28	Capacitor, .003 mf, 200V, paper tubular..............	CPB-003-011
C29, C30	Capacitor, 100 mmf, 500V, mica CM15..............	CMA-871-101
C31, C32, C40	Capacitor, 18-180 mmf, compression trimmer..........	CXA-002-003
C33	Capacitor, .1 mf, 400V, moulded paper tubular........	CPB-001-008*
C34	Capacitor, 8 mf, 350V, electrolytic tubular	CDB-003-006
C35	Capacitor, .1 mf, 200V, paper tubular...............	CPB-003-010
C36	Capacitor, 10 mf at 350V and 15-15 mf at 450V, electrolytic can	CDA-016-003
C37	Capacitor, .002 mf, 200V, paper tubular.............	CPB-004-001
C38	Capacitor, 510 mmf, 300V, mica CM15...............	CMA-770-511
C39	Capacitor, .05 mf, 200V, paper tubular..............	CPB-004-002
C41	Capacitor, .005 mf, 200V, paper tubular..............	CPB-004-003
C42	Capacitor, .5 mf, 200V, metal paper tubular...........	CPM-002-001
C43	Capacitor, 5 mf, 150V, metal paper tubular...........	CPM-003-001*
C44	Capacitor, 4 mf, 150V, metal paper tubular...........	CPM-003-002
C45	Capacitor, .5 mf, 200V, metal paper tubular	CPM-002-004
C46	Capacitor, 20 mf, 250V, electrolytic tubular	CDB-003-007
C47	Capacitor, .047 mf, 200V, paper tubular..............	CDB-003-012
C48, C49	Capacitor, 5 mmf, 500V, ceramic tubular.............	
C50, C51	Capacitor, 1 mf, 600V, metal paper tubular...........	CPM-002-002
C52	Capacitor, .05 mf, 1000V, paper tubular..............	CPB-003-013
C53, C54	Capacitor, .01 mf, 400V, paper tubular...............	CPB-003-003
C55	Capacitor, 20 mf, 350V, electrolytic tubular	CDB-003-013
CR1	Crystal IN34	
J1, J2, J3, J4, J5, J6, J7, J8	Binding Post, black bakelite with #6-32 stud.........	ETP-001-001
L1	Choke, filter 5 henries	LCB-005-001*
R1, R3, R33, R35, R67, R82	Resistor, 1 meg ±1% 1/2W, carbofilm	RQC-001-030*
R2, R34	Resistor, 1K, ±1%, 1/2W, carbofilm.................	RQC-001-027*
R4, R36, R68, R83	Resistor, 10K, ±1%, 1/2W, carbofilm................	RQC-001-026*
R5, R37, R69, R84	Resistor, 900K, ±1%, 1/2W, carbofilm...............	RQC-001-024*
R6, R38, R70, R85	Resistor, 110K, ±1%, 1/2W, carbofilm...............	RQC-001-025*
R7, R40, R71, R86, R97, R98, R117	Resistor, 1 Meg, 1/2W, composition..................	RCC-010-105
R8, R15, R16, R25, R26, R39, R50, R51, R60, R61, R72, R87	Resistor, 470 ohms, 1/2W, composition..............	RCC-020-471
R9, R41	Variable composition, 500 ohms, 1/4W linear taper.....	RVD-001-012*
R10, R11, R42, R43	Resistor, 2.4K, 1/2W, composition..................	RCC-005-242
R12, R44, R76, R91	Variable composition, 5K, 1/4W, linear taper...........	RVD-001-001*
R13, R45, R100	Resistor, 390 ohms, 1/2W, composition..............	RCC-010-391
R14, R30, R49, R65	Resistor, Variable composition, 50K, 1/4W, linear taper	RVD-001-005*
R17, R52	Resistor, Variable composition, 5K, 1/4W, linear taper	RVD-001-004*
R18, R53	Resistor, 2.2K, 1/2W, composition..................	RCC-020-222
R19, R20, R27, R28, R54, R55, R62, R63, R113	Resistor, 82K, 1/2W, composition..................	RCC-010-823
R21, R58	Resistor, Miniature variable carbon 500K, 1/10W, linear taper	*
R22, R23, R24, R56, R57, R59	Resistor, 470K, 1/2W	RCC-020-474
R29, R64	Resistor, 22K, 1/2W	RCC-020-223
R31	Resistor, 4.7 Meg, 1/2W...........................	RCC-020-475
R32, R66	Resistor, 56K, 1 Watt	RCD-010-563
R46	Resistor, Variable carbon 15K, 1/4W, linear taper.....	RVD-001-019*
R47	Resistor, 4K, ±1%, 1/2W, carbofilm................	RQC-001-033*
R48	Resistor, 20 ohms, ±1%, 1/2W carbofilm............	RQC-001-029

R73, R88	Resistor, Variable carbon 5K, 1/4W, linear taper	RVD-001-020*
R74, R75, R89, R90	Resistor, 3.9K, 1/2W.............................	RCC-010-392
R77, R78, R92, R93, R111	Resistor, 150K, 1/2W	RCC-010-154
R79, R94	Resistor, Miniature variable carbon 1K, 1/10W linear taper	*
R80, R95, R144	Resistor, 10K, 1/2W	RCC-020-103
R81, R96	Resistor, Variable carbon 25K, 1/4W, linear taper.....	RVD-001-021*
R99, R103, R118	Resistor, 1 Meg, 1/2W.............................	RCC-020-105
R101	Resistor, 68K, 1/2	RCC-020-683
R102	Resistor, Variable carbon, 10K, 1/4W, linear taper....	RVD-001-003*
R104	Resistor, 220K, 1/2W.............................	RCC-020-224
R105	Resistor, Variable carbon, 10K, 1/4W, linear taper....	RVD-001-007*
R106, R122	Resistor, 100K, 1/2W	RCC-010-104
R107, R115	Resistor, 47K, 1W	RCD-020-473
R108	Resistor, 3.3K, 1/2W.............................	RCC-010-332
R109	Resistor, 22K, 2W	RCE-020-223
R110	Resistor, 180K, 1/2W	RCC-010-184
R112	Resistor, Dual variable 3 Meg and 6 Meg.............	RVD-001-013*
R114	Resistor, 22K, 1W	RCD-020-223
R116	Resistor, 2.2 Meg, 1/2W.............................	RCC-020-225
R119	Resistor, Variable carbon 6 meg....................	RVD-001-022*
R120	Resistor, 6.8 meg, 1/2W, carbon....................	RCC-010-685
R121	Resistor, 330K, 1/2W	RCC-020-334
R123	Resistor, Variable carbon 200K, 1/4W, linear taper....	RVD-001-006*
R124, R129, R136	Resistor, 47K, 1/2W	RCC-020-473
R125	Resistor, 1K, 1/2W	RCC-020-102
R126, R138	Resistor, Variable carbon 500K, 1/4W linear taper	RVD-001-002*
R128, R137	Resistor, 820K, 1/2W	RCC-020-824
R130, R135	Resistor, Variable carbon, 1 meg, 1/4W linear taper...	RVD-001-023*
R131, R134	Resistor, 1.2 meg, 1/2W.............................	RCC-010-125
R132, R133, R127	Resistor, 1.5 meg, 1/2W.............................	RCC-020-155
R139, R140	Resistor, Variable carbon 1K, 1/4W linear taper	RVD-001-008*
R141	Resistor, 300K, 1/2W	RCC-005-304
R142	Resistor, 15K, 1/2W	RCC-005-153
R143	Resistor, 3.6K, 2W.............................	RCE-010-362
S1, S2, S3, S4	Switch, rotary 6 positions, 1 section	SWR-038-001*
S5	Switch, rotary 4 positions, 2 section	SWR-037-002*
S6	Switch, rotary 6 positions, 3 section	SWR-037-001*
S7	Switch, toggle SPST	
T1	Transformer, Power.............................	LPU-013-001*
V1, V4, V7, V9, V13, V14	Tube, 12AU7.............................	
V2, V3, V5, V6, V8, V10, V11	Tube, 12AX7.............................	
V12	Tube, 12AT7.............................	
V15	Tube, 6x4.............................	
V16	Tube, 1V2.............................	
V17, V18	Tube, 3SP1*.............................	
	Plug, male.............................	EPR-001-001
	Cord, power, 6' long	WPR-010-001
	Graph screen.............................	IPC-011-001*
	Escutcheon, rubber	INC-001-001*
	Light Shield	IPC-010-001*
	Leather Strap	ILB-002-001*
	Feet	INA-016-001*
	Knob, large.............................	NKB-003-001
	Knob, small.............................	NKB-001-001