

# INSTRUCTION MANUAL FOR

## Model 488



**EICO**

**EICO ELECTRONIC  
INSTRUMENT CO., Inc.**

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# **general description**

The EICO Model 488 Electronic Switch permits you to observe two voltage or current waveforms simultaneously on the screen of a single oscilloscope. The amplitude of each pattern is separately adjustable by means of individual gain controls in each input channel and the patterns may be superimposed or separated by any desired amount with a positioning control. In addition to its basic function as an electronic switch, the Model 488 is an excellent square wave generator over the range of switching frequencies (10 to 2000 cps.).

The electronic switch increases the usefulness of any oscilloscope more than any other accessory. In many cases, it makes one oscilloscope more useful than two would be. An invaluable aid in the design, study, and servicing of electronic and electrical power circuits, a few examples of its uses are the following: direct comparison of voltage and current amplitudes, waveforms, frequency, and phase relationships; establishing an always visible voltage reference level (when used with a voltage calibrator such as the EICO Model 495); establishing a zero base line; checking amplifier distortion; checking crossover networks. By using Model 488's in tandem, as many patterns can be observed simultaneously on the screen of a single oscilloscope as desired; two in tandem for three patterns, three in tandem for four patterns, and so on. The latter arrangement is very useful for investigation of polyphase power systems and equipment.

## **specifications**

### **APPROXIMATE SWITCHING RATES RANGES (also Square-Wave Generator Ranges)**

Low range: ..... less than 10 cps to 100 cps continuously variable.

Middle Range: ..... 50 cps to 400 cps continuously variable.

High Range: ..... 250 cps to 2000 cps continuously variable.

### **CONTROLS**

Amplitude 1 control, Amplitude 2 control, Positioning control, Freq. Selector switch, Freq. Vernier control.

**TUBE COMPLEMENT** ..... 2- 12AU7, 2- 6AU6, 1- 6X5

**POWER REQUIREMENTS** ... 105-125 volts AC, 50-60 cycles; 25 watts.

**SIZE** ..... 6" high, 8" wide, 6" deep.

**WEIGHT** ..... 7 lbs.

# circuit description

## GENERAL

Fig. 1 is a simplified block diagram of the electronic switch. The circuit consists of two identical channels — 1 and 2 — which operate alternately. The multivibrator stage in each channel develops a square wave which is 180 degrees out of phase with that developed in the other channel. These square waves are used to gate (control the off-on operation of) the two mixer output tubes so that the two impressed signals appear alternately at the output terminals. As a result of the persistence of vision of the human eye and the persistence characteristic of the fluorescent material on the oscilloscope screen, together with the fact that the oscilloscope is synchronized with the signal frequency and not the switching frequency, the entire waveform of both signals appears on the screen.

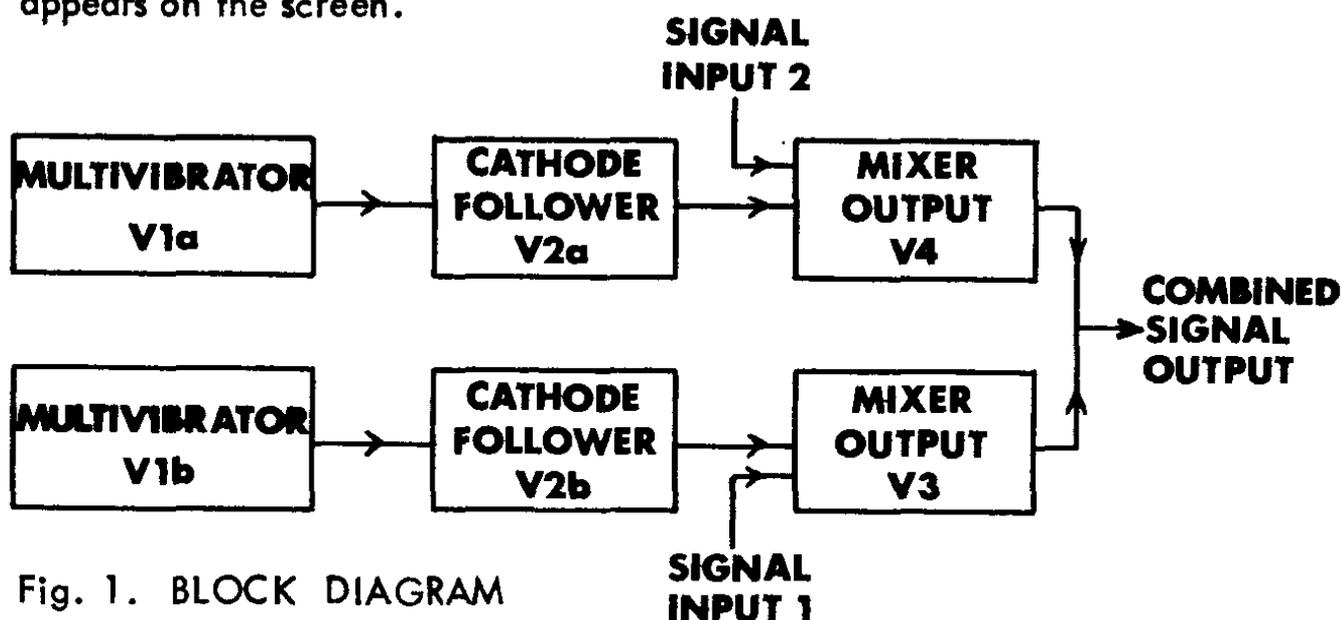


Fig. 1. BLOCK DIAGRAM

## SWITCHING ACTION

Cathode follower V2a controls mixer output tube V4 and receives its grid excitation through C7 from the plate of the V1a multivibrator. Cathode follower V2b controls mixer output tube V3 and receives its grid excitation through C8 from the plate of the V1b multivibrator.

V1a and V1b form a conventional multivibrator. The operating frequency of the multivibrator is variable in frequency by the coarse control S1 and the fine control R1. (S1 and R1 control the R-C combination which determines the charge and discharge time.)

The square wave output from each plate of the multivibrator is 180 degrees out of phase with the opposite plate. This phase relationship is maintained between the outputs of the two cathode follower stages V2a and V2b, which are in turn used to gate the two mixer output tubes V3 and V4.

For purposes of explanation, consider an instant when a positive pulse from V1a causes V2a to conduct. This causes current to flow through R9, common to the cathodes of V2a and V4, which increases the bias of V4 sufficiently to drive V4 to cut-off by making its cathode more positive (equivalent to a more negative grid). During the same half-cycle, a negative pulse from the plate of V1b biases V2b to cut-off, and so no current flows through R10, common to the cathode of V2b and V3. As a result, V3 operates with normal bias.

During the next half-cycle, V1b supplies the positive pulse and V1a the negative pulse. By similar reasoning, it can be seen that in this half-cycle V2a is biased to cut-off and V4 operates with normal bias while V2b conducts and V3 is driven to cut-off.

### POSITIONING (TRACE SEPARATION)

The vertical separation on the screen between the two signals is achieved and controlled by R13 (POSITIONING control) which varies the screen grid voltages of V3 and V4 (mixer output tubes) in opposite directions and therefore similarly varies the quiescent currents in these tubes. As a result the pulses at the output, derived alternately from the two mixer output tubes, are generally of different amplitude (unless the POSITIONING control is so set as to make the screen voltages equal, in which case one trace will be superimposed on the other). This difference in amplitude causes the output to be a square wave at the multivibrator operating frequency. The square wave is reproduced on the oscilloscope screen in the form of a vertical separation of the two signal traces, each of which is superimposed on one of the two sets of pulses arriving alternately at the output terminals.

### CHANNEL GAIN CONTROLS

As signal 1 is applied to R12 (AMPLITUDE 1 control) and the V3 input, the amplitude of signal 1 in the output is a function of the V3 stage gain and the setting of R12. As signal 2 is applied to R11 (AMPLITUDE 2 control) and the V4 input, the amplitude of signal 2 in the output is a function of the V4 stage gain and the setting of R11.

### POWER SUPPLY

The power supply consists of the power transformer T1 with a center-tapped (grounded) main secondary winding to each end of which is connected a plate of the full-wave, high-vacuum rectifier V5. The filter is composed of the two shunting capacitors C10 and C9D that present a low reactance to ground and a choke L1 in series that presents a high reactance to the ripple frequency so that a clean and relatively high dc output voltage is obtained. The T1 6.3 volt secondary winding supplies power for all filaments and pilot lamp 11.

# operation

To obtain proper results with your electronic switch, it is advisable to become acquainted with the functions and correct use of the panel controls and terminals by going through the procedure that follows. This procedure will also serve to assure you that the instrument is in proper working condition.

1) Connect the OUTPUT terminals of the electronic switch to the vertical input terminals of the oscilloscope, before turning the instrument on.

**CAUTION: DO NOT MAKE CONNECTIONS TO AND AVOID CONTACT WITH THE "HOT" OUTPUT TERMINAL WHILE THE INSTRUMENT IS TURNED ON, AS THERE IS A HIGH DC VOLTAGE ON THIS TERMINAL. (Conforming to the practice of most electronic switch manufacturers, there is no blocking capacitor in the electronic switch output. The reason for this practice is that most scopes have input blocking capacitors.)**

2) Set the electronic switch controls as follows.

a) Rotate the AMPLITUDE 1, AMPLITUDE 2, and POSITIONING controls to their extreme counter-clockwise positions.

b) Set the FREQ. SELECTOR at 50-400.

c) Rotate the FREQ. VERNIER control to its extreme clockwise position.

3) Set up the oscilloscope for normal operation and make the following control adjustments.

a) Set the horizontal input selector at internal sweep.

b) Set the sync selector at internal sync.

c) If the 'scope has a vertical input attenuator, set it at the position which provides an attenuation of about 100:1 or permits a maximum input voltage of several hundred volts. Do not be concerned with instruction if your 'scope has no vertical step attenuator.

d) Adjust the vertical gain control so that the upper and lower traces are about an inch apart.

e) Set the sweep frequency band selector (coarse frequency control) at a range comparable to 15-100 cps.

f) Adjust the sweep vernier (fine frequency) control until a pattern of 6-9 cycles is locked in place on the 'scope screen, using as little sync voltage as possible. The pattern should appear as in Fig. 2.

Portions "1" and "2" of the square wave will not generally be of precisely equal length. Whether they are or not is of no importance to the operation and performance of the instrument either as an electronic switch or as a square wave generator. You may also notice a barely visible "pip" which regularly appears on the trailing edge of the square wave. This "pip" does not interfere with the proper operation of the instrument in any way. It is characteristic of the circuit and will be found in far more expensive equipment of this type.

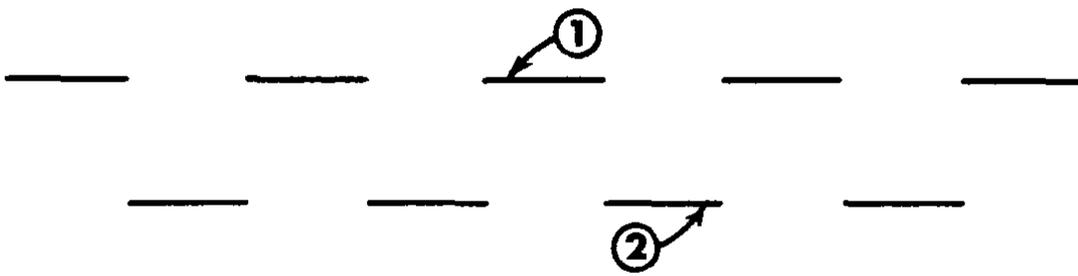


Fig. 2. POSITIONING CONTROL AT EXTREME COUNTER CLOCKWISE POS

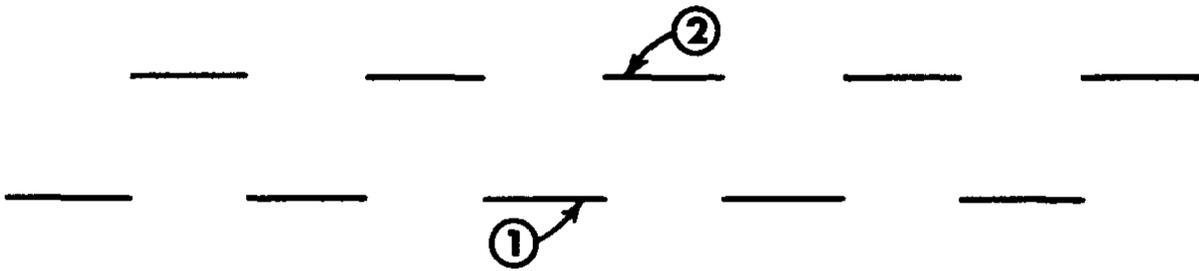


Fig. 3. POSITIONING CONTROL AT EXTREME CLOCKWISE POSITION



Fig. 4. POSITIONING CONTROL AT SOME INTERMEDIATE POSITION.

4) The POSITIONING control permits adjustment of the separation between the "1" and "2" traces. With it you may superimpose one trace upon the other or reverse the vertical order of appearance of the traces on the 'scope screen. The extreme counter-clockwise position of this control provides maximum separation of the traces for one vertical order of appearance ("1" above "2") as shown in Fig. 2. The extreme clockwise rotation yields maximum separation for the reverse vertical order of appearance ("2" above "1") as shown in Fig. 3. At some setting of the POSITIONING control between the extremes of rotation, one trace will be superimposed upon the other as shown in Fig. 4. Turn the POSITIONING control slowly to the maximum clockwise position and back to the maximum counter-clockwise position observing the action described above.

5) In this test, the identical audio frequency signal will be fed to both channels of the electronic switch in order to demonstrate the operation of the instrument and the use of the remaining controls and terminals. For convenience, the 60 cycle test output of the scope will be used as the audio frequency source, although an audio oscillator could be used instead.

Connect the 60 cycle test output of the 'scope to the upper INPUT 1 terminal post and then connect a jumper between the upper INPUT 1 and upper INPUT 2 terminal posts.

With the AMPLITUDE 1 and AMPLITUDE 2 controls at the extreme counter-clock-

wise POSITION, the 60 cycle test signal being fed into both amplifiers is not amplified and therefore does not show on the 'scope screen. Turn the AMPLITUDE 1 control clockwise and observe the drifting 60 cycle sine wave pattern superimposed on either the top or bottom of the square wave. Turn the AMPLITUDE 2 control clockwise and observe the appearance of a similar pattern superimposed on the opposite side of the square wave. The "checkerboard" pattern obtained is characteristic when the 'scope sweep is synchronized with the switching frequency of the electronic switch.

Now connect a jumper between the 60 cycle test output and the external sync terminal of the 'scope and set the sync selector at external sync. Note: If the selector on your 'scope has a 60 cycle sync position, the connection between the 60 cycle test output and the external sync terminal could be eliminated. However, we advise that you make this connection and use the external sync position anyway, since it corresponds to the procedure which must be followed in the normal use of the instrument when the signal source is external and not at line frequency or a multiple thereof.

Set the 'scope's sweep frequency band selector at a range including 30 cps and adjust the 'scope's sweep frequency vernier control until each pattern on the 'scope screen consists of two cycles (using as little sync voltage as possible). Readjust the 488's FREQUENCY VERNIER control to obtain as solid a trace as possible.

The 'scope sweep is now synchronized with the signal frequency as it always should be when the instrument is being used as an electronic switch. (When the instrument is being used as a square wave generator, it is the switching frequency itself which is being observed, and the oscilloscope is therefore synchronized with the switching frequency.)

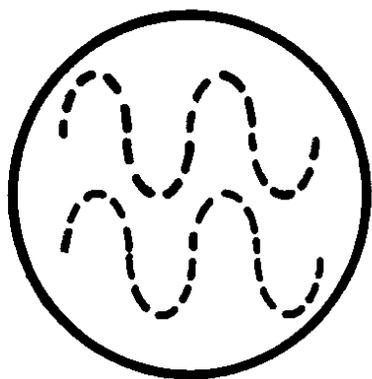


Fig. 5.

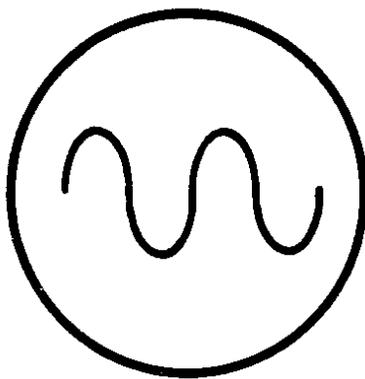


Fig. 6.

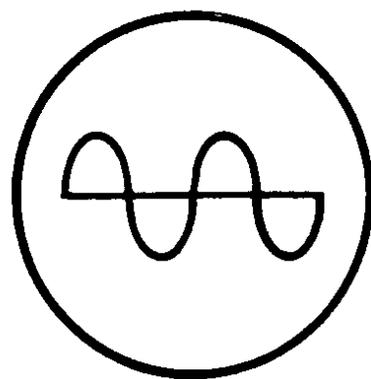


Fig. 7.

When operating the instrument as an electronic switch, do not synchronize or adjust the 'scope sweep at a multiple or sub-multiple of the switching frequency as the traces will appear as a series of dots or dashes (see Fig. 5). The latter phenomenon is unavoidable when observing low frequency signals, where a high

switching frequency is necessary to avoid serious flicker. In general, the switching frequency should always be adjusted to give as solid trace as possible, although the dot or dash pattern is very often unavoidable. Another thing that should be avoided is setting the switching frequency too low, as doing so will result in a noticeable flicker in the trace due to the limited persistence of an image on the screen.

As the final step in becoming acquainted with the electronic switch controls, vary individually the AMPLITUDE 1 and AMPLITUDE controls, noting that each controls the amplitude of one of the traces. Then adjust both traces to the same amplitude and use the POSITIONING control to superimpose one trace upon the other (Fig. 6). Finally, reduce the amplitude of one trace to zero, noting how in this manner the electronic switch can be used to provide a base line (Fig. 7).

## applications

### CHECKING AMPLIFIER DISTORTION

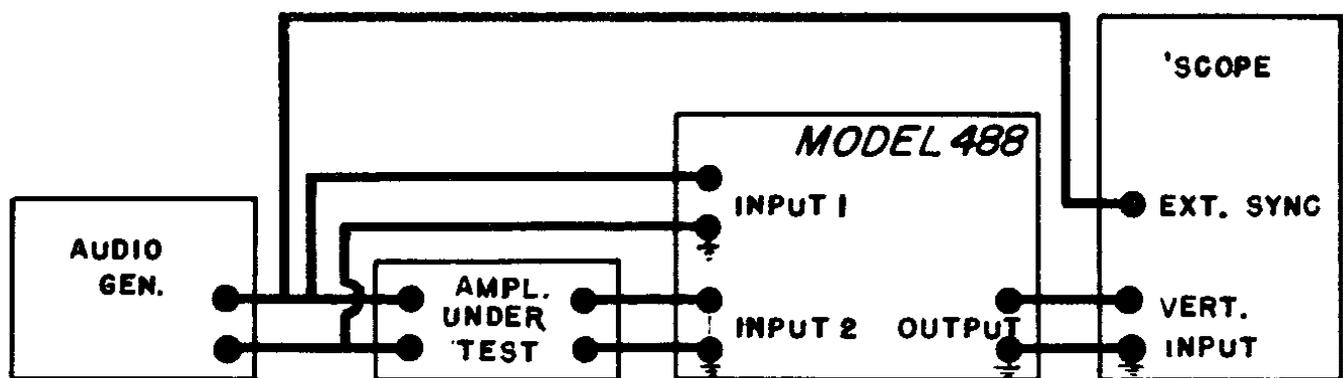


Fig. 8.

Fig. 8 illustrates the connections for viewing simultaneously the input and output waveforms of either a single stage or a complete amplifier. A sine or square wave signal is applied to the amplifier and the "1" input of the electronic switch. The output of the amplifier is applied to the "2" input. The output of the electronic switch is connected to the vertical input of the 'scope. Note that external synchronization is used and the synchronizing signal is obtained from the audio generator output. For very accurate checks of distortion, adjust the AMPLITUDE 1 and 2 controls until the two traces are of equal amplitude and then use the POSITIONING control to superimpose one upon the other. When this has been done, accurate point-to-point comparison of the traces will make any distortion apparent.

## ESTABLISHING A REFERENCE VOLTAGE LEVEL

An extremely rapid method for simultaneous waveform observation and accurate peak-to-peak voltage measurement is possible with the combination of a voltage calibrator (such as EICO Model 495) and an electronic switch. Fig. 9 illustrates the connections.

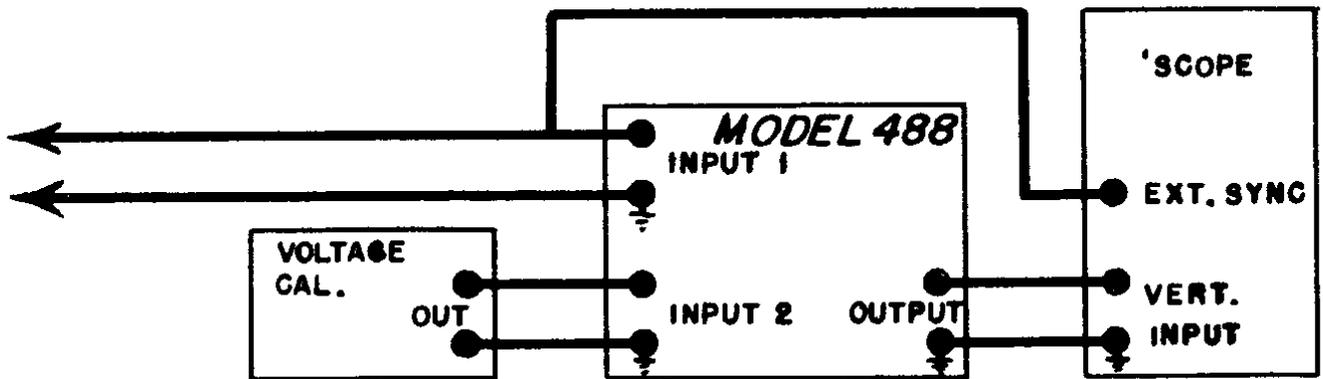


Fig. 9.

Before the signal is connected to input "1" however, the "1" and "2" inputs must be connected in parallel and the two electronic switch amplifiers adjusted for equal gain. The signal voltage for these initial adjustments (obtained from the voltage calibrator) should be in the same range as the voltages to be measured. For example, if voltages from 10 to 100 volts peak-to-peak are to be measured, use any voltage from 20 to 50 volts peak-to-peak for the initial gain adjustments. Use the POSITIONING control to superimpose one trace on the other and then adjust the AMPLITUDE 1 and 2 controls until the two traces exactly coincide at a suitable deflection for the range of voltages to be measured. When this is completed, the signal connection to the electronic switch can be made.

The appearance of the calibrator output (usually a 60 cycle square wave) will depend on the frequency of the signal (with which the 'scope sweep is synchronized). It will vary from a stationary square wave (Fig. 10) when the signal

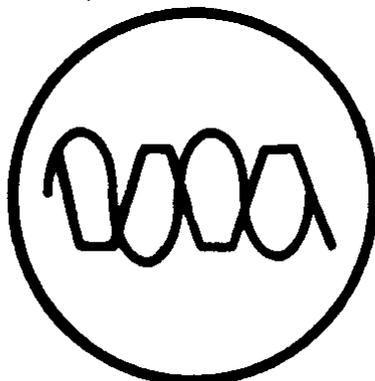


Fig. 10.

frequency is 60 cycles or a sub-multiple thereof to two bright horizontal lines with a dimmer luminous area between them at high sweep frequencies (Fig. 11). In any case it is only the peak-to-peak amplitude of the calibrator pattern which is of interest. The calibrator output is adjusted with the calibrator control only (do not touch the AMPLITUDE 1 and 2 controls after the initial adjustments are made for equal gain) until the calibrator pattern has the same peak-to-peak amplitude as the signal pattern and then the signal amplitude may be read directly from the calibrator dials in peak-to-peak volts.

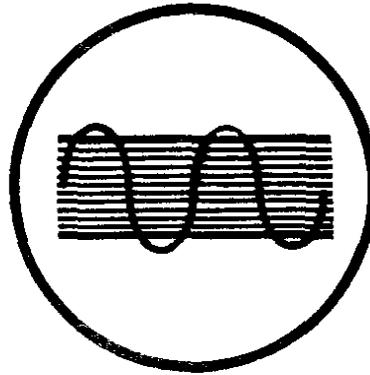


Fig. 11.

VOLTAGE AMPLITUDE COMPARISON

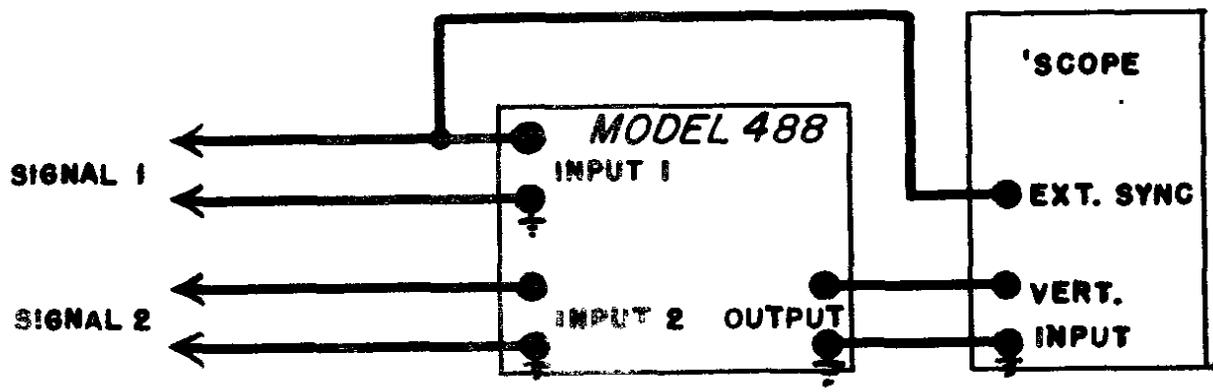


Fig. 12.

The method for voltage amplitude comparison is similar to the method just described for establishing a voltage reference level. Fig. 12 illustrates the connections. Here the voltage calibrator is replaced by another signal source but, just as before, the two electronic switch amplifiers must be adjusted for equal gain. Either one of the signal sources may be used for the initial gain adjustments. Once this has been done, the two signals will appear on the screen in the correct amplitude relationship.

PHASE-SHIFT MEASUREMENT

The method and connections for phase-shift measurement is the same as that for

voltage amplitude comparison. While equal gain adjustment is not a necessity here, it is certainly advisable however. Phase-shift (illustrated in Fig. 13)

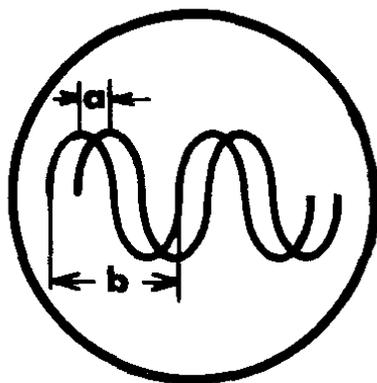


Fig. 13.

is approximately measurable by dividing the horizontal distance (a) between corresponding adjacent peaks of the two traces by the horizontal distance (b) occupied by a full cycle of the signal and multiplying the quotient by 360 degrees (degrees in a full cycle). Obviously, this method is not too good for measuring very small phase differences due to the difficulty in measuring the distance between adjacent corresponding sine-wave peaks.

### CHECKING CROSS-OVER NETWORKS

Cross-over (frequency divider) networks are used a good deal in the multiple-speaker systems incorporated in high-fidelity audio installations. They consist of high and low pass filters connected in parallel which are interposed between the amplifier output and the speaker voice coils. The "tweeter" speaker is connected to the output of the high-pass filter and the "woofer" speaker to the output of the low-pass filter. In this way, high frequencies are confined to the "tweeter" and low frequencies confined to the "woofer".

The cross-over frequency is that frequency which is attenuated equally by the high-pass and low-pass filters. The optimum cross-over frequency depends on the characteristics of the system and is generally chosen to match the characteristics of the "woofer" and "tweeter".

To check the cross-over frequency is often a job for the technician, particularly if the cross-over network is one he is designing himself. By the method given here, the cross-over frequency may be ascertained and changes made in the circuit to achieve the desired results. Fig. 14 below illustrates the connections.

The electronic switch amplifiers must first be adjusted for equal gain as described above, using the audio generator as a signal source (do not touch the AMPLITUDE 1 and 2 controls thereafter.). Once this has been done, the con-

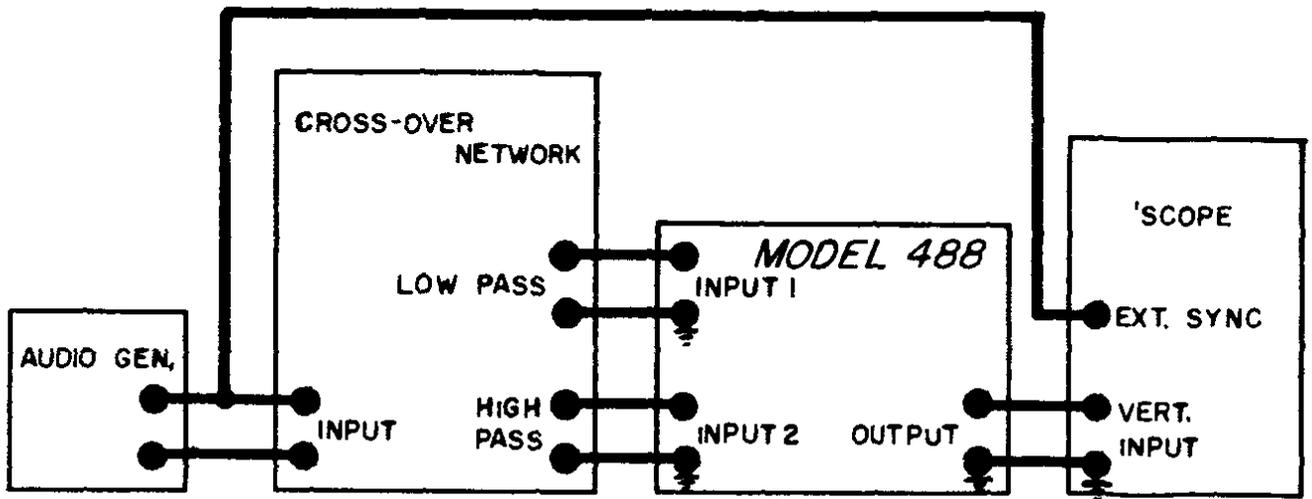


Fig. 14.

nections shown in Fig. 14 can be made and the audio generator frequency varied through the audio spectrum until the two sine wave traces on the screen are equal in amplitude. The frequency at which the audio generator is set when this result is obtained is the cross-over frequency.

### VIEWING MORE THAN 2 SIGNALS

By using Model 488's in tandem, as many patterns can be observed simultaneously on the screen of a single 'scope as desired; two in tandem for three pattern; three in tandem for four patterns, and so on. For example, the connections for viewing three patterns are as follows (see Fig. 15):

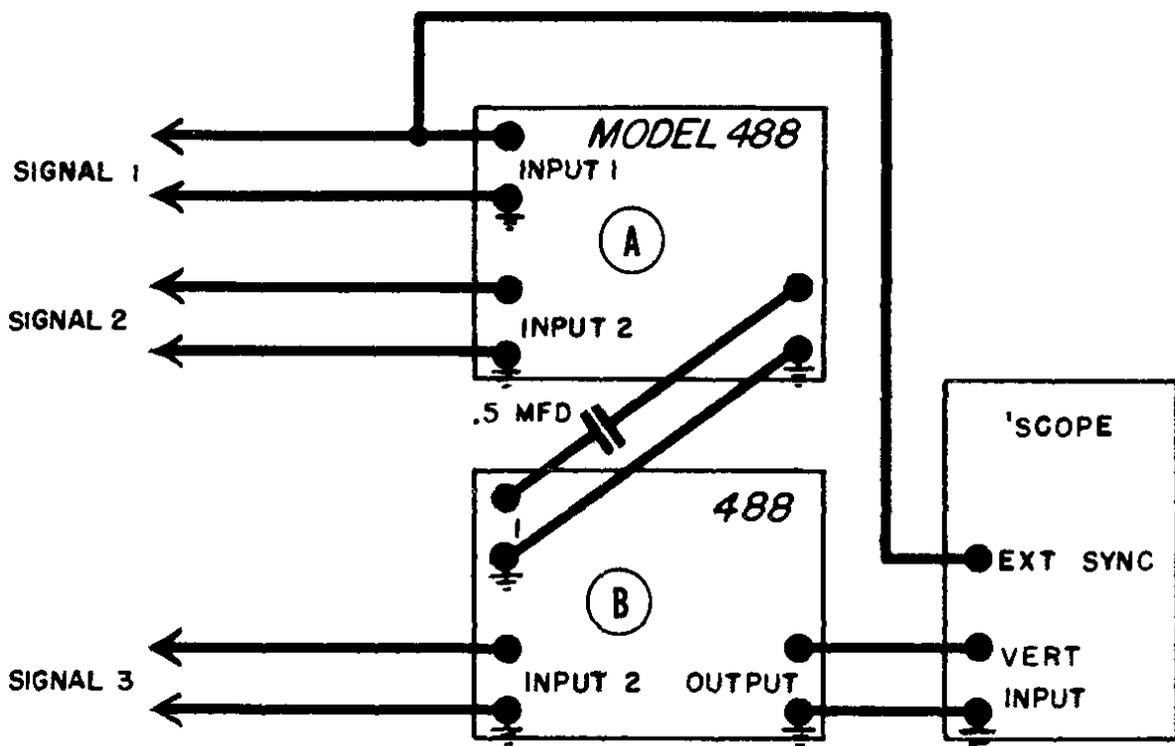


Fig. 15.

Connect signals 1 and 2 to inputs 1 and 2 respectively of electronic switch A. Connect the output of electronic switch A (through a .5 mf coupling capacitor) and signal 3 to inputs 1 and 2 respectively of electronic switch B. Connect the

output of electronic switch B to the 'scope input. As usual, the sync voltage is obtained from the signal source.

### SQUARE WAVE TESTING:

The square wave signal provided by the Model 488 Electronic Switch can be used to check amplifiers as to frequency response, phase shift, transient response, deficient design, or faulty components. The equipment is set up as shown in Fig. 16.

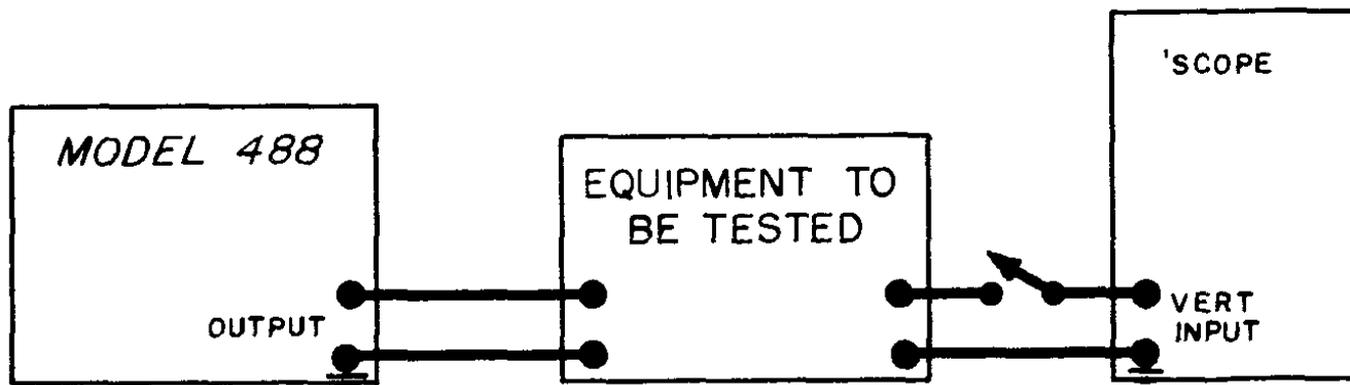


Fig. 16.

First, as a means of comparison, the square wave output from the electronic switch is viewed on the 'scope. The horizontal sweep of the 'scope should be adjusted so that at least two full cycles can be seen on the screen. (Fig. 17a shows one full cycle of a perfect square wave). The 'scope is then connected to the output of the amplifier under test so that the modified square wave can be viewed on the screen. Possible output wave shapes are shown in Fig. 17b to 17i, and the significance of each wave shape is explained below.

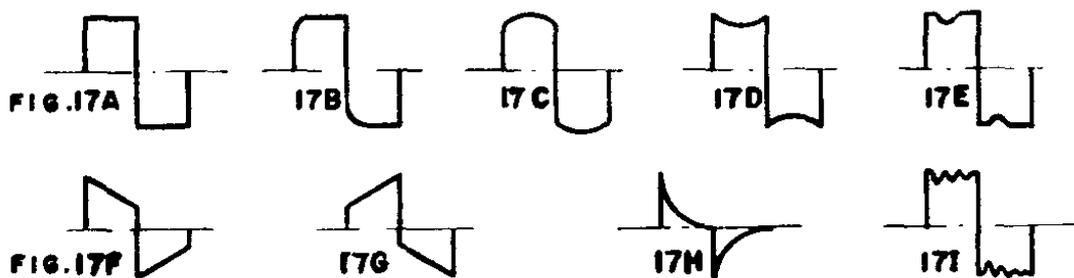


Fig. 17b shows "rounding" of the leading edge of the square wave. This indicates a drop-off in gain at high frequencies. "Rounding" will generally be observable when there is a substantial drop in the gain by the tenth harmonic (or less). Therefore, if a 2 Kc square wave fed to the amplifier is reproduced on the 'scope without "rounding", the amplifier is flat to  $10 \times 2 \text{ Kc} = 20 \text{ Kc}$ .

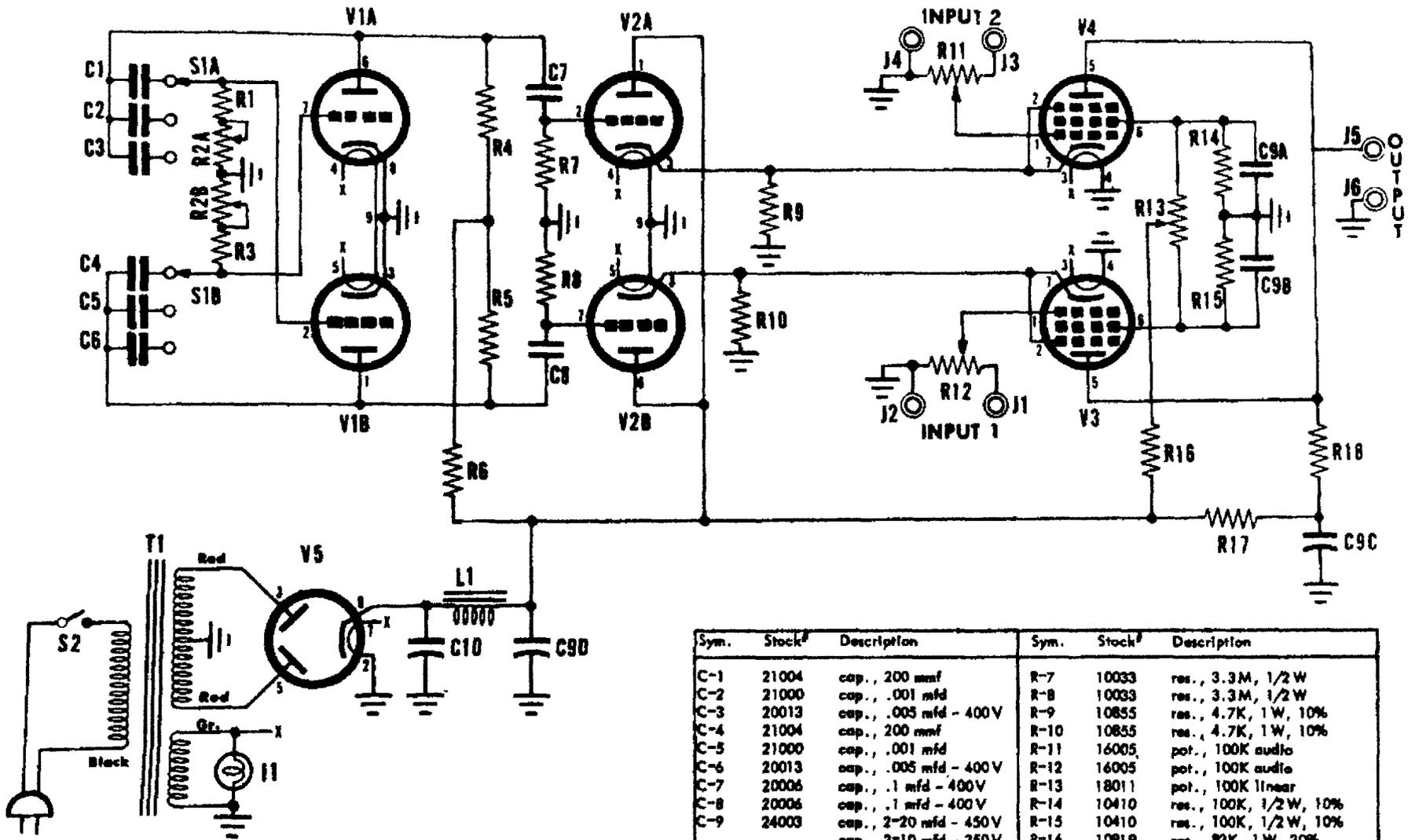
Fig. 17c shows the effect of increased gain and Fig. 17d shows the effect of decreased gain at the square wave frequency. Fig. 17e indicates lowered gain at a narrow frequency band. If the square wave frequency is brought into this narrow frequency band, Fig. 17d will result.

If, at low frequencies, there is phase shift in the leading direction, or a drop-off in gain, the square wave will be tilted as in Fig. 17f. If there is phase shift in the lagging direction, the top of the square wave will be tilted as in Fig. 17g. The steepness of the tilt is proportional to the amount of phase shift. Phase shift is not important in audio amplifiers, although the ear is not entirely insensitive to it. In television and 'scope amplifiers, however, phase shift should not be tolerated.

Fig. 17h shows the pulse output from the amplifier that results when the square wave has undergone differentiation. This will happen when the grid resistor or the coupling condenser is too low in value or if the coupling condenser is partially open. Lastly, Fig. 17i, shows a square wave with damped oscillations following the leading edge. This results when a high frequency square wave is fed to an amplifier in which distributed capacities and lead inductances resonate at low frequencies. In television and 'scope amplifiers it may result from an undamped peaking coil.

### EICO REPAIR SERVICE

If your instrument fails to function properly and the cause of the trouble can not be found, you may return it to the EICO repair department where it will be repaired at a charge of \$4.00 plus the cost of parts. (If your instrument has been built from the kit form, refer to the complete statement of the EICO servicing policy in your construction book.) Pack carefully and ship by prepaid Railway Express if possible. Return shipment will be made by express collect.



**VOLTAGE CHART**

Pin NO.	1	2	3	4	5	6	7	8	9
V1-12AU7	86	-1B	0	6.3AC	6.3AC	86	-1B	0	0
V2-12AU7	340	0	32	6.3AC	6.3AC	340	0	32	0
V3-6AU6	0	32	6.3AC	0	270	70	32	-	-
V4-6AL6	0	32	6.3AC	0	270	140	32	-	-
V5-6X5	0	0	260AC	-	260AC	-	6.3AC	350	-

All measurements made with a vvm. All controls set at the extreme counter-clockwise position with the exception of the FREQ. SELECTOR switch, which is set at "50 - 400".

Sym.	Stock <sup>#</sup>	Description	Sym.	Stock <sup>#</sup>	Description
C-1	21004	cap., 200 mmf	R-7	10033	res., 3.3M, 1/2 W
C-2	21000	cap., .001 mfd	R-8	10033	res., 3.3M, 1/2 W
C-3	20013	cap., .005 mfd - 400V	R-9	10855	res., 4.7K, 1 W, 10%
C-4	21004	cap., 200 mmf	R-10	10855	res., 4.7K, 1 W, 10%
C-5	21000	cap., .001 mfd	R-11	16005	pot., 100K audio
C-6	20013	cap., .005 mfd - 400V	R-12	16005	pot., 100K audio
C-7	20006	cap., .1 mfd - 400V	R-13	18011	pot., 100K linear
C-8	20006	cap., .1 mfd - 400V	R-14	10410	res., 100K, 1/2 W, 10%
C-9	24003	cap., 2-20 mfd - 450V	R-15	10410	res., 100K, 1/2 W, 10%
C-10	23005	cap., 2-10 mfd - 350V	R-16	10819	res., 82K, 1 W, 20%
L-1	92000	bulb #47	R-17	10819	res., 82K, 1 W, 20%
L-1	34000	choke, 5 hy.	R-18	10022	res., 47K, 1/2 W, 20%
R-1	10409	res., 560K, 1/2 W, 10%	S1	60017	switch, 3 pos. 2 pole, rotary
R-2	18003	pot., dual 4 meg	S2	61000	switch, 5PST, toggle
R-3	10409	res., 560K, 1/2 W, 10%	V1	90013	tube, 12AU7
R-4	10521	res., 47K, 1/2 W, 5%	V2	90013	tube, 12AU7
R-5	10521	res., 47K, 1/2 W, 5%	V3	90020	tube 6AU6
R-6	10908	res., 100K, 2 W	V4	90020	tube, 6AL6
			V5	90009	tube, 6X5

When ordering replacement parts, please include the stock number of the part requested as well as the description.

**MODEL 488 ELECTRONIC SWITCH**

