HYSTERESIS CURVE PLOTTING

APPLICATION NOTE 108

HEWLETT PACKARD hp MOSELEY DIVISION

HP AN108

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HYSTERESIS CURVE PLOTTING

433 NO. FAIR OAKS AVENUE, PASADENA, CALIFORNIA

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The usefulness of recorded hysteresis curves; B-H, force-displacement, or thermodynamic, has long been recognized in system testing and analysis. Permanent records of hysteresis curves have often been limited to small inaccurate pictures of oscilloscope traces that are difficult to graphically analyze. The following should help to catagorize and simplify some of the presently available methods for obtaining permanent records of hysteresis curves using X-Y recorders.

In each of the following setups, the key instrument is the Moseley 101 Waveform Translator. Its function is to transform via sampling techniques, the high frequency data to a low frequency that can easily be handled by an X-Y recorder. The Moseley 101, when operating in an X-Y mode rather than Y-T (time), requires an external trigger. The external trigger source must be synchronized to within a fraction of a cycle per second of the signal generator. The following setups demonstrate methods of obtaining the external trigger.

METHOD I

TRIGGER VIA INDEPENDENT GENERATOR

The first technique, (Figure 1) is to adjust two independent oscillators until their frequencies are within a fraction of a cycle per second. One oscillator excites the test body with a sin wave, the other supplies a square wave trigger signal for the Moseley 101. The oscillator frequencies should be matched to within a 1/4 or 1/5 of a cycle per second. This would allow 4 to 5 seconds for the trace to be made. This technique, although difficult to maintain (because of oscillator frequency drift), is effective below 1 kc.

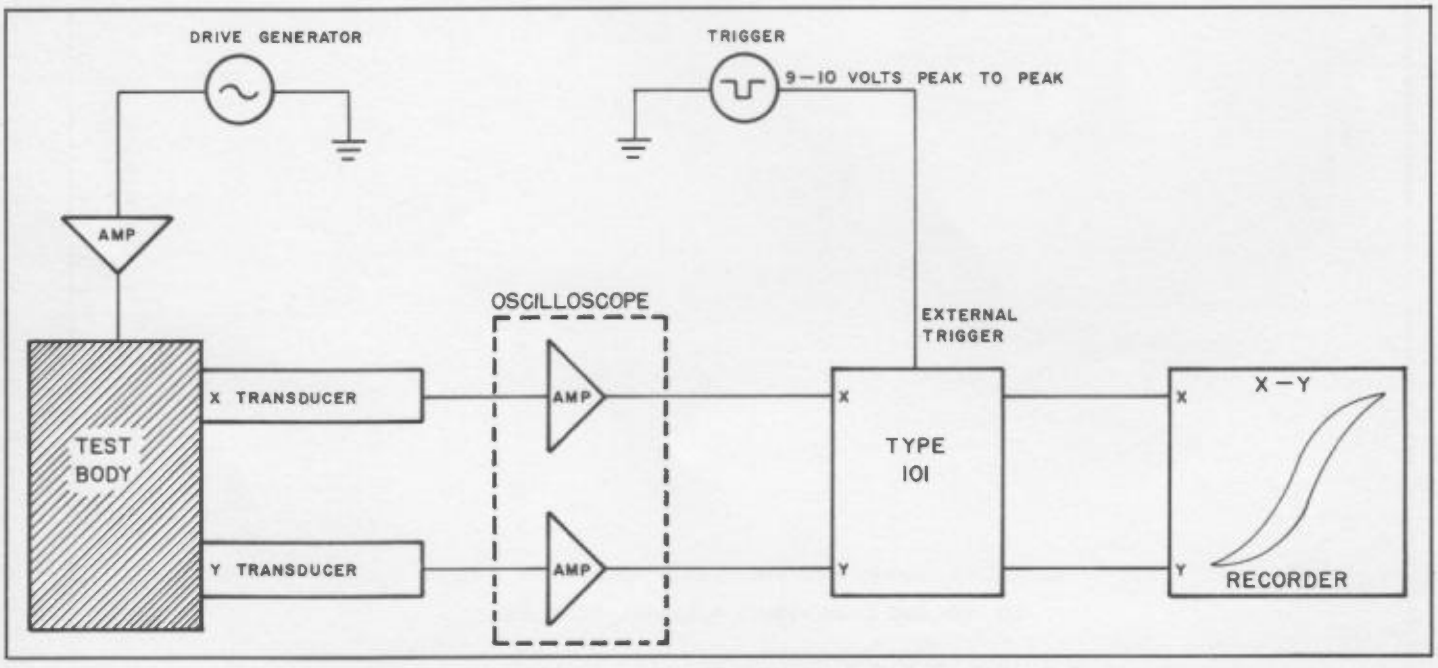


FIGURE 1. TRIGGER VIA INDEPENDENT GENERATOR

METHOD II

TRIGGER VIA PHASE SHIFT

The second system (Figure 2a, b) uses the phase lag dial on a Model 203A as a manual scan control to develop the trigger for the Moseley 101. This setup can be used at frequencies up to 60 kc (limited by the Model 203A). The only limitation here is that the smoothness of the trace is, to some extent, determined by the operator's care in turning the phase dial.

NOTE: In methods one and two a spike may appear in the X-Y trace. The Ramp Generator and Comparator Card in the Moseley 101 is not used in this mode of operation. Removal of this card will eliminate the spike.

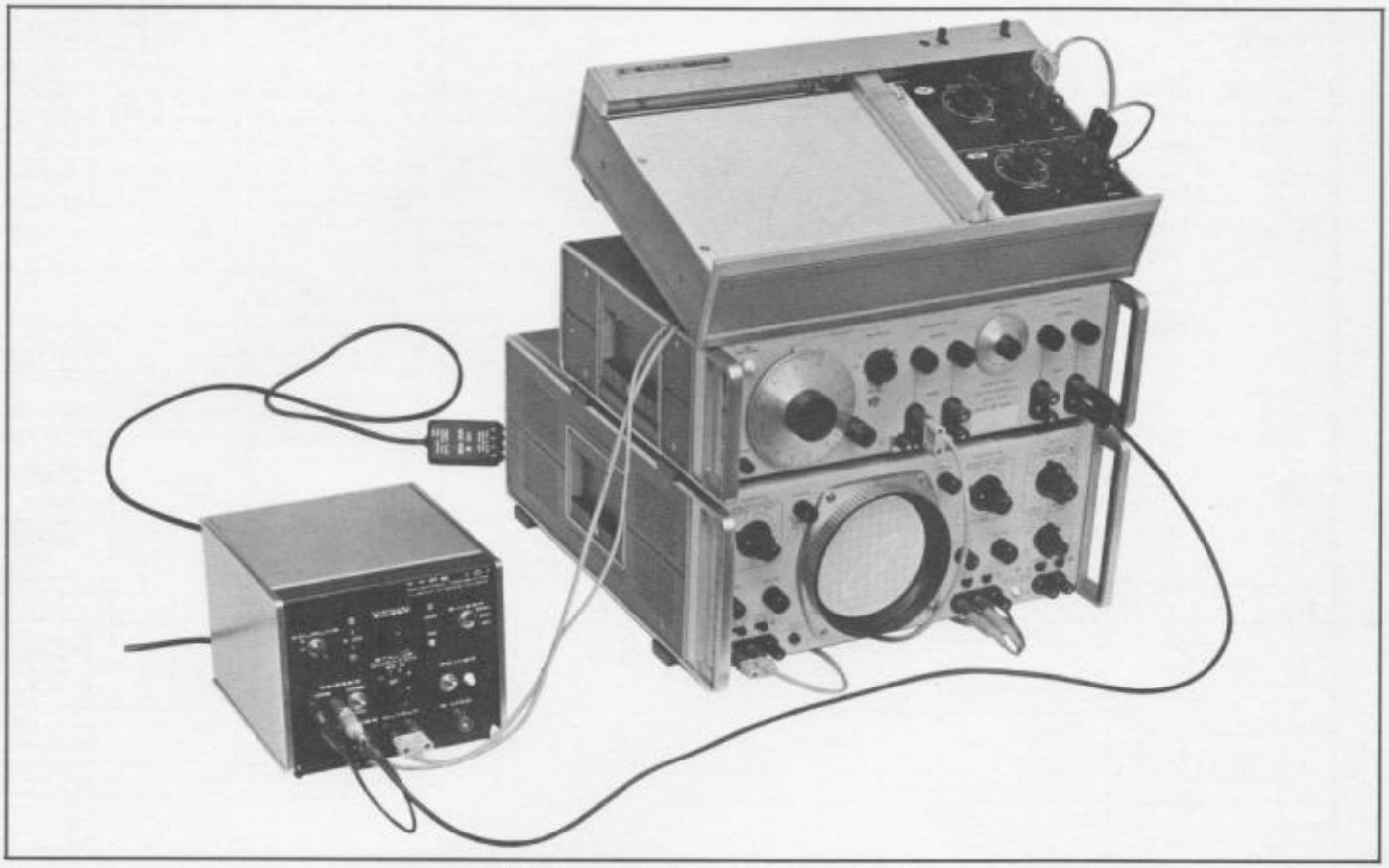


FIGURE 2a. METHOD II IN OPERATION

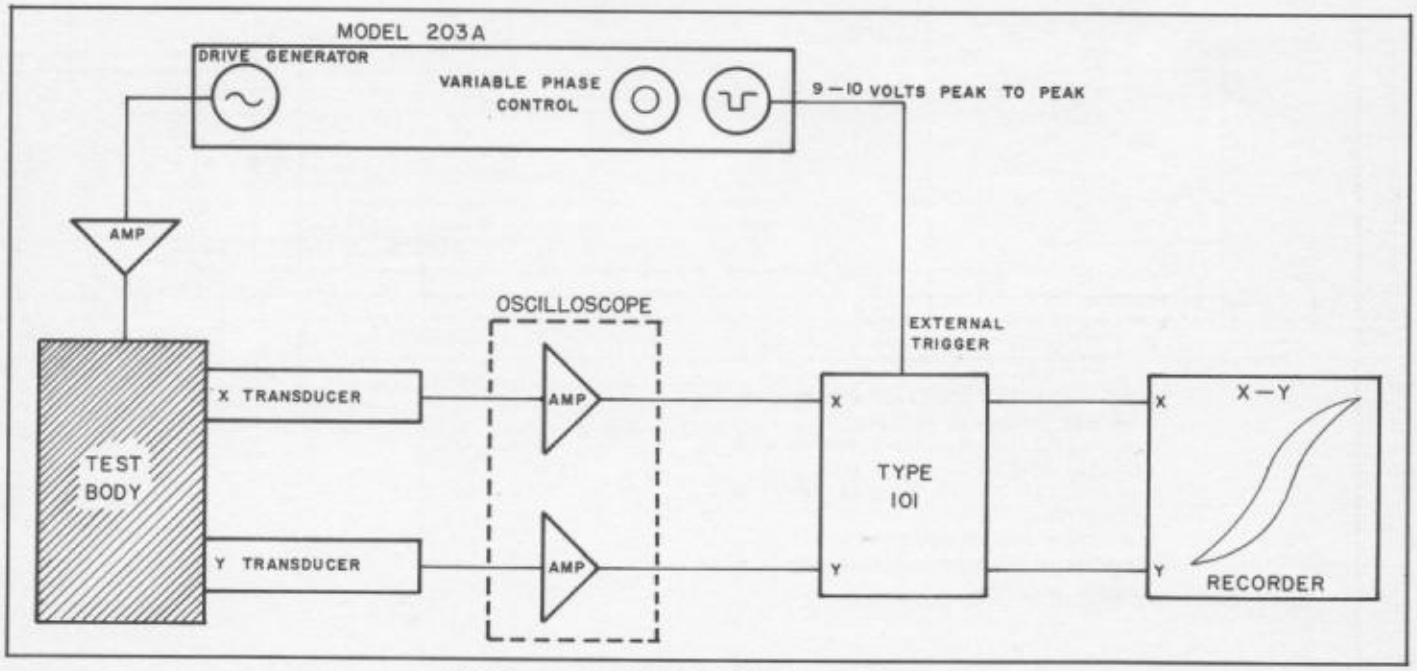
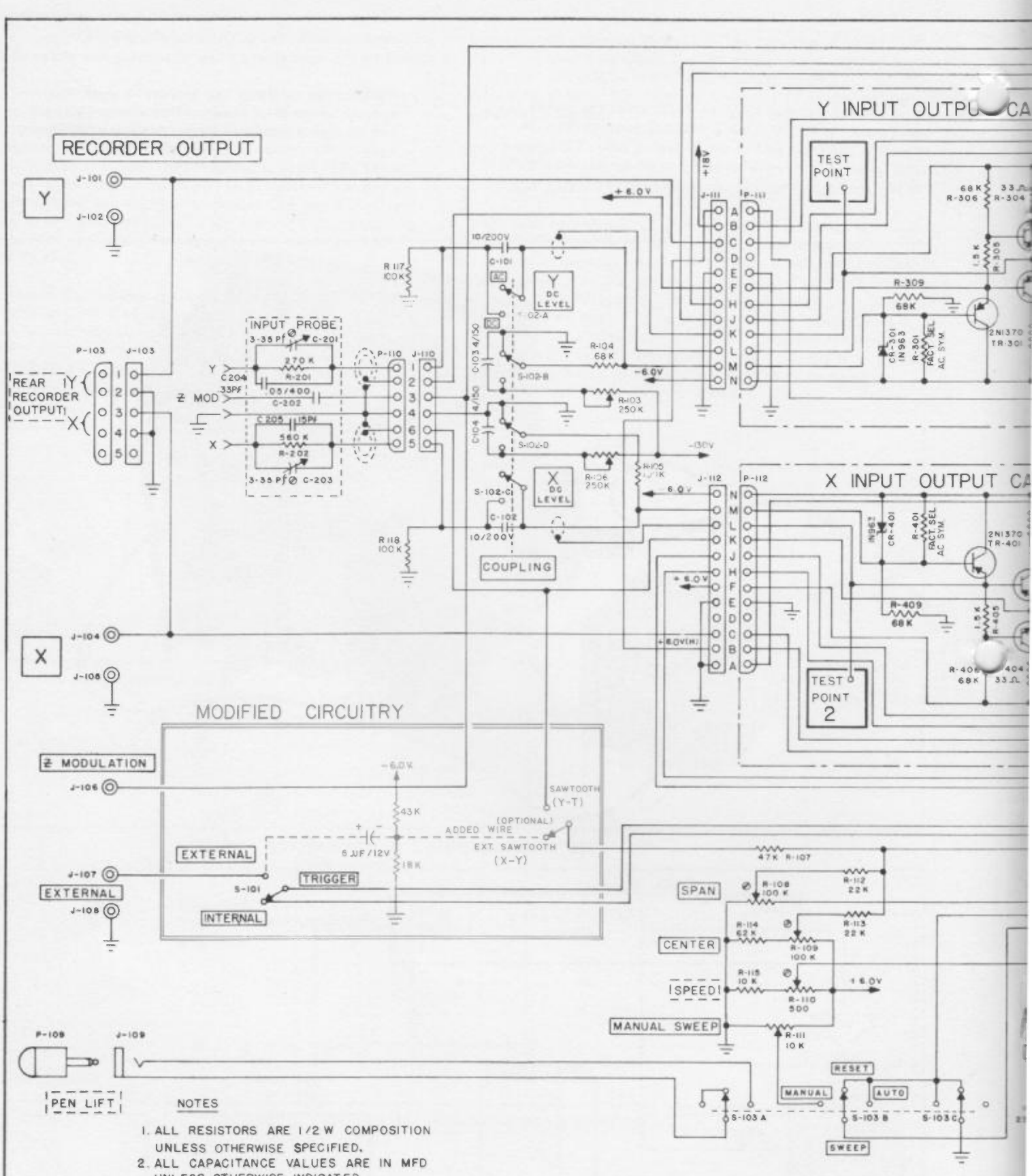
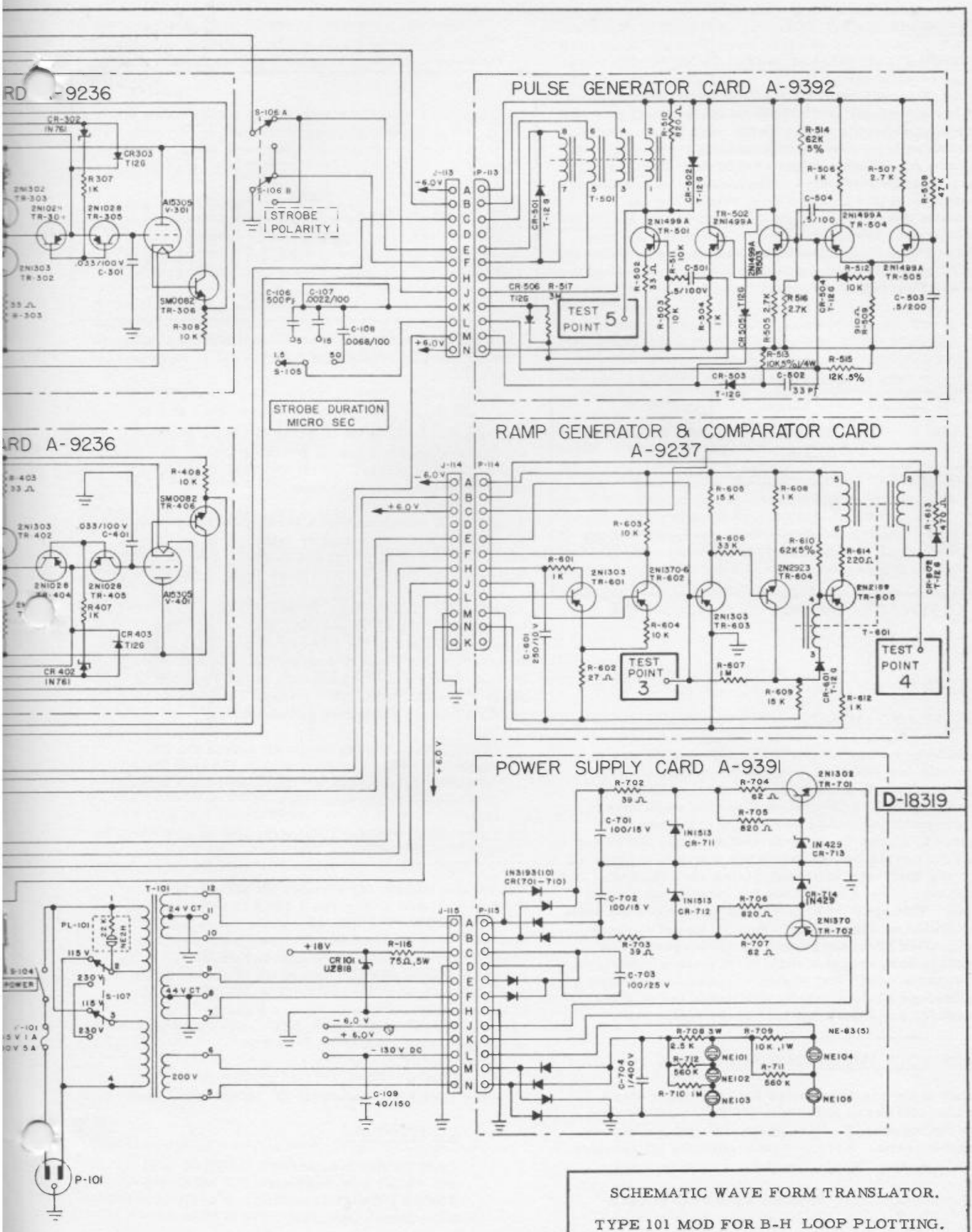


FIGURE 2b. TRIGGER VIA PHASE SHIFT



NOTES

1. ALL RESISTORS ARE 1/2 W COMPOSITION UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITANCE VALUES ARE IN MFD UNLESS OTHERWISE INDICATED.
3. ALL BOXED TITLES INDICATE FRONT PANEL LOCATION.
4. ⌀ SCREW DRIVER ADJUSTMENT.
5. ALL DASHED BOXED TITLES INDICATE REAR PANEL LOCATION.


PULSE GENERATOR CARD A-9392
RAMP GENERATOR & COMPARATOR CARD A-9237
POWER SUPPLY CARD A-9391
A-9236
A-9236
STROBE POLARITY
STROBE DURATION MICRO SEC
TEST POINT 5
TEST POINT 3
TEST POINT 4
D-18319
SCHEMATIC WAVE FORM TRANSLATOR.
TYPE 101 MOD FOR B-H LOOP PLOTTING.

METHOD III

TRIGGER VIA AUXILIARY OSCILLOSCOPE

The third setup (Figure 3) requires an oscilloscope that has a sawtooth available from either the rear horizontal deflection plates or the front panel. The sawtooth voltage must be attenuated to 4 - 5 volts peak to peak. Then a slight modification, discussed later, must be performed to the Moseley 101. The advantages of this setup is being able to use the automatic sweep mode in the 101 which will give traces free of any ripples that the operator may have induced in the Figure 2 setup and allows the remote pen lift capabilities of the recorder to be interlocked with the Waveform Translator.

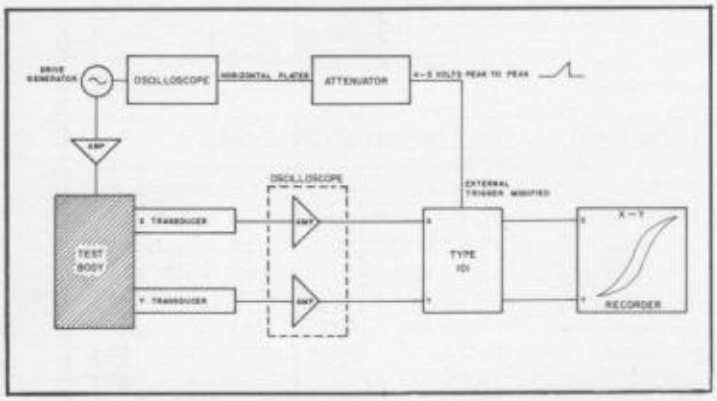


FIGURE 3. TRIGGER VIA OSCILLOSCOPE

METHOD IV

TRIGGER AND AMPLIFICATION VIA OSCILLOSCOPE

It should be remembered that the Moseley 101 was primarily developed for accurately recording oscilloscope traces with Moseley X-Y plotters. As such, the vertical and horizontal oscilloscope amplifiers could replace the transducer amplifiers shown in Figures 1, 2, and 3. In many oscilloscopes the sweep and sync remain operative and are simply disconnected from the horizontal deflection plates when the horizontal amplifier is being used for an external X input signal. This leads to Figure 4 which provides the same capabilities as Figure 3 but requires an oscilloscope modification (discussed under Oscilloscopes). The advantage here is that a slight modification (usually no more than a switch that shorts or opens 2 places in the oscilloscope circuit) usually eliminates the need for transducer amplifiers and thus saves equipment.

TRANSDUCER AMPLIFICATION METHODS

In each of the previous setups the transducer amplifier characteristics necessary for good performance were not mentioned. Here again, several connection variations exist. Without modification the 101 operates best if the input signals are in the following range:

X	55 to 100 volts Peak to Peak
Y	26 to 60 volts Peak to Peak

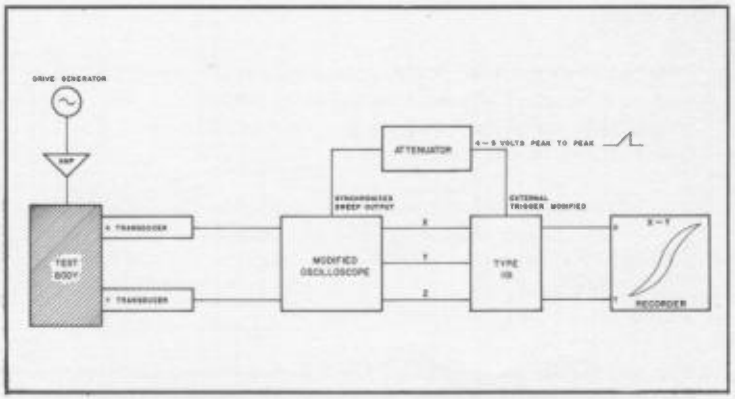


FIGURE 4. TRIGGER AND AMPLIFICATION VIA OSCILLOSCOPE

This means if one of the first three setups is being used, the amplifiers should put the signal in this range. If the signal is larger, the 101 will clip; if smaller, noise from the 101 will appear.

A method of operating with a lower voltage level is by shorting out the attenuator resistors in the 101 oscilloscope probe (R-201 and R-202). The 101 input will then only require 2 to 5 volts Peak to Peak.

This has the disadvantage of lowering the input impedance of the 101 to approximately 20K. The output impedance of the transducer amplifier must then be less that 200 ohms to prevent the lowering of the 1% system accuracy. Depending on the application the H-P Models 450A, 466A, 465A, and 467A are all possibilities for the transducer amplifier.

> CAUTION: Shorting the probe leaves the 101 circuitry without protection. Do not hook the modified probe to the oscilloscope plates without first checking the voltages.

101 EXTERNAL TRIGGER MODIFICATION FOR AUTOMATIC PLOTTING

The modification to the Moseley 101 necessary for the set-up shown in Figures 3 and 4 is indicated in red on D-18319. The indicated sawtooth switch is optional. For a permanent X-Y setup the switch is unnecessary but if the 101 is also to be used for Y-T recording the switch will return the recorder to an unmodified state. The resistors shown are Not those of the attenuator shown in Figure 3 and 4. The resistors establish a D. C. bias to insure sampling of the complete trace.

The required components for modification are:

COMPONENTS	P/N
6mf/12 volt Capacitor	0180-0340
18K 5% 1/2 watt Resistor	0686-1835
43K 5% 1/2 watt Resistor	0686-4335
Slide Switch (optional)	3101-0011

All components for the 101 modification can easily be added to the bottom of the 101. The vacant pin "D" on each printed circuit connector provides convenient tie points.

The optional switch can be mounted on the rear panel. For convenience the strobe polarity switch on the rear panel could be utilized for this function since this feature is not essential.

> NOTE: The function of the strobe is to indicate on the oscilloscope face the point of the waveform being sampled. The strobe polarity switch determines weather the trace is either brightened or blanked on the oscilloscope face.

The wires can be removed from the strobe polarity switch and deadened or shorted to give permanent brighting or blacking of the strobe. The switch can then be used as the optional external sawtooth switch.

> CAUTION: The attenuator shown in Figures 3 and 4 is very important for protecting the 101 circuitry. It should reduce the sawtooth voltage to 4 or 5 volts peak to peak. The design of the attenuator depends upon the oscilloscope and is left up to the operator.

OSCILLOSCOPE MODIFICATION

In all the setups, oscilloscope amplifiers can be used to amplify the transducer signals. The Hewlett-Packard 130C oscilloscope can be purchased with rear deflection plate terminals that easily connect to the Moseley 101. The model number to order is C41-130C. When connecting the 101 oscilloscope probe to the deflection plates, disconnect the Z axis shorting strap on the back of the oscilloscope case. A partial list of oscilloscopes and the methods of connecting to their deflection plates when used as amplifiers only, is attached.

If you desire to use the oscilloscopes both as a transducer amplifier and to obtain a synchronized sweep as in Figure 4, then actual oscilloscope modifications rather than just connections must be made. For this setup the oscilloscope must be equipped with a separate horizontal attenuator and sweep rate control (Example Model 130C). Usually two oscilloscope circuits must be modified.

1. Normally when the oscilloscope is used in the X-Y mode, power is removed from several tube plates in the sweep circuit. This voltage must be reapplied to obtain the sawtooth required by the Moseley 101.

2. Starting the sweep will activate the blanking circuit since we are making a continuous trace the blanking circuit must be disabled. Usually nothing more is required that removing power from the blanking tube circuit.

The mounting of a double pole, single throw switch on the oscilloscope to perform the appropriate switching for the sweep and blanking circuits is probably desirable. Note that even though the sweep rate switch will not control the oscilloscope picture, the length of the sweep sawtooth wave will determine the area of the hysteresis curve to be sampled. The sweep rate should be adjusted to allow the complete curve to be sampled once. This can easily be set by turning the manual sweep control on the 101 and watching the strobe move on the oscilloscope face and then adjusting the sweep rate on the oscilloscope. Information on this modification for some oscilloscopes is available. Step by step modification procedures are not available.

MERITS OF THE VARIOUS SETUPS

Many connection techniques are available with variations existing mainly between the quantity of equipment required and the ease of setting it up. For permanent installations Figure 4 is best because of the minimum amount of equipment involved. For a temporary setup such as a demonstration, Figure 2 with an oscilloscope as the transducer amplifier is easiest to achieve since no modifications are required.

Many combinations of equipment not mentioned here could be used. In Figure 3 a Model 3300A oscillator could replace the drive generator and oscilloscope. A triangle (not sawtooth) generator at one half the drive generator frequency (to obtain the same duration of a positive going ramp function) could be used to simultaneously drive the modified Moseley 101 and the external sync input of the Model 3300A. Thus, numerous combinations of equipment can meet a wide variation of system requirements.

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