OPERATING INSTRUCTIONS

JACKSON MODEL NO. 521 OSCILLOGRAPH

NOTE: In order that you may realize the most benefit from ownership of this instrument it is recommended that you carefully read the following instructions. No attempt will be made to completely cover all the uses of the Cathode Ray Oscillograph as this would be beyond the scope of these instructions. To fully acquaint yourself with the general theory of this type of equipment, we refer you to such books as Rider's "Cathode Ray Tube at Work", and periodical matter on the subject. We will, however, thoroughly explain the operation and describe briefly some of the most common uses of this instrument.

1 - GENERAL DESCRIPTION: This instrument is a self-contained unit being powered directly from a 110-volt 60 cycle supply. In order to widen its scope a vertical amplifier has been incorporated to increase the vertical deflection sensitivity throughout the audio and lower radio frequency spectrum.

2 - No horizontal amplifier is provided within the instrument. The horizontal deflection sensitivity is controlled by the sensitivity of the Cathode Ray tube itself. An A.C. sweep of the line power frequency is provided to supply a horizontal time axis at that frequency. For other timing frequencies an external timing voltage may be connected to the horizontal input posts direct.

3 - A linear horizontal timing circuit is not included in the instrument. It is not necessary for a large majority of the applications of the instrument and would so increase the cost to a value which would be prohibitive for many uses.

4 - Both the horizontal and vertical input circuits are provided with gain controls which control the deflection sensitivity regardless of the position of the "Horizontal Input" selector switch. Direct current voltages may be measured on the vertical or horizontal plates with this instrument.

5 - Two calibrated screens are furnished, one calibrated in arbitrary units and the other in kilocycles off resonance for visual selectivity tests. All tubes are supplied and installed within the instrument, which is ready to operate.

6 - ELECTRICAL SPECIFICATIONS:

Power supply: -
- Voltage - - - - - - - - - 110-120 volts A.C.
- Frequency - - - - - - - - 50-60 cycles
- Power consumption - - - 30 watts
- Fuse Protection - - - - .75 amperes

Vertical (Max.) input sensitivity: -
- Amplifier ON - - - - - - 1 volt A.C. RMS per inch
- Amplifier OFF - - - - - 75 R.M.S. volts A.C. per inch
- " " - - - - - 200 D.C. volts per inch

Horizontal (Max.) input sensitivity: -
- Direct - - - - - - - - - 75 RMS volts A.C. per inch
- " - - - - - - - - - 200 D.C. volts per inch

Input impedance to either Horizontal or Vertical input posts - - - - - - 1 megohm

Frequency range of vertical amplifier - - - 20 - 100,000 cycles

Maximum signal to input posts - - - - - - - 400 volts D.C.
300 volts A.C.

Tubes used: 1 Type 913 Cathode Ray Tube
1 " 6C6 Amplifier Tube
1 " 80 Rectifier Tube

7 - WARNING HIGH VOLTAGE: - Do not touch the grid cap of the 6C6 amplifier tube when the instrument is turned on. It will be noted by referring to the circuit diagram that "B" positive of the power supply is grounded. This places a high negative voltage on the grid circuit with respect to ground.

OPERATING CONTROLS

8 - The line power switch is located at the bottom of the instrument between the horizontal and vertical gain controls.

9 - The Intensity control adjusts the intensity of the spot or image upon the screen. The Focus control varies the focus or diameter of the spot to the desired size. These two controls are interlocking. For each position of the Intensity control a point will be found on the Focus control which produces an image of maximum distinctness. A spot of high intensity should not be allowed to remain stationary on the screen for any appreciable length of time. A brilliant stationary spot will burn the screen at that point and deteriorate the sensitized coating. When measuring D.C. the intensity control should be adjusted to produce a spot of moderate intensity and not allowed to remain stationary for periods of more than four or five minutes. In case no image is being observed, the intensity control should be turned counter-clockwise to a position of low intensity to preserve the life of the screen.

10 - The Vertical Input posts on the left of the instrument are connected to voltage to be observed for vertical deflection.

11 - The Horizontal Input posts on the right of the instrument connect to the horizontal deflecting plates when the "Horizontal Input selector" is set to a Direct position. Voltage applied to these posts produces horizontal deflection.

12 - The Vertical Gain control varies the sensitivity or height of the image on the screen with the Vertical amplifier either off or on.

13 - The Horizontal Gain control varies the sensitivity or width of the image on the screen.

14 - The Horizontal Input selector switch is divided into two sections. In the first two positions the vertical amplifier is ON. In the third and fourth positions the vertical amplifier is OFF, and the vertical deflecting plates are connected to the vertical input posts through the vertical input control.

15 - With the vertical amplifier either OFF or ON, the horizontal input is connected DIRECT to the input posts or to a 60 CYCLE SWEEP voltage within the instrument as designated by this switch.

APPLICATIONS

16 - The Cathode Ray tube is an inertialess indicator over an extremely wide range of frequencies. D.C. applied to its horizontal or vertical deflecting plates will change the position of the spot in a horizontal or vertical direction. Alternating currect moves the spot continuously at a speed dependent upon its frequency. When the frequency of the A.C. voltage, or a pulsating D.C. voltage occurs at a rate above the persistency of vision (approximately 14 cycles per second) the eye observes the phenomena as a line.

17 - A signal may be applied to the horizontal plates having a direct relation with that applied to the vertical plates producing a curve or pattern directly on the screen. This gives a complete graphic analysis of the phenomena under observation. The voltages maybe related with respect to time, frequency, phase or amplitude.

D.C. VOLTAGE MEASUREMENTS

18 - D.C. voltages may be measured on the vertical deflecting plates by turning the switch to the amplifier OFF section. With the switch in the "DIRECT" position, the spot will move in direct proportion to the applied D.C. voltage.

In the "60 cycle sweep" position, the horizontal gain control can be advanced to produce a horizontal line. Now when a D.C. voltage is applied to the vertical input post, the entire line will be deflected vertically by the voltage.

19 - D.C. voltage measurements may be made on the horizontal input posts by setting the switch to either direct position. The sensitivity of the horizontal deflecting plates is greater than the sensitivity of the vertical plates.

20 - D.C, potentials do not trace a line upon the screen but merely deflect the spot to a stationary position. Also, it will be noted that a D.C. potential cannot be applied to the vertical input posts with the vertical amplifier on. The amplifier does not respond to D.C., unless it is of a pulsating nature.

A.C. VOLTAGE MEASUREMENTS

21 - A.C. voltage measurements at any frequency including radio frequencies up to 100 megacycles can be made by connecting directly to the vertical or horizontal deflection plates (Amplifier OFF). The applied voltage will trace a line indicating the peak values of the voltage under measurement. Figure 1 on page 8 shows a pattern resulting when A.C. voltage is applied to the vertical input posts. Figure 2 shows horizontal deflection produced by A.C. Horizontal input.

22 - A.C. voltages from 10 cycles to 100 kilocycles may be measured on the vertical deflection plates with the vertical amplifier ON. This increases the voltage sensitivity of the vertical input circuit to approximately one volt RMS for one inch deflection. The gain of this amplifier drops sharply below a frequency of 30 cycles and above 100 kilocycles. The vertical gain control varies the input sensitivity of the amplifier over a wide range.

23 - It will be noted that an A.C. voltage applied to the vertical deflecting plates produces only a straight line. If at the same time, an A.C. voltage is applied to the horizontal deflecting plates, a two dimensional pattern will appear. This horizontal voltage may be an external timing voltage or the 60 cycle sweep provided within the instrument.

PHASE ANALYSIS

24 - The relative phase between two voltages of the same frequency can easily be checked by the use of this instrument. One voltage is applied to the horizontal and the other to the vertical input posts. If the voltages are in phase or 180 degrees out of phase, a straight line will be developed on the screen at an angle dependent upon the relative amplitude of the two voltages. If the two voltages applied are of equal amplitude, the line will be on an angle of 45 degrees. If the voltages are 90 or 270 degrees out of phase and the amplitude

of each are equal, a perfect circle will be developed. At phase angles between these values, ovals of various shapes depending upon the phase relation of the voltages, will appear. Figures 3, 4, 5, 6 and 7 illustrate the patterns obtained by various phase relations.

DISTORTION IN AUDIO AMPLIFIERS

25 - Distortion in audio amplifiers can be checked by connecting the input of the amplifier stage to one set of deflecting plates and the output of the stage to the other set of deflecting plates. It is generally advisable to apply the input signal to the vertical input post so the vertical amplifier may be used if necessary. A fixed frequency audio signal should preferably be applied to the amplifier input when making distortion tests. If the output wave is not amplitude or phase distorted, one of the patterns in Figures 3 or 7 will appear. If the input signal were exactly 180 degrees out of phase with the output signal, a single line pattern would result. In this case distortion would be indicated by a curved line. However, amplifiers usually have a certain amount of phase distortion. Phase distortion is not noticeable to the ear and therefore does not necessarily indicate that the stage is operating improperly.

26 - Very few amplifiers will be found which do not have a certain amount of phase distortion. Therefore the pattern observed will generally be an oval. Any irregularities in the oval indicate that distortion of the output wave is present. For example, if a square topped wave results from the output of an amplifier with sine wave input, the square top portion would appear as a straight horizontal line. If the input and output are in phase or 180 degrees out of phase, a pattern somewhat like Figure 8 would be developed. If the output were 90 degrees out of phase the same distortion would look like Figure 9. Any irregularities or non-symmetry of the pattern indicate that amplitude distortion is present.

27 - To check frequency distortion a variable frequency audio source is necessary. If the amplitude is constant throughout the frequency range no frequency distortion is present. At the same time amplitude distortion may be noted at the various frequencies under test, as indicated by the non-symmetry of the pattern.

VISUAL RESONANCE ANALYSIS

28 - This instrument can be used for making visual resonance tests in conjunction with any frequency modulated oscillator which supplies sufficient timing voltage to deflect the beam horizontally 1/2 inch. The Jackson Model 540 Oscillator is suitable for this purpose. The horizontal deflecting voltage as supplied by the instrument is applied to the horizontal deflector plates in "Direct" position with Vertical Amplifier on. The vertical input is connected to the output of the receiver circuit under test in accordance with the manufacturer's instructions. A vertical deflection of not more than 1/2 inch should be used on the tube for this purpose. With the amplifier gain at maximum the voltage required for this deflection will be approximately 1/2 volt. A calibrated frequency chart is provided for use with the Jackson Model 540 instrument. Relative output is indicated on this scale directly in "frequency off resonance". The stage is aligned so that the peak or resonance is on the exact center or "R" line of this scale. The circuits should be aligned so that the response pattern is symmetrical on either side of this resonance line. Further instructions should be obtained from the manual supplied with the frequency modulated oscillator and the set manufacturer's instructions, for the correct type of curve. A representative response curve is shown in Figure 10. In case the pattern develops only on one side of the tube screen, insert a 1/10 Mfd condenser in series with the horizontal timing voltage from the Oscillator.

LINEAR TIMING SWEEP

29 - In order to observe a recurrent wave form as a stationary pattern it is necessary to have a linear saw-tooth wave applied to the horizontal plates at the frequency of the signal under observation. If the sweep is linear the voltage wave form will be developed upon the screen with a true electrical relation with respect to time. A saw-tooth wave can be generated for this purpose in several ways. A potentiometer connected to a motor shaft supplying a constantly rising voltage which decreases to zero immediately after its maximum value, will supply a wave of this type. Thyratrons or gas filled triodes in special circuits are generally used for this purpose. Reference is made to technical matter on this subject, in case the owner wishes to incorporate a linear time axis on his instrument. The saw-tooth output voltage is applied to the horizontal deflecting plates with the horizontal input switch in the "Direct" position.

60 CYCLE HORIZONTAL SWEEP

30 - A 60 cycle horizontal sweep voltage is provided in the instrument when the horizontal input selector is turned to a "60 Cycle Sweep" position. This places an A.C. voltage on the horizontal plates which is sinusoidal and not linear. It enables an approximate study of wave form at frequencies which are multiples of 60 cycles and can be used for analysis purposes when this is kept in mind. The 60 cycle A.C. sweep deflects the beam faster at both ends of the horizontal trace than in the center. Therefore the center portion of the pattern should be used for analysis purposes to obtain the nearest approach to a wave form of correct geometric proportions.

31 - The 60 cycle sweep can also be advantageously used to provide a timing voltage when any frequency is applied to the vertical plates for measurement. However, if the frequency is not a multiple of 60 cycles a stationary image will not be developed upon the screen. It is, however, desirable to have a horizontal sweep of this type applied when observing voltages of varying frequency, and those which are not even multiples, to provide some basis for analysis. Without any horizontal voltage applied, a signal to the vertical input post produces a straight vertical line. With 60 cycle horizontal deflection at frequencies above 60 cycles a two dimensional pattern will appear, whose height will vary with the vertical signal intensity.

TRANSMITTER ANALYSIS

R.F. INDICATOR

32 - This instrument provides an excellent R.F. indicator for use at radio frequencies up to 100 megacycles. It can be coupled to an R.F. circuit for measurement and comparison of R.F. signal, in adjusting and analyzing transmitter operation. The horizontal input selector switch should be set to the section so the vertical amplifier is "Off". The vertical amplifier should not be used at frequencies above 100 kilocycles. If the selector switch is in the "Direct" position an R.F. voltage will be indicated by a straight vertical line, whose height is determined by the peak values of the R.F. voltage applied to the vertical input post. If the selector switch is set to a 60 cycle sweep position a block pattern will appear, whose height is controlled by the vertical signal.

33 - It is convenient to use the instrument in this manner for making exitation, bias, plate tank tuning, load, etc. adjustments. At frequencies above 100 kilocycles

with 60 cycle sweep applied to the horizontal plates, a pattern somewhat like Figure 18 is developed.

PERCENTAGE MODULATION

34 - Percentage modulation can most conveniently be measured by use of the trapezoid figure method. An R.F. signal is obtained from the modulated amplifier stage by coupling a few turns of wire to its tank coil. This voltage is applied to the vertical input posts with the vertical amplifier off. An audio frequency voltage obtained from the modulator stage plate output is then applied to the horizontal input posts with the horizontal switch in "Direct" position. A modulated signal of fixed amplitude should be applied to the input of the speech amplifier circuit. This signal can be of any audio frequency. The horizontal gain control can be adjusted to give a convenient degree of horizontal deflection as provided by the audio signal. The vertical gain control should be adjusted to give a convenient vertical height for observation.

35 - Now we have the audio modulating voltage deflecting the Cathode Ray beam in the horizontal direction. At the same time the R.F. voltage output from the R.F. amplifier is producing a vertical deflection. Due to the fact that the R.F. signal output is dependent upon the power supplied by the modulator, the vertical deflection varies in relation to the modulated signal applied. This developes a trapezoidal pattern of the modulated R.F. signal as illustrated in Figures 11 to 16. The percentage modulation is equal to the formula indicated below, as measured at the points indicated in Figure 11. If the wave is 100% modulated and is linear, a pattern such as Figure 13 will be developed.

$$\text{Percentage Modulation} = \frac{E\ MAX - E\ MIN}{E\ MAX + E\ MIN} \times 100$$

36 - In case over-modulation occurs on both the positive and negative peaks, a pattern such as Figure 14 appears. Over-modulation on the negative peaks is indicated by a straight line projected past the point of the pattern, indicating an A.F. modulated voltage being applied of a greater value than that which decreased the output of the modulated stage to zero. Over-modulation of the positive peaks is indicated by the vertical "whiskers" at the wide end of the pattern. Over-modulation can, of course, occur on either or both the positive and the negative peaks. It will occur on only one when the operation is not linear and probably indicates improper bias or exitation on the modulated stage.

37 - Figure 15 illustrates a pattern which is modulated 100% on its negative peaks but does not reach 100% on the positive peaks due to insufficient grid exitation of the modulated R.F. stage. Figure 16 indicates distortion of both the positive and negative peaks, probably due to insufficient exitation and incorrect bias. In all cases under proper operating conditions, regardless of the percentage of modulation, the sides of the pattern should be perfectly straight. A curvature of the sides indicates that non-linear operation is taking place.

38 - With the audio modulator signal at zero a straight line will indicate the presence of the R.F. carrier output. Now when modulation is applied the pattern will extend in both directions from this carrier point, developing the trapezoidal figure. It should extend an equal distance on either side of the R.F. carrier line. (Refer to Figure 17.) If the pattern does not extend an equal distance on either side of the R.F. carrier position, the presence of even harmonics such as the second, fourth, sixth, etc., is indicated. Odd harmonic content is not so easily recognized but is indicated by streaked portions of light intensity

running vertically through the pattern.

39 - Neutralizing, plate tank tuning and load adjustments will also be noticeable upon the trapezoidal figure. These adjustments should be made in conjunction with the oscilloscope to obtain the proper operating conditions.

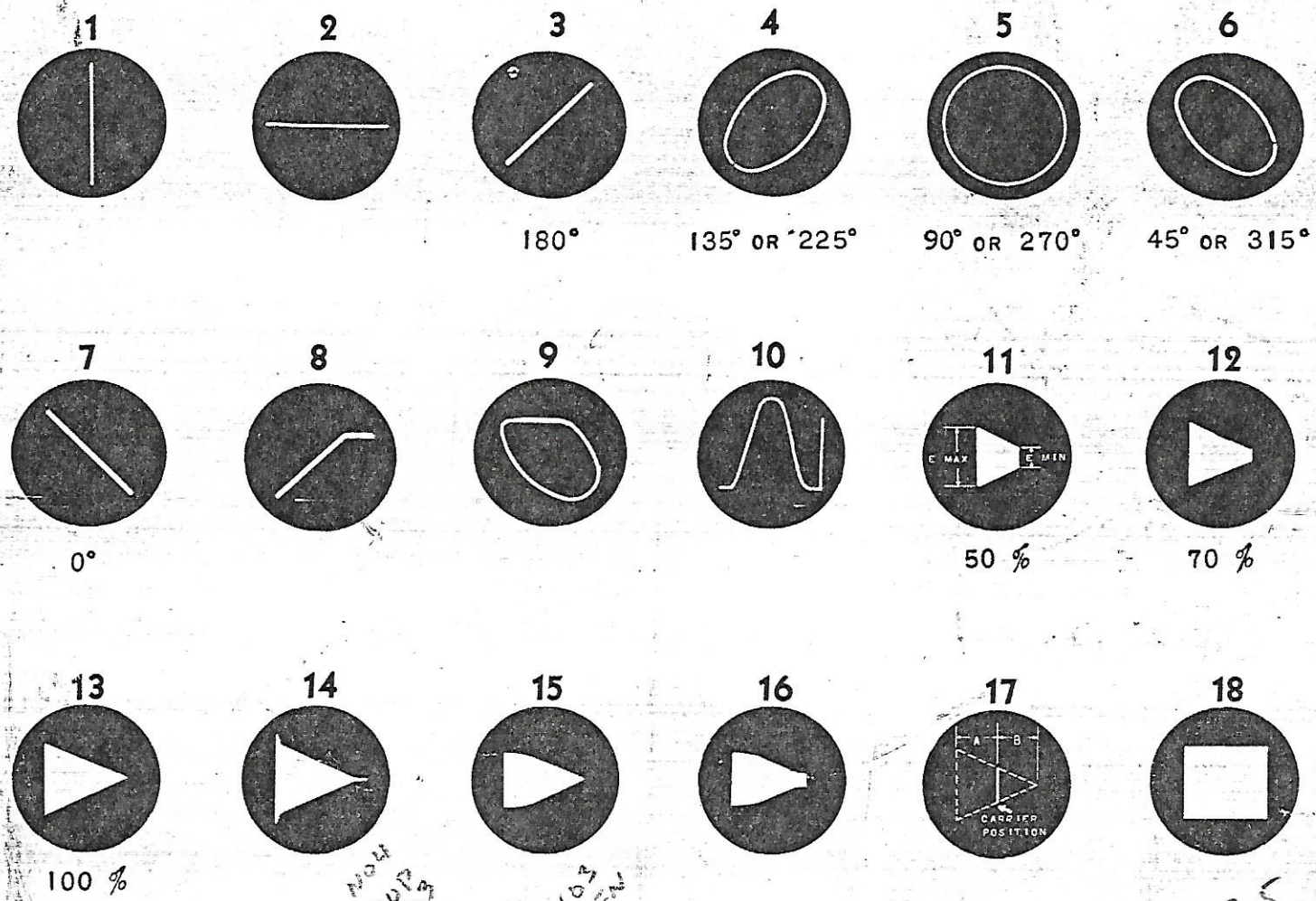
40 - A non-stationary image of the modulation can be obtained by applying the R.F. modulated voltage to the vertical input post and using 60 cycle sweep on the horizontal plates. During speech or music a constantly changing pattern will appear. 100% modulation on the negative peaks will be apparent by bright lines on the horizontal mean carrier axis. This method is often used in broadcast stations for continuous modulation monitoring.

41 - It must be remembered that voltage in excess of those listed under "Electrical Specifications" should not be applied to either the horizontal or vertical input posts without inserting a bleeder or suitable series resistance to drop the voltage applied to a safe value. The input resistance to either horizontal or vertical input posts is one megohm.

42 - IMPORTANT: When voltage is applied to the vertical input posts with the AMPLIFIER OFF or to the horizontal posts DIRECT, connection is made directly to the deflecting plates through the "GAIN" controls. This makes possible the measurement of D.C. voltages. To measure A.C. voltages on circuits where D.C. voltage is present, a condenser must be connected in series with the HIGH input post. This isolates the D.C. voltage of the circuit and permits measurement of the A.C. component only.

43 - To obtain a trapezoid pattern for modulation measurements a series condenser must be used between the horizontal HIGH POST and the modulator output circuit, if any D.C. is present at the point of connection. This condenser should be approximately .1 MFD.

If D.C. is present and a condenser is not used the pattern will probably be deflected off the screen.



3 x 3.5
φ 1.25 max