

## CHAPTER 8

# SPECIAL PURPOSE EQUIPMENT

The special purpose category of equipment includes individual equipments not classifiable into one of the other five categories. The major equipment types of this category include oscilloscopes, frequency counters, frequency oscillators, and the AN/GSQ-53 Time Signal Set.

### OSCILLOSCOPE

The fields of non-morse communications and electronic warfare employ many types of sophisticated electronic equipment. The oscilloscope, generally considered as an item of "test" equipment, is beginning to find more and more application in the analysis of non-morse communications systems and in Electronic Warfare Support Measures (ESM).

The oscilloscope is a device which produces a visual presentation of an electronic signal on the screen of a cathode ray tube (CRT) for analysis purposes. Oscilloscopes are set apart from other CRT displays because of their analytic design, purpose, and usage. As analytical tools, oscilloscopes require precisely calibrated timing and amplifying circuits; other CRT displays, those used only as tuning aids, have no provisions for precise signal measurements.

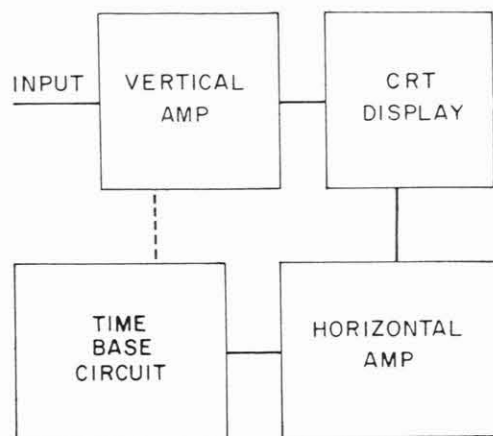
#### Basic Oscilloscope

Figure 8-1 is a block diagram of a basic oscilloscope. Use figure 8-1 in learning the stages and functions of the basic oscilloscope.

**VERTICAL AMPLIFIER.**—The VERTICAL AMPLIFIER normally has the signal that is to be analyzed as its input. This amplifier increases the strength of the signal so that it will cause the luminous spot on the CRT DISPLAY to move

up and down in accordance with the variations of the signal. The VERTICAL AMPLIFIER has a gain control which enables the amount of vertical deflection of the CRT spot to be directly related to a specific change in voltage amplitude of the input signal. The output of the VERTICAL AMPLIFIER goes to the VERTICAL DEFLECTION PLATES of the CRT display. The VERTICAL DEFLECTION PLATES cause the luminous spot to be moved vertically in accordance with the signal applied. A portion of the VERTICAL AMPLIFIER signal is routed to the TIME BASE circuits where it provides synchronization information to the TIME BASE OSCILLATOR.

**TIME BASE CIRCUITS.**—The TIME BASE CIRCUITS consist of an oscillator and appropriate sync circuits. The oscillator generates a precisely timed a.c. voltage which increases in a linear manner and, then, decreases rapidly back to zero. This "sawtooth" wave, so named because of its similarity in appearance to the teeth of a saw, causes the luminous spot of the CRT to move horizontally across the screen. The horizontal motion of the spot provides a time reference for observing the amplitude changes of the signal fed to the VERTICAL AMPLIFIER. The TIME BASE CIRCUITS are adjusted by controls calibrated in terms of the amount of time that will elapse as the spot moves horizontally across the screen. The signal fed to the TIME BASE CIRCUITS by the VERTICAL AMPLIFIER serves to synchronize the sawtooth waveform so that the CRT display remains stable. Thus, the variations of the input signal will remain in the same relative position on the screen of the CRT for successive cycles of the sawtooth waveform.



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Figure 8-1.—Basic oscilloscope block diagram.

**HORIZONTAL AMPLIFIER.**—The HORIZONTAL AMPLIFIER normally accepts the sawtooth waveform and amplifies it to the level required to drive the HORIZONTAL DEFLECTION PLATES. Occasionally, an external signal, such as that from a calibrated frequency and time standard, may serve as the input to the HORIZONTAL AMPLIFIER.

**CRT DISPLAY.**—The CRT DISPLAY is simply a cathode ray tube, similar in structure to the picture tube used in television receivers. It is designed to “fire” a stream of electrons at a fluorescent screen. When the electrons encounter the screen, the material will glow momentarily. This fact allows the visual presentation of an electronic signal by controlling the direction of motion of the stream of electrons in accordance with the signal and a time base waveform.

### TEKTRONIX 545B OSCILLOSCOPE

The Tektronix 545B Oscilloscope (figure 8-2) is typical of the many sophisticated oscilloscopes which may be encountered on the job. There are many other models of oscilloscopes, but most have similar controls and functions as the Tektronix 545B. Various plug-in units can be used in conjunction with the 545B. The “L” plug-in unit will be discussed in

addition to the basic Tektronix 545B Oscilloscope.

### Controls, Indicators and Functions

**NOTE:** (Functions explained pertain to both the A and B horizontal time base controls, whenever duplicate controls exist.)

The controls, indicators and functions of the Tektronix 545B Oscilloscope are described and explained in the following paragraphs (refer to figure 8-2): (Controls that are not explained do not apply and are not used by operators.)

**POWER ON SWITCH.**—This control is used to turn the 545B ON or OFF. Since the 545B is a tube-type oscilloscope, there is a built-in time delay which prevents use of the oscilloscope until power has been applied for at least 25 seconds. Stability of the circuits is not achieved until the instrument has been on for thirty or more minutes.

**INTENSITY CONTROL.**—This control adjusts the intensity of the spot produced on the screen of the CRT. When initially turning the oscilloscope on, the INTENSITY control should be turned fully counterclockwise to prevent damage to the screen material in case of misadjustment of it and other controls. NEVER run the spot intensity at an extremely high level when using the oscilloscope. This, too, can cause permanent damage to the screen of the CRT.

**FOCUS CONTROL.**—The FOCUS control is used to adjust the spot on the CRT for the sharpest and clearest image. The FOCUS control is used in conjunction with the ASTIGMATISM control to obtain a clear presentation.

**ASTIGMATISM CONTROL.**—This control is adjusted for the roundest spot and for the best focus of the trace as it moves over all parts of the CRT screen.

**SCALE ILLUM SWITCH.**—Varies the illumination of the graticule grid lines.

**BEAM POSITION.**—Four neon lamps (above CRT) with accompanying arrow indicating the

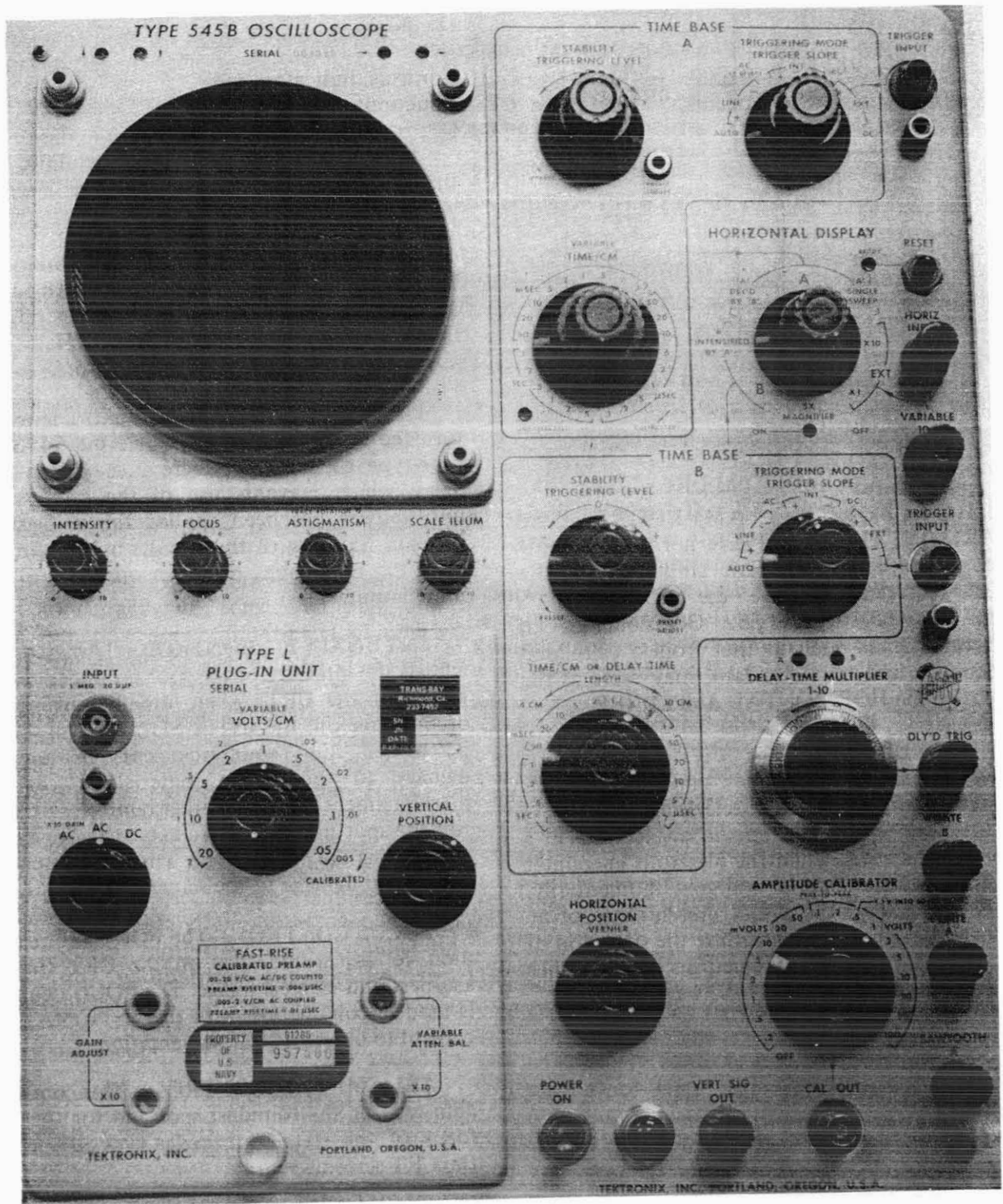


Figure 8-2.—TEKTRONIX 545-B Oscilloscope.

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direction of the "spot" when it is deflected out of the viewing area.

**TRIGGERING LEVEL CONTROL.**—Selects the amplitude point on the triggering signal where sweep-triggering occurs. The TRIGGERING LEVEL is disabled when the TRIGGERING MODE switch is in the AUTO position.

**STABILITY CONTROL.**—Adjusts the oscilloscope for a stable displayed waveform. The STABILITY control can be set to the PRESET position and left there. This position provides for convenient triggering since only the TRIGGERING LEVEL control needs to be adjusted to obtain a stable display. The STABILITY control is disabled when the TRIGGERING MODE switch is in the AUTO position.

**TRIGGERING MODE SWITCH.**—This switch selects the mode of triggering the time-base circuits. The 545B uses a triggering technique to synchronize the horizontal time base to the input vertical signal. The system works as follows: As the input signal rises to a particular voltage value, a single cycle of the sawtooth is initiated. Subsequent cycles of the sawtooth are prevented from occurring until the voltage point of the recurring input signal is again reached. At that instant, another cycle of the time base signal is "triggered." This technique ensures that repeated cycles of the input signal will be displayed in a stable, easily observed fashion.

a. **AUTO**—Permits normal triggering on simple waveforms with repetition rates higher than 50Hz. With no trigger signal, or with a lower repetition rate, the trigger circuit free runs at approximately 40Hz and triggers the time base at this rate, providing a reference trace.

b. **AC LF REJ (Time Base A only)**—A filter prevents false triggering by low a.c. frequencies below 30Hz.

c. **AC**—Blocks the d.c. component of the triggering signal and allows triggering to take place only on the changing portion of the signal. Use this position for best triggering at high frequencies.

d. **DC**—Permits triggering of low frequency signals. Use this position for frequencies below 30Hz.

**TRIGGER SLOPE SWITCH.**—This switch selects whether the triggering point should be at the selected voltage on the rising side (positive) of the waveform or on the falling side (negative) of the waveform.

a. **LINE**—Uses a line-frequency signal as a trigger.

b. **INT**—Uses a portion of the signal applied to the vertical deflection plated of the CRT as a trigger signal.

c. **EXT**—Provides external triggering on a signal applied to the TRIGGER INPUT connector.

**TIME/CM SWITCH.**—Selects the time-base sweep rate. The control settings are designated in terms of the amount of time that it will take the trace to move across the face of the CRT (time/cm). For example, when in the 1ms/cm position, the trace will move horizontally across the screen at a rate of one centimeter each millisecond. When in the 5ms/cm position, the trace will move horizontally across the screen at the rate of one centimeter every five milliseconds.

**VARIABLE (TIME BASE A) SWITCH.**—This switch provides an uncalibrated sweep rate adjustment. An UNCALIBRATED lamp lights when the VARIABLE switch is not in the CALIBRATED position. To obtain a calibrated position, rotate the VARIABLE switch in a clockwise direction until the UNCALIBRATED light is extinguished.

**LENGTH (TIME BASE B) SWITCH.**—This switch controls the length of the B sweep.

**HORIZONTAL DISPLAY SWITCH.**—This multiposition switch selects the type of signal to be input to the horizontal amplifier.

a. **A**—Allows only Time Base A to appear on the CRT.

b. **B**—Allows only Time Base B to appear on the CRT.

c. **"B" INTENSIFIED BY "A"**—In this position, Time Base A is displayed at the end of each delay period as determined by the B TIME/CM OR DELAY TIME and DELAY-TIME MULTIPLIER controls.

d. "A SINGLE SWEEP"—Allows the Time Base A generator to sweep once, upon receipt of trigger signal, and not sweep again until the circuit has been reset with the RESET button.

e. EXT X1 and X10—Permits an external signal to be applied to the horizontal deflection circuit. Sensitivity is continuously variable (with the VARIABLE 10-1 control).

VARIABLE 10-1 CONTROL.—Varies the sensitivity of external horizontal input signal.

READY LAMP.—Lights up when the time-base circuit is ready for triggering after having been reset.

HORIZONTAL POSITION AND VERNIER CONTROLS.—These controls are used to position the display along the horizontal axis of the CRT.

5X MAGNIFIER.—Expands the sweep by a factor of 5 at any setting of the TIME/CM switch. The center of expansion is the center of the graticule.

### TEKTRONIX TYPE "L" PLUG-IN UNIT

The Tektronix 545B Oscilloscope (figure 8-3) contains a built-in vertical amplifier, but

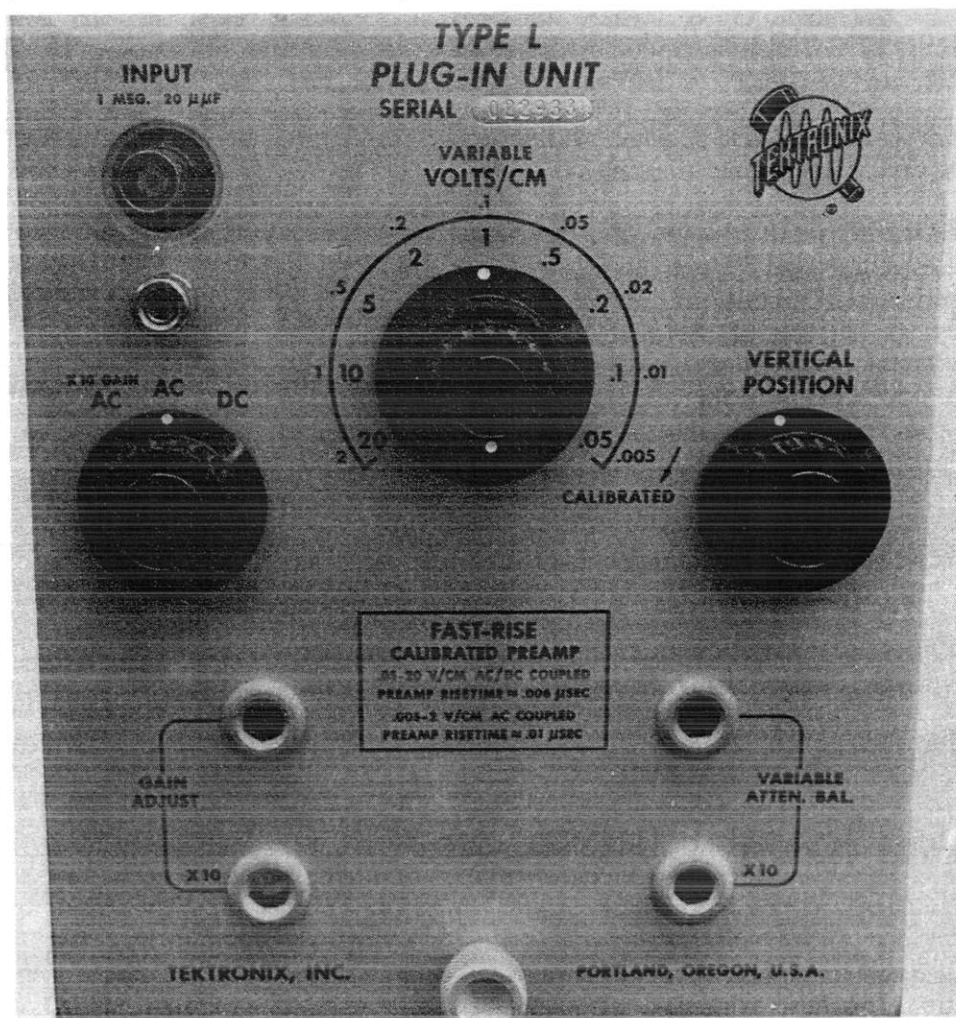


Figure 8-3.—Type L plug-in unit.

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requires the use of a plug-in vertical preamplifier. Several vertical plug-in units are available, but only the "L" unit will be covered in this publication. Other controls that exist but are not listed, do not apply to operator personnel.

### Operating Controls and Functions

The controls and functions of the type "L" plug-in unit are characteristic of most oscilloscope vertical amplifiers and are described and explained as follows:

**INPUT CONNECTOR.**—Used to connect the input signal source to vertical amplifier.

**VERTICAL POSITION CONTROL.**—This control is used to vertically position the trace of the CRT. By adjustment of the VERTICAL POSITION control, the image may be moved up and down on the screen of the CRT. The setting of this control affects the triggering circuits of the 545B oscilloscope when the TRIGGER MODE switch is in the DC position. Therefore, the trace must be positioned in the desired vertical location prior to adjusting the trigger circuits when using d.c. triggering.

**VOLTS/CM SWITCH.**—This calibrated switch enables the height of the signal image on the screen of the CRT to be adjusted. In all cases, the calibrated markings of the graticule can be used in conjunction with the calibration markings of the VOLTS/CM switch to read the actual input level of the signal.

**VOLTS/CM VARIABLE CONTROL.**—This control provides a continuously variable level control on the height of the signal image on the screen of the CRT. When in use, the markings on the VOLTS/CM switch cannot be relied upon to establish the true level of the input signal. When the VOLTS/CM VARIABLE control is fully clockwise the calibrated readings of the VOLTS/CM switch will hold true.

**AC (X10 GAIN)—AC—DC SWITCH.**—This three-position switch selects the type of coupling of the signal to the vertical amplifier.

a. **AC (X10 GAIN)**—In this position, a.c. components of the signal will be passed on to

the vertical amplifier circuits. Additionally, the gain of the amplifier stages are multiplied by a factor of ten. This position is used when analyzing extremely weak a.c. signals.

b. **AC**—In this position, higher level a.c. signals can be input to the vertical amplifier, as it is running in its normal range of gain (amplification). This is the position normally used.

c. **DC**—In this position, the direct current components of the input signal are also passed on to the vertical amplifier.

### Operating Procedures, Tektronix 545B With Type "L" Plug-In Unit

Follow the steps listed below to obtain a trace and to measure the period and amplitude of a sinewave:

### OBTAINING A TRACE

1. Turn the INTENSITY control to the full counter-clockwise position.
2. Place the POWER switch in the ON position and allow a 25-second delay for equipment warm-up.
3. Move the HORIZONTAL DISPLAY switch clockwise to the X10 position.
4. Adjust the HORIZONTAL POSITION control to the position at which point both HORIZONTAL POSITION indicator lamps (located at the top right of the CRT) are extinguished.
5. Adjust the VERTICAL POSITION control (on the type "L" plug-in unit) to the position in which both VERTICAL POSITION indicator lamps (located at the top left of the CRT) are extinguished.

**NOTE:** THE ARROWS, WHEN LIT, INDICATE THE LOCATION OF THE TRACE. MOVE THE CONTROLS IN THE OPPOSITE DIRECTION OF THE ARROWS IN ORDER TO CENTER THE PRESENTATION. WHEN THE HORIZONTAL AND VERTICAL ARROWS ARE EXTINGUISHED, THE SPOT IS APPROXIMATELY CENTER, ALTHOUGH IT CANNOT BE SEEN ON THE SCREEN.

6. Adjust the VOLTS/CM switch (on the type "L" plug-in unit) to 20 volts per cm and the red knob to CALIBRATE (indentation).

7. Turn the INTENSITY control slowly clockwise until a spot appears on the CRT. The INTENSITY should never be turned up to where a "halo" forms around the spot.

8. Ensure that all input signals to the oscilloscope are disconnected before adjusting the FOCUS and ASTIGMATISM controls. Adjust the FOCUS and ASTIGMATISM controls to obtain the smallest, most perfectly-round spot possible.

9. Move the HORIZONTAL DISPLAY control to the A position. At this point, a minor adjustment may be necessary to place the line at mid scale.

#### MEASURING THE PERIOD OF A SINEWAVE

1. Set the AC (X10 GAIN)-AC-DC selector switch (on the type "L" plug-in unit) to the AC position.

2. Check the following controls on the TIME BASE A section for the following settings and make any necessary changes.

- a. TRIGGER MODE to AUTO position.
- b. TRIGGER SLOPE to INT+ position.
- c. STABILITY fully counter-clockwise to PRESET position.
- d. TRIGGER LEVEL set to 0.
- e. CM/TIME to .1 millisecond/cm.
- f. TIME/CM VARIABLE fully clockwise to CALIBRATED.

3. Patch the signal source to the input connector of the type "L" plug-in unit.

4. Adjust the VOLTS/CM switch for a presentation height of slightly under 4 centimeters. Ensure that the VOLTS/CM VARIABLE control is in the CALIBRATED position.

5. Adjust the TIME/CM switch for 3 to 5 full sinewave cycles and center the display on the screen by means of the VERTICAL POSITION control.

6. Increase the VOLTS/CM control setting until the tops and bottoms of the sinewave are no longer visible.

7. Adjust the HORIZONTAL POSITION control so that the left-most line of the trace is exactly on the left-most vertical line of the graticule scale.

8. Measure the distance, in centimeters, along the horizontal centerline of the graticule, between the SECOND and FOURTH vertical trace lines.

NOTE: IF THE SECOND VERTICAL TRACE LINE FAILS TO FALL PRECISELY ON A VERTICAL LINE OF THE GRATICULE, THE HORIZONTAL POSITION CONTROL MAY BE ADJUSTED UNTIL IT FALLS PRECISELY ON THE NEAREST VERTICAL LINE OF THE GRATICULE. THIS WILL MAKE THE DISTANCE MEASUREMENT MUCH EASIER.

9. Multiply the distance, obtained above, by the calibration factor indicated on the TIME/CM control. The result will be the period, in milliseconds, of the sinewave signal which is being analyzed.

#### MEASURING THE AMPLITUDE OF A SINEWAVE

1. Reduce the VOLTS/CM switch so that the sinewave presentation on the CRT is again slightly under 4 centimeters high.

2. Adjust the VERTICAL POSITION control so that the bottom peaks of the sinewave fall precisely on a horizontal graticule line.

3. Measure the height of the sinewave against the graticule calibrations.

4. Multiply the measured height of the sinewave by the calibration markings from the selected position of the VOLTS/CM switch. This calculation yields the actual amplitude, in volts, of the sinewave signal that is input to the oscilloscope.

#### AN/GSQ-53 TIME SIGNAL SET

The AN/GSQ-53 Time Signal Set (figure 8-4) was designed to provide stable frequencies and real time information for signal analysis and data automation equipments. It consists of the

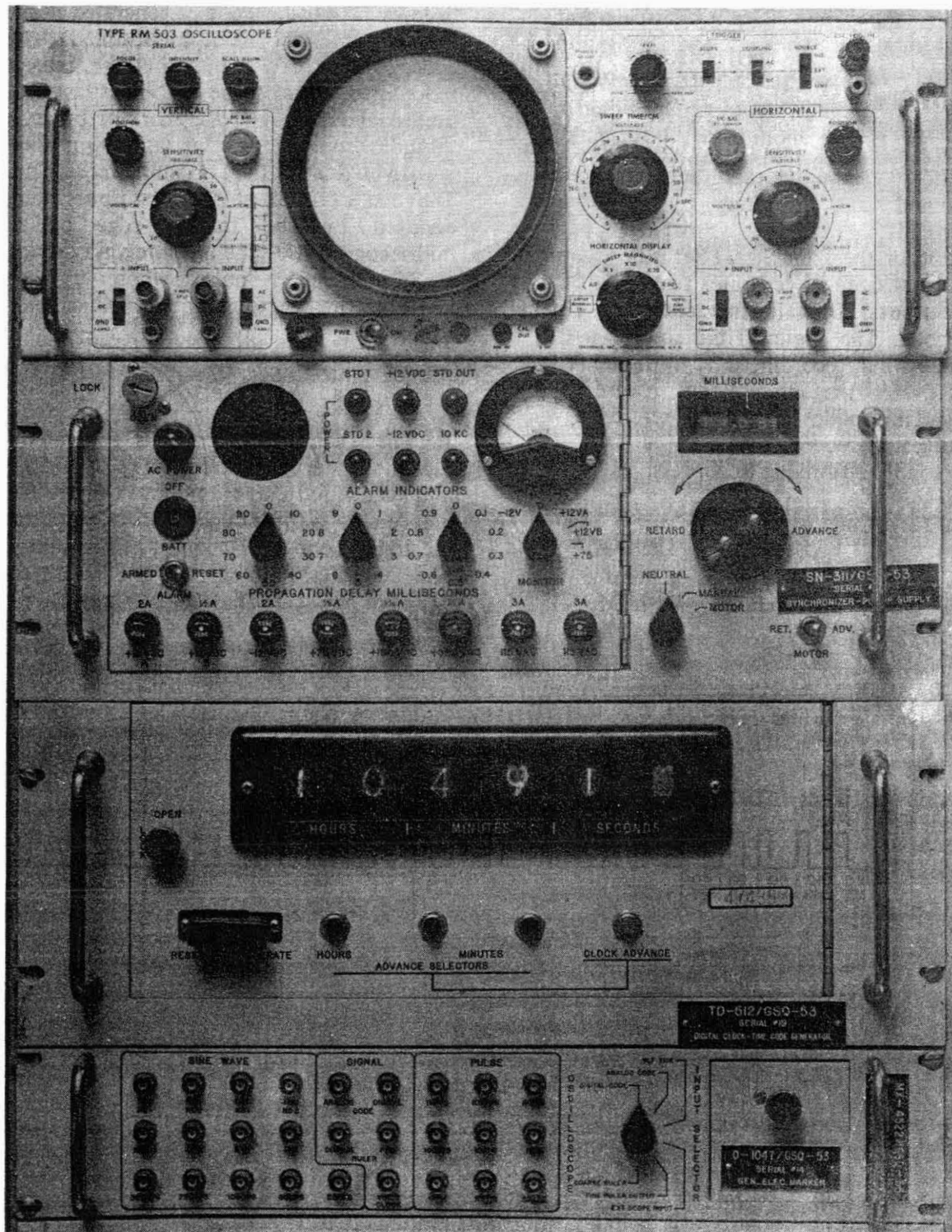


Figure 8-4.—AN/GSQ-53 time signal set.

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following major assemblies: VLF phase comparison, Time Generating equipment, Control-Indicator Group, and a group of Auxilliary equipments. The auxilliary equipment includes: Digital and Display indicators, Program Clock, Program Clock Control, Electronic Marker Generator and battery box. The AN/GSQ-53 Time Signal Set is normally maintained and checked by maintenance personnel; therefore, knowledge of the operation of the Time Signal Set is not required.

The AN/GSQ-53 generates two types of time code outputs: Digital Time code and Analog Time code. The Digital Time code is used for reference when recording data in digital format, i.e., RD-289 magnetic digital recorder. The Analog Time code is used for reference when recording with recorders such as the AN/GSH-19 and AN/GSH-28 Analog Recorders.

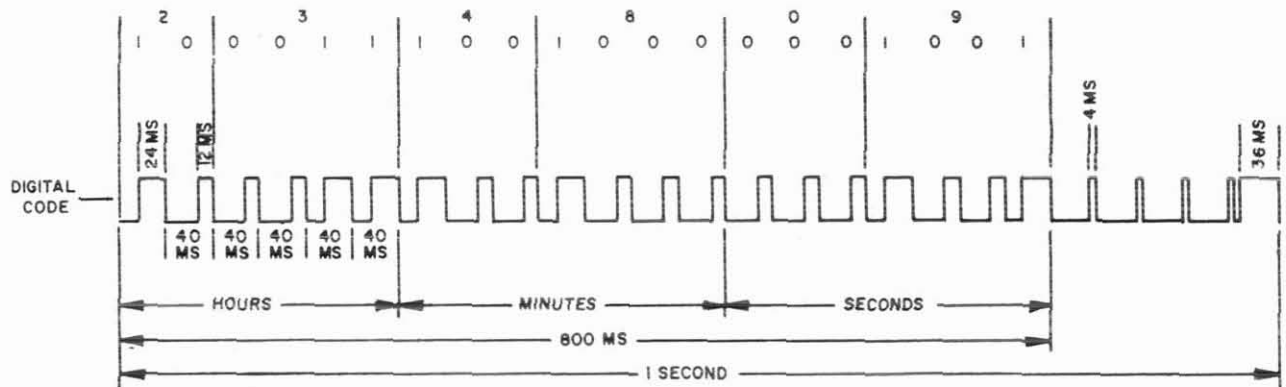
### Digital Time Code

The digital time code is generated in an 8-4-2-1 binary coded Pulse Width Modulated

Format. The code format, figure 8-5, is as follows: The time code is generated during the first 800 milliseconds of the SECOND. The time code consists of 20 bits that are pulse-width modulated. The space or binary zero is 12 milliseconds long and the mark or binary one is 24-milliseconds long. The last 200 milliseconds are divided into five, 40-millisecond intervals. The end of each of the first four intervals is denoted by the trailing edge of a four millisecond pulse. The last interval is denoted by a 36-millisecond pulse, whose trailing edge identifies the beginning of the next second.

### Analog Time Code

The analog time code is generated in an 8-4-2-1 binary digital code of 250 cycle amplitude-modulated tones, see figure 8-6. The binary zero is three cycles of high amplitude and the binary one is six cycles of high amplitude. The end of second marker is denoted by nine cycles of high amplitude.



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Figure 8-5.—Digital time code format.



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Figure 8-6.—Analog time code format.

### HP-651B TEST OSCILLATOR

The Hewlett-Packard model 651B Test Oscillator (figure 8-7) is a wide-range capacitance-tuned oscillator that has a variable output between the range of 10 Hz to 10 MHz. It generates a stable sine-wave output that is used to measure the pulse repetition frequency (PRF) of selected signals.

#### Operating Controls, Indicators, and Functions

The operating controls, indicators, and functions of the HP-651B Test Oscillator are described and explained in table 8-1.

#### Operating Procedures

The operating procedures for the HP-651B Test Oscillator are as follows:

1. Turn the LINE Power switch to the ON position.
2. Adjust the AMPLITUDE controls to obtain a zero dBm reading (bottom scale).
3. Patch the 600 ohm output into the inputs of an electronic counter and oscilloscope.
4. Set the OUTPUT ATTENUATOR switch to the desired voltage range.
5. Set the FREQUENCY RANGE control to the desired frequency range.

6. Turn the FREQUENCY dial to the approximate PRF of the signal (the signal should be in an almost stationary position on the CRT of the oscilloscope). Now, using the VERNIER dial, fine tune until the signal presentation is stopped on the CRT of the oscilloscope. The PRF of the signal can now be obtained by observing the readout of the electronic counter.

### HP-5532A ELECTRONIC COUNTER

The Hewlett-Packard 5532A Electronic Counter (figure 8-8) measures frequencies, period average, ratio of two frequencies, and total events. As an operator, the primary concern is only with measuring modulating frequencies, i.e., pulsed communication and pulsed non-communication systems. The frequency measurement is shown on a five-place Nixie tube display.

#### Operating Controls, Indicators and Functions

The operating controls, indicators, and functions are described and explained below (refer to figure 8-8).

ON POWER SWITCH.—Main power is applied to the unit when this switch is in the ON position.

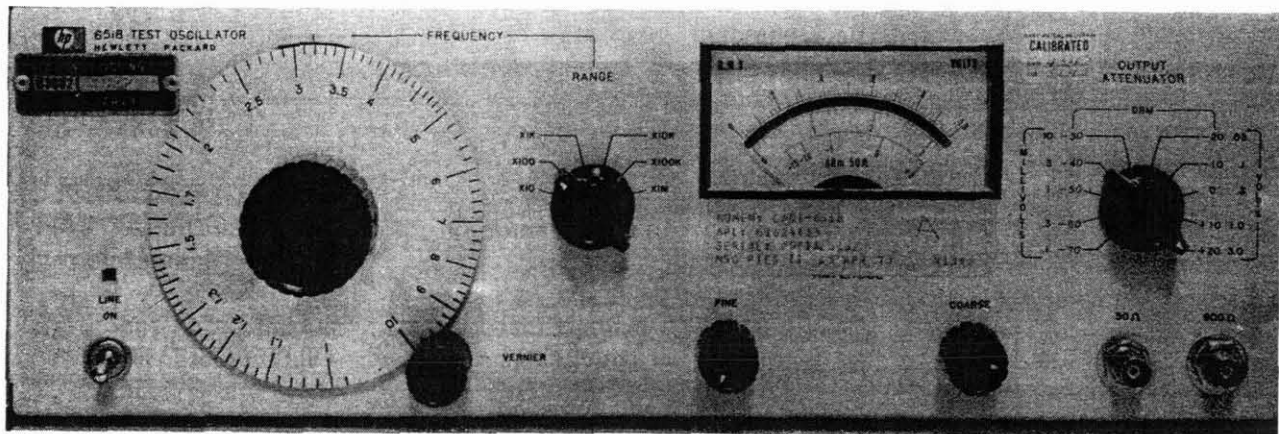


Figure 8-7.—Hewlett-Packard Model 651-B Test Oscillator.

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CRYPTOLOGIC COLLECTION EQUIPMENTS

Table 8-1.—Hewlett-Packard Model 651-B Operating Controls, Indicators, and Functions

CONTROL/INDICATOR	FUNCTION
FREQUENCY Dial	Varies the output frequency within each frequency range. The dial reading multiplied by the range setting is the output frequency.
FREQUENCY RANGE Switch	Selects one of six frequency ranges from 10Hz to 1MHz.
Output Monitor Meter	Indicates the amplitude of the test oscillator output.
Mechanical Zero Adjust Control	Allows the output monitor to be mechanically zeroed, when the equipment is OFF. This control is located at the bottom-center on the output monitor meter.
OUTPUT ATTENUATOR	Attenuates (weakens) the test oscillator output in nine steps of 10dB each.
Output Connectors	Provides the output signal at 50 or 600 ohms impedance levels.
AMPLITUDE COARSE and FINE controls	Controls the amplitude of the applied signal to the OUTPUT ATTENUATOR.
FREQUENCY VERNIER Control	Provides a fine frequency adjustment for the FREQUENCY dial.
LINE ON Switch and Pilot Lamp	Applies primary power to the equipment; Pilot Lamp glows to indicate the application of primary power.

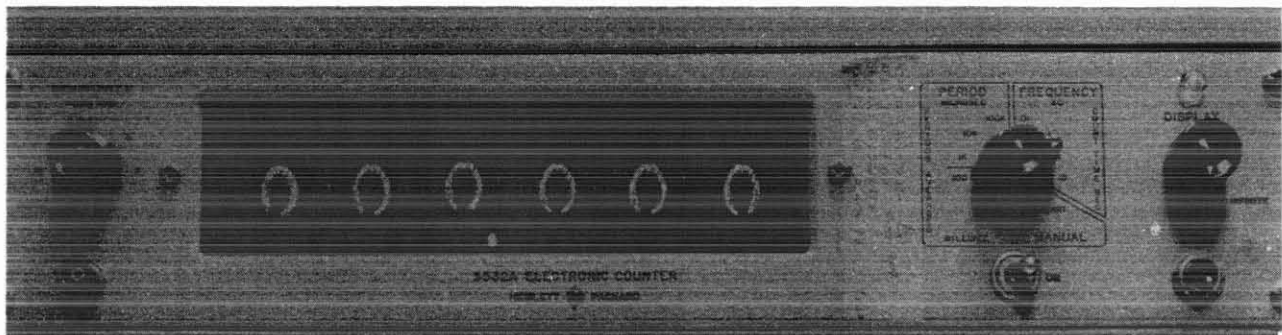


Figure 8-8.—Hewlett-Packard Model 5532-A Electronic Counter.

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**FUNCTION SELECTOR.**—The function selector is a twelve-position switch used to select both the measurement function and the time base or multiplier desired for the measurement. In the **MANUAL** position, the **DISPLAY** is read directly; the decimal point is not lighted.

**SENSITIVITY CONTROL.**—The **SENSITIVITY** switch adjusts the sensitivity of the input signal.

**DISPLAY CONTROL.**—The **DISPLAY** control sets the rate the Nixie readout is displayed. It is adjustable from approximately 0.2 seconds to at least 5 seconds as a maximum. A control setting (**INFINITE**) is provided to hold the display readout indefinitely.

**RESET PUSHBUTTON.**—The **RESET** pushbutton, when depressed, resets the display and internal count to zero. The counter, after reset, is ready to begin a new counting cycle.

**INPUT JACK.**—Provides input to the Electronic Counter of the signal to be measured.

#### Operating Procedures

Follow the steps listed below to obtain the frequency measurement of a desired signal.

1. Turn the power **ON** switch to the **ON** position.
2. Set the **DISPLAY** control for the desired readout rate.
3. Set the **SENSITIVITY** switch to the **10 VOLTS RMS** position.
4. Set the function selector switch to any **FREQUENCY** position.
5. Connect the unknown frequency to the **INPUT** jack.
6. Turn the **SENSITIVITY** switch clockwise until a consistent count is displayed.
7. Read the frequency in kHz. The decimal point is positioned automatically.