

**SCIENTIFIC-ATLANTA  
SERIES 1580 ANTENNA PATTERN RECORDER**

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## PURPOSE AND APPLICATION

Antenna pattern recorders are used to plot the relative signal strength of an antenna under test as a function of the angular position of the antenna.

The signal plotted is obtained from the output of a receiver or directly from a microwave detector.

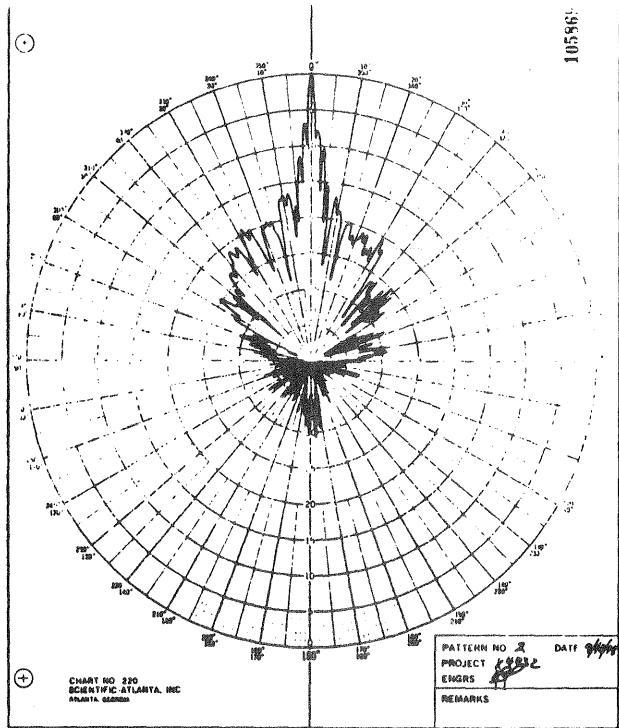
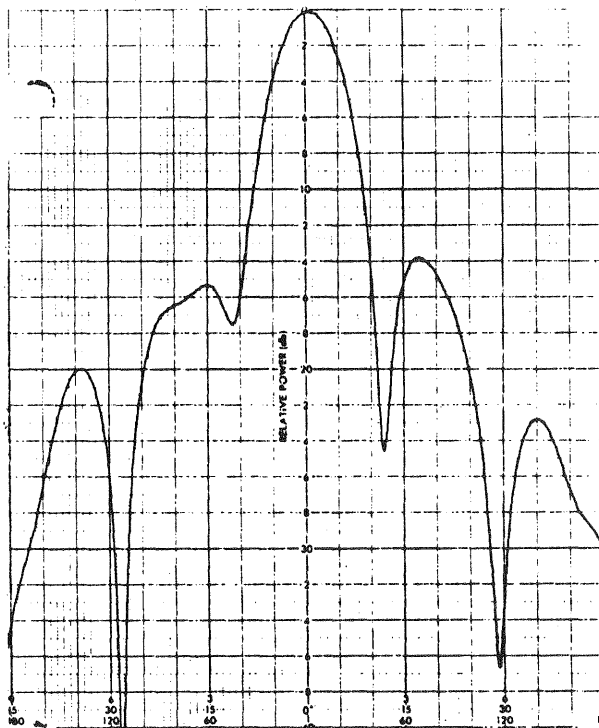
The position information is normally obtained from synchro transmitters geared to the test positioner axis.

Typical antenna pattern recorders are electromechanical devices which employ servo systems to drive the recorder axis. A chart drive servo system positions the recording paper as a function of the angular position of the antenna. A pen servo system positions a recording pen in response to the amplitude of the input signal.

Usually, provisions are made for a selection of amplitude functions. The pen deflection may be directly proportional to the amplitude of the input signal to the recorder, or the response may be proportional to the square, square-root or logarithm of the input. If the proper pen function is selected for the particular type detector used, either a linear or square law detector, the recording may be proportional to the RF Voltage, power or relative signal level in decibels.

When the receiving system provides a dc signal whose amplitude is proportional to the relative RF phase angle between two signals, the linear pen function may also be used to plot phase angle.

The pen function has typically been accomplished by precision potentiometer physically attached to the pen input servo system. Changing pen functions requires removal and installation of the potentiometer assembly.



Antenna patterns may be recorded in either polar or rectangular coordinates. Polar coordinates are often preferred for plotting patterns of antennas that are not highly directional.

Generally, polar pattern recorders employ a turntable which rotates as the positioner moves, while rectangular recorders move the chart paper linearly. This mechanical difference requires separate recorder assemblies for generation of polar and rectangular plots.

### OVERVIEW OF AN ADVANCED ANTENNA PATTERN RECORDER

With the advent of the microprocessor and other advanced digital devices, many improvements to the Antenna Pattern Recorder design are possible.

- The pattern recorder becomes a digital instrument operating under control of firmware stored in read only memory.

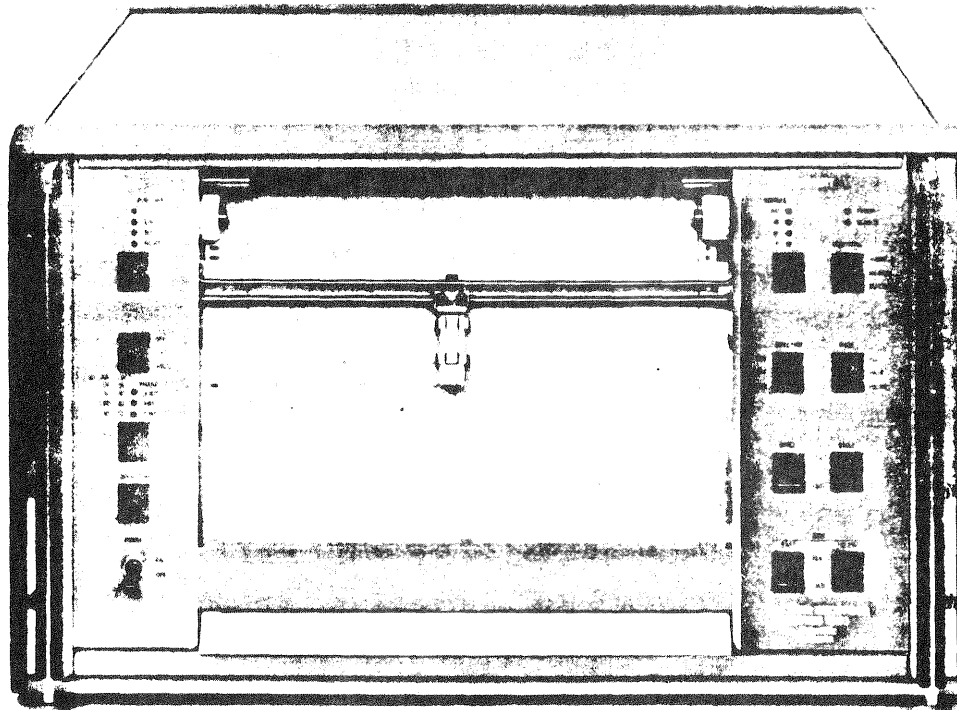
- Pen functions are performed by firmware and are selected by front panel controls.

- Analog or digital inputs are possible in both the chart and pen axis.

- Polar and rectangular plots may be generated on a single recorder.

- Digital interfaces also permit control by calculator or computer outputs.

Such a recorder now exists as the Scientific-Atlanta Series 1580 Antenna Pattern Recorder.

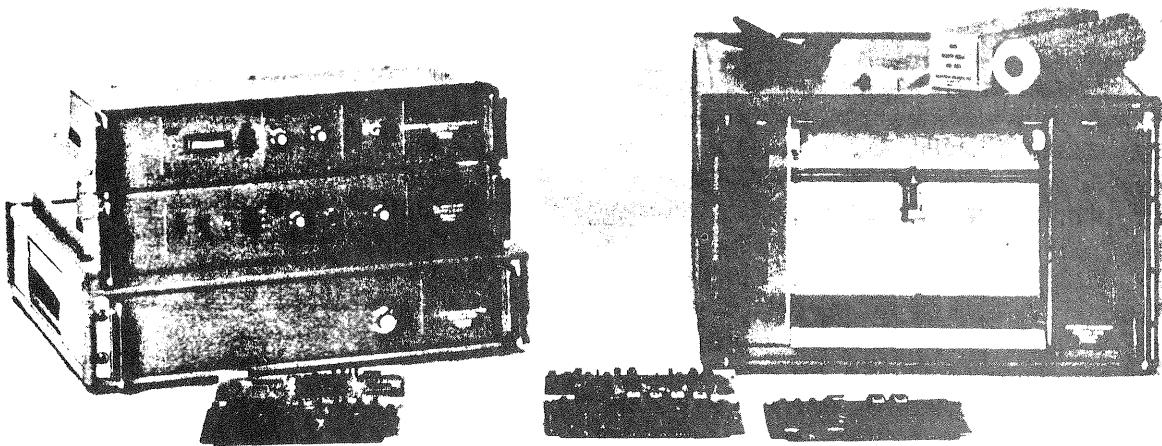


Series 1580 Antenna Pattern Recorder

## SERIES 1580 PATTERN RECORDER

The 1580 Pattern Recorder consists of a basic mainframe and a number of optional modules. Some options are installed directly into the mainframe and others are external units.

The following paragraphs will discuss the mainframe, internal options, and then the external options. Later paragraphs will discuss recorder features implemented by firmware.



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### Series 1580 Antenna Pattern Recorder and accessories

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#### MAINFRAME

The recorder mainframe includes the head assembly, control panel, digital card assembly, and power supplies for the mainframe and all optional units.

Contained in the head assembly are:

- Chart and pen drive motors and optical encoder
- Chart drum, paper supply holder, and paper idler arm

- Pen drive pulleys and cable system
- Paper sensors

The head assembly tilts forward and out of the recorder for paper installation. Chart paper is supplied in preprinted rolls with either rectangular or polar format.

The digital card assembly contains the microprocessor and memory circuit boards, front panel interface, chart and

pen servo interface, and slots for optional plug-in cards.

The microprocessor is a Texas Instrument TMS 9900. This is 16-bit general purpose device which internal hardware multiply and divide. Control is provided by executing instructions stored in read only memory.

A main memory module, 4K words of read-only memory with 526 words of read and write memory, supplies instructions for basic recorder operation. This includes front panel control, chart and pen servo control, data input, pen functions, and chart scaling.

An optional 2K memory module supplies program instructions for rectangular to polar conversion and instructions necessary for operation of the IEEE-488 standard interface.

The optional IEEE-488 card provides a hardware interface in accordance with the IEEE-488 1975 Standard Digital Interface for Programmable Instrumentation. This interface permits operation of the recorder from computers or calculators using simple ASCII commands.

Other mainframe plug-in options permit analog or digital inputs directly to the chart or pen axis.

Pen axis input option may be either digital for accepting parallel or byte input from digital devices; or analog to digital converter for interfacing to external AC or DC Preamplifier units.

The chart axis input may also be digital (parallel or byte); or an analog synchro input. Synchro inputs of 1:1 or 36:1 ratio will be accepted and processed by the recorder.

#### **MODEL 1587 DC AMPLIFIER**

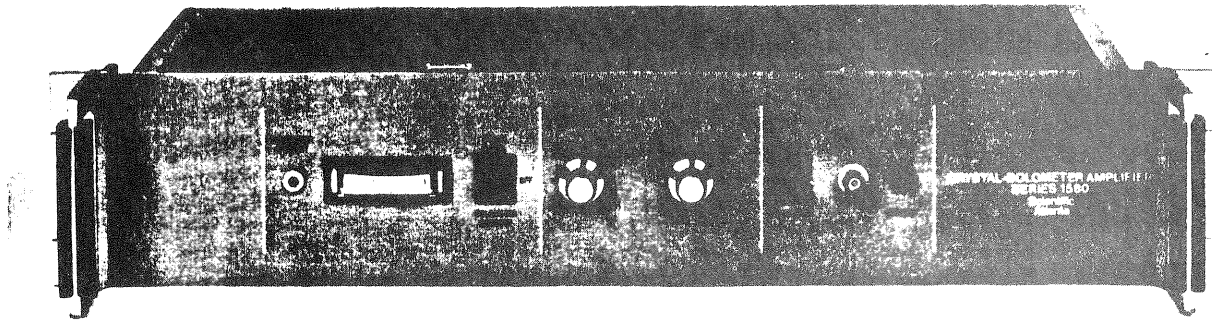
The Model 1587 DC Amplifier is a dc preamplifier which accepts dc inputs from microwave receiving systems or other test or measurement equipment.

Input voltages may be unipolar (0.1 to 10 volts) or bipolar ( $\pm 5$  volts) with offset voltages up to 100 volts.

Front panel controls include variable attenuation over a 20 dB range and offset adjustments. Indication is provided for reverse polarity inputs and amplifier overload.

Output dc voltage is sent to a digital to analog converter interface located in the recorder mainframe.

An application example using the dc amplifier is with components of a Scientific-Atlanta receiving system such as the Series 1820 Digital Phase Display and Series 1833A Logarithmic Ratiometer. From these units, dc signals are available which permit recording of relative phase or signal level respectively.



### Model 1587 DC Amplifier

#### MODEL 1586 AC AMPLIFIER

The Model 1586 AC Amplifier is a high gain, low noise, narrow band preamplifier for low level inputs such as generated by bolometer or crystal detectors, or the 1 kHz output of a microwave receiver.

Signal inputs may range from 1 microvolt to 1V RMS for full scale pen deflection. Dynamic operating range is 80 dB.

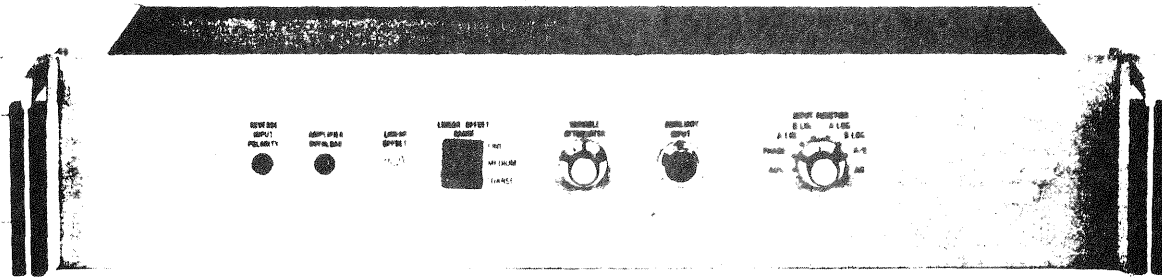
To reject harmonics of the ac power line, standard filter center frequencies are 1000 Hz for 60 Hz line operation and 1025 Hz for 50 Hz operation. Typical filter bandwidth is 25 Hz. Analog signals processed by the preamplifier are sent to a digital to analog converter interface located in the recorder mainframe.

Front panel controls include bolometer bias adjustments, detector selection, and attenuation controls. Bolometer burnout protection is provided.

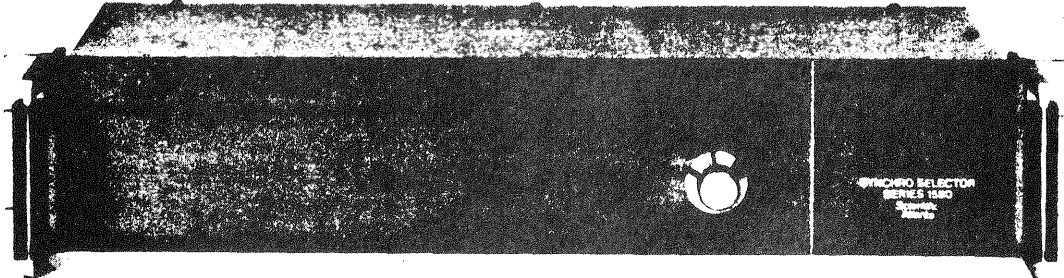
#### MODEL 1588 SYNCHRO SELECTOR

The Model 1588 Synchro Selector permits one of four possible synchro inputs to be switched into the synchro-to-digital converter located in the recorder mainframe.

Synchro input may be 1:1 ratio or 36:1 ratio. The ratio selected is transmitted to the recorder microprocessor and appropriate scaling is performed.



**Model 1586 Crystal-Bolometer Amplifier**



**Model 1588 Synchro Selector**

## **OTHER RECORDER FEATURES**

Firmware, or microprocessor programs stored in read only memory, provide many features which were not practical to implement in earlier antenna pattern recorders. Firmware instructions can replace functions and operations that previously were implemented in hardware.

Basically, firmware instructions are executed in a continuous "loop" to read input data, perform pen function and chart scaling, and position the chart and pen servo system. Loop time is approximately five (5) milliseconds and varies slightly with the functions selected and options installed.

## **CHART AND PEN SERVO SYSTEM**

Direct current motors provide drive to the chart and pen system. Optical encoders attached to each motor shaft provide position error feedback to the microprocessor. An external rate loop is provided for both chart and pen drive systems.

The encoder provides clockwise and counterclockwise pulses which drive up-down counters. On each program loop the counters are read and reset by the microprocessor. The counter value represents the position error.

Position commands, feedback error, plus any position changes caused by input data (from the receiver or positioner system) are output to digital to analog converters. Power drivers provide amplification for driving the chart and pen torque motor.

Pen position is absolute with 4100 discrete addressable positions over 250mm of pen travel. Maximum pen writing speed is 1500mm per second. Typical position accuracies are  $\pm 0.15$  dB over a 40 dB dynamic range (pen function).

Chart position is relative with 9600 discrete positions over a full scale chart cycle of 540mm. Maximum chart speed is 750mm per second. At chart speeds of 100mm per second, with a 36:1 synchro input, dynamic position error is 0.127cm. Static position error is 0.038cm.

## **PEN CALIBRATION**

On power up, the microprocessor drives the pen to the top of the chart to establish a physical reference point. From this position all pen movements are referenced.

To eliminate paper expansion error caused by humidity, a pen correction factor is applied to each pen position command. Digital adjustments are provided for the operator to enter the pen correction factor.

When a calibration switch is activated, the pen is driven exactly 4100 counts from the power up reference point. By adjusting the digital pen correction switches until the pen lies on top of the bottom printed line on the chart paper, any dimensional error in the pen axis are effectively removed. When the calibration switch is returned to "operate", all pen positions will be corrected by the microprocessor.

## **PEN FUNCTION**

Pen function calculations involve processing the input pen data in a manner to permit a logarithmic, linear, square or square-root display. All pen functions are performed by microprocessor operations and are selectable by front panel switches.

Analog pen data from the AC or DC Preamplifier units is received in the mainframe through an analog to digital converter. Data includes a 10-bit binary value representing a 22 dB range, and range signals indicating one of four 20 dB ranges. A 2 dB overlap is provided for range switching hysteresis.

Analog signals are processed to permit log, linear, square or square-root displays. Log and antilog conversions are performed by a 22 dB lookup table. Table entries are spaced at 1 dB intervals. Linear interpolation is used for fractional dB values. The A/D range bits determine if 20, 40, or 60 dB offset is to be added.

Square-root pen function is performed by accessing the lookup table to determine the log and performing a division by 2.

Digital pen data is displayed using a linear pen function. This permits plotting the data directly as received, since normally digital pen data arrives at the recorder in a directly usable format.

## **FILTER DELAY CORRECTIONS**

Overlaid antenna patterns produced with alternate scan directions with constant frequency and signal level, often show an apparent angular displacement of the plotted pattern. This occurs due to delays of the incoming signal as it passes through analog filters in audio frequency IF amplifiers.

To eliminate this problem, the microprocessor delays the incoming chart command for a time delay equivalent to the analog filter delay.

The delay is accomplished by storing incoming chart commands in a rotating buffer. Buffer rotation time is equivalent to the measured filter delay (17msec) of the AC and DC Preamplifier units.

## **PEN SMOOTHING**

Pen smoothing, a form of digital filtering, is selectable for analog inputs. It is performed by firmware averaging pen data over a number of samples. Chart position commands are delayed (stored by the microprocessor) to permit the average pen positions to be determined by a number of samples before and after the current value. In effect, a "look ahead" is performed since the chart command is delayed.

The degree of smoothing is determined by the number of samples in the average. This feature is selected only when "real time" analog data is being input to the recorder.

## **RECTANGULAR TO POLAR CONVERSION**

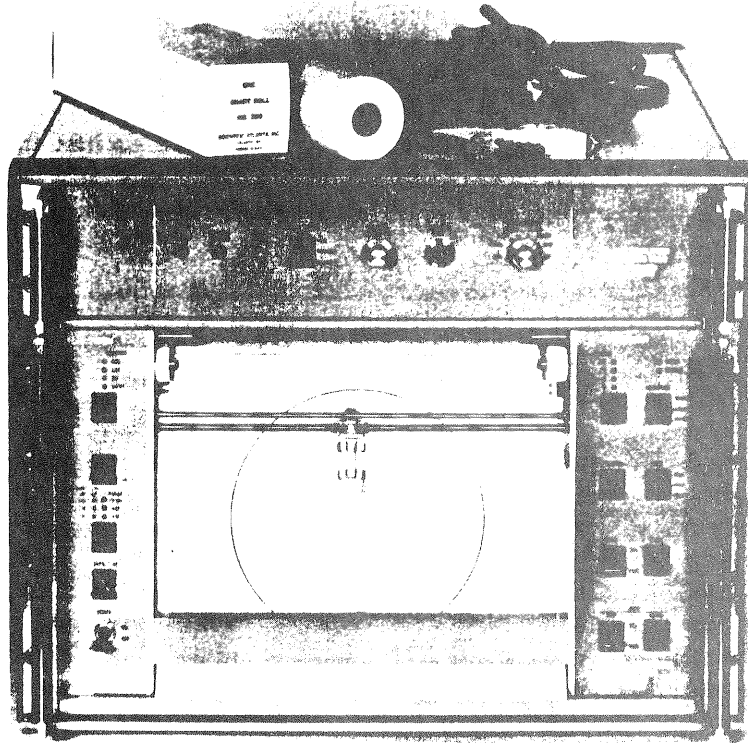
For generation of polar plots, the optional memory module contains firmware which converts rectangular pen and chart positions into polar coordinates. Selection of this mode is by front panel switch.

This feature is possible due to the dynamic response of the chart system. At many angular positions of the incoming angular information, the chart will be required to respond to the input signal, including noisy signals.

Coordinate conversion is performed by trigonometric lookup tables. A  $90^\circ$  sine table, at one degree intervals, is used for sine and cosine lookup. Cosines are obtained by accessing the sine table in reverse. All angles are reduced to the table

range before lookup. Offsets are then added to restore the original quadrant.

Since the chart axis resolution differs from the pen axis, chart commands are scaled to permit "perfect" circles to be drawn.



**Series 1580 Recorder with polar option**

## **VECTORIZING**

Vectoring is performed by firmware intercepting large chart and/or pen positioning commands and dividing the movement into segments of shorter lengths. Vectoring permits straight lines to be drawn for positioning steps which exceed the capability of the chart and pen servo system.

Straight lines, other than vertical or horizontal lines, require both chart and pen axes to be driven simultaneously. When vectoring is performed, the chart and pen commands are divided into separate vectors and output to the servo system.

When the error feedback diminishes to near zero, the next segment is output. This process continues until the end point is reached.

Vectoring does require longer plotting time and is used primarily for computer or calculator inputs. Normal "real time" data recording, where inputs from a receiver and positioner are monitored continuously, does not use vectoring and pen response is not slowed by the vectoring process.

## PAPER SENSE

Paper supply is sensed by a mechanical switch in contact with the roll paper supply. When the paper supply diminishes beyond a certain limit, a signal is sent to the microprocessor. This feature is primarily for remote operation.

Paper edge sensing is performed by infrared sensor located in the front of the recorder. This feature prevents driving the paper back into the recorder. When the edge is reached, the recorder will automatically perform a format change cycle to advance the paper out of the recorder.

## REMOTE OPERATION

With the optional memory module and IEEE-488 standard digital interface, the recorder may be programmed by external computers or calculators. Programming commands are in simple ASCII format and permit all recorder controls to be operated remotely. Status supplied by the recorder permits the controller to monitor paper supply, error, and busy status.

Data inputs may be amplitude or phase angle, and angular position in degrees. With these data formats, the recorder

performs processing just as if the data had been received directly from a receiver and positioner.

An alternate data format permits specifying absolute chart and pen position. With the absolute data format, the recorder may be used as a normal X-Y recorder under control of an external controller.

## CONFIDENCE EXERCISE

For a microprocessor based instrument, it is often desirable to provide means for the operator to invoke an automatic procedure that will demonstrate operation of the basic instrument performance.

By actuating certain front panel controls, the recorder will perform an exercise which indicates correct performance of many internal circuits, including the microprocessor and memory.

When the front panel buttons are depressed simultaneously, the recorder will plot a test pattern consisting of triangles of increasing height. Successful completion of this exercise indicates correct operation of the microprocessor, memory, front panel interface, and servo system. Other modules, such as input cards, may be exercised by normal recorder operation.

