OPERATING & MAINTENANCE MANUAL

for

H/P PART NO. 00002-91329

MODEL 2S

X-Y RECORDER

by

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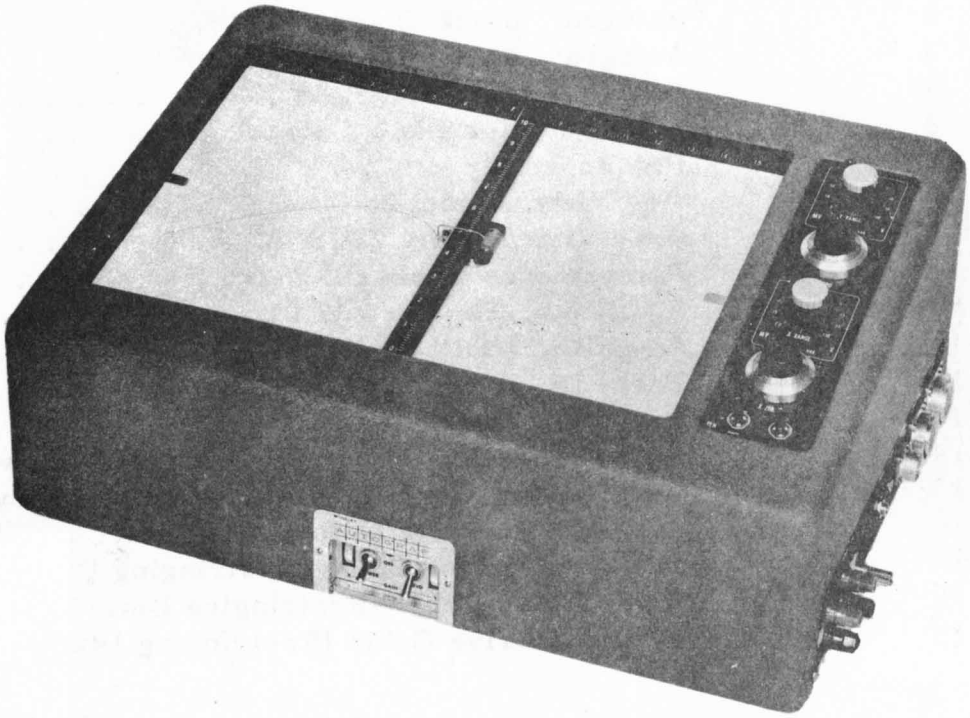


Model 2S AUTOGRAF

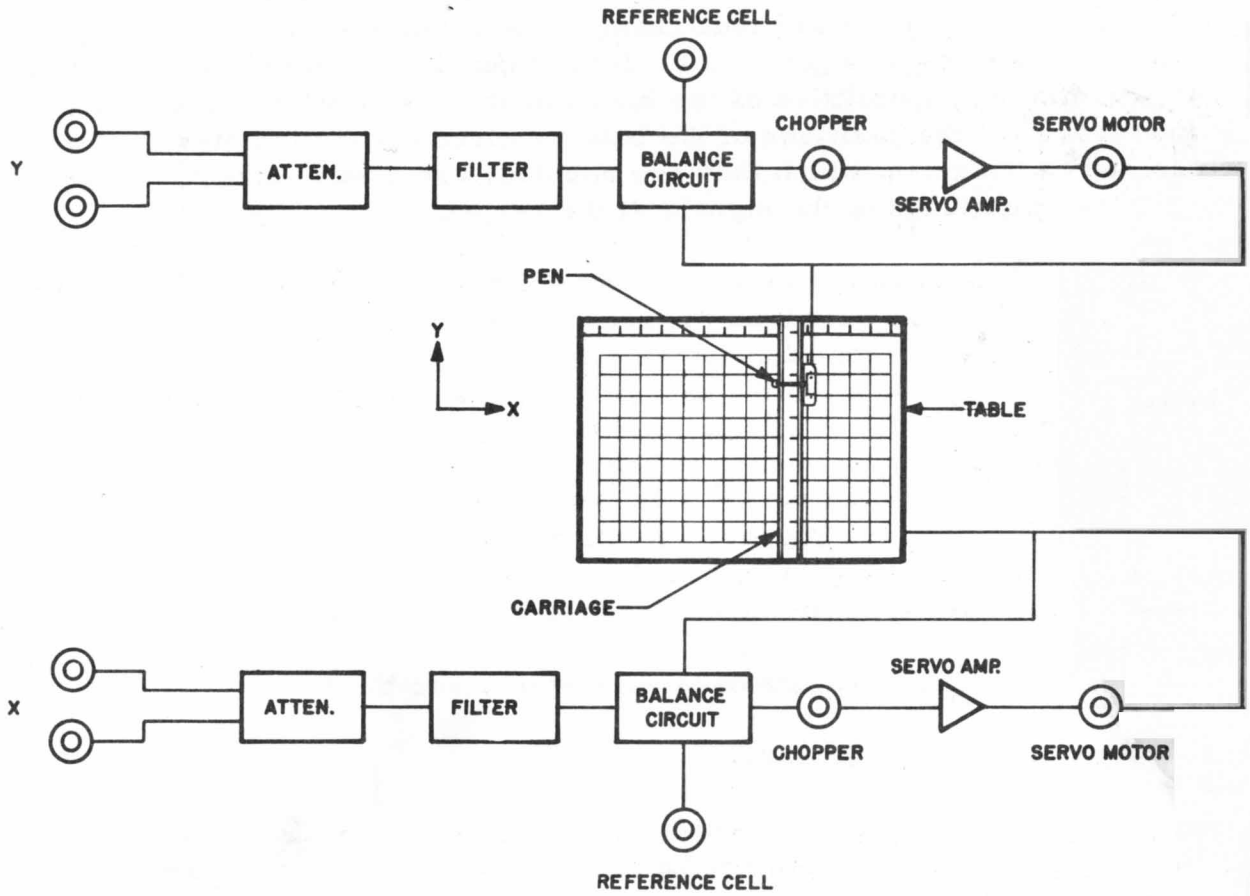
Fig. 1

SECTION I - DESCRIPTION

A. GENERAL DESCRIPTION

The Autograf, Model 2S, is a two-axis, flat-bed, graphic recorder designed for general laboratory use. The Model 2S has in addition a built-in time base (or sweep circuit) operating optionally on the X-axis. The flat horizontal recording surface accommodating 11" x 17" standard graph paper with recording accomplished on two axes, Y and X, corresponding to the pen and carriage, respectively. Each axis is controlled by an identical self-balancing servo-mechanism, electrically independent and isolated from ground. In operation, one servo-mechanism moves the recording pen in a vertical direction and the other in a horizontal direction in response to input signals representing the desired data applied to the respective input terminals. The resulting relative motion of the two servo-mechanisms traces a cartesian coordinate graph of the relationship on the paper.

The sequence of basic recorder functions is outlined in the following block diagram, Fig. 2.



AUTOGRAF Block Diagram
Fig. 2

The basic voltage range of the servo systems is 0 to 5 millivolts for the Y axis and 0 to 7.5 millivolts for the X axis for full scale travel. Operation with greater voltages is obtained by means of a step attenuator inserted between the input terminals and the balance circuit. Each range step may be made continuously variable by operation of a transfer switch which inserts a variable potentiometer and extends that range to about five times its fixed value. The range position is selected so that the amplitude of the input data will be within the travel limits of the instrument. Included in the input circuit is a variable filter which minimizes undesirable noise and ripple disturbances in the input signals.

After passing through the input filter and attenuator, the input signal is applied to the balance circuit, where it is cancelled by an internally supplied opposing voltage derived from a reference cell and potentiometer. Under these conditions there is no signal output from the balance circuit and the servo system is at rest. When the input signal changes to a new value it is no longer canceled in the balance circuit and the unbalance voltage, or error signal, is applied to the chopper where it is converted to a 60-cycle form. The AC output of the chopper is amplified and applied to the control winding of a two-phase servo motor. The motor is mechanically coupled to the balance circuit potentiometer and thus changes the balance voltage until it again cancels the new value of input signal. If the input data is constantly changing at rates within the capabilities of the instrument, this rebalancing action is continuous. Thus the positions of the balance circuit potentiometers and of the pen and carriage, to which they are coupled, are always directly proportional to the amplitudes of the signals at the respective input terminals.

The use of the X-axis with a variable input voltage or as a sweep circuit is selectable by a function switch on the rear panel. Operation of the time base is dependent on the fact that the charging current taken by a condenser will assume a constant value when the charging voltage is controlled so as to increase at a uniform rate. Existing facilities of the recorder are utilized to apply a linearly increasing voltage to the X-axis servo amplifier causing the pen to advance at a uniform rate in total sweeps dependent on the constants switched into the circuit. These constants are so selected during manufacture that the time required for full scale pen travel equal, in seconds, the numerical values of the millivolt steps of the X-axis range selector.

The Model 2S Autograf consists of three major assemblies:

1. A removable aluminum case.

2. The base plate assembly, mounting the amplifier chassis (which contains the chopper, two high gain amplifier channels and a power supply for the amplifier), the various input plugs (mounted on a side panel), the reference cells, the primary power control panel, and the vacuum pump.

3. The recording table assembly, including the control panel, the input attenuators and filters, the moving pen and carriage mechanisms, the control motors and balance potentiometers with their drives. The recording table is attached to the base plate with supporting posts at each corner, and can be rotated up and forward on front post pivots.

B. SPECIFICATIONS

1. MECHANICAL DATA

Case Form: Sheet aluminum case, with rubber feet for bench use.

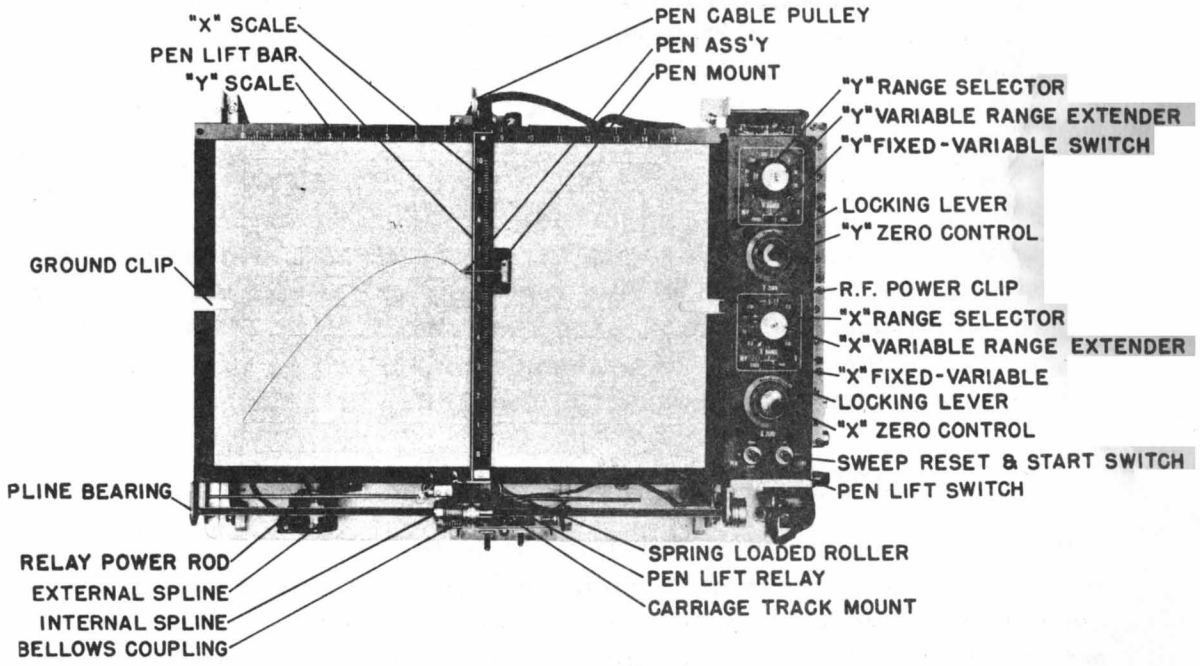
Dimensions: 24" wide x 9" high x 16" deep.

Weight: Approximately 55 pounds.

Controls: All operating controls are mounted on a sloping panel at the right of the recording surface. The servo gain controls are located in the window at the front of the case beside the servo and power switches, and are operated by knurled knobs projecting through slots at the bottom of the window frame.

a. Power Switch

The left-hand toggle switch in the window at the front of the case applies power to the instrument and closes the relay connecting the reference cells. This switch has three positions, the third position controlling operation of the vacuum pump.



AUTOGRAF, Mod. 2S, Top View
Fig. 3

b. Servo Switch

The right-hand toggle switch in the window at the front of the case energizes the servos and choppers. With this switch in the down position, the recorder is in a "standby" condition and the pen and carriage may be moved by hand.

c. Scale Range Controls

The scale range controls are located on the control panel. Both stepped and continuously variable controls are provided. The scale positions represent input voltages required to drive the X or Y axis from zero to full scale. The volts/inch calibration of each axis is identical for corresponding fixed selector ranges (viz. 1.5 v and 1.0 v on X and Y axes respectively). Beneath each range selector is a two-position slider switch for selection of either fixed or variable range. With this switch in the "variable" position, the maximum voltage acceptance of any range for full scale deflection can be continuously extended to about five times its indicated value by adjustment of the potentiometer knob projecting through the center of the range selector knob. This feature can be used to permit convenient fitting of experimental data to any portion of the recording area. The volts/inch calibration of the instrument as determined by the position of these controls does not change with the setting of the zero control. CAUTION: Input voltages should never exceed 500 volts.

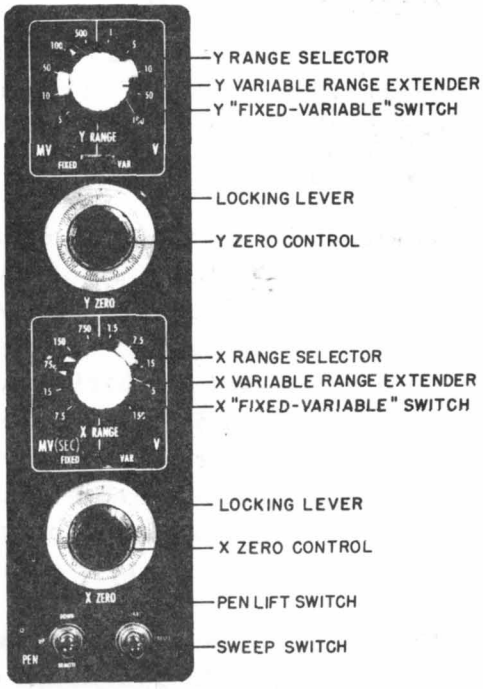
d. Time Sweep Control

Voltage range selection and time sweep selection are combined in the same X-range switch. With the Volts-Time switch (on the rear function panel) in "Volts" position, the recorder operates as a normal two-axis plotter; with this switch in the "Time" position, the X-axis operates as a time base with sweep ranges (in seconds) corresponding to millivolt values on the switch selector scale. Sweeps available in the standard Model 2S are 7.5, 15, 75, 150, and 750 seconds for full scale X-axis pen travel. When operating with the sweep circuit, variations in full scale time intervals of up to five times the calibrated values may be obtained by placing the X-range expander switch in the "VAR" position and adjusting the top knob of the range control. Use in this manner will not disturb the basic calibration of the timing circuits.

e. Zero-Setting Controls

The zero-setting controls are located on the control panel and consist of 10-turn potentiometers with counting dials. By means of the zero-setting controls the electrical zero of the instrument can be set anywhere on the paper, or up to one scale-length to the left and below the lower-left hand

corner of the paper regardless of the scale range setting. Hence, through proper adjustment of the controls, data can be plotted in any desired quadrant. A locking lever prevents the control knob from turning while the instrument is in operation.



Control Panel, Mod. 2S
Fig. 4

f. Pen Lift Switch

The pen lift switch is at the bottom left of the control panel. In the "down" position it applies power to a relay on the carriage track mount to release a spring and lever mechanism normally holding the pen from the paper. A "remote" position is furnished to provide automatic pen operation with the sweep switch. Power must be "ON" for the pen solenoid to operate; thus with power removed from the instrument the pen will always be in a non-writing position. The "UP" position of this switch is also used for point plotting, the contacts of the switch being shunted, through the connections to the point plotter receptacle, by an external accessory which supplies a "plot" signal.

g. Time Interval Actuator Switch

When using the time base feature, initiation of a selected time sweep action for the X-axis is accomplished with the toggle switch to the right of the pen lift switch. Movement of this switch down starts the time interval; restoring to center position resets the circuit for the next operation. Remote position of the pen lift switch parallels internal contacts for simultaneous pen and sweep operation.

h. Curve Follower - Record Switch

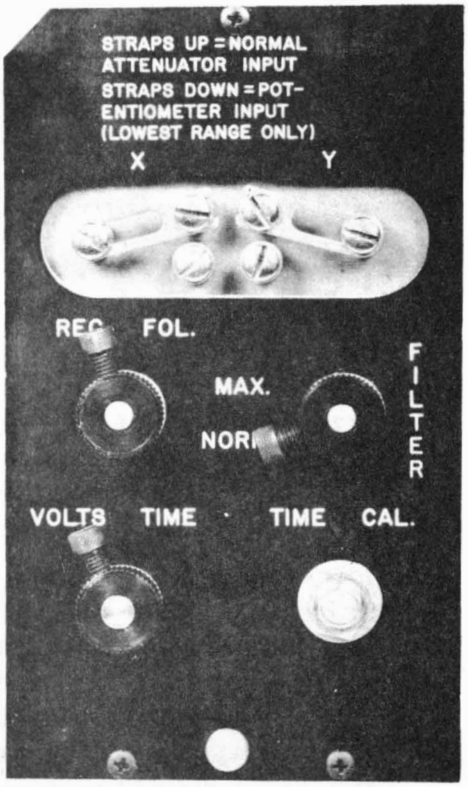
This control is located on the small panel at the rear of the machine. When the Autograf is used as a recorder the Record-Follow switch must be in the Record position. When in the Follow position the Y axis amplifier is switched to the Curve Follower (C. F.) adapter receptacle located on the input plug panel.

i. Input Filter Switch

The input filter switch is located on the rear exposed panel. This switch has two positions providing the following filter characteristics:

Position 1: Normal: Low pass filter with 26 db of attenuation at 60 cycles and rapid cut-off at higher frequencies. Without impairing normal recorder performance, use of this filter will eliminate most forms of undesirable noise often present in laboratory test set-ups.

Position 2: Maximum: Low pass filter with additional capacity resulting in more rapid cut-off at low frequencies. In this position it is possible to plot the output of an unfiltered half-wave 60 cycle rectifier. CAUTION: When using this filter the recorder must be operated much slower than normal to avoid plotting errors caused by filter delay.



Rear Function Panel, Mod. 2S
Fig. 5

j. Paper Requirements

Recording is done on standard 11" x 16-1/2" graph paper; the scales on the machine are accurately aligned with Moseley H-100150, 10 x 10 to the inch, or other similar papers may be used, such as Dietzgen #340 D-10.

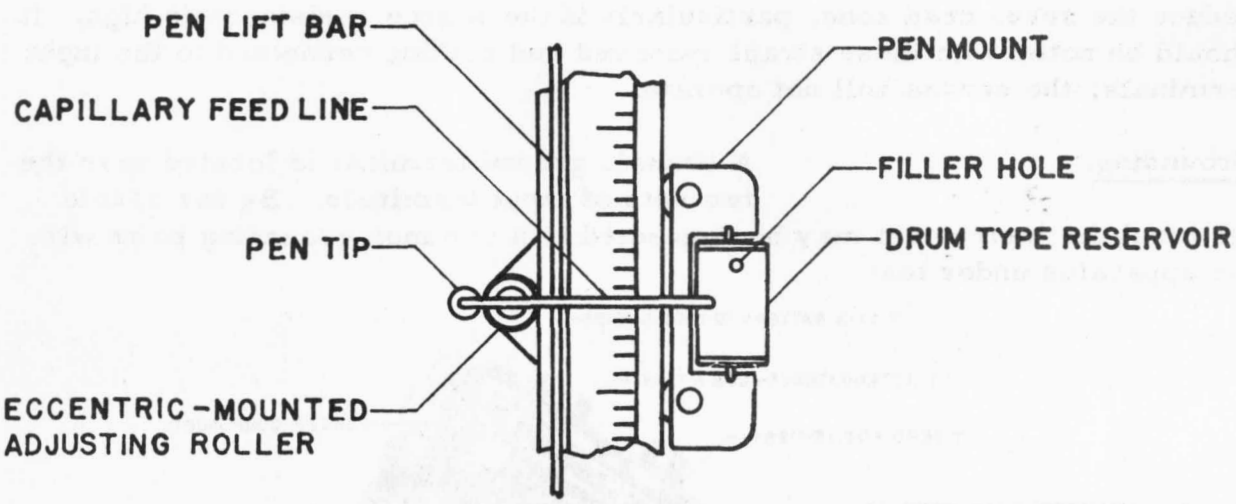
k. Pen Assembly

The pen assembly consists of a drum-type ink reservoir resting in a pivot mount which moves along the carriage beam. A rigid capillary tube feed line leads from the reservoir to the point. The pen is raised from the paper by a lever system which is released by a relay.

l. Carriage Assembly

The carriage assembly consists of an inverted "U" beam with tracks on either side for the pen mount rollers and a rear pulley for the pen mount cable, a spring-loaded, roller-mounted "T-square" type carriage mount which is cable-driven along a track at the lower front of the recording table, and a non-guiding roller mount at the rear. The drive sheave for

the pen mount cable is housed in the carriage mount. It is bellows-coupled to its drive spline shaft, assuring bind-free carriage travel.



Pen Assembly
Fig. 6

2. ELECTRICAL DATA

Power Requirements: 115 volts, 60 cps, single phase, approximately 100 voltamperes. Special models operating from 220 volts and/or 50 cps are available on special order. For optimum performance the third prong of the AC power cord should be grounded.

Vacuum Tubes: Standard RETMA vacuum tubes are used as follows:

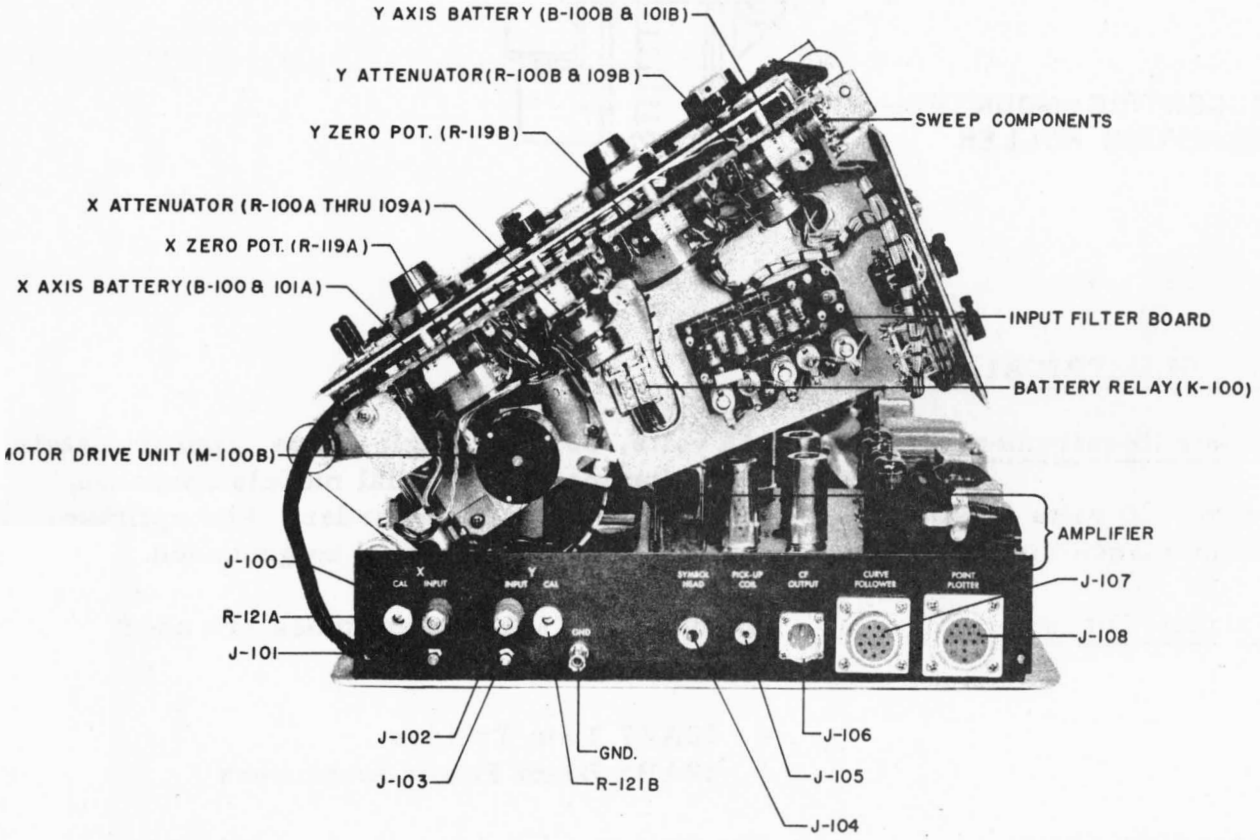
4 12AX7 Twin Triodes
4 12AB5 Beam Power Amplifiers

Input Data Signals: The Autograf input terminals must be supplied with DC signals which are linear functions of the original information. The input signals must vary at a rate within the response capabilities of the machine and have amplitudes within the scale ranges of the recorder. An appropriate input filter setting may be used to render the input reasonably free of AC ripple or other transient disturbances. CAUTION: Input voltages in excess of 500 volts should not be used.

Input Connections: The input panel is on the right side of the instrument. In operations where minimum current drain is required, the machine may be used as a self-balancing potentiometer by disconnecting the binding post straps located on the small panel at the rear of the machine. When these straps are removed the input voltages bypass the input

attenuators and the full sensitivity of the instrument is utilized. The attenuator controls should be in the 5 and 7.5 mv positions and the source resistance should be 1500 ohms or less. The amplifier gain may have to be increased to reduce the servo dead zone, particularly if the source resistance is high. It should be noted with these straps removed and nothing connected to the input terminals, the servos will not operate.

Grounding: A chassis ground terminal is located near the two sets of input terminals. By use of this terminal the instrument may be connected to a common grounding point with the apparatus under test.



Side View, Mod. 2S
Fig. 7

3. PERFORMANCE DATA

Accuracy and Resolution: As shipped from the factory, the Autograf has initial accuracy of .25% of full scale on all ranges. Resolution is within this figure.

Response Speeds: Both axes have identical response, requiring a maximum of 1 second for full scale travel. The pen traverses the 11" side of the paper; the carriage moves along the 16-1/2" side.

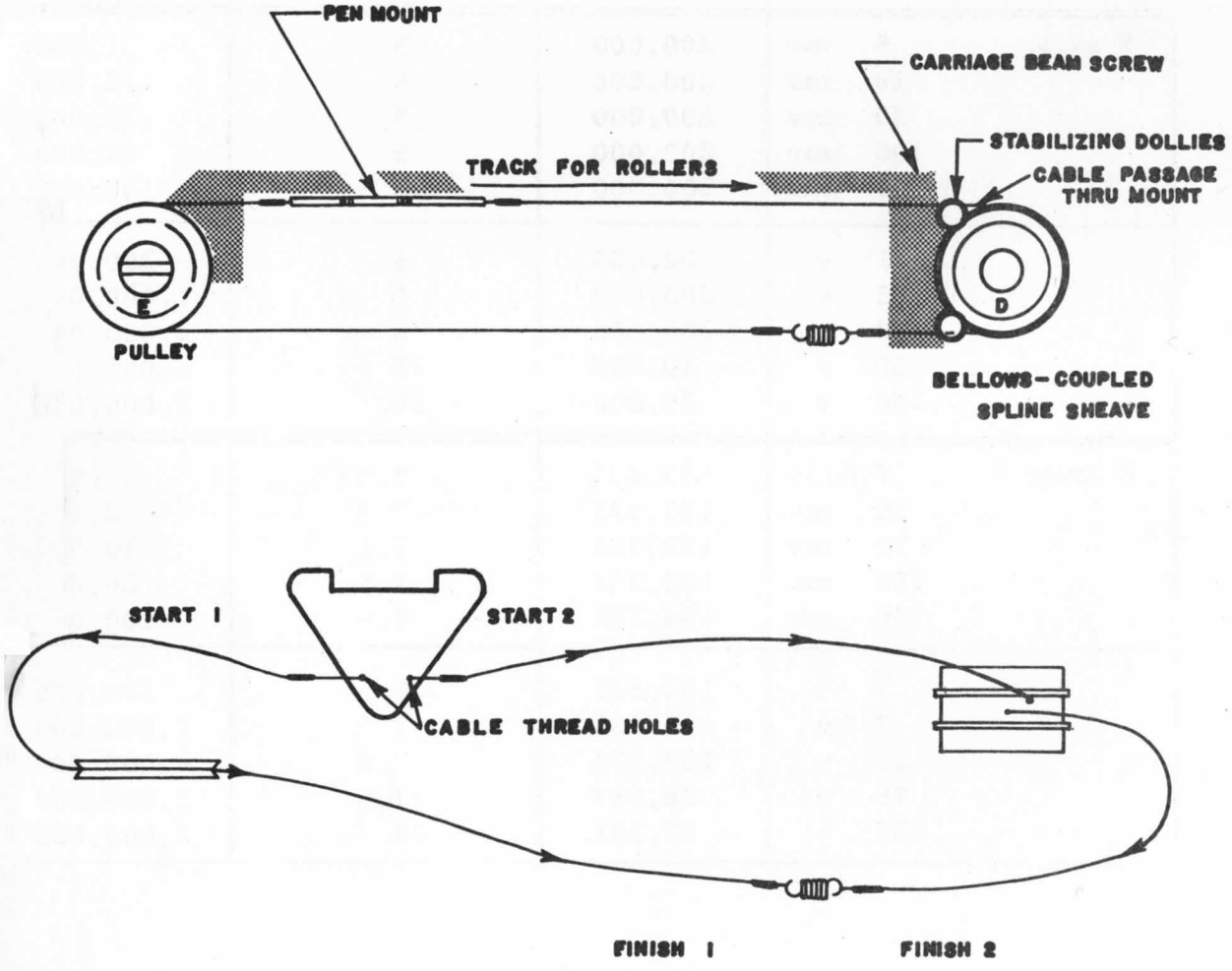
Voltage Ranges and Sensitivity: Each axis of the Model 2S Autograf provides 10 voltage ranges. In addition, the "fixed-variable" selector switch and potentiometer can be used to continuously extend the maximum voltage acceptable by each range about 5 times. The X axis ranges are 0 to 7.5, 15, 75, 150 and 750 millivolts; 0 to 1.5, 7.5, 15, 75 and 150 volts. The Y axis ranges are 0 to 5, 10, 50, 100 and 500 millivolts; 0 to 1, 5, 10, 50 and 100 volts. The X axis scales from 7.5 mv to 15 volts have an input sensitivity of 133,333 ohms per volt. The Y axis scales from 5 mv to 10 volts, have an input sensitivity of 200,000 ohms per volt. The 50, 75, 100 and 150 volt scales have an input sensitivity of 200,000 ohms per volt. The 50, 75, 100 and 150 volt scales have an input resistance of 2 megohms. If the variable range extender is used, sensitivity is decreased only if the input voltage actually exceeds the fixed range setting. The sensitivity, input resistance, and full current drain for all fixed ranges are as follows:

	Range	Sensitivity (ohms/volt)	Full Scale current drain (micro-amperes)	Input resistance (ohms)
Y axis:	5 mv	200,000	5	1,000
	10 mv	200,000	5	2,000
	50 mv	200,000	5	10,000
	100 mv	200,000	5	20,000
	500 mv	200,000	5	100,000
	1 v	200,000	5	200,000
	5 v	200,000	5	1,000,000
	10 v	200,000	5	2,000,000
	50 v	40,000	25	2,000,000
	100 v	20,000	50	2,000,000
X axis:	7.5 mv	133,333	7.5	1,000
	15 mv	133,333	7.5	2,000
	75 mv	133,333	7.5	10,000
	150 mv	133,333	7.5	20,000
	750 mv	133,333	7.5	100,000
	1.5 v	133,333	7.5	200,000
	7.5 v	133,333	7.5	1,000,000
	15 v	133,333	7.5	2,000,000
	75 v	26,667	37.5	2,000,000
	150 v	13,333	75	2,000,000

X-Axis Sweep Ranges and Linearity: Sweep ranges correspond numerically in seconds to the millivolt ranges on the X-range selector scale. These sweeps, for full scale travel, are 7.5, 15, 75, 150, and 750 seconds. A variation of up to five times the indicated fixed intervals may be obtained by operation of the X-range expander control with the switch in the "VAR" position. Sweep linearity is governed by the circuit constants and normally does not vary more than ± 2%.

Calibration Stability: Short term calibration drift of the Autograf is negligible. Long term calibration change due to aging of the reference cells will accrue at the rate of .25% each 6 months. During the 12 to 18 months expected life of the reference cell, this drift can be compensated by recalibrating the recorder when maximum accuracy is required. Calibration procedure is given in the "Maintenance" section of this manual.

Calibration Stability: (Sweep Ranges) Sweep intervals are established by special component selection for each instrument during manufacture. The reference cells used for axis calibration also supply voltage for operation of the time base. Initial accuracy will be maintained during the normal life of the reference cells.



Rear View, Model 2S
Fig. 8

SECTION II - OPERATION

A. OPERATING INSTRUCTIONS (As two-axis recorder)

For satisfactory operation of the Autograf the phenomena to be recorded must:

a. Be reduced to direct current, the available voltage being a linear function of the original information.

b. Have amplitudes within the scale ranges of the recorder (X input; 7.5 mv to 150 v; Y input: 5 mv to 100 v; range can be extended to 500 v, each axis).

c. Vary at a rate within the response capabilities of the instrument.

Provided the above signal conditions are met, the Autograf may be placed into operation as follows:

1. Connect the power cord to a 115 volt, 60 cps line and turn the unit on by moving the Power switch to the "UP" position. The pilot light will indicate that power is applied.

2. Place ink in the pen reservoir. This is done using a hypodermic syringe. Do not completely fill the reservoir and use Esterline-Angus recording ink only. Apply a syringe to the filler hole to force ink through to the pen tip.

3. Load paper as follows:

   a. Place pen lift switch in "UP" (vertical) position so that pen is off the paper.

   b. Turn the servo switch OFF. (down position).

   c. Push the carriage by hand to approximately 4" from the left-hand end of the recording table.

   d. Slide paper under the carriage onto the paper bed.

   e. Align paper with table edge scales.

   f. Turn vacuum switch "ON". Readjust alignment of paper with scales and smooth out paper surface.

   g. When paper is to be removed, turn off vacuum switch to save wear on pump.

4. Connect the X and Y components of the data to be recorded to the X and Y input terminals and set the scale range switches to the expected maximum values.

5. With the pen lifted from the paper, turn the right-hand toggle switch (servo switch) to the "UP" position to energize the two servos, and move the Record-Follow switch to the Record position. The input data can now be dry run through its range and its position on the paper set by adjusting the Zero-setting controls as desired. The pen may now be lowered to the paper and the data run through its range to produce the desired record. To establish accurate zero offset in the Y or X axis connect the desired offset voltage to the appropriate input terminals and adjust the zero setting control so as to bring the carriage or pen index into exact agreement with the "O" mark on the corresponding scale.

6. The right-hand, servo-energizing, toggle switch applies 115 volt, 60 cps power to the fixed phase windings of the two drive motors, and 6.3 volts to the chopper. This switch should be placed in the "stand-by", or "OFF" position whenever the Autograf is not being operated, thereby lowering power dissipation, and avoiding unnecessary wear of the balancing potentiometers and other mechanical parts.

7. When a voltage in excess of the scale setting is applied to either input terminal the servo will move quickly to one end of travel and strike the drive mechanism stop. These stops protect the balancing potentiometers from damage. The driving mechanism also incorporates a slip-clutch which allows the motor to continue running until the data signal is reduced to an on-scale value. The Autograf should not be allowed to run against the stops for prolonged periods as heating of the motor and excessive clutch wear may result.

B. OPERATING INSTRUCTIONS (Using X-axis as TIME BASE)

1. Prepare recorder as in steps 1 through 3 of paragraph A. above.

2. Connect data to be recorded to Y input terminals.

3. Place function switch (on rear panel) in "TIME" position.

4. Select total time interval desired on combination X-range switch.

5. Data may now be "dry-run" as in step 5, paragraph A by operating "TIME" switch to "ST". When recording is desired, place pen-lift switch in "remote" position and movement of "TIME" switch to "ST" automatically lowers pen and starts the sweep action.

6. Observe precautions outlined in steps 6 and 7, paragraph A.

C. TYPICAL RECORDING PERFORMANCE

Figs. 9A, 9B and 9C show actual Autograf recorder performance. These curves were drawn on a normal production recorder and reproduced here at 1/2 size

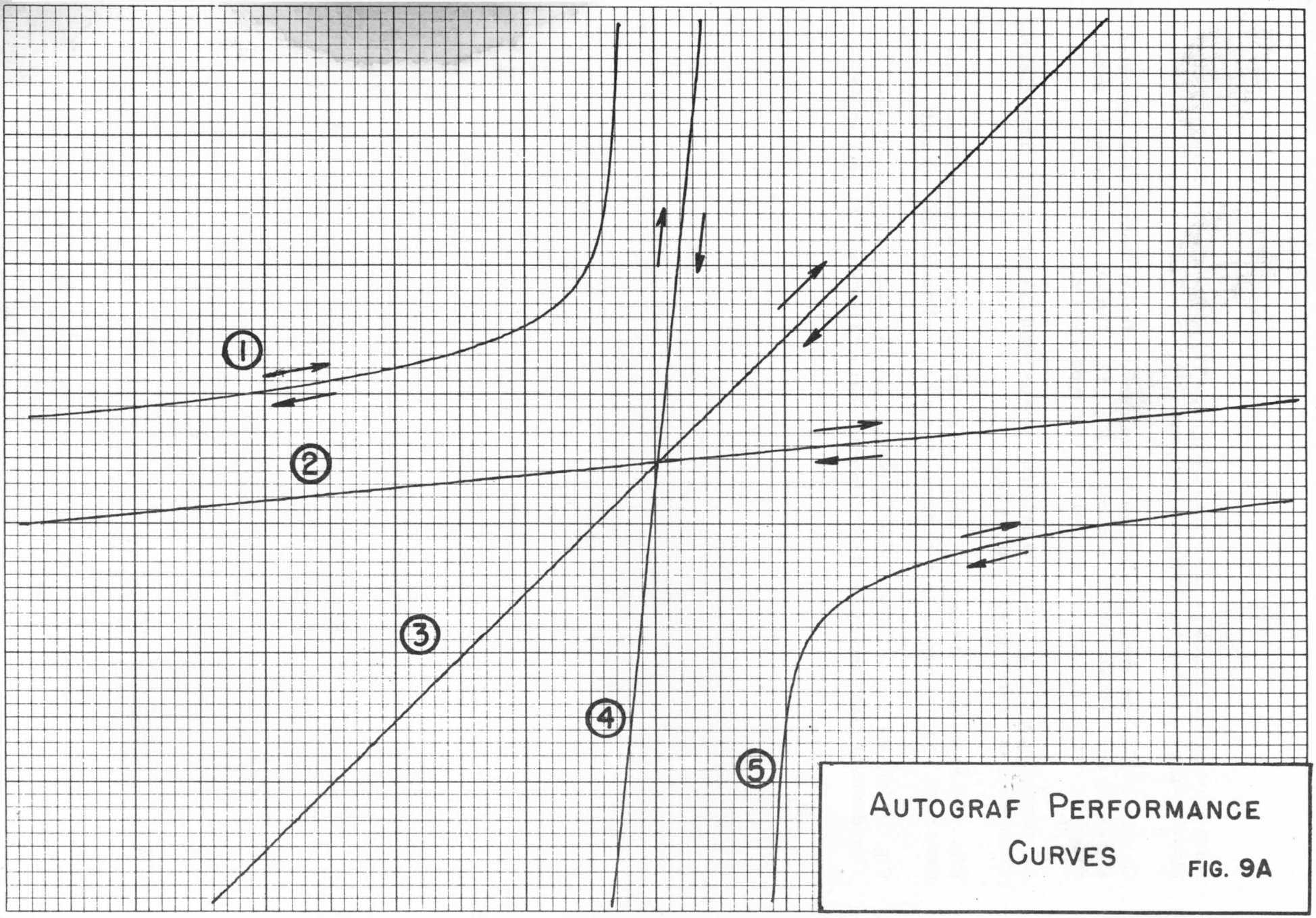
from the original tracings to fit these pages. The graphs were drawn on Moseley paper, using the Autograf ink pen.

Curves of Fig. 9A show straight lines and curves drawn from a hand-operated signal source, similar to the test rig of Fig. 12. Curved records were produced by recording current vs. voltage of a type 1N34 diode.

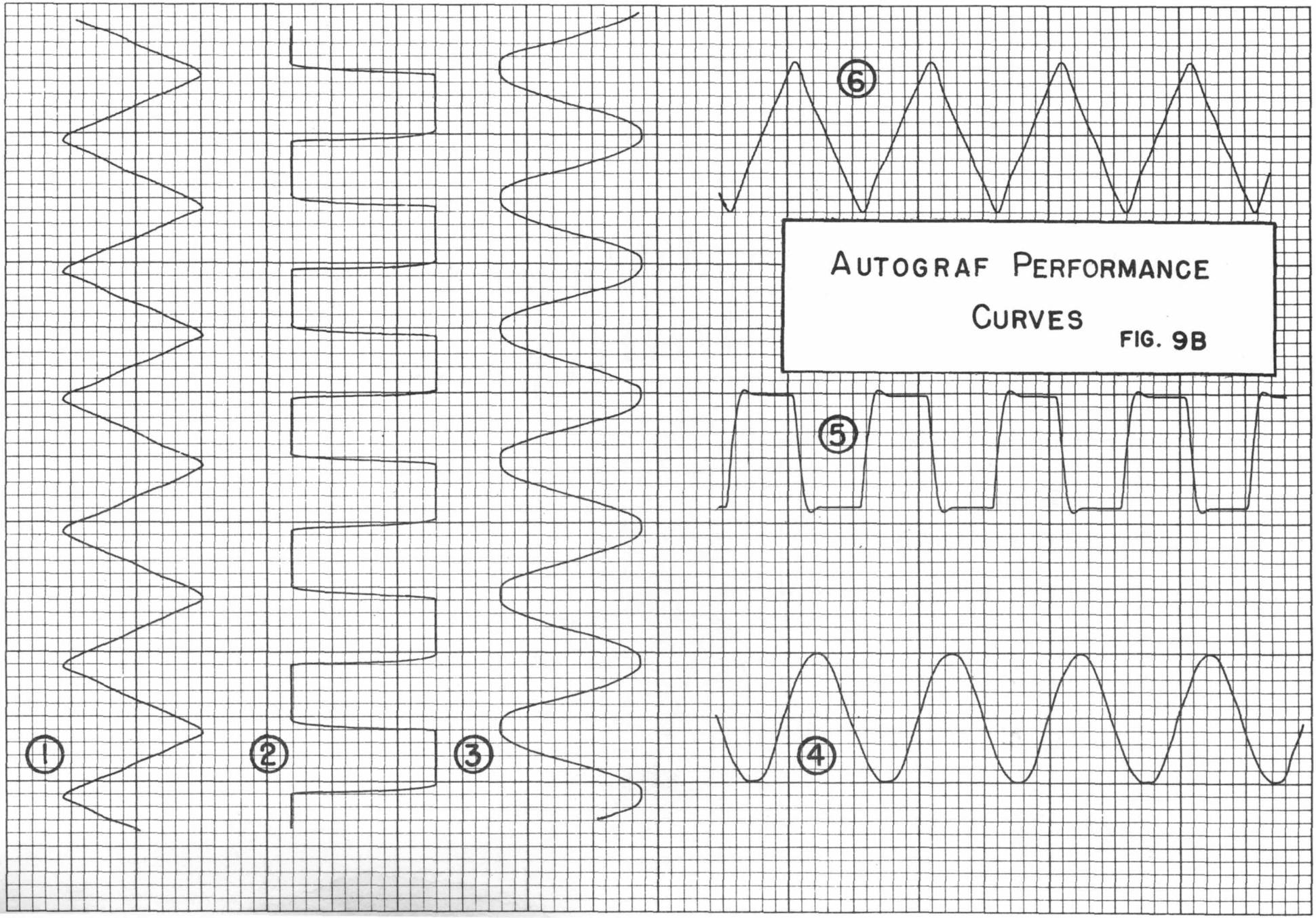
All recordings of Fig. 9A show original "trace" and "reference". This clearly illustrates any servo dead-zone or lag.

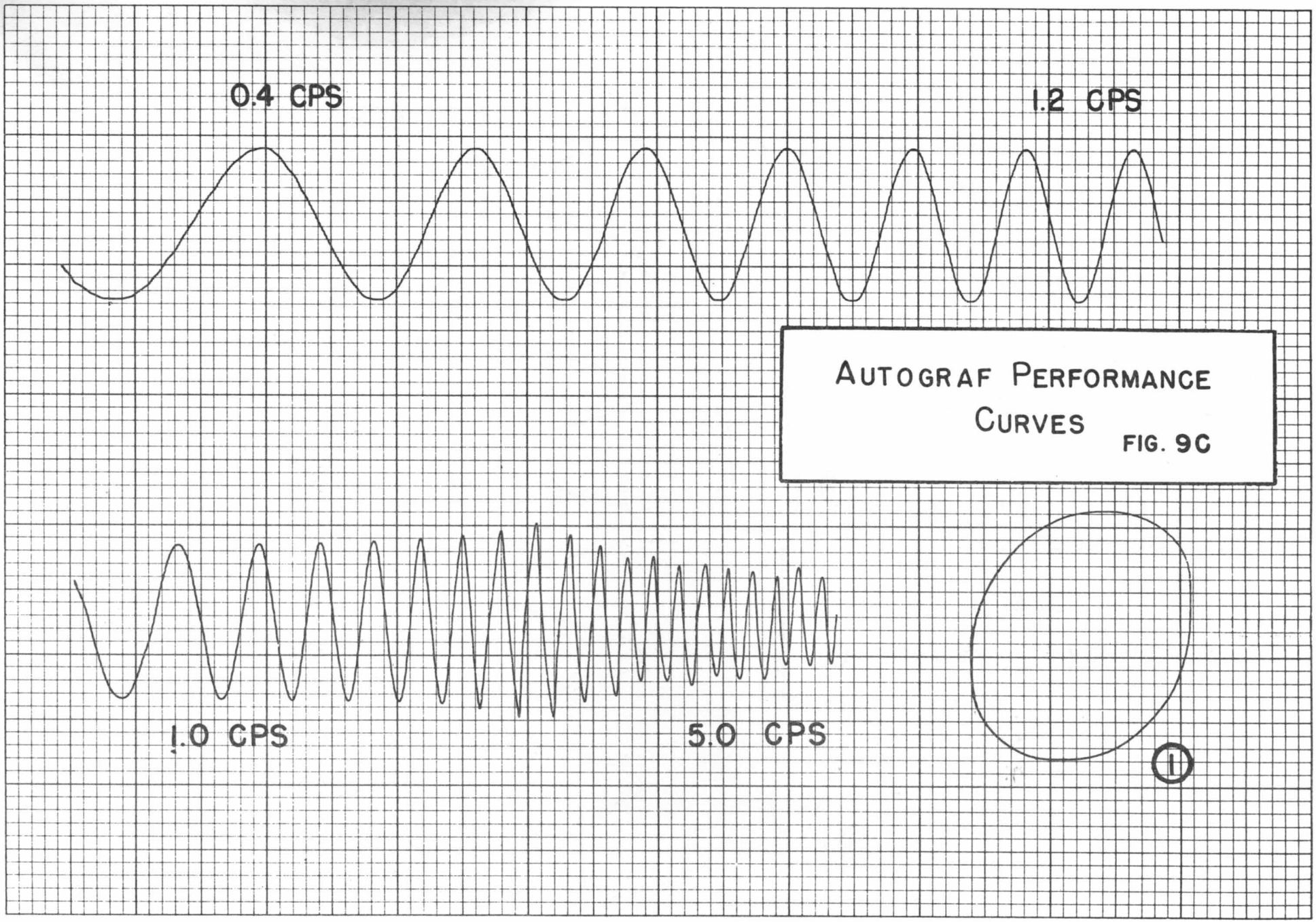
Fig. 9B shows sine, triangular, and square waves plotted against time. The time base was derived from a battery, resistor, and condenser circuit.

Fig. 9C shows a sine wave recorded from a variable frequency oscillator. This demonstrates the speed and following characteristics of the recorder.



AUTOGRAF PERFORMANCE CURVES FIG. 9A


AUTOGRAF PERFORMANCE
CURVES
FIG. 9B
1
2
3
4
5
6



AUTOGRAF PERFORMANCE CURVES FIG. 9C

SECTION III - CIRCUIT DESCRIPTION

It is the purpose of this section to describe the Model 2S Autograf recorder in detail. Reference should be made to the circuit schematic diagram in the back of this manual.

A. INPUT ATTENUATOR

Each pair of input terminals connects to a precision step attenuator which determines the voltage range. The Autograf input attenuator is composed of 10 precision (±0.1%) wirewound resistors. The precision resistors making up the attenuators may be seen in Figs. 8 and 9. With the selector switch in the 5 or 7.5 mv position the input voltage is applied across 1000 ohms and goes directly to the balance circuit with no attenuation. The balance voltage is always either 5 or 7.5 mv full scale. Thus to obtain higher voltage ranges, resistance is inserted in series with the 1000 ohms. Above the 10 volt scale, changes are made by varying the resistance appearing in the balance circuit (normally 1000 ohms) and no series resistance is added to the string.

B. POTENTIOMETRIC INPUT

For maximum sensitivity, potentiometer-type operation is selected by removing the binding post straps on the rear of the recorder, disconnecting the attenuators. Full scale deflection is then obtained with 7.5 and 5 millivolts on the X and Y axis respectively. S-102A and S-102B, the fixed variable switches on the control panel, route input voltage through the variable extender potentiometers R-110A and B and R-152A and B, which are attenuated by R-111A and B to limit maximum voltage acceptance multiplication to about 5.

C. INPUT FILTER

The input filter is composed of three RC sections comprising capacitors C-101, 102, 103, 104 and resistors R-122, 123, and 124. "Normal" position of the filter switch utilizes all components except C-103. "Maximum" position adds C-103 to the second section providing substantially faster cut-off at low frequencies. The effects of filter delay in this position necessitate slower-than-normal operation of the recorder.

D. BALANCE CIRCUIT

Cancellation voltage for balance is obtained from the mercury cells B-100 and B-101. Rheostat R-121 is connected in series with these cells to permit adjustment of voltage for purposes of calibration. (Relay K-100 disconnects the cells from the circuit to conserve battery life).

Potentiometer R-119 is the zero-setting control (located on the control panel). Potentiometer R-118 is the rebalance potentiometer, geared to the servo motor through a clutch and gear reduction. A sheave on the shaft of the potentiometer operates the pen or carriage by means of cables, translating

angular displacement of the shaft into a linear motion of the pen or carriage. The cancellation potential in the Y axis appears across R-115B and is in series with the zero-setting potential (across R-114B) and with the attenuator and amplifier input. Corresponding resistors in the X axis are R-211 and R-203.

It will be noticed that the values of the resistors R-116A and R-113A are 220K and 30 K respectively in the X axis balance circuit, whereas the corresponding resistors in the Y axis circuit are 330K and 47K. This is necessary to equalize the sensitivity of the two channels in terms of millivolts per inch of travel.

The choice of resistance values in the balance circuit is governed by the requirement that the potentiometers must impose little drain on the reference cells, yet be low in value compared to R-116A (in the X channel) or R-116B (in the Y channel), so that the potentiometer loading, the resultant nonlinearity, will be held within the accuracy limits of the instrument. In addition, the DC attenuation provided by R-115 serves the beneficial purpose of reducing potentiometer noise by a ratio of better than 200:1. This noise is predominantly the result of two effects: imperfect contact of the slider on the resistance element during rotation, which results in a saw-tooth component of noise voltage, and a triboelectric DC voltage which is generated by friction of dissimilar metals.

E. TIME BASE CIRCUIT

The operation of the time base is dependent on the basic fact that the charging current taken by a condenser will assume a constant value when the charging voltage is controlled so as to increase at a uniform rate. Using the existing facilities of the X-axis high gain chopper input servo system and the addition of extra circuitry and controls, the above functions are accomplished as follows: (Refer to schematic)

The voltage drop across R-205 (or R-206) is balanced against the drop taken from a section of the time control potentiometer, R-207, R-208, or R-209, depending on the time interval range selected. The difference voltage is applied to the X-axis servo amplifier through the chopper input causing rotation of the potentiometer R-118A in a direction tending to equalize the voltage between the control resistor R-205 and the charging resistor R-207. Thus any movement of potentiometer R-118A tending to increase the charging voltage applied to the charging condenser C-131 through R-205 also increases the charging current which varies the voltage drop in a direction which will cancel the fixed voltage supplied from R-207.

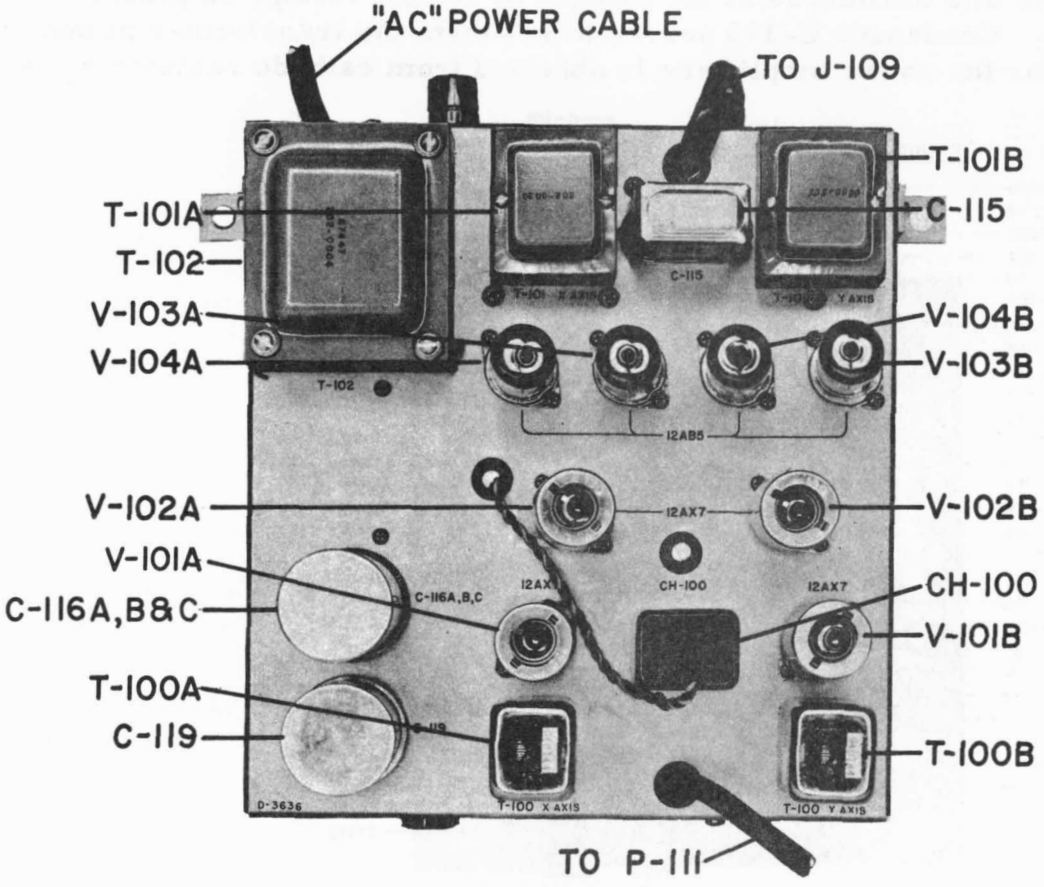
Resetting and starting of the time interval action is controlled by S-111. With this switch closed the amplifier input is connected to R-205, R-206 and the variable arm of R-118A. The system then operates until R-118A and R-207 are in balance. Opening S-111 starts the timing action. R-212, R-213, C-130, and C-133 provide an error-rate damping network for the input to the servo amplifier.

F. CHOPPER AND INPUT TRANSFORMER

The DC difference between the input signal and the rebalance voltage (error signal) is converted to 60 cps AC by the chopper. As the chopper is driven in synchronism with the power line, the AC error signal output from the transformer will be either (disregarding chopper lag) in phase or 180 degrees out with respect to the line, depending on the polarity of the DC error signal. The direction of rotation of the servo motor is determined by the relative phasing of excitation of its two windings and this phase-sensing causes the motor to drive the potentiometer R-118 in the proper direction to seek balance.

A voltage gain of about 13 is realized in the transformer, T-100, the secondary of which is resonated by C-108.

The total magnitude of error signal never exceeds 5 or 7.5 mv, and, as the instrument must be sensitive to approximately .1% of this voltage, it is obvious that the error signals being dealt with are exceedingly small, of the order of microvolts. Accordingly all input circuitry is carefully designed and laid out to minimize interference from stray hum pickup and thermal EMF's.



Amplifier, Top View
Fig. 10

G. FIRST AND SECOND VOLTAGE AMPLIFIER STAGES (V-101, Type 12AX7)

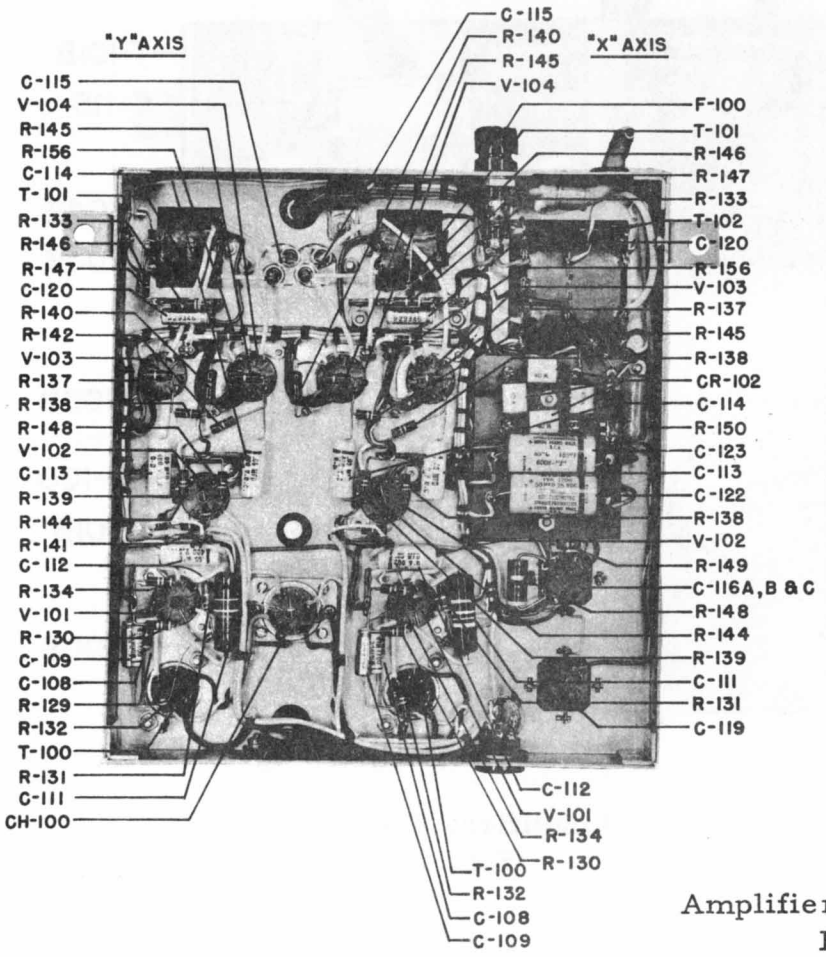
The two triode sections of this tube are connected in cascade as conventional voltage amplifiers. As the first stage operates at extremely low signal levels it is sometimes necessary to select tubes for low hum and microphonics.

H. PHASE INVERTER (V-102, Type 12AX7)

The output of the second triode section of V-101 is fed to the grid of the phase inverter through poteniometer R-135. This stage is conventional, with overall gain of about 15.

I. POWER AMPLIFIER (V-103 & V-104, Type 12AB5)

The power output stage is a push-pull pentode power amplifier. A small amount of degeneration is incorporated to lower the output impedance of the amplifier, and thus prevent the motor from running "single-Phase", as it otherwise would if one winding were open circuited while the other is energized. The required feedback is obtained from the divider R-146 and R-147 at the output transformer and introduced at the cathode of second voltage amplifier through R-133. Condenser C-115 serves to resonate the transformer primary. Cathode bias for the power amplifiers is obtained from cathode resistor R-140.



Amplifier, Bottom View
Fig. 11

J. POWER SUPPLY (CR-102)

A full wave rectifier circuit employing a silicon rectifier in a bridge circuit provides plate voltage for both amplifier channels. Power for the output stages is supplied directly from the rectifier, while the low level stages receive plate potential filtered by R-148-149 and C-116A-B-C. Switch S-107 is the main power switch; S-108 the servo on-off control, removes the line excitation from the motors and de-energizes the input choppers.

K. MOTOR - POTENTIOMETER

The servo motor is a Diehl 5-watt, 2-phase induction motor, one phase of which is energized from the AC line, the other being excited in phase quadrature from the amplifier output. Direction of motor rotation is determined by whether a leading or lagging 90° relationship exists. A pinion on the motor shaft meshes with a large fiber gear, which in turn drives a 3-turn precision potentiometer through a friction clutch. The reduction is 20:1. Also carried on the drive shaft is a 3-turn counting stop, which limits the shaft rotation, protecting the potentiometer from damage.

SECTION IV - MAINTENANCE

A. ELECTRICAL MAINTENANCE

1. CALIBRATION

The Autograf Model 2S as shipped is standardized against a Weston Standard Cell. Based upon expected shelf life of the Mercury cell, the calibration should accumulate error at the rate of about 0.25% every six months. The Mercury reference cell may be considered at the end of its useful life in approximately 18 months.

If necessary, the instrument may be recalibrated as follows:

a. For maximum accuracy (0.1% or better):

1. Move the Power and Servo switches to the "ON" position and allow the various components of the instrument to reach a stabilizing temperature.

2. Move the Record-Follow switch to the Record position and adjust the Zero setting controls to bring the pen and carriage indices into exact agreement with the "10" mark on the X and Y scales.

3. Set the X and Y Scale Ranges to the 1.5 and 1 volt positions respectively, and the "fixed-var" switch to "fixed".

4. Connect an accurately established 1 volt source (as obtained, for example from an L & N precision potentiometer and Weston Standard Cell) with reversed polarity to the recorder input terminals. Connected in this manner, the source voltage will drive the pen and carriage close to the lower left-hand corner of the paper.

5. Adjust the standardizing rheostats R-11 (mounted on the input plug panel, near the terminals) to bring the pen and carriage indices into exact agreement with the "0" mark on the X and Y scales. Remove input and check to see if pen and carriage move back to initial position. Repeat adjustment if necessary.

b. For moderate accuracy (0.25%)

Follow steps 1, 2, and 3, as above. Connect a Weston or other Standard Cell to the recorder input terminals with reversed polarity, using an appropriate, accurate, series resistor to establish a 1 volt source. Proceed as in step 5 of (a).

The correct value of the series resistor to be used with a Weston Standard Cell (1.01859 volts) is 2,968 ohms. This figure takes into account the internal resistance of the cell (750 ohms at 68° F. or 20° C.).

c. For rough accuracy (1%)

Follow steps 1, 2, and 3, as above. Connect a fresh Mallory mercury cell (such as those used in the Autograf, Mallory type #RM 12) to the recorder input terminals with reversed polarity through a series resistor. Proceed as in step 5 of (a).

The correct value of the series resistor to be used with a Mallory #RM 12 cell (1.345 V) is 69,000 ohms.

d. In the event the recorder cannot be brought to "0" by use of the calibrating control, the Mallory mercury cells should be replaced. This cell is a Mallory type RM 12, which may be obtained from drug stores or electronic supply houses where it is generally stocked for use as a replacement in electronic hearing aids.

e. Replacement of Mallory Cells

1. Remove instrument case.

2. Remove old cells from clips and insert new cells in correct position for proper polarity (plus end of battery toward red battery clip).

3. Make sure clips are clean and cells are firmly in place to insure low contact resistance.

2. CALIBRATION OF TIME BASE

The various sweep circuit intervals are established during manufacture and normally will not change appreciably. If excessive deviation from the fixed intervals is experienced proceed as follows:

a. For sweep periods of 50 seconds or over, a rough check of timing accuracy may be made with a stop watch.

b. For shorter sweep periods an accurate timing function should be generated on the Y-axis for comparison to the actual X-axis pen advance.

c. Deviations from full scale accuracy may be compensated for by means of a screw driver adjustment potentiometer on the rear function panel.

d. When it is desired to vary the full scale sweep slightly to accommodate a particular operation this may be accomplished by use of the X-voltage range control operating in the variable position. This method will not disturb the basic calibration.

3. LINEARITY (Time Base)

a. Linearity of the time sweep action may be checked by generating an accurate linear function, applying to the Y-axis and plotting against the time base. Any distinguishable curvature of the drawn line when compared to a straight-edge indicates non-linearity. It should be recognized that the degree of non-linearity will be a function of the several factors involved, including the generated signal and the basic accuracy of the recorder. Refer to trouble shooting section for possible corrective measures.

4. GAIN ADJUSTMENTS

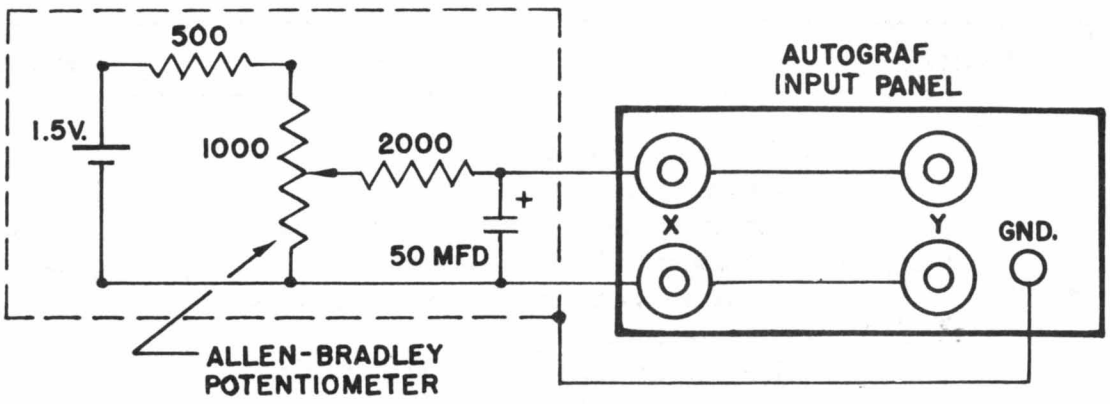
a. Set gain control of one axis (knurled knobs projecting through bottom of power switch window at front of instrument) to a position where the recorder hunts or oscillates. Turn gain control back until oscillation or hunting ceases. Repeat for other axis.

b. Check the servo for proper operation by rotating zero setting control on the recorder control panel. If servo response is sloppy and not precise, increase the gain to eliminate this. Repeat for each axis.

c. Generally, an optimum setting of the gain controls will be found to produce essentially zero retrace when a test signal is introduced into the recorder to draw a record over and back on the same line. See Fig. 15.

5. PERFORMANCE CHECKING

The simplest method of checking the Autograf is to apply a smoothly varying voltage to both pairs of input terminals, and observe the record which is produced. For this purpose a simple test rig is a convenience, and one may be made up as shown in Fig. 12. When signals from the test rig are fed to the recorder, records should result as shown in Fig. 9. Note that these curves are drawn on a "trace and re-trace" basis; that is, the curve is drawn up and back over the same line. This procedure shows the servo dead zone and permits gain adjustment to be made to optimum performance.



Test Rig, Fig. 12

Gain limits are usually fixed by the following factors:

a. Gain too low:

Servo "dead zone" resulting in excessive "retrace" or space between the "up" trace and the "down" trace.

b. Gain too high:

Recorder jitters or oscillates at high frequencies with small amplitude.

In order to check damping a more rapid variation of recorder input may be utilized. Apply a constant voltage to one axis, while flipping the attenuator switch between two adjacent positions or use a square wave input, while spreading the graph by rotating the zero control of the other axis.

Damping limits are usually indicated by the following factors:

c. Damping insufficient:

Excessive overshoot and oscillation (jagged "teeth" in square wave pattern).

d. Damping excessive:

Sluggish, lagging response, resulting in less than optimum reproduction of the input waveform (excess rounding of square wave).

A recorder which is performing properly will have a low "stand-by" voltage supplying each of its servo motors. This may be verified by placing an AC

AUTOGRAF RECORDINGS ILLUSTRATING MALFUNCTIONING OF INSTRUMENT

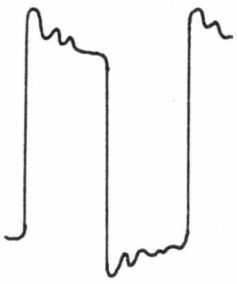
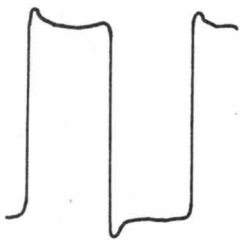
WRONG	TEST PROCEDURE	RIGHT
	Set X on 750 MV range. Set Y on 5 V range. Rotate potentiometer of test rig slowly in both directions. Poor retrace indicates low gain in Y channel. Repeat for X channel with settings of X = 7.5 V; Y = 1 V.	
	Use same range settings for each channel as above. Erratic writing over whole range indicates gain setting too high in channel being tested.	
	Use same range settings for each channel as above. Erratic writing in one or more portions of range indicates worn or dirty balance potentiometer.	
	Use same range settings for each channel as above. Three cycles of erratic retrace indicate over-tight adjustment of gear train mesh. See Sect. IV, par. 3.	
	With 1-1/2 volt battery connected to Y channel input and X input open, slowly rotate X zero control while rapidly changing Y range switch between the 5 and 10 volt positions. Excessive overshoot indicates too low gain in Y channel.	

Fig. 13

voltmeter across terminals 2 and 4 of the X and Y motors, in turn. A stand-by voltage of 5 to 10 volts is normal. If the servo is coerced from its resting position by manually rotating its drive sheave, the standby voltage will rise rapidly to a maximum of about 100 volts. The drive clutch should slip, accompanied by a whirring noise, at about 60-70 volts.

Fig. 13 shows a group of records illustrating typical troubles which may be encountered and their probable cause.

A useful check of recorder linearity may be made by connecting the output of the test rig to both axes of the recorder simultaneously. If suitable signals are chosen to produce a line extending entirely across the paper, essentially from corner to corner, the straightness of this line will be a good indication of potentiometer linearity. If both the pen and carriage potentiometers are perfectly linear and both servo systems are tight, a smooth straight line will be drawn. If the line is curved to any appreciable extent, then the trouble may be due to a defective or worn potentiometer R-118.

B. MECHANICAL ADJUSTMENTS

1. AUTOGRAF DISASSEMBLY

Access to the various components of the Autograf may be obtained as follows:

a. Disconnect AC power cable.

b. Remove (2) 10-32 screws from each end of case.

c. Lift case up and off.

d. Mallory cells and most tubes are accessible; further access to tubes and X and Y pen cables can be secured by loosening the screws on the bottom of the recording table rear support studs, then lifting the rear of the recording table upward, pivoting on the front supports.

e. Adjustment of Carriage Angle: To adjust "T"-square angle between carriage track mount and track (Fig. 3), loosen small Allen set screw holding adjustment screw (left-top of carriage mount); turn adjustment screw (controlling eccentric roller spindle) until correct angle is obtained; retighten set screw.

f. Adjustment of Pen Mount: To adjust left pen mount roller (Fig. 3), loosen mounting screw and turn eccentric mounting spindle by inserting a fine stiff wire in side hole; then retighten mounting screw.

2. POTENTIOMETER REPLACEMENT

The gear drive system is designed to give trouble-free operation. In the event

that performance tests produce non-linear or rough traces, one or both potentiometers may need replacement. Procedure is as follows:

a. Disconnect potentiometer wires.

b. Loosen nut between drive sheaves and potentiometer mounting bracket. Pull out shaft.

c. Mount new potentiometer on bracket.

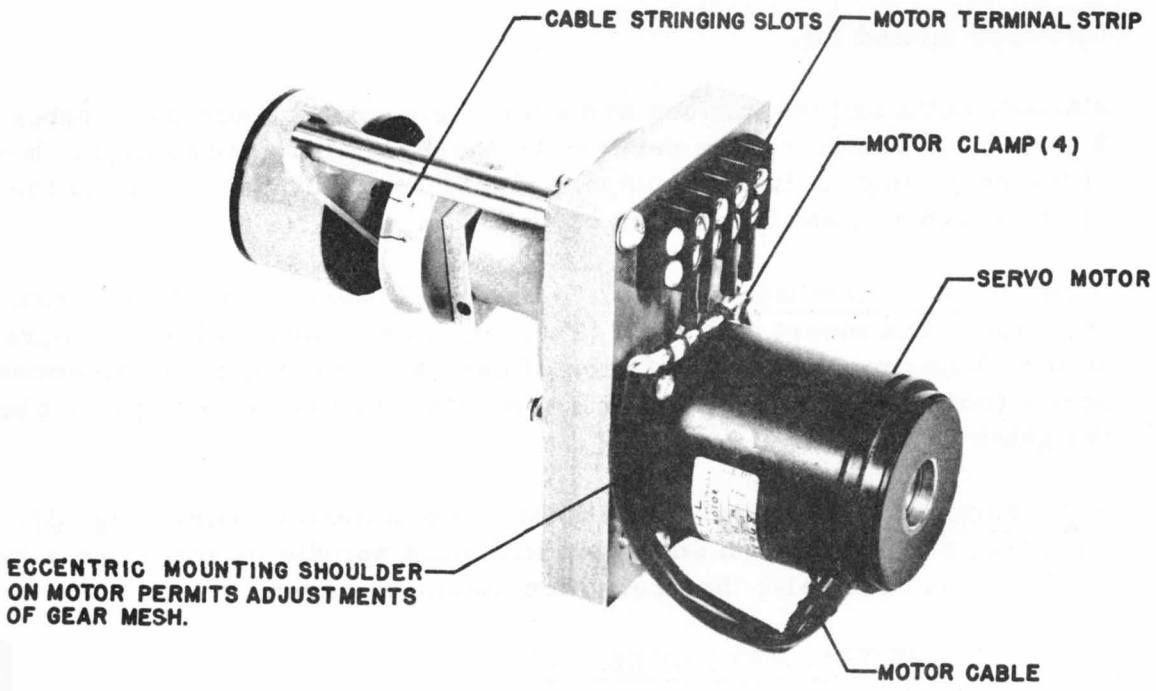
d. Rotate drive sheave clockwise until stop is reached.

e. Rotate shaft of potentiometer counter-clockwise until stop is reached.

f. Holding drive sheave in stop position insert potentiometer shaft partially in sheave socket with mounting bracket slot misaligned with holding bar slightly (about 1/2 inch) in a counter-clockwise direction. Still holding drive sheave in stop position, align slot with bar and complete insertion of shaft. Tighten lock nut. (The purpose of this operation is to insure that the clutch stops and not the potentiometer stops absorb the mechanical action.)

3. ADJUSTMENT OF GEAR MESH

Backlash of the gear drive system may be adjusted as follows (with case removed and instrument turned off):



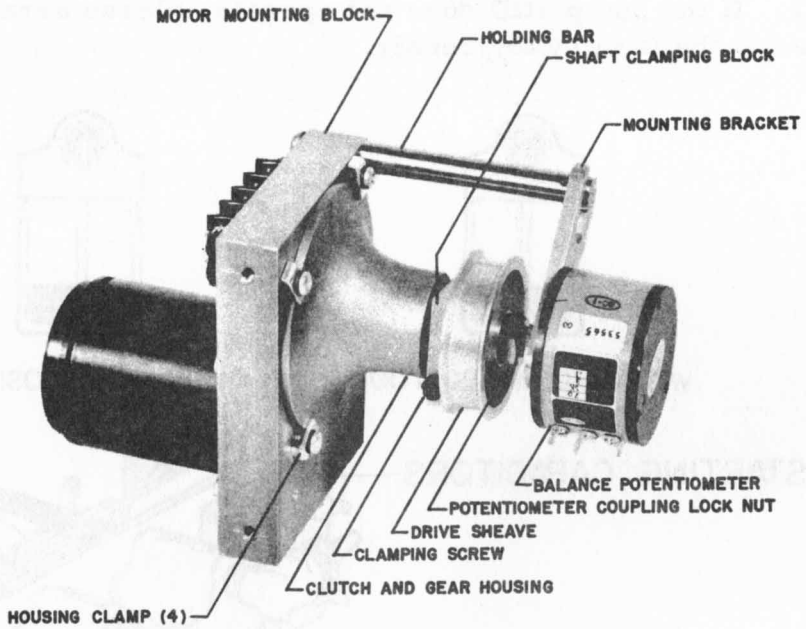
Servo Motor and Potentiometer Assembly (Rear)
Fig. 14

a. Loosen motor mounting clamp screws, Fig. 14.

b. Rotate motor slightly first in one direction then in the other, meanwhile rapidly rocking drive sheave back and forth to feel for ease of rotation with minimum backlash.

c. Rotation of motor assembly will move motor gear into or out of close mesh with clutch gear due to eccentric shoulder on motor.

d. After backlash has been minimized, tighten four motor clamp screws.



Servo Motor and Potentiometer Assembly (Front)
Fig. 15

4. PEN MAINTENANCE

The pen assembly may be removed and cleaned up by soaking in alcohol. If alcohol does not dissolve dried ink, clean tip with fine wire or apply pressure through ink filler hole with syringe.

5. LUBRICATION

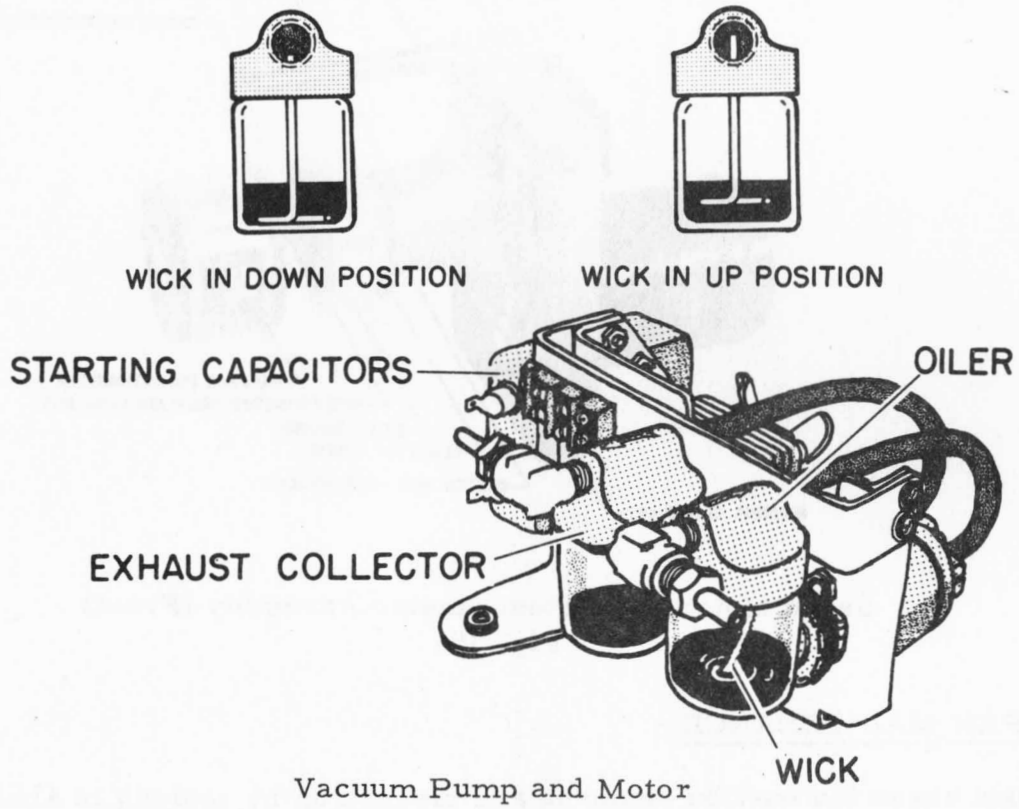
a.	Pen carraige	A very thin film of light oil should be applied occasionally to the spline.
b.	Motor and Gear Train	The motor and gear train are lubricated at the factory and do not require lubrication in service.

c. DO NOT OIL POT BEARING

Oil leakage into the resistance element will cause poor wiper contact.

6. VACUUM PUMP MAINTENANCE

Ordinarily the vacuum pump assembly should require no maintenance except oiling which is explained below. However, if the pump should stop working properly, do not disassemble it, since proper assembly is rather difficult. First check all hose couplings for leakage, then try flushing with carbon tetrachloride or similar solvent. To flush, remove the hose from the intake oil bottle, and, with the pump running, apply solvent to the intake with an eye dropper. If the pump still does not operate, please arrange to have the pump returned to the factory for repair.



Vacuum Pump and Motor
Fig. 16

Oiling: Note the two oil bottles mounted on the vacuum pump assembly. The one with the wick introduces a fine oil mist to the pump, and the other collects the used oil.

Before operating pump, fill intake bottle with oil to about 1/2 inch from the bottom. Do not use an oil with additives. Use a pure oil not heavier than S. A. E. 10. We recommend Shell "Cornea Oil 15", which can be purchased from any Shell distributor. A small bottle of this oil is supplied with each recorder.

Oil should be consumed at about the rate of 1/2 inch per each 50 hours of operation. To adjust rate of consumption, push wick up or down as shown in Fig. 16. If oil drips from the exhaust pipe, oil is being used too rapidly.

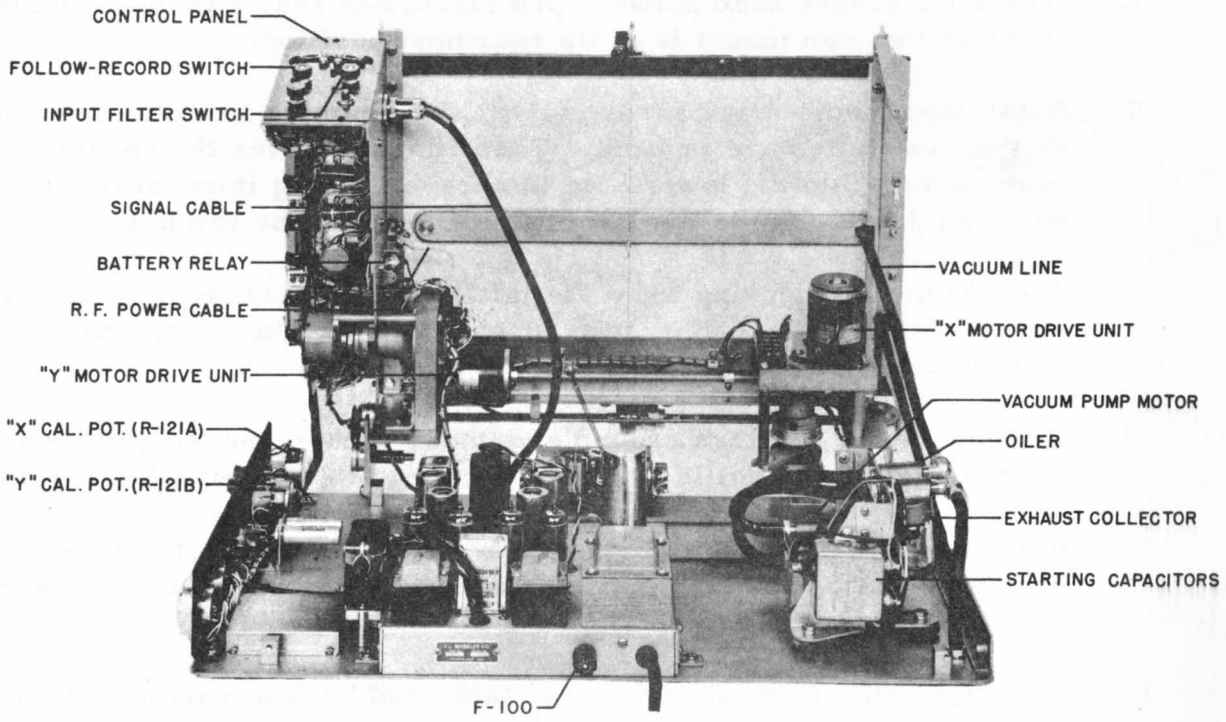
7. RESTRINGING INSTRUCTIONS

Three independent cable and sheave assemblies are used in the driving mechanism of the pen and carriage. The cable used in the Autograf is a seven-strand stainless steel cable 1/64" in diameter. The cable should be handled carefully to avoid kinks.

The sheave slots should point in the direction shown in the restringing diagrams, to assure uniform tension throughout the pen and carriage travel ranges. In each case the cable should be only tight enough to prevent lost motion. Excessive tension may cause "retrace" trouble.

The stringing is very simply done if the following instructions are followed:

a. Pen Axis



Pen Mount Drive Cable
Fig. 17

i. Pen Mount Drive Cable (Fig. 17)

1. Take off instrument case and remove binding-head screw attaching front end of carrying beam to track mount. NOTE: Be careful not to damage pen lift spring.

2. Pull pen-lowering relay actuating lever straight up and out of its rest in track mount.

3. Lift front end of carriage up enough to slide pen mount off its track.

4. Fasten ends of two pieces of cable to holes on each side of pen mount, and slide pen mount back onto its track.

5. Frontmost cable will be strung first. Insert it through passage in track mount, drop relay actuating lever back into its rest in track mount, and reattach carriage beam to track mount, positioning pen lift spring properly.

6. Connect a rubber band between pen mount and rear pen mount pulley stud, so that pen mount is at its rearmost position.

7. Rotate pen mount drive sheave fully CCW, looking from the left, so that the two holes are in front. Then run cable over the sheave and immediately into the lower hole in sheave. Bring it out of the upper hole and downward, to the left of itself between the two holes.

8. Loop cable CW (looking from the left) around the sheave, on the right side of the entering cable, progressing to the right on the sheave, making three complete turns.

9. Continue about 1/2 turn around and under sheave, passing between the sheave-stabilizing dollies. Tilt recording table upward for access.

10. Remove rubber band and slide pen mount to front end of carriage beam, keeping cable pulled taught around sheave. Place a piece of tape around sheave.

11. Continue cable from sheave under table and hook to spring approximately 2" from rear of table.

12. Hold spring in one hand and with the other hand carry other cable from pen mount under carriage beam and over rear pulley (A). Bring free end of cable under table and hook to other end of spring. Tighten cable only enough to prevent lost motion (enough to just begin to feel spring tension) and fasten.

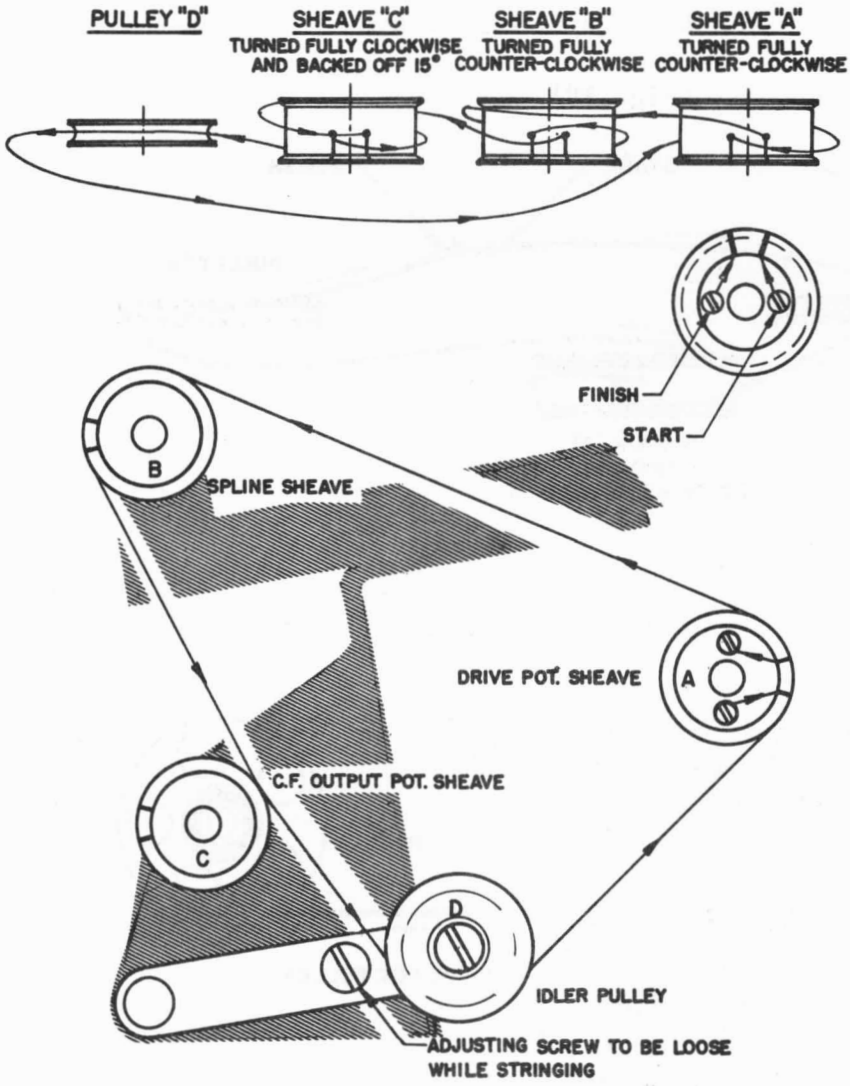
ii. Spline Drive Cable (Fig. 18)

1. Loosen the idler pulley adjusting screw.

2. Turn sheave "A" fully CCW. The positions of the slots in sheaves "A", "B", and "C" must be as in Fig. 18.

3. Put looped end of cable in lower slot of sheave "A" and fasten loop under screw. Pull cable over top of sheave "A" and carry over top of sheave "B".

4. Starting from inboard side wind cable around sheave "B" four times CCW. Put end of cable in lower slot and bring out through upper slot, continuing on inboard side of itself between the slots. Then wind once more CCW on outboard side of other cables.



Spline Drive Cable
Fig. 18

5. Carry cable to inboard side of "C" sheave, and take four turns CW around sheave, proceeding toward outboard side. Bring cable in through upper slot and bring out through lower slot running on inboard side of itself between the slots.

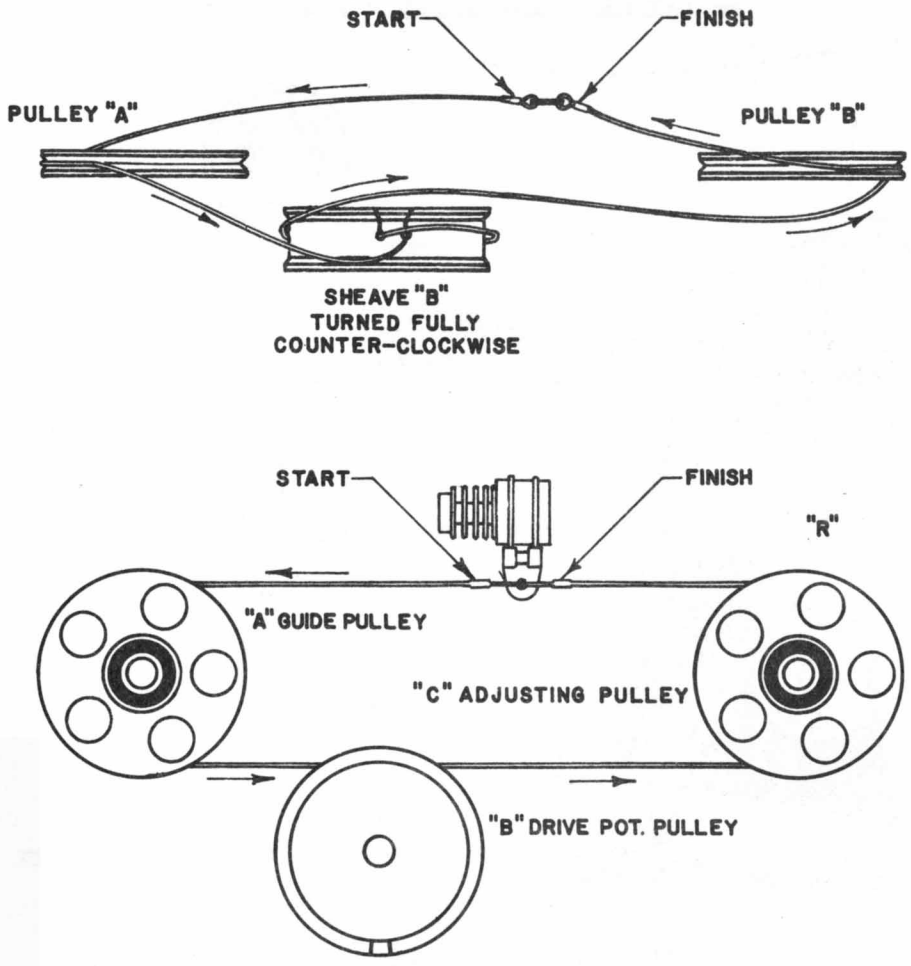
6. Carry Cable over top of sheave "C" and underneath Idler Pulley to sheave "A".

7. Starting from outboard side, wind cable CCW around sheave "A" toward inboard side four times.

8. Put cable end through upper slot of sheave "A" passing it on inboard side of beginning cable. Loop cable around upper screw and fasten into place.

9. Adjust cable tension by adjusting position of Idler Pulley. Lock Idler Pulley into place with Adjusting Screw.

b. Carriage Drive Cable (Fig. 19)



Carriage Drive Cable
Fig. 19

1. Move carriage to extreme right of recording table and hold with a rubber band.

2. Loosen mounting screw of pulley "C".

3. Turn carriage pot drive sheave fully CCW.

4. Attach a cable to the eye on the bottom of the track mount and fasten.

5. Run cable left from eye and CCW around pulley "A".

6. Run cable from Pulley "A" over drive sheave "B" and into lower slot. Bring cable out of upper slot passing on inboard side of itself between the slots. Continue CW three complete turns around sheave, on outboard side of entering cable, progressing toward outboard side.

7. Run cable around sheave almost one additional turn, coming off the top. Keeping cable pulled taught around sheave, turn sheave fully CW, and hold carriage to left of recording table with rubber band.

8. Run cable around pulley "C" CCW and across to eye in track mount. Pull free end tight and fasten cable.

9. Adjust pulley "C" to obtain required tension in cable and tighten mounting screw to hold in desired position.

When stringing is completed, slide pen and carriage from end to end of travel and check to see that the drive systems stop just beyond the end of the engraved scale on each end of travel. If such over-travel is symmetrical, the pen or carriage will be stopped by the corresponding counting stop mechanism in the drive unit. The travel may be brought within the proper limits by loosening the Allen set screw in the pen or carriage pot sheave, and rotating the sheave slightly, re-tightening the set screw and checking again for indicated stop limits.

C. TROUBLE SHOOTING

The following difficulties, other than malfunctioning caused by improper adjustment may be encountered:

TROUBLE	POSSIBLE CAUSE
Dead zone, manifested by inability to obtain acceptable retrace.	1. Weak 12AB5 tubes in amplifier. 2. Loss of voltage gain in amplifier due to weak 12AX7 tubes or component failures.

TROUBLE	POSSIBLE CAUSE
	3. Friction in mechanical linkage.
	4. Weak reference cell (s).
Noisy, or rough trace	1. Microphonic V-101 (12AX7) or input transformer.
	2. Worn or noisy potentiometer (if roughness usually appears at same portion of scale).
	3. Input filter not functioning.
	4. Instrument not grounded.
	5. Poor battery relay contact.
	6. Loose signal cable shield connection.
	7. Poor reference cell contact.
Inability to obtain damping; tendency to oscillate.	1. Loss of gain in last two stages.
Overheating of Output Cathode Resistor R-140	1. Gassy 12AB5.
Interaction between axes	1. Unbalanced output tubes (12AB5).
	2. Microphonic V-101 or input transformer.
Machine inoperative after replacement of reference battery. Pen or carriage hits stops.	1. Batteries inserted with wrong polarity.
Pen lowering circuit fails to operate.	1. Open pen coil.
	2. Dirty pen relay power rod.

SECTION V - ACCESSORY EQUIPMENT

While the basic Model 2S Autograf Recorder has many direct uses, its utility may be increased by the addition of accessory equipment available for specialized applications. For the user's information these various accessories are listed and briefly described here. For additional information and specifications consult the Autograf bulletins indicated or write the factory.

A. CURVE FOLLOWER ADAPTER (Type F-1)

The Type F-1 Curve Follower Adapter unit is a plug-in attachment to the Autograf. Substitution of a pick-up coil for the pen makes possible the read-out of a complex curve drawn with conducting ink. Empirical data can be reduced to electrical form; digital output available on special order. See Moseley Curve Follower Bulletin.

B. POINT PLOTTING

The Model 2S Autograf is furnished with input facilities for accessory units making possible point plotting from:

1. Keyboards (Model 40A and 40B, full keyboard type; or Model 41A, ten key).
2. Tape Translator (Model 50).
3. Card Translator (Model 30A or 30B).
4. Combination of tape, keyboard, card (Model 42).

These accessory units are available separately or as an assembled system on special order. (See pertinent bulletins).

C. STRAIN GAGE PLOTTING

On special order the Autograf may be modified at the factory with the addition of facilities for plotting information from strain gage resistance bridges.

D. AC TO DC CONVERTER (Type A-1)

This accessory accepts AC input voltages and provides a DC output voltage proportional to the average value of the AC signal.

E. LOGARITHMIC CONVERTER (Model 60B)

This accessory accepts DC or AC input voltages and provides an output DC voltage proportional to the logarithm of the positive peak amplitude of the input voltage. This converts Autograf input on one axis from linear to loga-

rithmic (db scale), permitting direct plotting on semi-log paper. Since the logarithmic scale compresses the higher amplitudes and expands the lower ones, this permits plotting of wide ranges in level with maximum accuracy at low amplitudes. (See Moseley Model 60B Logarithmic Converter Bulletin).

F. CHARACTER PRINTERS (Types D-1A, D-2, D-3)

When it is necessary to identify a series of curves obtained from digital information, three types of character printers are available:

1. Type D-1A. Supplied in kit form for customer installation. Replaces pen; requires manual operation or external contact closure.

2. Type D-2. Supplied in kit form. Provides automatic indexing in fixed sequences of up to six characters (per printer wheel).

3. Type D-3. Must be factory installed on special order. Provides symbol programming where arbitrary selection of characters is necessary.

G. STEP INPUT UNIT (Model 51)

Makes possible the incremental advance of one axis of the recorder permitting data to be plotted at preset intervals along one axis while varying the other.

SECTION VI
PARTS LIST - MODEL 2S AUTOGRAF

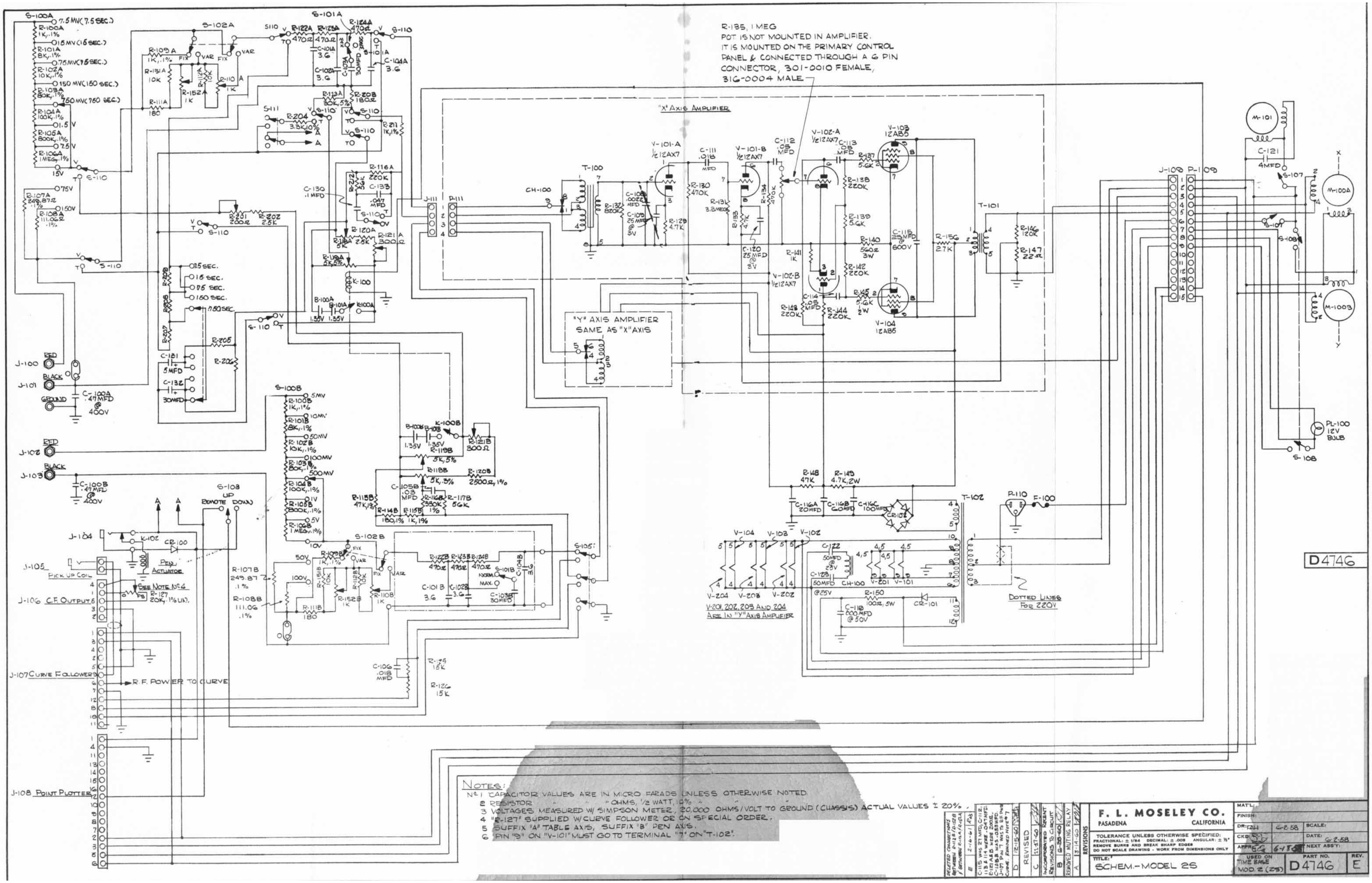
Circuit Symbol	Moseley Part No.	Description	Mfr. / Mfrs. Designation
B-100 A-B	329-0001	Battery, Mercury 1.35 V	Mallory RM-12R
B-101 A-B		Same as B-100 A-B	
C-100 A-B	233-0008	Capacitor, paper .47 MFD/400 V	Sprague 78P47404S5
C-101 A-B	235-0008	Capacitor, tantalum 3.6 MFD/60 V	Fansteel F-115
C-102 A-B		Same as C-101 A-B	
C-103 A-B	235-0007	Capacitor, tantalum 30 MFD/6 V	Fansteel PP30B6A1
C-104 A-B		Same as C-101 A-B	
C-105 B	233-0024	Capacitor, paper .03 MFD/400 V	Sprague 4TM
C-106	233-0022	Capacitor, paper .018 MFD/400 V	Sprague 67P18394
C-108	233-0019	Capacitor, paper .0022/100 V	C-D Miniroc STM ID22
C-109	231-0020	Capacitor, electrolytic 25 MFD/3 VDC	Sprague TE1055
C-111		Same as C-106	
C-112	233-0043	Capacitor, paper .05 MFD/400 V	C-D, #WMF-4S5
C-113		Same as C-112	
C-114		Same as C-112	
C-115	233-0044	Capacitor, paper .25-.25 MFD/600 V	Guideman #B-823
C-116 ABC	231-0007	Capacitor, electrolytic 100-60-20 MFD/300-250-250 VDC	Mallory FP335
C-119	231-0023	Capacitor, electrolytic 500 MFD/50 VDC	Sprague TVL1330
C-120	231-0020	Capacitor, electrolytic 25 MFD/3 V	Sprague TE 1055
C-121	233-0028	Capacitor, paper 4 MFD/400 V	Aerovox P30Z
C-122	231-0006	Capacitor, electrolytic 50 MFD/25 V	Sprague TVA1206
C-123		Same as C-122	
C-130	234-0004	Capacitor, metallized .1 MFD/400 V	Electro-Cap R-378
C-131	235-0003	Capacitor, tantalum 5 MFD/50 V	Fansteel PP5B50A1
C-132	235-0007	Capacitor, tantalum 30 MFD/6 V	Fansteel PP30B6A1
C-133	233-0020	Capacitor, paper .047 MFD/400 V	Sprague 67P47304
CH-100	221-0007	Converter, mechanical 50/60 CPS D. P. D. T.	Stevens-Arnold B-11-11
CR-100	254-001	Rectifier, selenium	I. R. C. 3Y1
CR-101	252-0005	Rectifier, silicone	GE 1N91
CR-102	252-0006	Rectifier, silicone bridge	Sparks-Tarzan 1N1442

Circuit Symbol	Moseley Part No.	Description	Mfr. / Mfrs. Designation
F-100	331-0003	Fuse 3 Amp, 250 V	Bussmann AGC312003
J-100	312-0002	Binding Post (Red)	Superior DF-30RC
J-101	312-0003	Binding Post (Black)	Superior DF-30BC
J-102		Same as J-100	
J-103		Same as J-101	
J-104	346-0008	Jack, phone, female	Switchcraft L-12A
J-105	346-0026	Tinijax (pickup coil)	Switchcraft #41
J-106	318-0003	Connector, 5 pin, female	Cannon WK-5-3ZS
J-107	318-0002	Connector, 12 pin, female	Cannon RGK-12-31SL
J-108	318-0001	Connector, 16 pin, female	Cannon RSK-C16-31SL
J-109	317-0003	Connector, 15 pin, female	Cinch-Jones P-315-CCE
J-111	316-0002	Connector, 4 pin, female	Amphenol 91MC4F1
J-112	301-0010	Connector, 6 pin, female See Schematic Note	Amphenol 78-S65
K-100 A-B	326-0067	Relay, D. P. D. T. 26.5 V DC	Advance TH1005
K-102	A-6054	Pen Magnet	Moseley
M-100 A-B	227-0004	Motor servo, round frame, 2 phase, 2 pole, 115/115 VAC, 60 CPS	FPE 25L-156-1
M-101	226-0013	Motor, vacuum pump	General Industries
P-109	317-0004	Plug, 15 pin, male	Cinch-Jones P-315-EB
P-110	296-0001	Plug and Power Cord 3 pin, male	Belden
P-111	316-0001	Plug, 4 pin, male	Amphenol 91PC4M
P-112	316-0004	Plug, 6 pin, male See Schematic Note	Amphenol 91MPM6L
PL-100	336-0012	Pilot light Min. Bayonet, 12V	Tung-Sol #53
R-100AB	243-0018	Resistor, precision WW 1000 ohms, .1%	Cinema 410E
R-101 A-B	243-0025	Resistor, precision WW 8000 ohms, .1%	Cinema 410E
R-102 A-B	243-0026	Resistor, precision WW 10,000 ohms, .1%	Cinema 410E
R-103 A-B	243-0027	Resistor, precision WW 80,000 ohms, .1%	Cinema 410E
R-104 A-B	243-0028	Resistor, precision WW 100,000 ohms, .1%	Cinema 410E
R-105 A-B	243-0008	Resistor, precision WW 800,000 ohms, .1%	Cinema B111E
R-106 A-B	243-0052	Resistor, precision WW 1 meg, .1%	Cinema B111E

Circuit Symbol	Moseley Part No.	Description	Mfr. / Mfrs. Designation
R-107 A-B	243-0010	Resistor, precision WW 249.87 ohms, .1%	Cinema 410E
R-108 A-B	243-0011	Resistor, precision WW 111.06 ohms, .1%	Cinema 410E
R-109 A-B	243-0024	Same as R-100 A-B	
R-110 A-B	236-0032	Resistor, variable, dual 1 K, works with R-152 A-B	Allen-Bradley JJU-1021
R-111 A-B	241-0032	Resistor, composition 180 ohms, 5%, 1/2 W	Allen-Bradley
R-112 A-B	241-0021	Resistor, composition 10 K, 5%, 1/2 W	Allen-Bradley
R-113 A	243-0030	Resistor, precision WW 30 K, 1%, 1/2 W	Cinema B111JE
R-113B	243-0047	Resistor, precision WW 47 K, 1%, 1/2 W	Cinema B111JE
R-114 B	243-6180	Resistor, precision WW 180 ohms, 1%, 1/2 W	Cinema B111JE
R-115 B	243-0014	Resistor, precision WW 1000 ohms, 1%	Cinema B111JE
R-116 A	243-0267	Resistor, precision WW 220 K, 1%	Cinema B111JE
R-116 B	243-0330	Resistor, precision WW 330 K, 1%	Cinema B111JE
R-117 B	241-0028	Resistor, composition 56 K, 10%, 1/2 W	Allen-Bradley
R-118 A-B	244-0011	Resistor, variable WW 5 K	Spectrol 850-70
R-119 A-B	240-0015	Resistor, variable WW 5 K, 5%, 5 W	Ohmite
R-120 A-B	243-1025	Resistor, precision 2500 ohms, 1%	Cinema
R-121 A-B	236-0046	Resistor, variable 300 ohms	Chicago Telephone #31795
R-122 A-B	241-1470	Resistor, composition 470 ohms, 10%, 1/2 W	Allen-Bradley
R-123 A-B		Same as R-122 A-B	
R-124 A-B		Same as R-122 A-B	
R-125	241-0015	Resistor, composition 15 K, 10%, 1/2 W	Allen-Bradley
R-126		Same as R-125	
R-127	244-0003	Resistor, variable 20 K, .1% linearity Note: R-127 supplied with Curve Follower	Helipot #20 KC1
R-129	241-1047	Resistor, composition 4.7 K, 10%, 1/2 W	Allen-Bradley
R-130	241-0470	Resistor, composition 470 K, 10%, 1/2 W	Allen-Bradley
R-131	241-2033	Resistor, composition 3.3 Meg, 10%, 1/2 W	Allen-Bradley
R-132	241-0044	Resistor, composition 820 K, 10%, 1/2 W	Allen-Bradley
R-133		Same as R-129	
R-134		Same as R-130	
R-135	236-0010	Resistor, variable 1 Meg, 1" shaft	Centralab BA211-1294
R-137	241-1056	Resistor, composition 5.6 K, 10%, 1/2 W	Allen-Bradley
R-138	241-0220	Resistor, composition 220 K, 10%, 1/2 W	Allen-Bradley
R-139	241-1056	Resistor, composition 5.6 K, 10%, 1/2 W	Allen-Bradley
R-140	240-0003	Resistor, 560 ohms, 3 W	Sprague 151 E
R-141	241-0024	Resistor, composition 1000 ohms, 10%, 1/2 W	Allen-Bradley
R-142		Same as R-138	
R-143		Same as R-138	
R-144		Same as R-138	
R-145		Same as R-137	
R-146	241-0120	Resistor, composition 120 K, 10%, 1/2 W	Allen-Bradley
R-147	241-0005	Resistor, composition 22 ohms, 10%, 1/2 W	Allen-Bradley
R-148	241-0047	Resistor, composition 47 K, 10%, 1/2 W	Allen-Bradley
R-149	241-3047	Resistor, composition 4.7 K, 10%, 2 W	Allen-Bradley
R-150	240-0006	Resistor, WW 100 ohms, 10%, 5W	Ohmite
R-151 A-B	241-0021	Resistor, composition 10 K, 5%, 1/2 W	Allen-Bradley
R-152 A-B	236-0032	Resistor, variable, dual 1 K, works with R-110 A-B	Allen-Bradley JJU-1021
R-156	241-0042	Resistor, composition 2.7 K, 10%, 1/2 W	Allen-Bradley
R-201	236-0033	Resistor, variable 200 ohms	Clarostat 43-200 W/FKS-1/4 shaft
R-202	243-0159	Resistor, precision WW 2500 ohms, 1/10%	Cinema 410E
R-203	243-6180	Resistor, precision WW 180 ohms, 1%	Cinema B111JE
R-204	241-1033	Resistor, composition 3.3 K, 10%, 1/2 W	Allen-Bradley
R-205 through R-209		Factory selected values for each instrument	
R-211	243-0014	Resistor, precision 1000 ohms, 1%	Cinema B111JE
R-212	241-0028	Resistor, composition 56 K, 10%, 1/2 W	Allen-Bradley
S-100 A	262-0045	Switch, Rotary X att.	Moseley
S-100 B	262-0046	Switch, Rotary Y att.	Moseley
S-101 A-B	261-0006	Switch, Rotary, Min. Filter	Centralab PA2015
S-102 A-B	261-0031	Switch, Slide, D. P. D. T. Fixed-Var.	Oak #212548-78

Circuit Symbol	Moseley Part No.	Description	Mfr. / Mfrs. Designation
S-103	261-0028	Switch, Lever Pen	Switchcraft L13006
S-105	261-0006	Switch, Rotary Follow - Rec.	Centralab PA2015
S-107	261-0014	Switch, Toggle PW-VAC	AH&H82024H
S-108	261-0001	Switch, Toggle Servo	AH&H20902
S-110	261-0018	Switch, Toggle Volts - Time	Carling HK233
S-111	261-0029	Switch, Lever Sweep	Switchcraft L13036
T-100	204-0002	Transformer, input	Triad G40144
T-101	204-0020	Transformer, output	Triad 45567
T-102	202-0006	Transformer, power	Triad 67447
V-101 A-B	251-0007	Tube, 12AX7	RCA 12AX7
V-102 A-B		Same as V-101 A-B	
V-103	251-0016	Tube, 12AB5	RCA 12AB5
V-104		Same as V-103	

Circuit Symbol	Moseley Part No.	Description	Mfr. / Mfrs. Designation
	MISCELLANEOUS ITEMS		
	A-1739	Plungers	Moseley Co.
	A-1844	Ribbon, purple	Calif. Ribbon
	A-1844	Ribbon, blue	Calif. Ribbon
	318-0019	Curve Follower Adapter Plug	Cannon WK-523C-3/8
	B-1322	Curve Follower pick-up coil	Moseley Co.
	333-0007	Curve Follower Conducting ink	Dupont "Silver"
	294-0001	Drive Cable	Mac Whyte
	B-2101	Ink pen assembly	Sheldon
	333-0005	Recording ink - red	Esterline-Angus
	333-0006	Recording ink - green	Esterline-Angus
	333-0017	Pippette Bulb Size A	Central Scientific #18075
	333-0008	Filler Bottle	Walsco 989
	266-0002	Pump, Vacuum	Gast AD440-8A
	209-0004	Belt, Vacuum pump	Minnesota Rubber and Gasket #ME 1-34
		Oil, Vacuum Pump	Shell Cornea #15


R-135, 1 MEG
POT IS NOT MOUNTED IN AMPLIFIER.
IT IS MOUNTED ON THE PRIMARY CONTROL
PANEL & CONNECTED THROUGH A 6 PIN
CONNECTOR, 301-0010 FEMALE,
316-0004 MALE
"X" AXIS AMPLIFIER
"Y" AXIS AMPLIFIER
SAME AS "X" AXIS
V-201, 202, 203 AND 204
ARE IN "Y" AXIS AMPLIFIER
DOTTED LINES
FOR 220V
R.F. POWER TO CURVE
J-105 PICK UP COIL
J-106 C.F. OUTPUT
J-107 CURVE FOLLOWER
J-108 POINT PLOTTER
PL-100
12V
BULB
D4746
NOTES:
Nº1 CAPACITOR VALUES ARE IN MICRO FARADS UNLESS OTHERWISE NOTED
2 RESISTOR OHMS, 1/2 WATT, 10%
3 VOLTAGES MEASURED W/ SIMPSON METER, 20,000 OHMS/VOLT TO GROUND (CHASSIS) ACTUAL VALUES ± 20%.
4 "R-127" SUPPLIED W/ CURVE FOLLOWER OR ON SPECIAL ORDER.
5 SUFFIX "A" TABLE AXIS, SUFFIX "B" PEN AXIS.
6 PIN "9" ON "V-101" MUST GO TO TERMINAL "7" ON "T-102".
REVISIONS
A 12-14-60 REMOVED MUTING RELAY
B 6-28-60 INCORPORATED RECENT REVISIONS TO CIRCUIT
C 11-17-60
D 12-15-60 REVISED
E 2-16-61
F. L. MOSELEY CO.
PASADENA CALIFORNIA
TOLERANCE UNLESS OTHERWISE SPECIFIED:
FRACTIONAL: ± 1/64 DECIMAL: ± .005 ANGULAR: ± ½°
REMOVE BURRS AND BREAK SHARP EDGES
DO NOT SCALE DRAWING - WORK FROM DIMENSIONS ONLY
TITLE: SCHEM.-MODEL 2S
USED ON TIME BASE MOD. 2 (2S)
PART NO. D4746
REV. E
DATE: 6-2-58