

# IBM

**Field Engineering  
Instruction - Maintenance  
Manual**

**1626** Control Unit

**1627** Plotter

# IBM

**Field Engineering**

**Instruction - Maintenance**

**Manual**

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# 1626

**Control Unit**

# 1627

**Plotter**

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IBM 1626 Control Unit and  
IBM 1627 Plotter Models 1 and 2

INTRODUCTION

The IBM 1626 Plotter Control Unit provides an on-line output channel for the attachment of the 1627, Model 1 or 2 incremental plotter to any IBM 1620 Central Processing Unit, Model 1 or 2.

Digital information from the 1620 is translated into plotter commands by the 1626. Thus, the attached plotter can be commanded by the 1626 to illustrate digital information in any desired graphic form.

The IBM 1627 Models 1 and 2 are functionally identical. Physical differences between the two models are shown in Table 1.

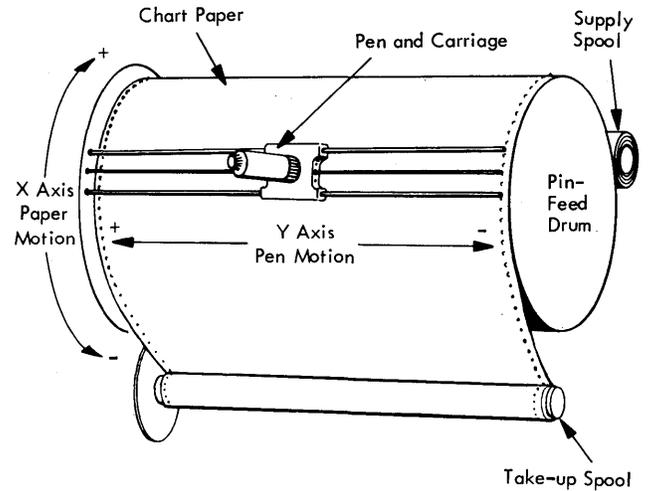


Figure 1-1. Paper and Pen Motions

OPERATING CHARACTERISTICS

Under program control, data from 1620 core storage is transferred serially by digit to the 1626. This transfer involves the use of the 1624 Paper Tape Output Channel. Once data is received by the 1626, it is immediately translated into the appropriate plotter commands.

Recording Function

The actual recording is produced by the independent or combined incremental motion of pen or paper as illustrated in Figure 1-1.

The pen is mounted in a carriage that is capable of horizontal motion. Control is also provided to raise or lower the pen to the recording surface. Vertical motion of the paper is accomplished by rotating the pin feed drum in a forward or reverse direction. The drum also functions as a platen.

Each digit of the output record causes the pen and/or drum to move 1/100" or the pen to raise or lower. The direction of movement or action is determined by the numerical value of the record digit. As illustrated in Figure 1-2, a record digit of 3 or 7 causes paper movement along the X axis; a record

MODEL NO.	SPEED			CHART PAPER				
	X - Axis	Y - Axis	Z - Axis (Pen)	Width	Plotting Width	Length*	Sprocket Hole Dim	Step Size
I	300 Steps/Sec.	300 Steps/Sec.	10 Operations/Sec.	12"	11"	120'	.130" dia. on 3/8" centers	1/100"
II	200 Steps/Sec.	200 Steps/Sec.	10 Operations/Sec.	31"	29.5"	120'	.188" dia. on 1/2" centers	1/100"

\*Single sheet short lengths can be used.

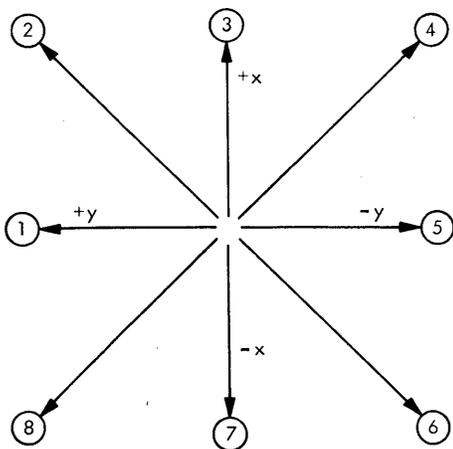
Table 1. IBM 1627 Plotter Specifications

digit of 1 or 5 causes pen movement along the Y axis; the record digits 2, 4, 6, or 8 cause simultaneous motion of pen or paper to produce a resultant diagonal motion (diagonal motion is 1.414 times a horizontal or vertical motion); a record digit of 9 causes the pen to raise, while a record digit of 0 causes the pen to lower.

Record digits, 1 through 8 require 3.4 milliseconds (ms) of plot time (5 ms for Model 2), while record digits 0 and 9 require 100 ms for the plotter to complete the required pen motion. Positive or negative digits, except -0, in numerical (0 through 9) or 2-digit alphameric (70 through 79) form can be used in the output record. The use of other characters is not recommended because they can cause conflicting plotter commands.

## FUNCTIONAL DESCRIPTION (1627)

The plotter (Figure 1-3) employs a bi-directional rotary step motor on both the X and Y axis drives. Each step causes the drum or pen carriage to move 1/100" in either a positive or a negative direction.



Pen  
9 - Raise Pen  
0 - Lower Pen

NOTE: The encircled numbers are the record digits that correspond to the indicated direction of plotting movement as viewed from the front of the plotter. Normally, graphs are plotted so that their horizontal axes are, in reality, the X axis as shown above.

Figure 1-2. Direction of Movement Related to Control Digits

The motors are capable of operating at a rate of 300 steps per second (200 steps per second on the 1627 Model 2).

A roll paper feed and take-up mechanism is provided which accepts chart paper rolls 12" wide by 120' long. The feed and take-up mechanism is bi-directional. Holes on both edges of the paper are engaged by sprockets on the drum. Thus the paper is driven and maintained in accurate registration. If desired, single sheets of graph paper 8-1/2" x 11" or 11" x 17" can be used for recording instead of the roll paper.

Six electrical inputs from the 1626 control the recorder in each of the six operating modes: drum up, drum down, carriage left, carriage right, pen up, and pen down. In addition, front panel controls on the 1627 are provided for manual control of each of these modes (Figure 1-4).

## CONTROL SWITCHES AND LIGHTS

As shown in Figure 1-3, seven operating controls and one indicator lamp are mounted on the front panel of the instrument. Their functions are described in the following paragraphs.

### Power On/Off

The Power On/Off switch connects 115 volts AC from the P5 connector on the rear panel of the recorder to the cooling fan and the power supply transformer. A neon indicator, located directly below the switch, is lighted whenever the switch is on.

### Carriage Fast Run

The Carriage Fast Run switch allows the pen carriage to be stepped rapidly to the left or right at the rate of 120 steps per second. The switch may be used to move the carriage to any desired area of the graph, or for operational checkout of the carriage control circuits and the carriage step motor.

### Carriage Single Step

The Carriage Single Step switch allows the pen carriage to be moved in single step (1/100") increments either to the left or right. This control, in combination with the drum single step control, permits the operator to accurately align the carriage on a point or fixed coordinate on the graph.

### Chart Drive On/Off

The Chart Drive On/Off switch allows the operator to disable the front and rear chart takeup motors. This permits the use of single sheets of graph paper in place of the paper rolls.

### Pen Up/Down

The Pen Up/Down switch provides a means of manually raising and lowering the pen from the surface of the drum.

When the recorder is first turned on, or if the pen is removed and replaced when the pen is in the up position, the pen can remain down. When this occurs, turn the switch first to the down position, then to the up position.

### Drum Fast Run

The Drum Fast Run switch allows the drum to be stepped rapidly up or down at the rate of 120 steps

per second. The switch is used in the same manner as the carriage fast run control to move the pen to any desired area of the graph, or for operational checkout of the drum control circuits and the drum step motor.

### Drum Single Step

The Drum Single Step switch allows the drum to be moved in single step (1/100") increments either up or down. This control, in combination with the carriage single step control, permits the operator to accurately align the pen on a point or fixed coordinate on the graph.

### Carriage Scale Factor Adjustment (Model 2 Only)

A carriage travel scale factor adjustment is provided for the purpose of varying the carriage travel to compensate for stretch or shrinkage in the graph paper (Figure 1-5). The graph paper is printed at 50% relative humidity to a high degree of accuracy,

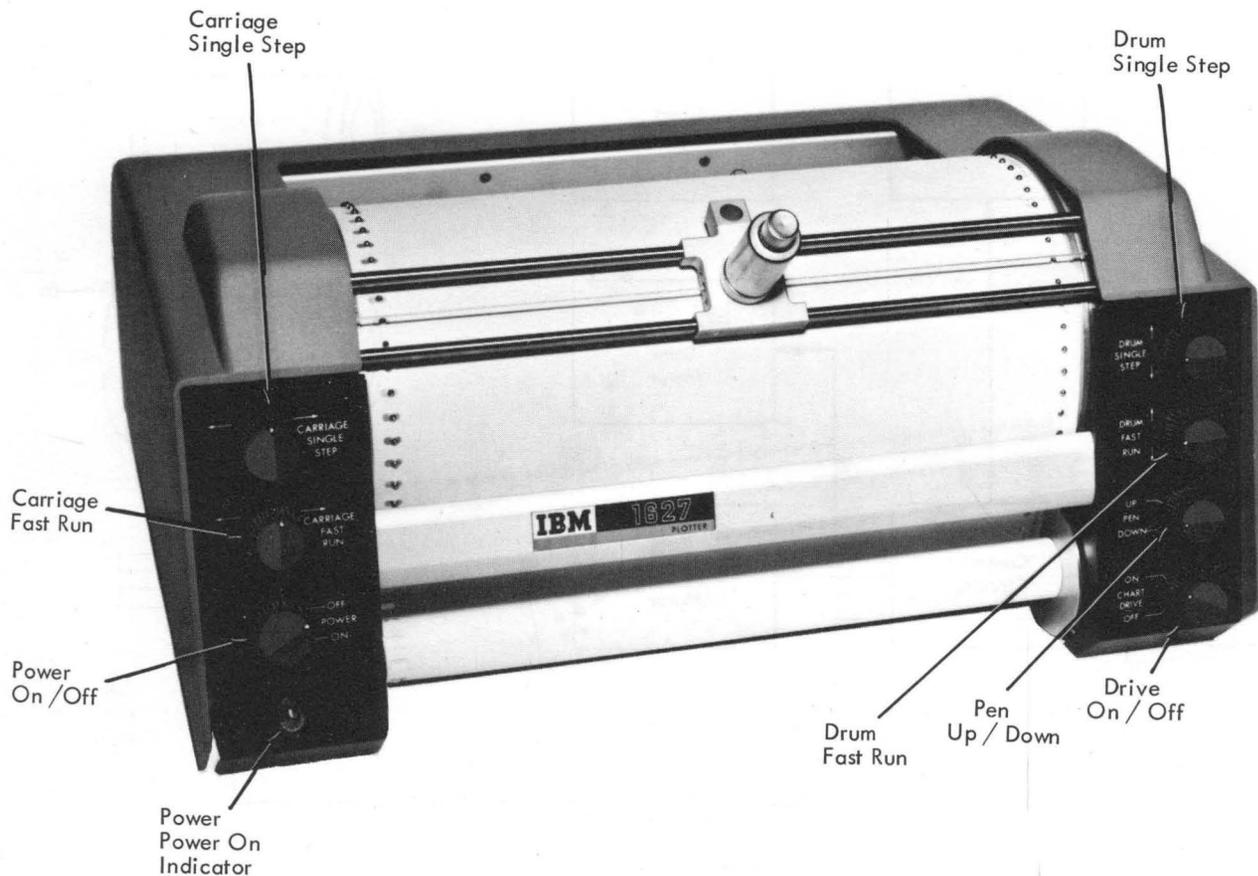


Figure 1-3. IBM 1627 Plotter Model 1

but is subject to either stretching or shrinking at extreme humidity conditions. In order to maintain the desired high accuracy of the plotter, when plotting on chart paper with a printed grid, a scale factor adjustment mechanism is provided on the carriage axis for increasing or reducing the size of each step of the carriage a small amount to match the grid.

This is accomplished by providing a variable size loop in the carriage drive cable between the step motor and the carriage. A control mechanism allows the loop to be made larger or smaller at a variable rate proportional to the carriage travel. The rate at which the size of the loop is changed is determined by means of the control knob projecting through the top of the cabinet near the left hand side. When this scale factor adjustment control knob is set at zero, the loop is maintained at a size that will give absolute .010" steps, or 29.000" of carriage travel for 2900 input pulses. For each division plus or minus on the knob, the total carriage travel of 29" will be changed plus or minus .010", i. e., plus one increment will give a total carriage travel of

29.010" for 2900 input pulses and minus one increment will give 28.990". A maximum of  $\pm 30$  divisions on the knob provide limits of carriage travel from 28.700" to 29.300" for 2900 input pulses.

When plotting on blank chart paper or whenever constructing grid lines, the scale factor adjustment knob should be set at zero for accurate carriage travel. However, when printed grid paper is being used, the carriage scale factor may be "trimmed" to the grid by either of the following methods: the grid on the paper may be measured from the right hand to the left hand border with an accurate steel rule. The dimension between borders should be noted and a correction set on the scale factor adjustment knob, i. e., if the dimension between the borders is  $29 - 1/16$ ", the knob should be set at plus six divisions, or  $+ .060$ ". The second method of setting the scale factor adjustment is to accurately set the carriage on the right hand border of the graph, apply 2900 input pulses to the carriage and note the position of the carriage at the left-hand border. If the carriage, for example, is  $1/16$ " short of the border, the carriage may be moved to the border by rotating

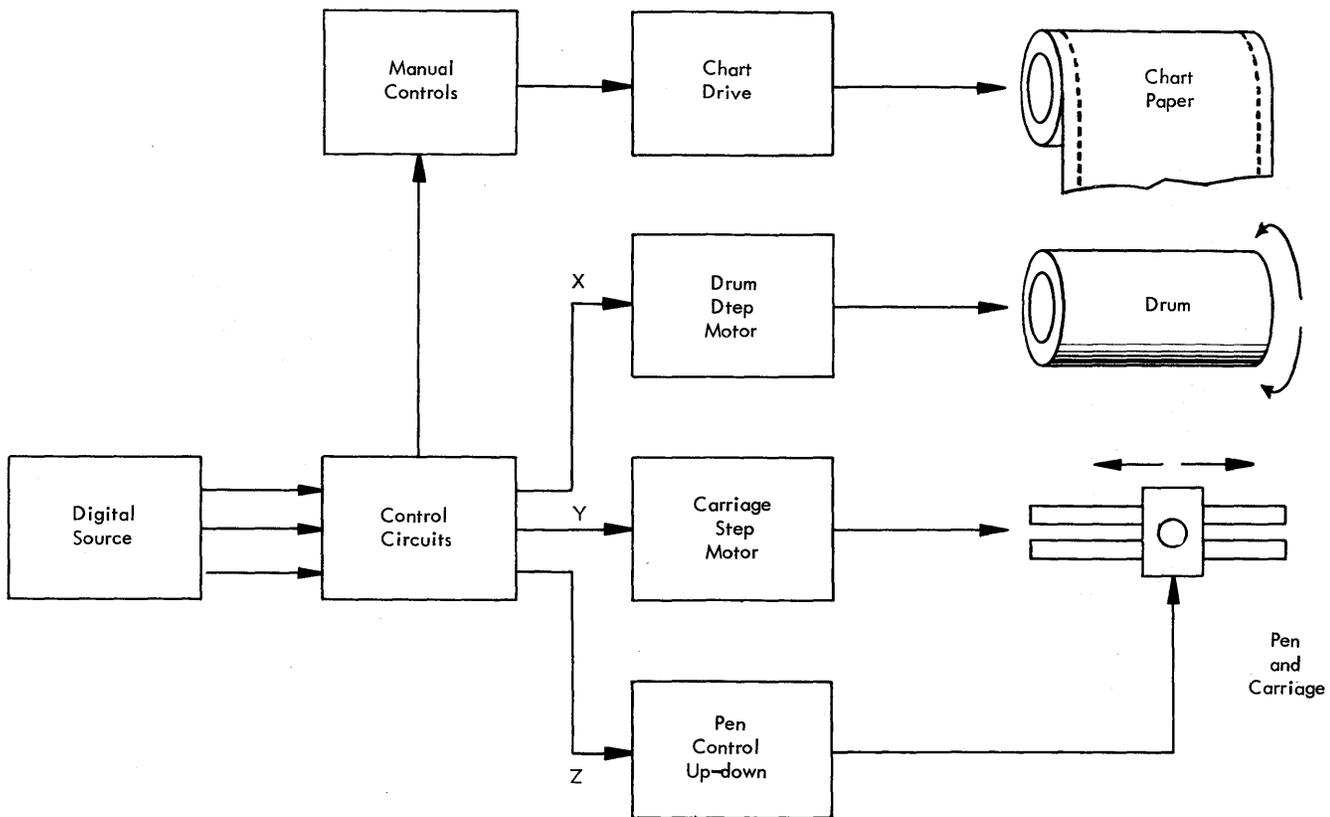


Figure 1-4. 1627 Functional Diagram

the scale factor adjustment knob plus six divisions.

The scale factor adjustment feature may be checked for accuracy by the following procedure: with the adjustment knob set at zero, draw a short vertical line on a piece of graph paper near the right-hand border. Apply 2900 input pulses to the carriage and draw another short vertical line. Remove the paper and measure between the vertical lines with a steel machinist's rule. The lines should be exactly 29.000" apart.

#### OPERATING PROCEDURES (1627)

Operating procedures for the recorder consists of loading the chart paper, performing an operational checkout, and aligning the carriage with the zero axis of the graph.

#### Installation of Chart Roll

1. Set power switch to OFF.

2. Loosen the knurled nut at the bottom of the pen holder and remove the pen assembly from the carriage.

**WARNING:** Use care not to drop the pen assembly or any of its parts. The assembly is constructed to close tolerances for optimum performance.

3. Rotate the right rear paper spool by hand until the drive key points upward.
4. Hold the new roll of chart paper so that the key slot in the core points upward. Place the roll against the spring loaded left rear idler spool and force the spool to the left.
5. Lower the paper roll into the paper well and slide the right end on to the drive spool. Make certain the drive key engages the key slot in the core.
6. Install a paper roll core on the two front spools below the drum, in the same manner as the paper roll.

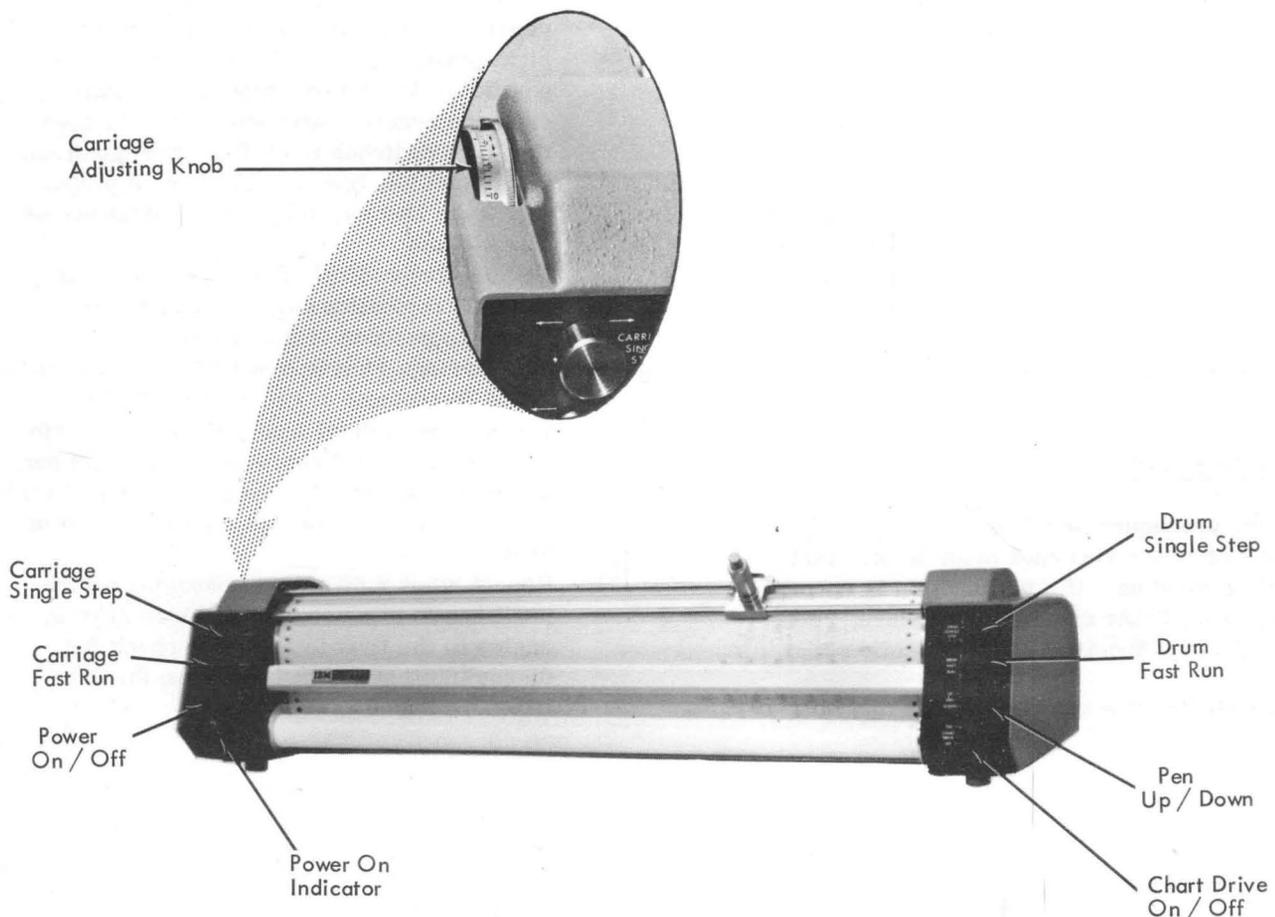


Figure 1-5. IBM 1627 Plotter, Model 2

7. Pull a short length of paper off the roll, slide the end under the carriage rods, tear bar, paper roll core, and fasten to the front side of the core with two or three short pieces of tape. Wind one or two turns of paper onto the core. Make certain the drum sprockets are properly meshed with sprocket holes on both sides of the paper (Figure 1-5).

#### Removal of Chart Paper

The roll of chart paper or single sheet of graph paper is removed in the reverse sequence to the installation procedure previously described. If a single sheet of graph paper is used, any remaining tape adhesive should be cleaned from the drum surface with cleaning solvent.

#### Installation of Single Sheet Graph Paper

Single sheets of graph paper, 8-1/2" x 11" or 11" x 17" may be used for plotting in place of the chart paper roll. To install a single sheet of graph paper, proceed as follows:

1. Set power and chart drive switches to OFF.
2. Remove the pen assembly from the carriage.
3. Slide the graph paper sheet under the carriage rods and on to the drum surface.
4. Fasten the top edge of the paper to the drum with two or three short pieces of tape. Rotate the drum by hand keeping the paper smooth and flat against the drum surface. Fasten the bottom edge of the paper in the same manner as the top.

#### Operational Checkout

The following procedure provides an over-all check of the operation of the recorder prior to the start of automatic recording. If a malfunction is encountered at any point in the checkout procedure, refer to the 1627 Trouble Shooting Guide in Section 2.

1. Install fine line graph paper (1/100") on

plotter then install pen assembly in its carriage.

2. Set Power and Chart Drive switches to ON.
3. Set Drum Fast Run to up position. Check that pen traces a vertical line on graph.
4. Turn Pen switch to down, then up. Check that pen lifts off drum surface.
5. Set Pen switch to down, then set Drum Fast Run to down. Check that pen again traces a vertical line on graph.
6. Set Carriage Fast Run switch to left position. Check that pen traces a horizontal line on graph and that carriage step motor stops when carriage reaches its limit of travel. Repeat with Carriage Fast Run switch in right-hand position.
7. Alternately operate Carriage Single Step and Drum Single Step switches. Check that both carriage and drum move only one step each time one of the switches is operated. Check that both horizontal and vertical steps are equal to the distance between fine lines on graph paper (1/100").
8. Move carriage near left margin of graph paper. Set Carriage Fast Run switch to right position and Drum Fast Run to down position. Allow instrument to run until carriage reaches right side of track, then turn both switches to OFF (center) position. Check that pen traces a 45° line on graph. Check the line carefully for any evidence of discontinuity.
9. Operate Drum Single Step switch several times to reposition pen either above or below its position at the end of Step 8.
10. Set Carriage Fast Run switch to left position. Allow instrument to run until carriage reaches left side of track, then return both switches to the off position. Check that pen again traces a 45° line on graph, and that this line is exactly parallel to the line traced in Step 8.
11. Repeat Steps 8 through 10 changing switch positions to produce two 45° lines at right angles to the first two. Again check for discontinuities and make certain the two lines are parallel.

## Reticle Adjustment

Two alignment reticles are provided to permit manual alignment of the carriage to the desired zero point on the graph (Figure 1-6). Either reticle may be used by the operator to perform the adjustment.

The A reticle in Figure 1-6 is placed in the reticle receptacle as shown. It need not be removed during plotter operation. The B reticle is inserted in the hole in the carriage that is used by the pen assembly. It therefore, must be replaced by the pen assembly during plotter operation.

Once the reticle to be used is installed in its receptacle, rotate the reticle until the crosshairs are parallel with the horizontal and vertical planes of the plotter. Position the carriage and drum to the approximate desired zero point using the Fast Run controls. (If the A reticle is used, the intersection of the crosshairs is exactly one inch in the plus X direction from the pen point.) Use the Single Step

controls to accurately position the crosshairs on the zero-plot point.

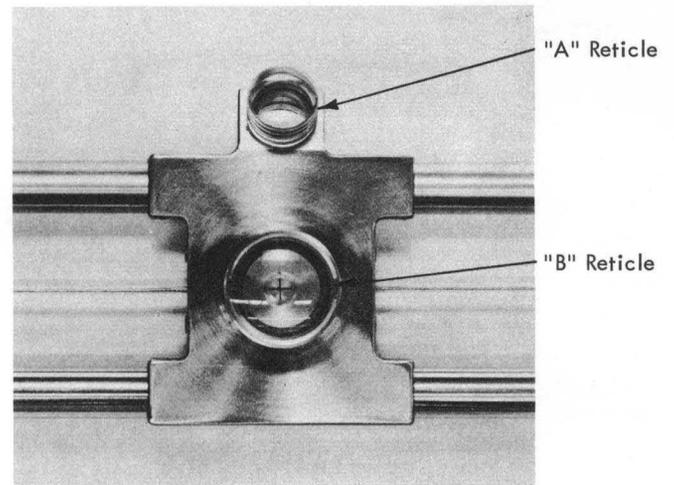


Figure 1-6. Reticle Adjustment

## SAFETY

Personal safety cannot be over-emphasized. To insure personal safety and the safety of others, make it an every day practice to follow all safety precautions at all times. Become familiar with, and use safety practices, outlined in the IBM pocket sized card, Form 124-0002, issued to all Customer Engineers.

## INSTALLATION PROCEDURE

The 1626 and the 1627 are shipped in separate containers. Both units are completely assembled except for the 1627 pen assembly. The 1626 is designed to be connected directly into the 1620 Paper Tape Punch Data channel, and the 1627 is connected directly into the 1626. To satisfactorily accomplish the installation, perform the following steps in sequence:

1. Unpack the 1626 as described in the packaging instructions attached to the machine. Place the 1626 in its proper location in machine room.
2. Unpack the 1627 using the following procedures:
  - a. Remove shipping cover.
  - b. Remove protective liner that surrounds the unit inside the container.
  - c. Remove accessory packages; check items against included accessory list.
  - d. Lift out plotter and attached plywood shipping base.
  - e. Remove three screws and washers that fasten plywood base and spacer blocks to plotter base.
  - f. Place 1627 on top of 1626.

**WARNING:** The recorder depends upon free circulation of air under the base for proper cooling. Do not place the unit on top of any loose papers or cloth.

Loose materials of this type can block the ventilating louvres in the base plate and cause overheating. In addition, the unit should not be placed on top of any other heat-producing equipment.

- g. Check recorder for signs of physical damage in shipment. Make certain that all front panel controls are secure on the control shafts. Check that the pen carriage can be moved freely by hand across its track, and that the drum can be rotated manually on its axis.
3. Install paper as described in Section 1 then assemble 1627 pen by inserting desired color pen into plunger, then insert pen and plunger into holder and install threaded cap. Align key on holder with key slots in carriage and press pen assembly into pen mounting. Tighten knurled nut on bottom of pen assembly (Figure 2-1).

**NOTE:** Before the recorder is placed in operation, the reticle adjustment described in Section 1, can be performed.

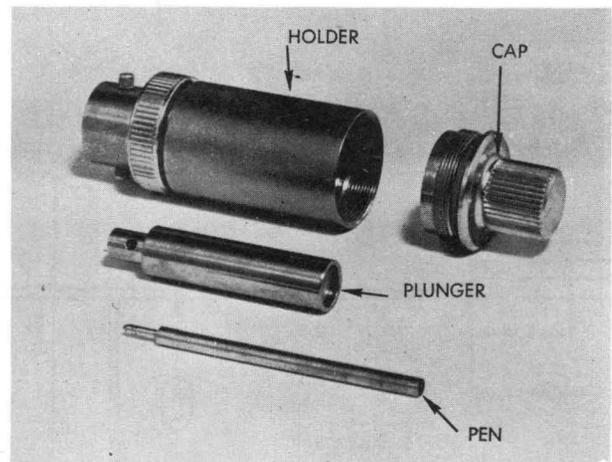
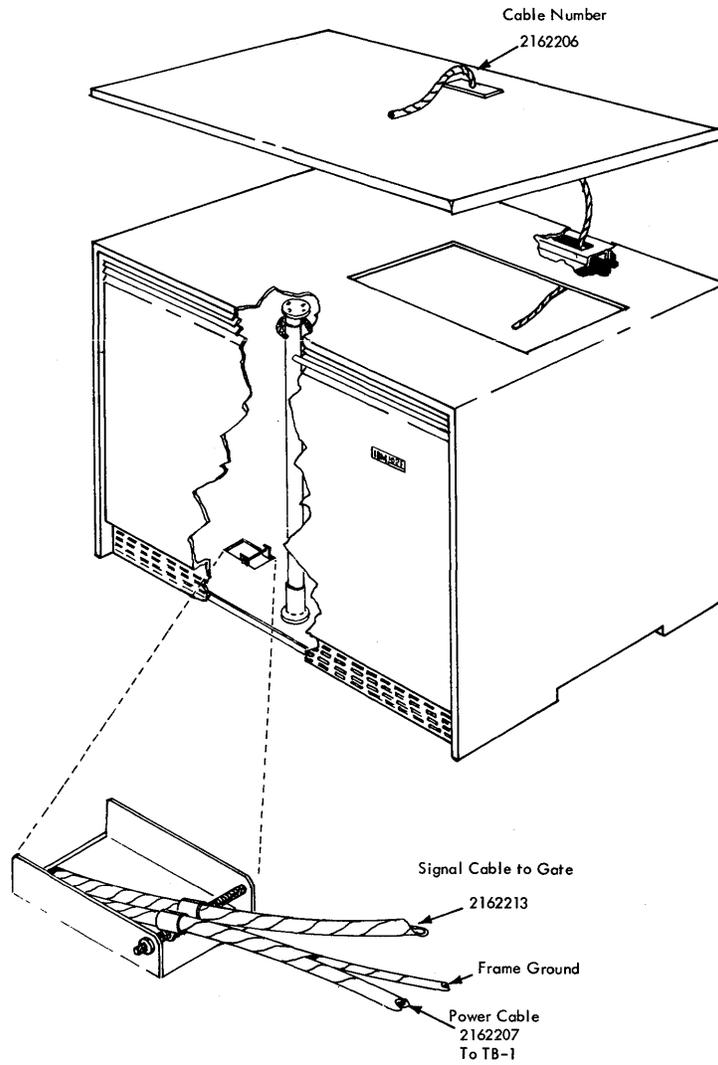


Figure 2-1. Pen Assembly



AIB03

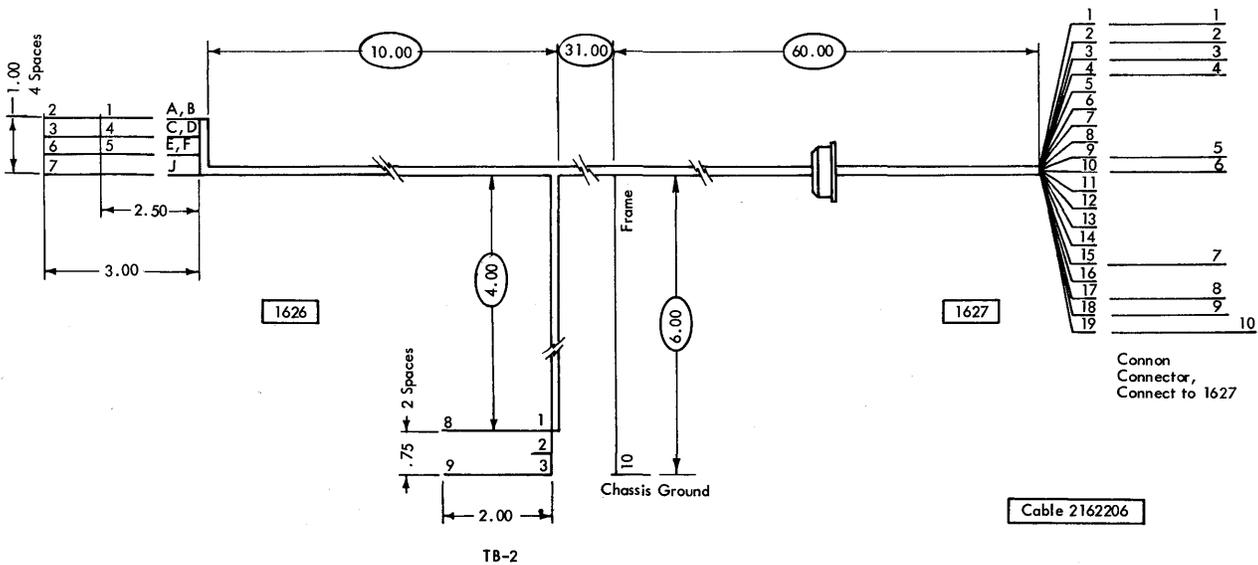


Figure 2-2. Cable Installation

4. Install cable, P/N 2162206, between 1626 and 1627 per Figure 2-2.

NOTE: Insert paddle connector end of cable down through rectangular opening in 1626 top cover. TB-2 is located on wiring side of CE panel (26.85.26.1).

5. Install the 1626 end of the signal cable per signal cable diagram included in the shipping group.

NOTE: Insert cable end up through opening in bottom of 1626 (Figure 2-2). Refer to the system reference manual for system cable connections, cable routing, etc.

6. Install the 1626 end of the power cable per power cable diagram included in the shipping group. (See Note under Step 5).

NOTE: TB-1 (1626) is located at the top of gate A on the wiring side.

7. After the cables are properly installed, bring power up on the using system. Place the 1626 Off-Line and make sure 110 v rheostat is on high range (fully clockwise).
8. Check 1627 operation by performing the Operational Checkout listed in Section 1. Correct any trouble found in the 1627.
9. Turn plotter Power switch to OFF.
10. Check timing of 1626 single shots in the following manner. Tolerance on all single shot adjustments is  $\pm 10\%$ .
  - a. Use the CE panel to develop a constant pen-up or pen-down command.
  - b. Observe the output at A1A19 P for a pulse length of 100  $\mu$ secs. Adjust tuning slug as necessary.
  - c. Observe the output at A1A20 P for a pulse length of 50  $\mu$ secs. Adjust tuning slug as necessary.
  - d. Observe the output at A1A21 P for a pulse length of 60  $\mu$ secs. Adjust tuning slug as necessary.

- e. Observe the combined outputs of A1A24 and A1A26 at A1A18G for a total pulse length of 100  $\mu$ secs. Each single shot is adjusted to provide approximately 50% of the total pulse, thus, limiting the duty cycle of each to 50% of the total cycle.
- f. Change the set-up on the CE panel to develop a constant drum-up or drum-down signal.
- g. Observe the combined outputs of A1A23 and A1A25 at A1A18G for a total pulse length of 3.4 ms (5 ms for 1627 model 2 plotters). Each single shot is adjusted to provide approximately 50% of the total pulse; thus, limiting the duty cycle of each to 50% of the total cycle.
11. Restore CE panel to the On-Line status.
12. Turn 1620 meter switch to CE position and turn 1626 meter switch ON. 1626 meter will not run as long as 1620 meter is in CE position.
13. Turn the plotter Power switch to On and run the plotter diagnostic test (DT0044). Correct any trouble found.
14. Make sure all CE Switches are properly set before releasing machine to customer.

#### MACHINE SPECIFICATIONS

The following is for information only. Any unique problems involving machine specifications should be referred to District Physical Planning through the customer's salesman. Variations between the 1627 Model 1 and Model 2 are given in Table 1.

#### Power and Signal Requirements

1. 1626 DC bias voltage:  
+12 v DC
2. 1627 AC voltage:  
115 v AC
3. 1627 DC bias voltage:  
+3, +1.5, -7.5, -9.0-24.0 v DC
4. 1627 input signal voltage:  
Minimum up level +5.6 v  
Minimum down level +0.2 v

Miscellaneous

$$(10 \sqrt{\frac{.100 \text{ sec}}{1.000}} = 100 \text{ ms/operation})$$

Environmental Operating Conditions

- 1. Temperature 60° F. to 90° F.
- 2. Relative humidity 20% to 80%

See note following Item 1.

Attachment to 1620

- 1. The 1620 Model 1 must have feature code 5514 installed.
- 2. The 1620 Model 2 must have feature code 5515 installed.

SCHEDULED MAINTENANCE

Scheduled maintenance of the 1626 and 1627 is limited to periodic cleaning and operational checkout. No lubrication is required. A small amount of IBM #20 grease can be used on the threaded portion of the pen carriage to facilitate removal and installation of the pen assembly. Use caution to prevent any lubricant from getting on the electrical spring contacts in the key slots on the carriage.

1626 Unit Dimensions. 1627 Unit Dimensions

		<u>Model 1</u>	<u>Model 2</u>
Height	30"	9-3/4"	9-3/4"
Width	43"	18"	39-3/8"
Depth	24"	14-3/4"	14-3/4"

Because the Operational Checkout described in Section 1 is normally performed at the start of each recording run, this portion of the maintenance schedule may be omitted if the instrument is frequently used. If the plotter is used infrequently, it is recommended that an operational checkout be performed at least once a week.

Operating Speeds

- 1. Drum and/or carriage motion for the 1627 Model 1 are rated at a maximum of 300 steps per second (200 steps/sec on the 1627 Model 2). Other rates can be obtained by adjusting the single, shot triggers in positions A1A23 and A1A25 to provide a total delay in milliseconds equal to 1 divided by the rate in cycles per second.

The carriage rods, the drum surface, and the metal plunger inside the pen assembly should be cleaned periodically. The intervals at which cleaning should be performed is determined by the operating environment and the frequency of use. All normal cleaning can be accomplished with a soft, dry cloth. If necessary, the cloth can be moistened with IBM cleaning solvent to remove foreign matter. The inside of the pen assembly plunger (Figure 2-1) is cleaned by pushing one corner of the cloth through the center. If the plunger is clogged, it can be dipped in cleaning solvent and then wiped dry.

$$(200 \sqrt{\frac{.005 \text{ sec}}{1.000}} = 5 \text{ ms/step})$$

NOTE: Refer to Step 10 of the Installation Instructions for single shot adjustment procedures.

- 2. Pen up and down motions for both models are rated at a maximum of 10 operations per second. Other rates can be obtained by adjusting the single shot triggers in positions A1A24 and A1A26 to provide a total delay in milliseconds equal to 1 divided by the rate in cycles per second.

NOTE: Customers should be informed that ballpoint pens characteristically accumulate ink at the tip. The pen should be removed and cleaned about every hour of operation. Pen life is approximately 5 to 7 hours. Pen replacement should be considered before critical drawings are made to reduce the possibility of smear.

**CAUTION:** Use care to avoid damage to the insulation on the carriage drive cable. This cable supplies -24 volt power to the pen solenoid.

## SERVICE INFORMATION

### CE Test Panel

The CE test panel, located in the 1626, provides for off-line operation of the 1626 and 1627 for diagnostic purposes (Figure 2-3). A description of the CE test panel switches and lights follows.

**On-Line/Off-Line Switch.** This toggle switch, when placed in the off-line position, causes the 1626 response line (P3) to the using system to be interrupted. The 1626 meter switch should be turned off to prevent the 1626 meter from running if the CPU is to be used by the customer. Functions involving the using system and other I/O devices are not disturbed. If actual plotter motion is not desired during off-line testing the 1627 Power On/Off switch can be turned off.

**Pen Up/Pen Down Switch.** This momentary toggle switch is used to simulate a pen up (digit 9) command or a pen down (digit 0) command to the 1627. Two indicating lamps are associated with this switch to indicate the status of the 1626 pen control circuits. If the lamps fail to light when the switch is operated, the pen command, in most instances, is not transmitted to the plotter.

**Eight-Position Rotary Switch.** This switch is used to select the simulated drum and/or carriage commands to be transmitted to the plotter. The direction of the resultant plot is indicated by the pointer located on the switch knob. This switch must be used in conjunction with the CE Plot switch.

**CE Plot Switch.** This toggle switch is used in conjunction with the 8-position rotary switch to activate the plotter after the rotary switch has been properly positioned. It must be in the off position when operating on-line. This switch also causes one of the 4

lamps located around the rotary switch to light if the corresponding simulated plotter command is transmitted to the plotter.

**110 v Rheostat.** This rheostat is used to lower the AC line voltage to the plotter a maximum of 10%. In this manner a marginal operational check of the 1627 stepping motors and power supply can be made. The two output hubs below the rheostat are used to monitor the AC line voltage to the plotter.

**WARNING:** The rheostat gets quite hot if left on the low range for an extended period of time.

### Isolation of 1627 Troubles

Most troubles can be quickly isolated to the using system 1626, or 1627 using standard diagnostic procedures. Troubles occurring in the 1627 can be quickly isolated to one functional circuit by performing the Operational Checkout described in Section 1. Following this, the trouble can be isolated to a single component by performing systematic checks of voltages and waveforms at the test points shown on the circuit diagrams in Section 3. Waveforms illustrated on the circuit can be obtained by using the Manual Fast Run controls on the 1627 or by using the CE test panel in the 1626 as previously described. The waveforms shown for the pen control circuits can be obtained by programming the using system to perform alternate pen up and pen down motions. A guide to trouble analysis is given in Table 2.

**CAUTION:** Use extreme care when performing tests on the plotter with power on and the cover removed. Accidental short circuits between terminals on the printed circuit board can burn out a diode or transistor. Use care also to avoid shorting the carriage drive cable or its idler pulley to the chassis. When power is on, -24 volts DC is present on the cable and the pulley.

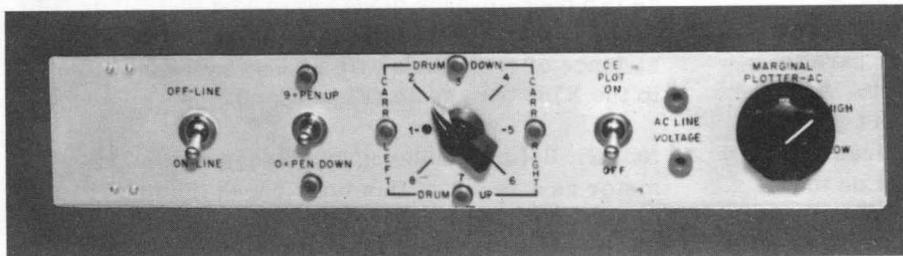


Figure 2-3. CE Test Panel

SYMPTOM	PROBABLE CAUSE
Unit inoperative; neon power indicator does not light	<ol style="list-style-type: none"> <li>1. Fuse F1 blown; check for short circuit, then replace fuse</li> <li>2. Defective Power switch S3</li> <li>3. Defective wiring or connector P5</li> </ol>
Unit inoperative neon power indicator lights	<ol style="list-style-type: none"> <li>1. Fuse 2 blown; check for short circuit then replace fuse</li> <li>2. Defective power transformer T1</li> <li>3. Defective power supply component; make voltage and continuity checks; see Fig. 3-7</li> </ol>
Both chart drive motors inoperative	<ol style="list-style-type: none"> <li>1. Defective Chart Drive switch S4</li> <li>2. Defective AC wiring</li> </ol>
One chart drive motor inoperative	<ol style="list-style-type: none"> <li>1. Defective motor; check continuity of windings</li> <li>2. Defective phase-shift component, R6-C8 or R7-C9</li> </ol>
Drum step motor inoperative but carriage operation normal; or carriage motor inoperative but drum operation normal	<ol style="list-style-type: none"> <li>1. Defective step motor; check continuity of windings</li> <li>2. Open current limiting resistor or shorted diode; check continuity; see Fig. 3-7</li> <li>3. Defective drive transistor or ring counter stage; check waveforms per Fig. 3-6</li> </ol>
Drum step motor or carriage step motor inoperative in one direction only; operation normal in opposite direction	<ol style="list-style-type: none"> <li>1. Defective Single Shot; check waveforms</li> <li>2. Defective input trigger circuit; check waveforms and continuity</li> </ol>
Discontinuities in plotting, or inaccurate plotting	<ol style="list-style-type: none"> <li>1. Improper adjustment of step motor; see Removals, Replacements, and Adjustments</li> <li>2. Double stepping due to noise on input signal line; check for excessive power supply ripple; check for defective switching filter components, loose connections, bad solder joints</li> </ol>
Operation normal on automatic plot but abnormal on manual operation	Defective control switch or associated wiring
Operation normal on manual but abnormal on automatic plot	Defective input trigger circuit or associated wiring
Pen control circuit inoperative	<ol style="list-style-type: none"> <li>1. Defective solenoid; check continuity between key pins on pen assembly</li> <li>2. Defective trigger or current control circuit; check waveforms</li> </ol>

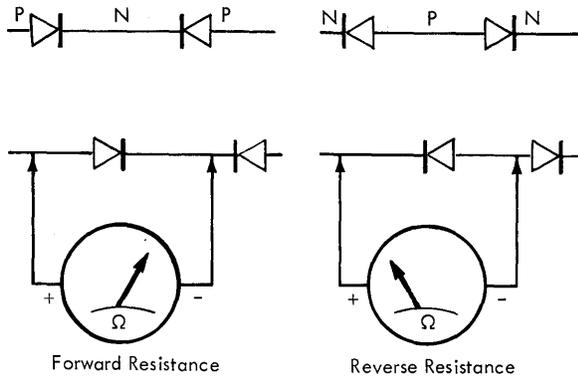
Table 2. Trouble Analysis Guide

### Circuit Board Component Measurements

After a trouble has been located to a specific stage, by performing systematic checks of voltages and waveforms, most defective components can be located by using an ohmmeter to check for an open or shorted condition. Be sure to consider parallel components when testing with an ohmmeter. An excellent method of determining the correct reading is to compare the readings of an identical component with another, identical, circuit on the board (drum and carriage circuits are identical). Specific component checks are given in the following paragraphs.

Transistors. A good-bad test to indicate open or shorted transistor junctions can be performed on transistors without removing them from the circuit board. For this test, transistors are considered as two back-to-back diodes arranged in PNP or NPN configuration. Check the forward and reverse resistance of each diode with an ohmmeter adjusted to the X100 ohm scale (Figure 2-4).

NOTE: Before removing and discarding the transistor as a result of this test, check the printed card to establish that a shorted transistor junction is not the result of its being shunted by a low-resistance component. The X100 scale of the ohmmeter should



Reverse Resistance should measure at least 10 times forward resistance

Figure 2-4. Transistor Testing

always be used to protect transistors from excessive currents.

**Diodes.** Test diodes with an ohmmeter in the same way that transistors are tested.

**Fuses.** An effective way to locate a blown fuse is to connect a voltmeter across it. If the fuse is blown, the terminal voltage of the power supply will indicate on the meter. If there is no meter indication, and the power supply is operating properly, the fuse is good. Be sure to use the proper scale on the meter.

## SERVICING PROCEDURES

### 1627 Disassembly

The 1627 plotter is easily disassembled for maintenance or repair. Normal disassembly is limited to removal of the cover, plotter circuit board, and plug-in power supply. No special instructions are required for removal of individual components on the main assembly, the circuit board, or the power supply.

#### Cover

To remove the cover, remove six binder head screws from the bottom of the cover (Figure 2-5).

**WARNING:** Remove only those screws designated A in Figure 2-5. Removal of screws other than those designated A, B or C will cause mechanical misalignment or damage.

#### Circuit Board

After removing the cover, remove the connector bracket by removing screws marked C in Figure 2-5. Remove six round head screws that fasten the circuit board to mounting standoffs on the main chassis and the power supply chassis. Carefully disengage the assembly from connectors J1 and J2 on the power supply chassis.

**WARNING:** The circuit board is flexible. Twisting the board during removal and replacement can crack the etched pattern.

#### Power Supply Chassis

Remove the cover and the screws marked B in Figure 2-5. Remove the circuit board then remove the two hexagon head screws that fasten the extended tabs on the power supply chassis to the side frames. The power supply chassis can now be removed by pulling it straight back.

**WARNING:** Remove only those screws designated A, B, or C in Figure 2-5.

### Removals and Replacements, and Adjustments

With the exception of replacement and adjustment of the drum step motor, the carriage step motor and the carriage drive cables described in the following paragraphs, no special instructions are required for adjustments or replacement of components in the 1627.

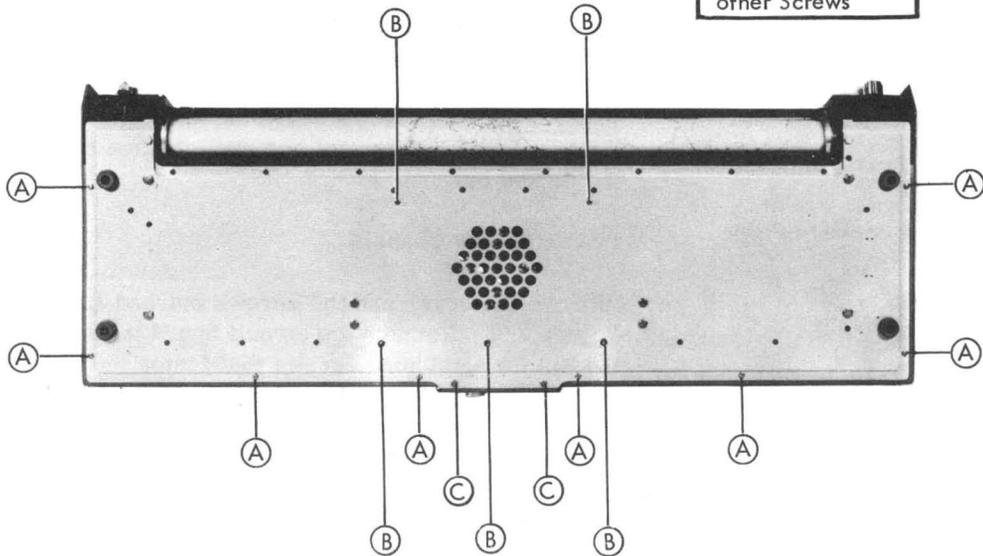
#### Step Motor Replacement and Adjustment

Location of the carriage and drum step motors, M3 and M4 respectively, is shown in Figure 2-6 and 2-7. The step motor and its primary gear train are matched at the factory and must be replaced as a complete assembly. To replace either of the step motors, proceed as follows:

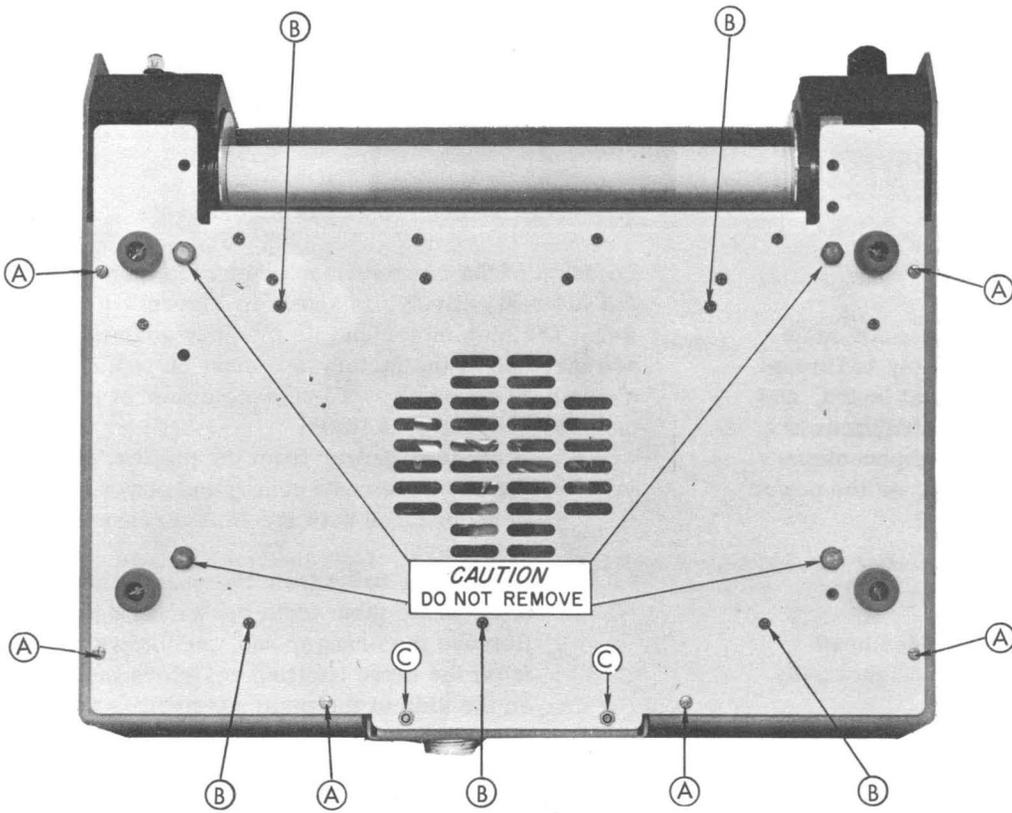
1. Disconnect power from the plotter. Remove the cover, circuit board, and power supply in accordance with the 1627 disassembly procedure.
2. Clip lacing twine from the step motor leads to separate them from the wiring harness. Remove the orange, red, and brown wires from the three limiting resistors mounted on the side of the main assembly. Note these connections carefully so that the replacement motor can be connected properly. Disconnect the remaining black wire from the standoff insulator.

- (A) Cover Screws
- (B) Power Supply Screws
- (C) Connector Bracket Screws

Caution  
Do Not Remove Any  
other Screws



MODEL II



MODEL I

Figure 2-5. Location of Cover and Power Supply Mounting Screws

3. Remove the two Allen head cap screws which mount the motor to the main assembly. Remove the motor and primary gear train.
4. Place the replacement motor and gear train assembly in position and hold the motor so that the protruding pinion gear is below the center axis of the motor.

**WARNING:** Use care when sliding the replacement motor into position to avoid damaging the plastic gear that mates with the pinion. Do not force the pinion into mesh.

5. Install, but do not tighten, the two Allen cap screws that mount the motor to the main assembly.
6. Carefully rotate the motor case clockwise until the pinion meshes and bottoms with the plastic gear. Maintain clockwise pressure while tightening the two cap

screws. This prevents backlash in the gear train.

7. Rotate the drum or the carriage drive pulley by hand. Both must move freely, but with perceptible resistance. There must be no perceptible backlash when the drum or carriage is rocked back and forth. If the resistance is excessive, loosen the cap screws and rotate the motor slightly counter-clockwise. If backlash is present, rotate the motor slightly clockwise and again tighten the cap screws.
8. Connect the lead wires from the new motor to the three resistors and the standoff insulator. Make certain the connections are the same as those on the motor removed in step 2:

brown	-	top terminal
red	-	center terminal
orange	-	bottom terminal

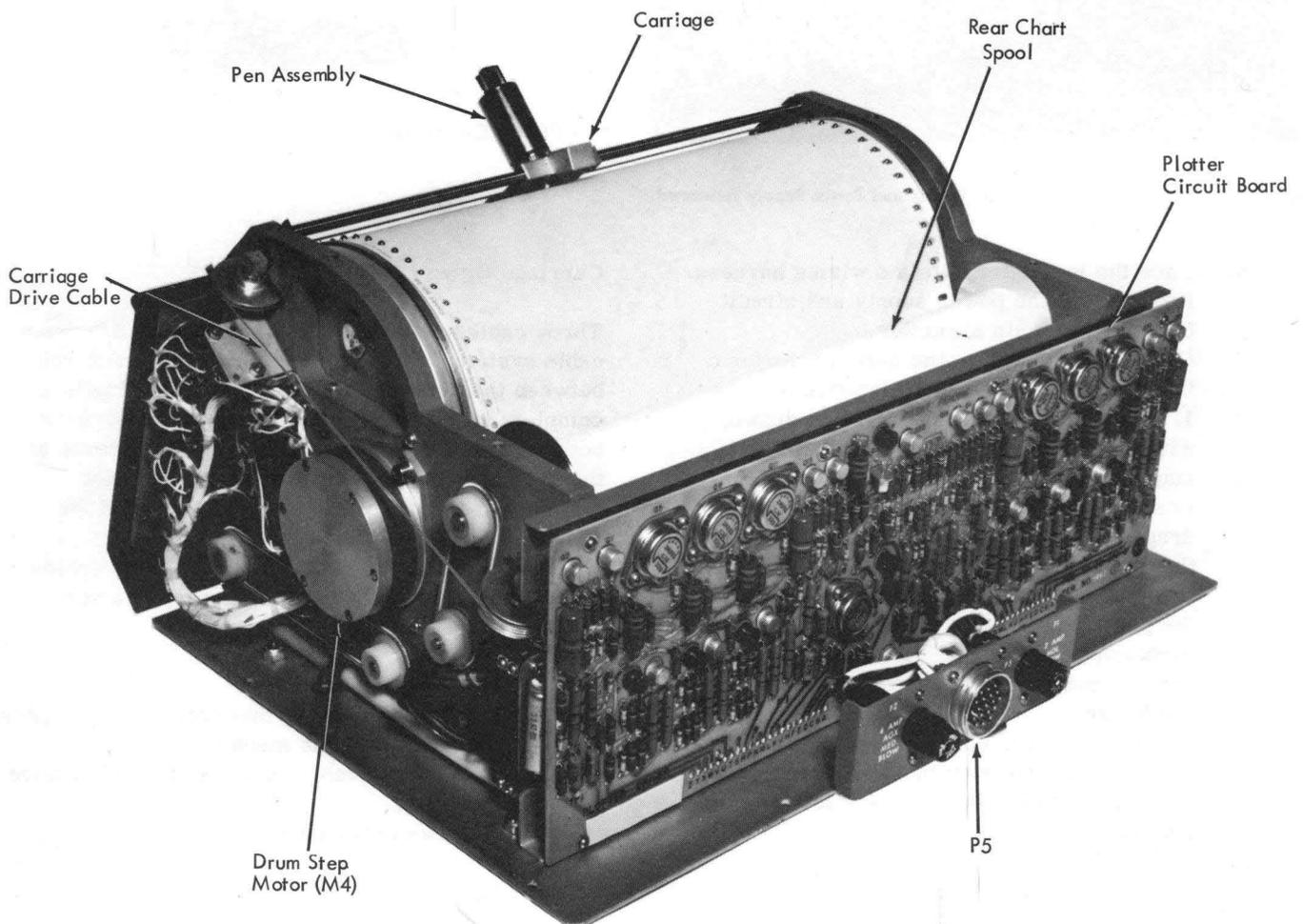


Figure 2-6. 1627 Rear Oblique View

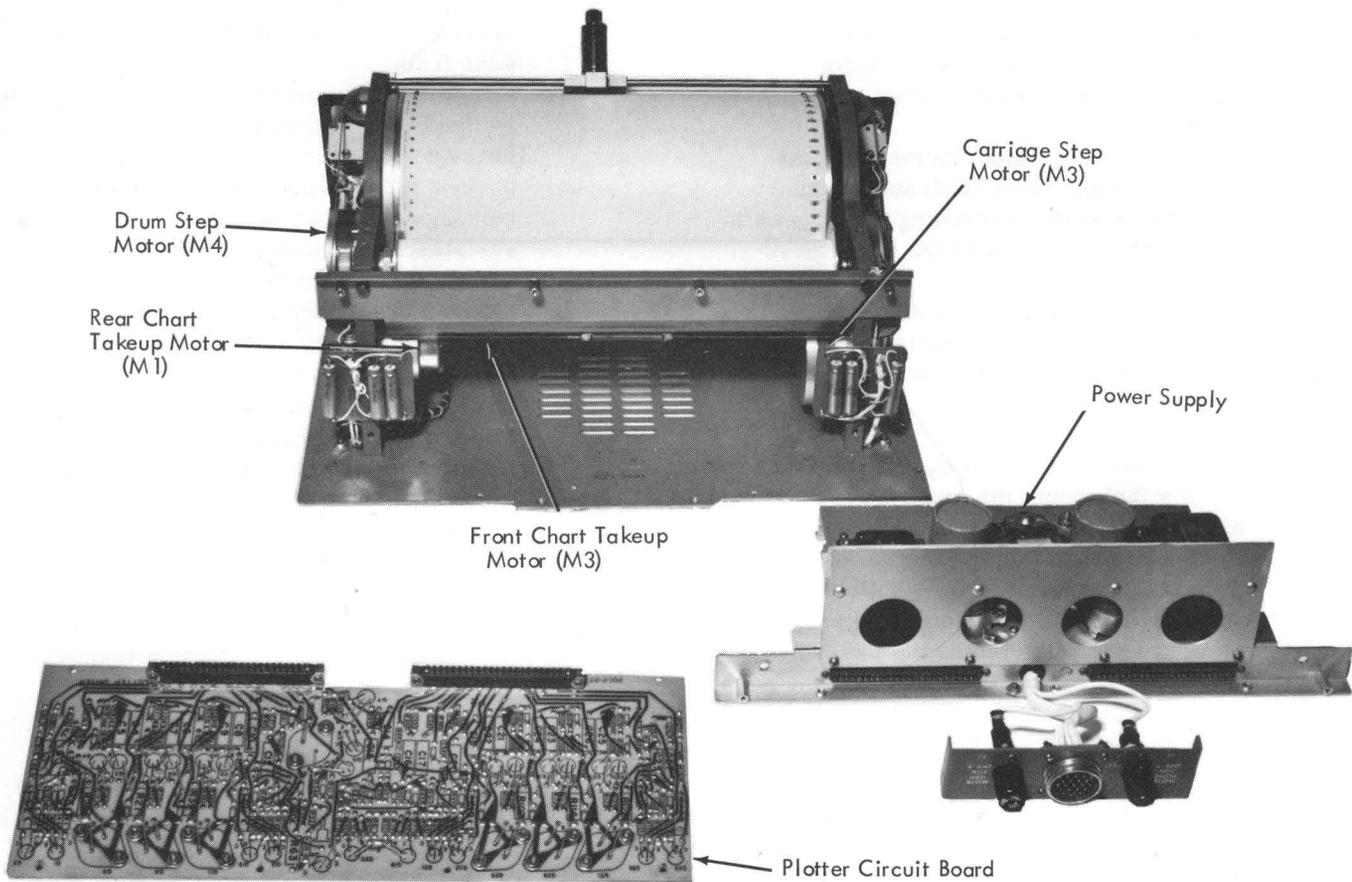


Figure 2-7. 1627 Rear View, Circuit Board and Power Supply Removed

9. Lace the motor leads to the wiring harness. Reassemble the power supply and circuit board to the main assembly.
10. Connect AC power to the unit and perform the Operational Checkout listed in Section 1. Discontinuities in the 45° line drawn, with the carriage fast run and drum fast run controls on, indicates that the motor is skipping steps because of excessive drag. Loosen the cap screws and rotate the step motor slightly counterclockwise. If the operation is excessively noisy or if the pen overshoots on incremental steps, backlash is indicated. Loosen the cap screws and rotate the motor slightly clockwise.
11. When checkout is completed satisfactorily, make certain the step motor mounting cap screws are tight, then replace the cover on the unit.

#### Carriage Drive Cables (Figure 2-8)

Three cables make up the complete carriage drive cable system. The one unshielded cable that runs between the drive pulley and the rear spring is a complete subassembly with the copper sleeves at both ends crimped tightly. The copper sleeves at the eyelet end of the other two cables are not crimped so that the eyelets can be removed for assembly to the carriage.

To properly install the carriage drive cables, proceed as follows (See Carriage Scale Factor Recalibration Model 2 only):

1. Remove top cover.
2. Remove the spring that connects the cables at the rear of the machine.
3. Clip off old cables at carriage and remove cables.
4. Remove lower carriage rod.

5. Remove cable terminations from inside the carriage, using long nose pliers.
6. Partly straighten new bare cable at eyelet end where it is kinked over copper sleeve; the eyelet will fall off so that the sleeve can be removed. Do not straighten cable so completely that the position of the kink is lost. Mark the position of the kink with a grease pencil or marking pen to prevent position of the kink from becoming lost.

7. Insert new cables through clearance holes in side of carriage from the inside. Be careful not to scrape or cut teflon insulation on carriage contact.

NOTE: The shortest cable must be installed on the left side of the carriage.

8. Using tweezers, long nose pliers, or a very small screwdriver, hook flattened end

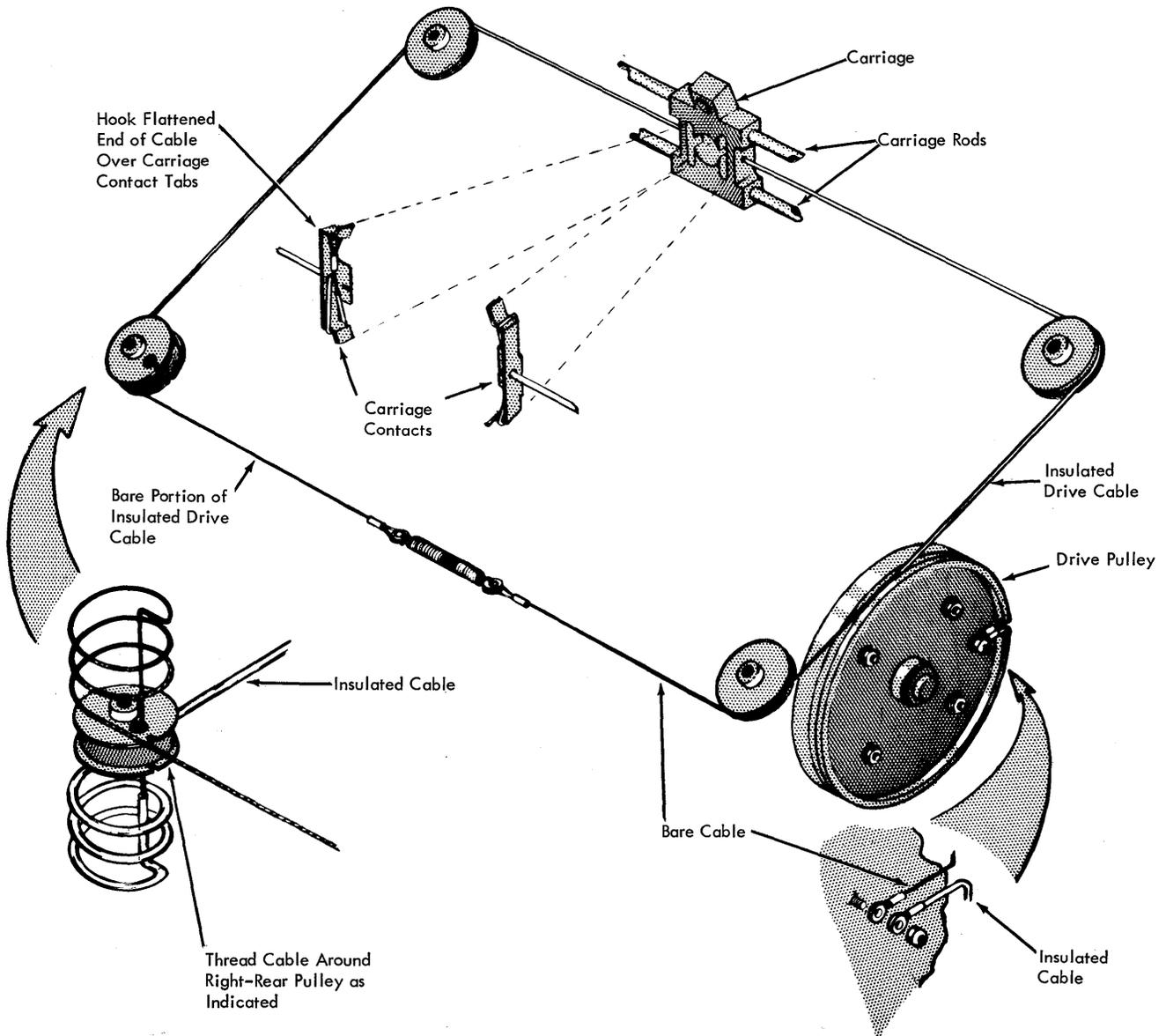


Figure 2-8. Carriage Drive Cable Replacement

of cable over one of the tabs on the carriage contact; loop the bent section of cable with the teflon sleeving over the other tab and pull cable taut. In order to keep cable from springing off tabs while assembling carriage, stuff small wads of soft paper into contact cutout area of carriage around the cable.

9. Use the following procedure to install the eyelets removed in Step 6.
  - a. Push end of cable through copper sleeve, form a loop, insert eyelet into the loop, and push cable back through sleeve.
  - b. Pull cable taut, with eyelet as close to sleeve as possible and with original kink in end of cable (described in Step 6) adjacent to inside end of sleeve.

NOTE: If the original position of the kink in the cable is not noticeable, the excess bare cable end should measure exactly 5 inches past the inside of the sleeve. The nylon eyelet must be installed on the righthand cable to insulate the cable from the spring.

10. Squeeze copper sleeve lightly with parallel jaw pliers (such as the inside of a pair of long nose pliers). Clip off excess cable end. Do not nick cable. Squeeze sleeve hard to firmly grip cable.
11. Thread cables around pulleys as indicated in Figure 2-8.
12. Connect cables at rear of machine using spring removed in Step 2.
13. Check carriage movement by hand for freedom from binds.
14. Perform operational checkout listed in Section 1.
15. When the operational checkout is completed satisfactorily, replace top cover.

#### Carriage Scale Factor Recalibration (Model 2 Only)

When the carriage scale factor adjustment mechanism is found to be in error, or if repair has been performed on any part of the mechanism, a carriage scale factor recalibration should be performed.

If replacing or restringing of the carriage cable is required, the nut holding the drive pulley pinion (designated "A" in Figure 2-9) should be loosened, freeing the pinion to turn on its shaft. In restringing the carriage cable, care should be exercised to start winding the cable at the proper

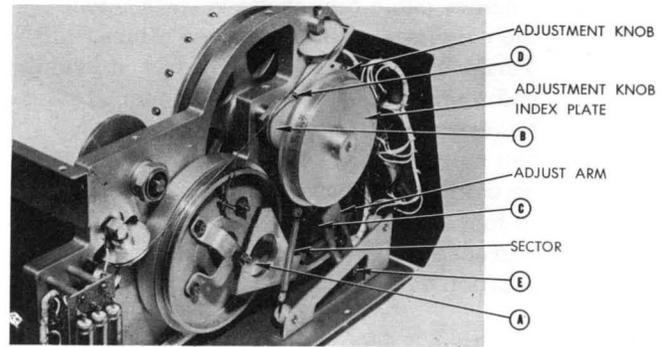


Figure 2-9. Carriage Scale Factor Recalibration

location on the drive pulley, so that the cable does not wind upon itself. The bare-wire part of the cable running to the spring at the rear of the plotter is started at the extreme inside of the drive pulley and wound toward the outside. The insulated cable running to the carriage started at the outside flange of the drive pulley and wound toward the inside. The insulated cable unwinding from the drive pulley must feed over the outside idler pulley (designated "B" in Figure 2-9) on the adjustment knob shaft, then under the idler pulley (designated "C" in Figure 2-9) in the sector slot, and over the inside idler pulley (designated "D" in Figure 2-9) on the adjustment knob shaft.

**CAUTION:** Reversing the location of the cable on the two idler pulleys designated "B" and "D" will cause the cable to improperly wind on the drive pulley.

After the carriage cables have been strung, proceed with the following adjustments:

1. Manually slide the carriage to the right, until the carriage barely touches the right-hand limit switch plate.
2. Rotate the adjustment knob (Figure 2-9) to position the "zero" at the reference dot.

NOTE: If necessary, loosen the three screws locking the index plate to the hub, and rotate the index plate to position the reference dot to the "zero" on the adjustment knob. Align "zero" to the reference dot and tighten the screws.

3. Position the sector so that the drive pulley pinion is near the top of the gear section. The bottom of the gear section should be approximately parallel to the plotter base. Tighten the nut holding the pinion.

NOTE: If necessary, loosen the nut (designated "E" in Figure 2-9) which clamps the adjust arm to the adjustment knob cable, then position the adjust arm so that the idler pulley designated "C" is directly over the sector pivot shaft and tighten the nut, clamping the adjust arm to the cable.

After completing preliminary adjustments, turn plotter power ON. (Power ON will prevent the carriage drive pulley from turning.) Proceed to recalibrate the carriage scale factor adjustment as follows:

4. Rotate the adjustment knob over the full range of its travel from -30 to +30 while carefully observing the two idler pulleys designated "B" and "D". There should be no rotation of either of these pulleys. If pulleys rotate, set the adjustment knob at "zero" loosen nut "A" locking the pinion, rotate the pinion slightly, and lock the pinion by tightening the nut. Rotate the adjustment knob again through its entire range and observe the two idler pulleys. If the rotation of the two pulleys has decreased, repeat the procedure until there is no movement of either pulley. If the movement of the pulleys has increased, rotate the pinion in the opposite direction from which it was first moved. When there is no movement of the idler pulleys as the adjustment knob is turned, it is then possible to set the carriage on a reference mark at the

right hand edge of the chart paper and make a scale factor adjustment without disturbing the initial reference setting.

5. With a piece of chart paper in the plotter, and with the adjustment knob set at "zero" draw a short vertical line near the right hand border of the paper. Apply 2900 input pulses to drive the carriage toward the left and draw another short vertical line. Remove the paper and measure between the two vertical lines. The lines should be exactly 29.000 inches apart. If the carriage failed to move 29.000 inches, run the carriage to the right hand border and loosen the nut (designated "E") clamping the adjust arm to the adjust cable. If the carriage travel was in excess of 29 inches, move the adjust arm slightly toward the rear of the plotter and tighten the clamping nut. If the carriage travel was short, move the adjust arm forward. Check the carriage travel again and repeat the procedure above, if necessary. Fine adjustments may be made by rotating the adjustment knob one or two divisions and resetting the index plate to match.

WARNING: In working upon carriage scale factor adjustment mechanisms, use extreme care to avoid personal contact with exposed terminals, as well as to idler or drive pulleys which may have applied voltages with respect to ground.

## INTRODUCTION

The circuits presented in this section describe the theory of operation for both the 1626 and the 1627. The 1626 is presented first.

## CIRCUIT DESCRIPTIONS — 1626

Figure 3-1 and the Instructional System Diagram Section (Section 4) of this manual are used to supplement the following circuit descriptions.

### Translator

The translator circuits are used to convert the character record BCD bits from the using system into the appropriate plotter commands. The incoming thyatron punch signals (character record bits) are converted to -R levels by resistors tied to +12 volts in the 1626 (26.85.20.1). The -R signals are then converted to +S signals by CB-- cards and delivered to the translating and control circuits (26.85.22.1). Once On the thyatrons remain On until after the plotter command is transmitted to the plotter. They are then reset by the "quench thyatron" line. This reset is explained under the heading Reset and Response. The thyatrons that are not fired leave +R signals on the inputs to the CB-- cards. These +R signals are converted to -S signals by the CB-- cards and are delivered to the translating and control circuits.

The translator is composed of a number of AND/OR circuits. The inputs to the AND circuits are logically arranged so that the resultant outputs are the decimal equivalents of the BCD inputs (Figure 3-1). These resultant outputs (decode lines) are then logically arranged to provide the inputs to the OR circuits. The OR circuit outputs, when gated by "plotter gate" constitute the appropriate plotter commands.

### Synchronizer and Delay Timers

The synchronizer circuits generate timed impulses that cause the 1620 to operate in step with the plotter. The delay timers are used to interlock the 1626 control circuits to prevent the start of a plotter operation if the preceding plotter operation is not complete.

A plotter cycle is started when the inputs to the 100  $\mu$ sec single shot (SS) and the delay inverters (26.85.23.1) are satisfied. The inputs are satisfied when the timers are off the CE On/Off Line switch is in the Off line position or the meter switch is turned on and one or more of the bit lines (0, 1, 2, 4, 8) from the using system are active. The 100  $\mu$ sec SS is used to delay the start of the plotter gate until the input signals and, hence, the translation circuits have had time to stabilize. The delay inverters are used to delay the leading edge of the start signal until after the 100  $\mu$ sec SS has had time to turn on.

When the 100  $\mu$ sec SS times out, its output is gated by the output from the delay inverters to fire the 50  $\mu$ sec gate plotter SS (26.10.00.1). This 50  $\mu$ sec pulse is used to gate the plotter control signals to the plotter (26.85.22.1), to provide a start pulse to the delay timers (26.85.24.1), to provide the P3 response signal to the using system and interrupt the PCB-1 response signal to the using system (26.85.23.1). Note, "PCB -1 response" is an inversion of "P3 response," therefore, "PCB -1 response" is re-established after "P3 response" turns off.

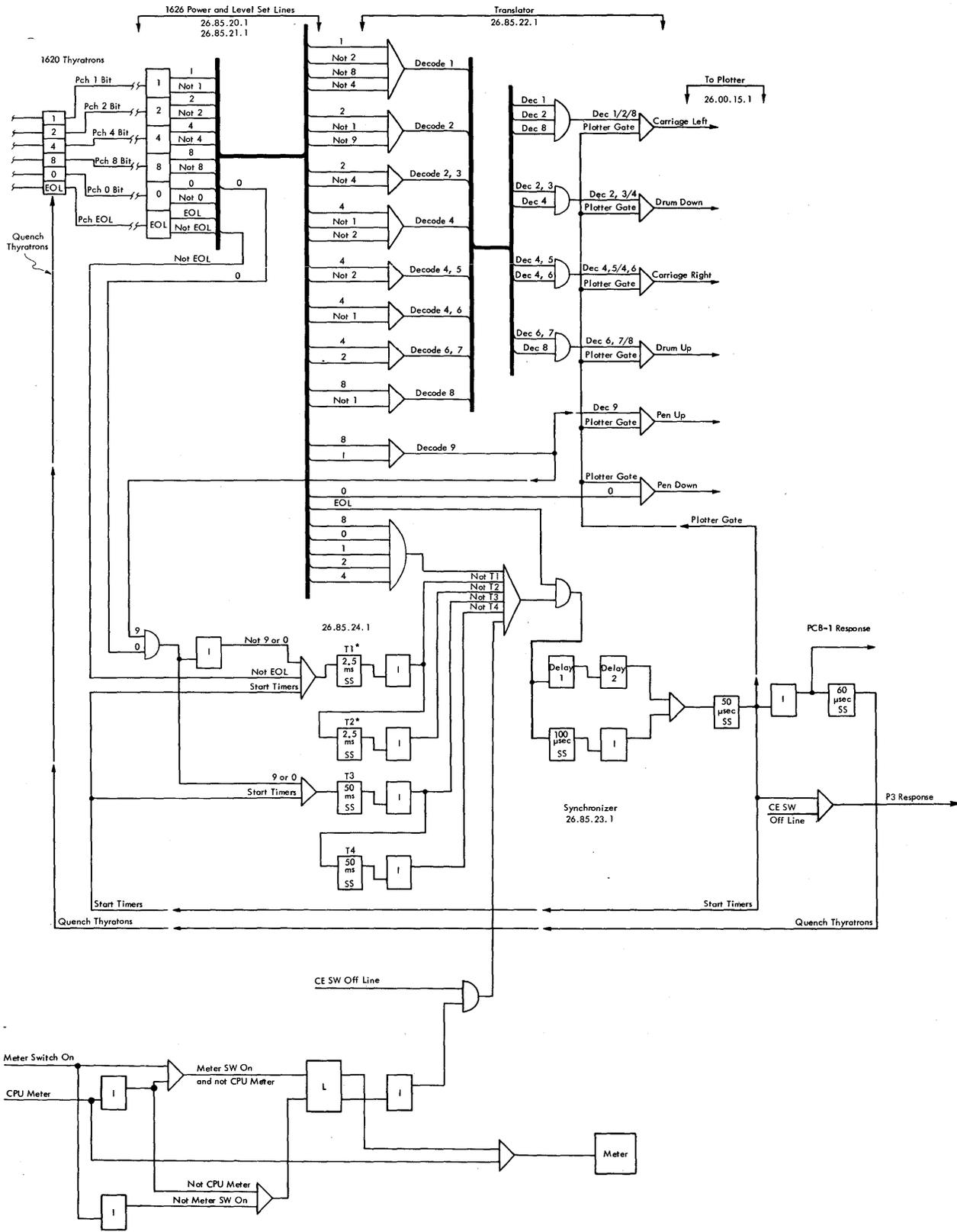
### Delay Timers

Two distinct time delay circuits are provided by the delay timers. One circuit develops a 3.4 ms delay, (5 ms for 1627 Model 2) to the start of a plotter operation, when the preceding plotter operation involves a carriage or drum motion. The other circuit develops a 100 ms delay to the start of a plotter operation when the preceding plotter operation involves a pen up or down motion. Each timer circuit is composed of a pair of single shots in series. This arrangement limits the duty cycle of each single shot to 50% of the total duty cycle.

The 100 ms timer is turned on by the start timer pulse if there is a 0 or 9 present. The 3.4 ms timer (5 ms timer for 1627 Model 2) is turned on by the start timer pulse if there is neither a 0 or 9 or an end of line (EOL) signal present.

### Reset and Response

As previously mentioned, when the 1620 thyatrons are turned on they stay on until turned off. Normally, the thyatrons are turned off by reducing the applied



\* 1.7 ms for Model 1

Figure 3-1. 1626 Positive Logic ILD

collector voltage to zero by means of a circuit breaker. However, the 1626 circuits are designed to reset the thyratrons in a different manner. This method employs a CA-- card wired in parallel with the thyatron collector circuit (26.85.20.1). When this circuit is turned on by the "quench thyatron" line, the thyatron collector voltage and current are diverted through the shunt circuit formed by the CA-- card and the thyatron is starved off. "Quench thyatron" is generated when the 60  $\mu$ sec SS is fired on 26.85.23.1. The 60  $\mu$ sec SS is fired when the 50  $\mu$ sec gate plotter SS times out.

#### End of Line Operation

An EOL signal from the using system fires the 50  $\mu$ sec plotter SS directly (26.85.23.1). This causes the "plotter gate," "start timer," and "P3 response" pulses to be generated in the normal manner. However, data is not being transmitted to the 1626 translator circuits (26.85.22.1) therefore commands are not transmitted to the plotter. In addition, the delay timers are not started by the "start timer" signal because the timers are not gated by the EOL signal (26.85.24.1).

When the 50  $\mu$ sec plotter gate SS times out (26.85.23.1), PCB-1 response is re-established and the 60  $\mu$ sec SS is fired to reset the EOL thyatron in the normal manner. Thus, if the 1626 receives an EOL signal before the plotter has completed the previous plot command, the response signals are sent to the using system without waiting for the timer to time out.

#### Meter Operation

The meter circuit is designed to allow the 1626 meter to run only if the 1626 meter switch is turned ON prior to receiving a plotter command. If the 1626 meter switch is OFF and a plotter command is received, the system "hangs-up" with all meters OFF. If the 1626 meter switch is then turned ON, the meters start and the operation is resumed.

The 1626 meter will not run if the 1626 meter switch is Off. Placing the 1626 in the Off-line status opens the P3 response line to the CPU. The 1626 can, therefore, only be operated Off-Line from the 1626 CE Panel.

NOTE: If the 1626 meter switch is not turned off when the 1626 is Off-Line, the 1626 meter will run if the CPU is operated in the customer status.

#### Logic Flow

Figure 3-2 illustrates the 1626 logic flow. This figure provides an overall view of the circuit operation of the 1626. It is presented to summarize the foregoing circuit descriptions and to assist the readers recall during diagnostic sessions. The following steps present the logical sequence of events for plotter operations.

1. Fire 1620 output register thyratrons.
2. Translate from BCD bits to plotter commands and fire 100  $\mu$ sec SS\*.
3. Fire 50  $\mu$ sec SS when 100  $\mu$ sec SS times out.
4. Gate plotter commands to plotter for 50  $\mu$ sec and start either the 3.4 ms (5 ms for 1627 Model 2) or the 100 ms delay timer.
5. Interrupt "PCB-1 response" to the using system, transmit "P3 response" to the using system.
6. Fire 60  $\mu$ sec SS when 50  $\mu$ sec SS times out.
  - a. Reset thyratrons.
  - b. Re-establish "PCB-1 response."
  - c. Interrupt "P3 response."
7. Repeat steps 1 through 6 for multiple character records. Repeat steps 3, 5, and 6 when end of line signal is received.

\*The 100  $\mu$ sec SS is fired when timers have timed out from the previous plotter operation or directly when an end-of-line signal is received.

#### FUNCTIONAL DESCRIPTION 1627

The detailed block diagram of Figure 3-3 illustrates the operation of the 1627 in terms of signal flow and functional circuits. Inputs to the recorder from the 1626 consist of drum up and drum down, carriage left and carriage right, and pen up and pen down pulses. These three groups of signals are generally referred to as the X-axis, Y-axis, and Z-axis signals, respectively.

#### Drum Control

The X-axis signals from the 1626 are applied to separate 1.5 ms single shots, which in turn control the action of a reversible ring counter, through suitable diode gating circuits. The ring counter consists of three stages, each of which supplies current to one pair of stator coils in the drum step motor. The design of the ring counter is such that only one pair of coils receives current at

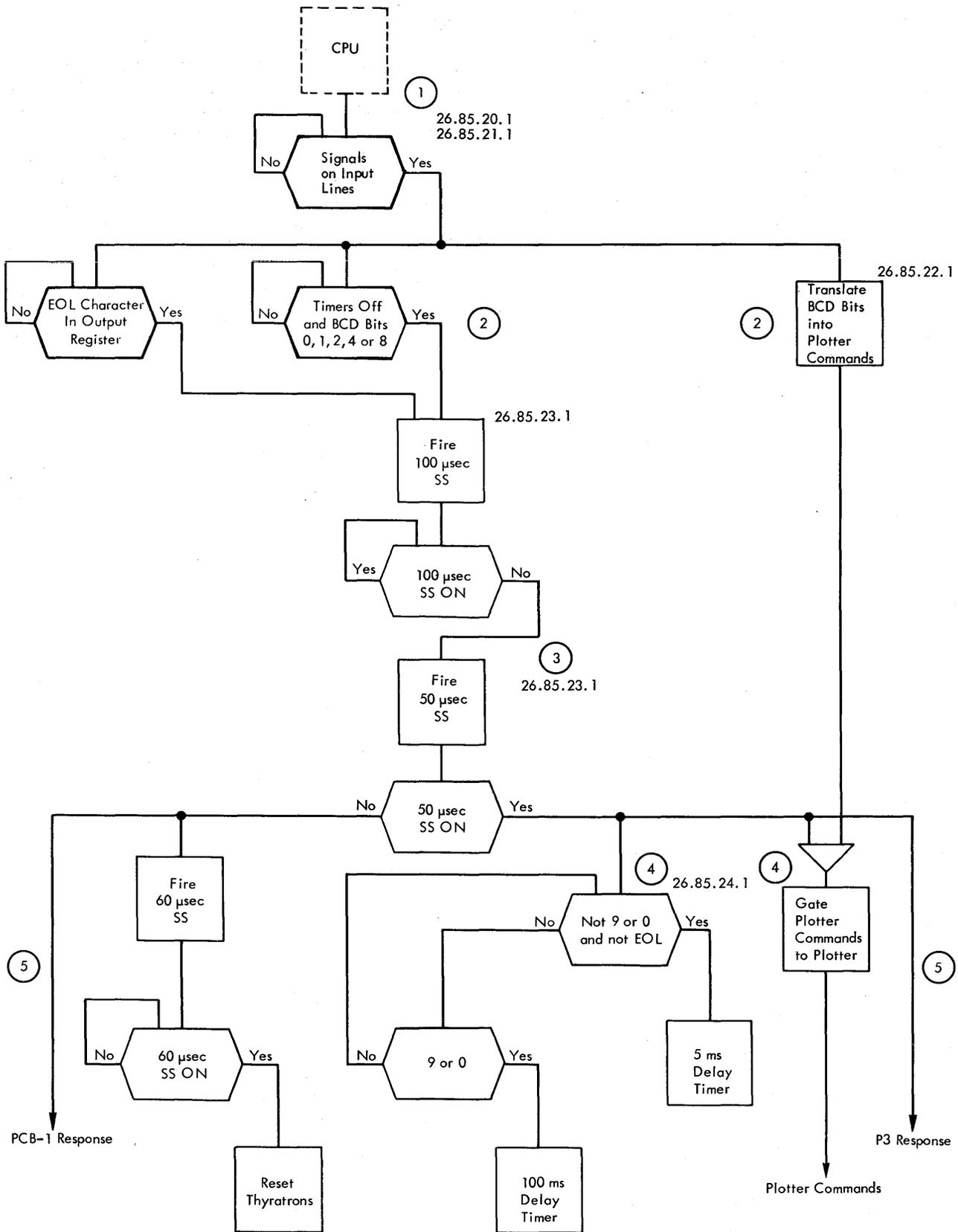


Figure 3-2. 1626 Logic Flow

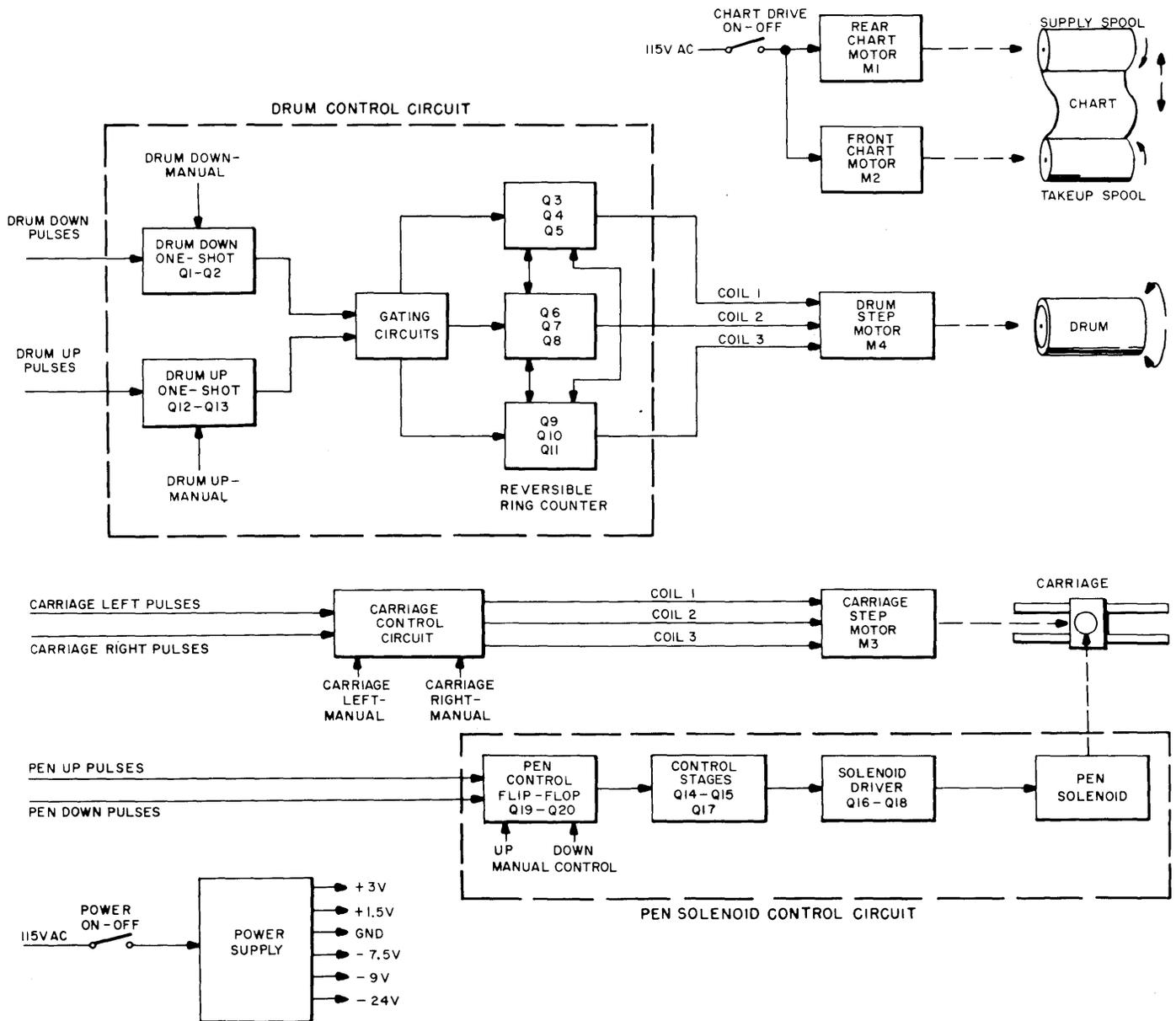


Figure 3-3. 1627 Block Diagram

any given time. When an incoming pulse fires one of the single shots, the ring counter changes state. The direction of change depends upon whether the incoming pulse is a drum up or a drum down signal.

When the ring counter changes state, the step motor current is switched from one pair of coils to an adjacent pair. This causes the motor to rotate 1/12 of a revolution clockwise or counterclockwise. The drum step motor is connected to the drum through a reduction gear train that causes the drum to move 1/100" for each step of the motor.

Manual positioning of the drum is provided by two front panel controls that allow the drum to be advanced up or down in single steps, or continuously at the rate of 120 steps per second.

### Carriage Control

The Y-axis signals from the 1626 are applied to the carriage control circuit. This circuit and the carriage step motor are identical to the drum control circuit and step motor described above. Front panel

controls are also provided for manual positioning of the carriage.

### Pen Control

The Z-axis signals from the 1626 control a pen solenoid which, when energized, lifts the pen off the chart. The incoming pen up and pen down pulses are applied to a trigger. The trigger acts as an electronic switch that controls current to the pen solenoid through the suitable control stages and a current driver. Manual control of the pen solenoid is provided by means of a front panel switch.

### Chart Take Up Motors

The remaining functional circuits of the 1627 are the chart take up motors and power supply. The chart motors operate in a stalled condition to maintain proper tension on the chart spools. A front panel ON/OFF switch is provided to allow the chart motors to be disabled when single sheets of graph paper are used in place of the continuous roll. (See Operating Instructions in Section 1).

### Power Supply

The power supply consists of a silicon bridge rectifier and filter divider components. The supply provides two positive and three negative output voltages, referenced to a circuit ground that is isolated from the 1627 chassis. The output voltages from the power supply are:

- +3.0 volts DC
- +1.5 volts DC
- 7.5 volts DC
- 9.0 volts DC
- 24.0 volts DC

### CIRCUIT DESCRIPTIONS — 1627

The drum, carriage and pen solenoid control circuits are contained on a single printed circuit board. Because of this, ALDs are not available for the 1627. In place of ALDs, the printed circuit board is presented in schematic form in Figure 3-6.

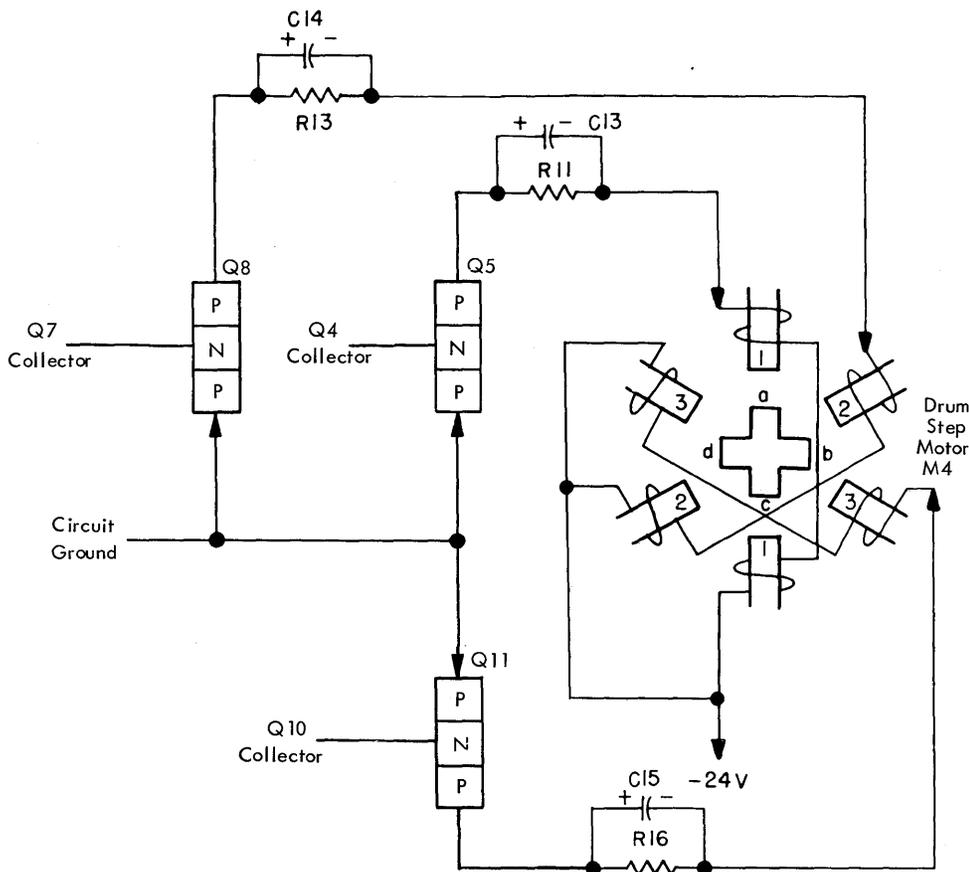


Figure 3-4. Step Motor Drive Schematic

## Step Motors

A simplified schematic diagram of the drum step motor is shown in Figure 3-4. The motor consists of a stator with three pairs of poles arranged symmetrically around a 4-pole soft iron rotor. Each of the three pairs of poles has a separate current winding that is controlled by a transistor current driver. The motor advances  $1/12$  of a revolution each time the current is switched off in one stator winding and switched on in another winding. The direction of rotation is determined by the sequence in which the windings are energized.

For illustrative purposes, the three pairs of stator windings, shown in Figure 3-4 are numbered 1, 2, and 3. The four poles of the rotor are designated a, b, c, and d. Assume that transistor Q5 is conducting. The circuit is designed so that when Q5 conducts, Q8 and Q11 are cut off. Current, therefore, flows only in stator winding number 1. This current creates a magnetic field that holds poles a and c of the rotor in alignment with the number 1 stator poles. If transistor Q5 is switched off and Q8 is switched on, the rotor turns until one pair of its poles is aligned with the poles of stator winding number 2. Because poles b and d are the closest to the number 2 stator poles, the rotor steps counterclockwise.

In the above example, if transistor Q11 is switched on instead of Q8, the rotor steps clockwise until poles b and d are in alignment with the poles of stator winding number 3.

If the current is continuously switched between windings in a clockwise sequence (i. e., 1-2-3-1-2-3, etc.) the rotor steps counterclockwise. Conversely, if the switching sequence is counterclockwise, the rotor steps clockwise.

The rotor shaft of the drum step motor is coupled to the drum through a reduction gear train. The gear train consists of a 9-tooth pinion on the rotor shaft which engages a 75-tooth gear in the primary gear box on the motor assembly. A 12-tooth pinion mounted on the same shaft as the 75-tooth gear rotates at the rate of one revolution per 100 steps of the motor. The 12-tooth pinion drives a 225-tooth gear fastened to the end of the drum.

The mechanical and electrical design of the carriage step motor and its associated circuit are identical to that of the drum step motor, except that the 12-tooth pinion on the carriage step motor drives a 156-tooth gear on the carriage drive pulley. On both motors, the 12-tooth pinion in the primary gear box is mounted off center. This permits the backlash between the pinion and the drum or carriage gear to be adjusted to zero. Resistors R15, R11 and R16, shown in Figure 3-4 are current limiters.

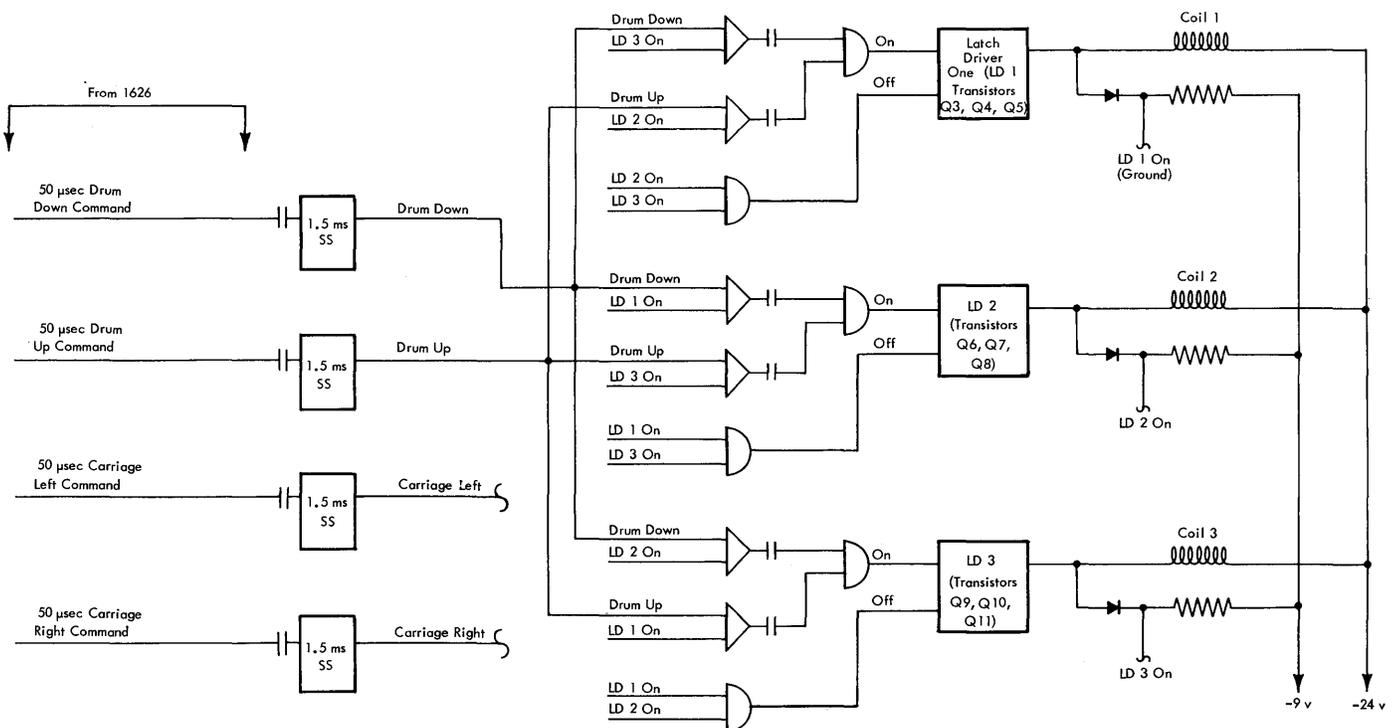


Figure 3-5. Drum Stepping Logic

A suppression diode is connected across each of the three windings in both step motors to damp out the high counter-emf generated by the decaying magnetic field when the current is switched off.

### Reversible Ring Counters

The carriage and drum step motors described in the preceding paragraphs are each driven by a reversible 3-stage ring counter. The ring counter associated with the drum step motor consists of transistors Q3 through Q11 (Figure 3-5). The ring counter for the carriage step motor consists of transistors Q23 through Q31. Since the two circuits are identical, only the drum ring counter circuit is described.

Refer to Figure 3-5 and 3-6. Assume that transistor current driver Q5 is conducting, supplying current to coil 1 of the drum step motor. Because only one driver stage can be in conduction at any given time, Q8 and Q11 are cut off. In the absence of a clock pulse from the drum up or drum down single shot, the ring counter is held in this state in the following manner.

Control stage Q3 an NPN Transistor, is not conducting, because its emitter is connected to -7.5 volts and its base is returned to -9 volts through R16, R35 and R17, R30. The base potential is held at approximately 8.5 volts. Since no collector current can flow in Q3, the base of Q4 is held at approximately +3 volts, through resistor R19. The emitter of Q4, a PNP transistor, is returned to +1.5 volts. Thus, Q4 is also cut off. Since there is no collector current through Q4, the base of Q5 is biased negative with respect to its emitter and Q5 conducts. Because the emitter of Q5 is at ground potential, and the step motor is returned to -24 volts (Figure 3-4), the collector of Q5 is at approximately ground potential while this stage is conducting.

Diode CR8 conducts because its cathode is returned to -9 volts through resistor R32. The bases of Q6 and Q9 are therefore returned to ground potential, through CR8 and resistors R24 and R33, respectively. Both Q6 and Q9 are thus driven into conduction. The collector current of Q6 is supplied from the base of Q7 and the collector current of Q9 is supplied from the base of Q10. Consequently, Q7 and Q10 are saturated. The bases of Q8 and Q11 are at approximately +1.5 volts, and the emitters are at ground potential, hence these transistors are cut off.

Assume that with the ring counter in the state described above, a drum down clock pulse is applied at pin R of connector P1. Pin R is normally at approximately -7 volts, and is driven positive to essentially ground potential during the clock pulse period of approximately 1.5 ms. This positive

going pulse is applied to the cathodes of diodes CR6, CR10, and CR12, but affects only CR10. The anodes of CR6 and CR12 are returned to -9 volts through resistors R14, R35 and R28, R30, respectively. Thus, these diodes are initially cut off and remain cut off during the clock pulse period. However, CR10 is conducting, since its associated resistor R22 is returned to ground potential through diode CR8 and conducting driver stage Q5. Capacitor C6 is therefore initially charged to -7 volts. The positive going clock pulse at the cathode of CR10 cuts off the diode and C6 discharges through R26 and the base-to-emitter circuit of Q6. At the end of the clock pulse, when the voltage at pin R returns to -7 volts, the clock pulse is capacitively coupled through C6, causing a negative going pulse to appear at the base of Q6. This negative pulse cuts off Q6, which in turn cuts off Q7 and allows Q8 to conduct, supplying current to coil 2 of the drum step motor.

The collector of Q8 is now at ground potential, and resistors R17 and R31 are therefore returned to ground potential through diode CR11. This causes both Q3 and Q9 to conduct. Q4 and Q10 also conduct, switching Q5 off, keeping Q11 cut off in the manner described previously. Gating diodes CR6 and CR10 are now cut off and CR12 is conducting. Thus, if another drum down clock pulse is applied to the circuit, capacitor C9 drives the base of Q9 negative and Q11 conducts.

The gating diodes associated with the clock drum up signal input at pin U of P1 are CR7, CR9 and CR13. The action of this circuit is the same as that of the clock drum down circuit, except that the counter changes state in the reverse direction when a clock pulse is applied at pin U.

### Single Shots

The clock drum up and clock drum down signals that control the ring counter circuit previously described are provided by Single Shot circuits. A Single Shot is provided for the drum-up and drum-down functions, and for the carriage left and carriage right functions. The Single Shots for these four functions, shown schematically in Figure 3-5, are Q1-Q2, Q12-Q13, Q21-Q22, and Q32-Q33, respectively. Since all four circuits are identical, only the drum-down circuit is described in detail.

The purpose of the Single Shot is to provide a time delay during which the circuit will not accept another step signal. This delay, equal 1.5 ms protects the ring counter against double stepping due to transients or noise.

As shown in Figure 3-5, either a positive or a negative going signal may be used to trigger the

drum-down Single Shot. However, when the 1627 is used with the 1626 only the positive going pulse is used. In the absence of an input signal from the 1626, transistor Q1 is normally conducting and Q2 is cut off. The regenerative cycle is initiated by applying a positive pulse to the base of Q2, driving this stage into conduction. Conventional cross-coupling holds Q1 cut off and Q2 in conduction for a period of time determined by the RC time constant of Q2 and R5. This period is set to a nominal value of 1.5 ms. When the base potential of Q1 decays to a value equal to the emitter potential, this stage again conducts and its negative-going collector voltage cuts off Q2. The circuit then remains in its original state until another positive pulse is received.

When the Single Shot is fired by a positive input to pin W from the 1626, Q1 is cut off for a period of 1.5 ms. This causes the voltage at the junction of R7 and R8 to rise from approximately -7 volts to essentially ground potential for 1.5 ms. This comprises the clock drum-down signal output, which is connected from pin Z through an external jumper to pin R at the input to the ring counter circuit.

Manual drum step signals are applied to the single shot circuit through the diode CR5. The manual input signal may consist of either a single positive going pulse, or a continuous series of 120 cps positive going pulses. (See Drum and Carriage Manual Control Circuits.)

The operation of the carriage left and right Single Shots is identical to that of the drum-up and down Single Shots. However, the Single Shot output (clock) signals are connected to the carriage ring counter through left and right limit switches (Figure 3-7). The limit switches disconnect the associated single shot output whenever the carriage has reached the left or right limit of travel, and thus prevent further stepping action in that direction.

#### Pen Solenoid Control Circuit

The schematic diagram for the pen solenoid control circuit is shown in Figure 3-6. In this circuit, a trigger is used for current control instead of the Single Shots used in the step motor control circuits. The trigger, consisting of transistors Q19 and Q20, remains in the state to which it was set by the last signal pulse, until another signal pulse causes it to change state. The triggering circuit is designed so that pulses of either polarity can be used to set the trigger to either state. However, when the 1627 is used with the 1626, only the positive input is used.

In the normal, or pen down state, Q19 is conducting and Q20 is cut off. The trigger is switched to the pen up state by applying a positive pulse at the base of Q20. Q19 is then held cut off by the negative

voltage at the collector of Q20, and Q20 is held in conduction by the positive voltage at the collector of Q19. The trigger then remains in the pen-up state until a positive trigger pulse is applied to the base of Q19.

Manual pen-up and pen-down signals are applied to the trigger through diodes CR30 and CR26, respectively. Both the manual inputs consist of a single positive going pulse. (See Pen Manual Control Circuit.)

The output voltage from the pen control trigger, obtained from the junction of resistors, R73 and R74, is applied to the base of the driver transistor Q18. When the trigger is in the pen-down state, Q20 is cut off and Q18 is biased off. When the trigger changes state, Q20 conducts and the base of Q18 becomes negative. Q18 is driven into conduction and supplies current to the pen solenoid.

The driver transistor Q18 performs a dual function in the pen control circuit. It supplies current to actuate transistor Q14, and it supplies a continuous holding current to keep the solenoid retracted as long as the trigger remains in the pen-up state. When Q18 is first driven into conduction, its collector voltage changes very rapidly from a negative potential to ground potential. This causes a large positive pulse to be coupled through capacitor C13 to the cathode of diode CR20. Transistor Q14 is normally biased on by the voltage divider action of R54, CR20, and R53, which maintains a negative potential at the base. When the positive pulse appears at the cathode of CR20, the diode is cut off and the base of Q14 then becomes positive, because resistor R54 is returned to +3 volts. Transistor Q14 is therefore cut off, and its collector voltage goes negative. Because the collector is tied to the base of Q16, this negative voltage now causes Q16 to conduct. Q16 supplies a surge of current to the pen solenoid through pin J of P1. This initial surge is sufficient to overcome inertia and lift the pen from the paper. Q14 remains cut off and Q16 conducts for a period determined by the RC time constant of C13 and R53. The voltage at the cathode of CR20 decreases exponentially as C13 charges, and when the cathode becomes more negative than +1 volt, diode CR20 again conducts and Q14 is driven into conduction. The collector current of Q14 produces a voltage drop across resistors R55 and R56 that cuts off Q16. At this time, only the holding current is supplied to the solenoid, through the collector of Q18, resistor R63, and diode CR22. The nominal value of holding current is approximately 35 milliamps.

From the foregoing it is seen that if the pen and its solenoid are removed from the carriage while the

circuit is in the pen-up state, only the holding current is supplied to the solenoid when the pen is replaced. This also occurs if the trigger assumes the pen-up state when power is first applied. The pen therefore remains down even though the trigger is in the pen-up state and the pen-up signals have no effect. In this event, the manual control must be turned first to the pen-down and then to pen-up. The pen-down signal resets the trigger to the down state, and the pen-up signal sets it to the up state. As the trigger switches back to pen-up state, the initial surge of current supplied by Q16 lifts the pen.

Transistors Q15 and Q17 with their associated components comprise a protection circuit that automatically resets the trigger to the pen-down state, if a short circuit occurs at the pen solenoid. Transistor Q17 is normally conducting. Its base is biased positive with respect to the collector by the action of R62 and R59, which form a voltage divider between ground and -7.5 volts. The emitter of Q17 establishes the emitter potential of Q15. Transistor Q15 is normally cut off by the positive bias applied to its base, which is tied to the base of Q16. If a short circuit occurs at the solenoid, Q16 conducts and its emitter is at a negative potential determined by the voltage drop across parallel resistors R58 and R60. This causes the bases of both Q16 and Q15 to be driven negative. When the base of Q15 is more negative than the emitter voltage established by Q17, Q15 conducts. This causes a positive going pulse to be coupled to the base of Q19, which has the same effect as a pen-down signal. The trigger is therefore reset to the pen-down state and current is cut off from the solenoid. During the short period required for this action to occur, the current through Q16 is limited to 600 milliamps by the action of R58 and R60.

#### Drum and Carriage Manual Control Circuits

The manual controls for the drum and carriage control circuits are shown in the schematic diagram of Figure 3-7. Separate controls are provided for single and continuous stepping (fast run) of both the drum and the carriage. Because the drum and the carriage controls are identical, only the drum controls are described in detail.

#### Drum Single Step Switch

The Drum Single Step switch S7 is a spring-loaded three-position wafer switch that permits the drum to be manually advanced upward or downward in single steps. In the off position, both the drum up input, and the drum down input signal lines to the single

shots are returned to -24 volts. The return path for the drum up input is from pin K of J1, through Pin 12 of P3 and J3, through terminal 10 of wafer 7B on switch S7, through terminals 10 and 2 of wafer 8B on switch S8, to the -24 volt bus. The drum down input is returned to -24 volts through a similar path, from pin X of J1. If switch S7 is momentarily turned to the up position, the drum up manual input line is disconnected from -24 volts and connected through terminal 1 of wafer 7B to resistor R8, which is returned to circuit ground through resistor R2. This causes a positive going pulse to appear at J1 pin K, which fires the drum up Single Shot. Conversely, if S7 is turned to the down position, the drum down manual input at J1 pin X is connected to R8 through terminal 9 of wafer 7A, causing the drum down Single Shot to be fired. The RC combination of R8, R2, C6 causing double firing. These components are also connected to the carriage single step circuit associated with switch S5.

#### Drum Fast Run Switch

The Drum Fast Run switch S8 is a detent 3-position wafer switch that permits the drum to be continuously stepped in either direction at the rate of 120 steps per second. When the switch is in the off position, both the drum up and drum down lines are returned to -24 volts through the circuit paths described in the preceding paragraph. If switch S8 is set to the up position, the drum up input line is disconnected from -24 volts at terminal 2 of wafer 8B and is connected to resistor R4, through terminal 3 of wafer 8B and pin 14 of J3 and P3. Resistor R4 is connected to the unfiltered output of the bridge rectifier circuit, which provides a continuous series of pulses that vary sinusoidally from -40 volts to approximately +4 volts, at the rate of 120 cycles per second. Diode CR4, capacitor C1, and resistor R1 function as a wave shaping circuit. Capacitor C1 charges through CR 4 on the negative voltage excursion, and discharges through R1 on the positive excursion. This effectively isolates the fast run signal line from line and switching transients. If switch S8 is set to the down position, the action is identical, except that the drum down input line is connected to resistor R4 through terminal 1 of wafer 8A. Resistor R4 functions as a current limiting and voltage dropping resistor. Resistor R9 performs the same function for the carriage fast run circuit associated with switch S6.

#### Pen Solenoid Manual Control Circuit

The manual control circuit for the pen solenoid is shown in the schematic diagram of Figure 3-7. The

pen UP/DOWN switch S9 is a spring-loaded 3-position wafer switch identical to the Drum Single Step and Carriage Single Step switches S5 and S7. Operation of the switch is the same as for the drum and carriage switches. For example, when switch S9 is momentarily turned to the up position, the pen up input line at J2 pin V is disconnected from -24 volts at terminal 10 of wafer 9B and is connected to ground potential at R8, through terminal 1 of wafer 9B.

#### AC Power Distribution and DC Power Supply

The 1627 incremental plotter is designed to operate from a source of 115 volt, 50/60 cycle single phase primary power. Power is applied to connector P5 (Figure 3-7) mounted on the rear of the main assembly. One side of the AC line is routed through a 2.0 amp fuse F1 and the Power On/Off switch S3 to a cooling fan B1 and power transformer T1. The other side of the AC line is connected directly to the fan and the transformer. A front panel indicator lamp DS1 is lighted whenever switch S3 is on.

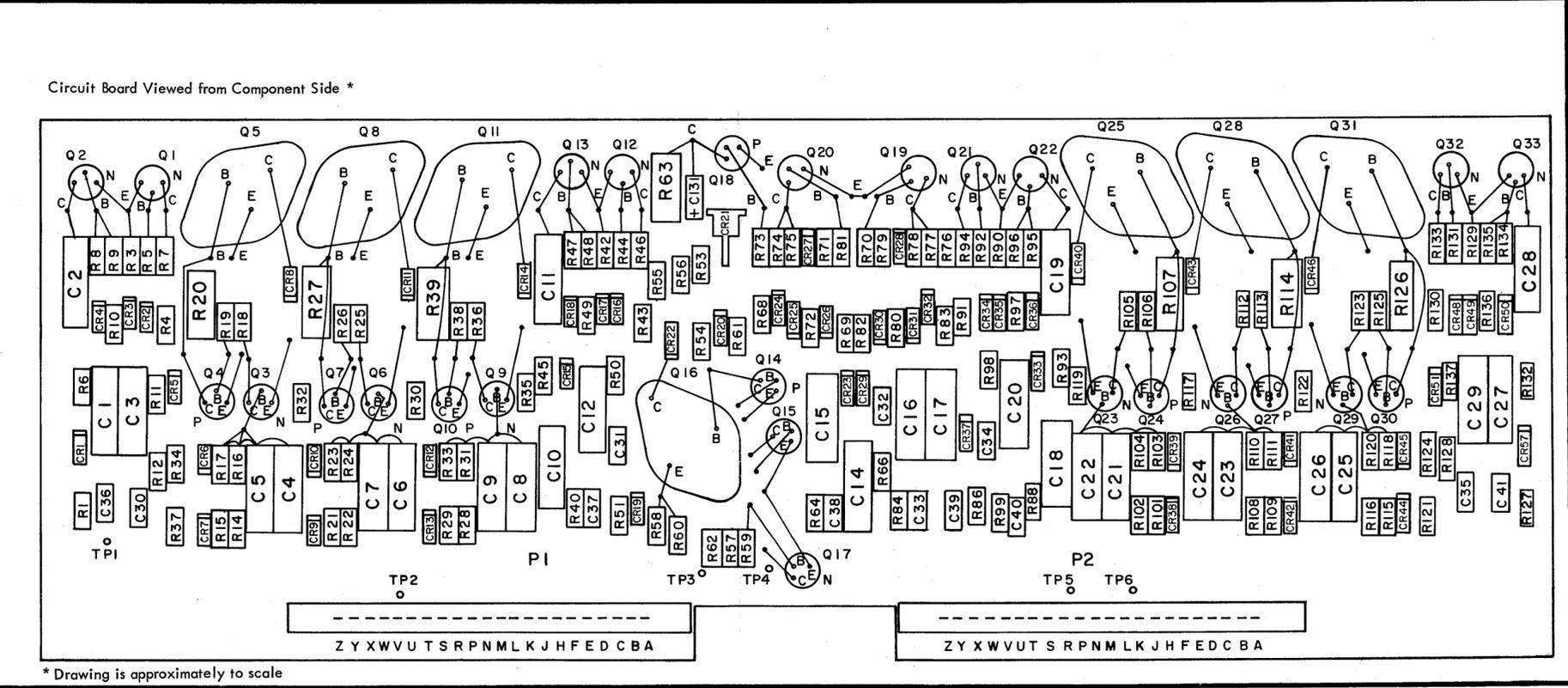
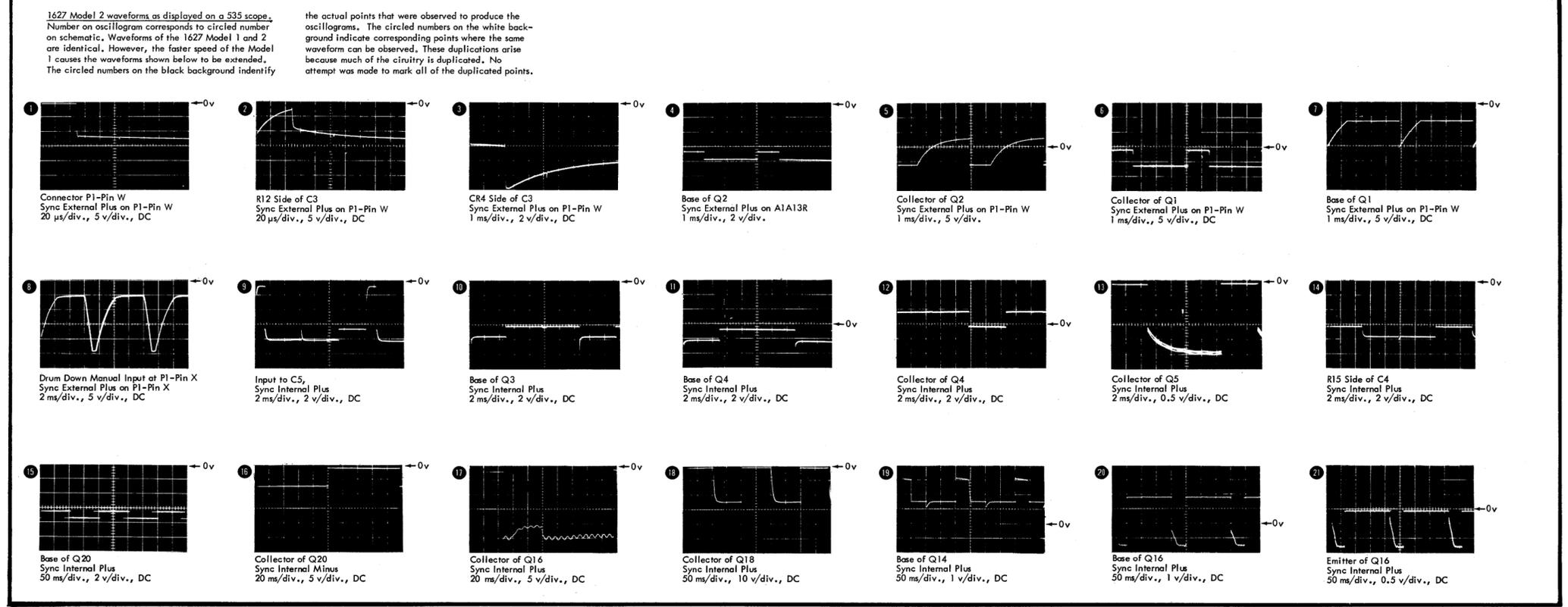
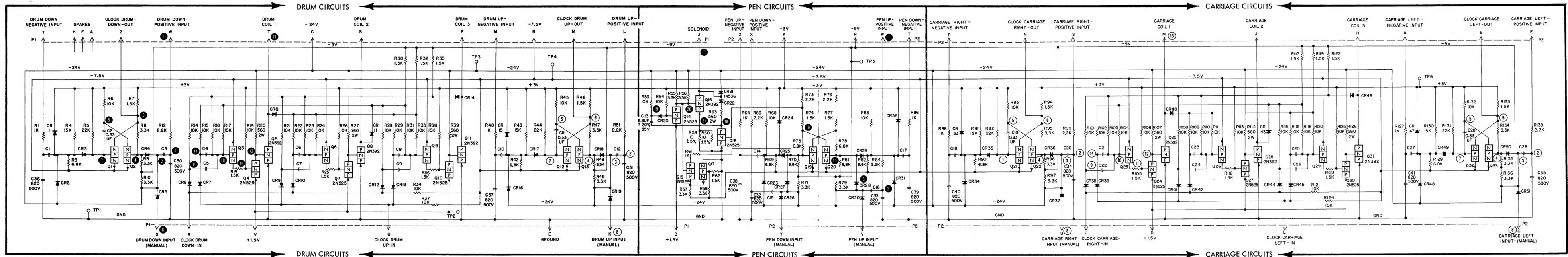
The cooling fan B1 mounted on the power supply subassembly, draws air in from the underside of the recorder and directs it over the silicon rectifiers, the step motors, and the chart motors.

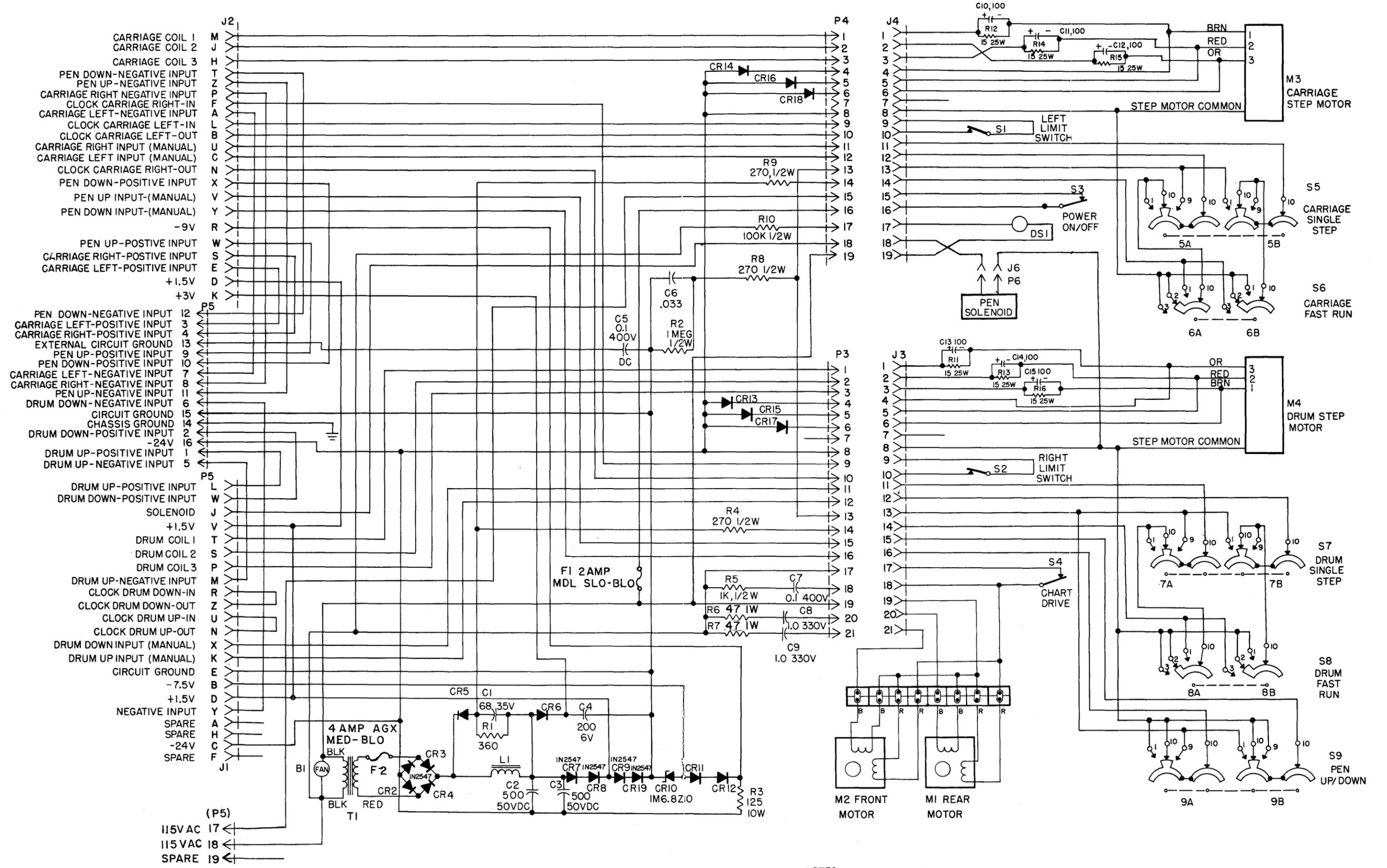
Power transformer T1 supplies alternating current to the silicon rectifiers CR1 through CR4, which are connected in a conventional bridge circuit. Fuse 2 provides an over current protection for the power supply. The bridge rectifier provides a total DC output voltage of approximately 27 volts. Circuit ground is established at .3 volts below the positive

side of the output. Filtering is provided by choke L1 and electrolytic capacitors C2 and C3. Diodes CR7, CR8, CR9, CR19, CR11, and CR12, Zener diode CR10, and resistors R3 comprise a voltage divider network across the output. DC supply voltages are obtained at +3, +1.5, -7.5 -9 and -24 volt taps on the divider network. Zener diode CR10 provides close regulation of -7.5 volt supply that is used as a bias reference in the transistor circuits associated with the various control functions.

Chart take up motors M1 and M2 are 115 volt 2-phase motors that normally operate in a stalled condition to maintain proper tension on the roll of chart paper. When Chart Drive switch S4 is on, one winding of each motor is connected directly across the AC line. The second winding of each motor is connected to the AC line through a phase-shifting network that supplies current in the correct phase relationship to produce a torque on the armature. The phase-shifting networks consist of R6 and C8 for the rear take up motor, and R7 and C9 for the front take up motor. A filter network, consisting of R5 and C7, is connected across the contacts of chart drive switch S4. The purpose of this circuit is to prevent switching transients from feeding back through the power circuits and producing a false step signal.

All input signals to the 1627 are connected to 1627 at P5 mounted on the rear of the main chassis. The -24 volt and circuit ground buses from the internal power supply are also terminated at P5 to permit their use as reference potentials in external equipment. A chassis ground is also provided at pin 14 of P5.





NOTES:  
 1. DIODE CR19 IS OUT OF SEQUENCE  
 2. UNLESS OTHERWISE SPECIFIED,  
 ALL RESISTOR VALUES ARE IN OHMS  
 CAPACITOR VALUES ARE IN MICROFARADS  
 ALL DIODES ARE IN536

Figure 3-7. Main Assembly Schematic

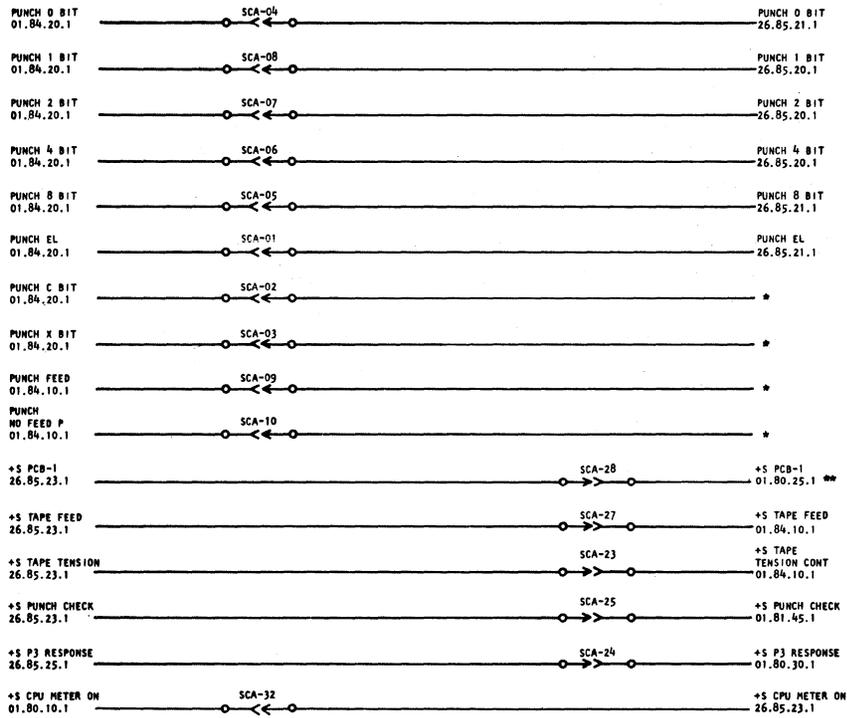
SECTION 4 INSTRUCTIONAL SYSTEM DIAGRAMS

The diagrams in this section are to be used for instructional purposes only. The 1626 circuit portion of this manual was written to describe these diagrams.

Use the system diagrams sent with the machine from the plant for machine maintenance and repair.

<u>Logic Title or Function</u>	<u>Logic Page Number</u>
CE Panel	26.85.25.1
CE Switches and Lamps	26.85.26.1
Connector and Voltage Ref	26.00.15.1

Convert 1-2-4	26.85.20.1
Convert 8-0-EL	26.85.21.1
Delay Timers	26.85.24.1
Plotter I/O Lines	02.84.50.1
Synchronizer	26.85.23.1
Timing	26.10.00.1
Translator	26.85.22.1
Unit Plugging Chart	26.00.10.1
CA-- CTRL - 'P' Type	C.00.02.0
CB-- CTRL - 'N' Type	C.00.02.0
DHE- SDTRL - Single Shot	C.00.03.0



\* UNUSED WIRES  
 \*\* PAGE NO. IS 01.80.30.1 FOR A THROUGH D SUFFIX 1620



UNIT PLUGGING CHART  
REMARKS E.C. 48934

26 A 1

1626

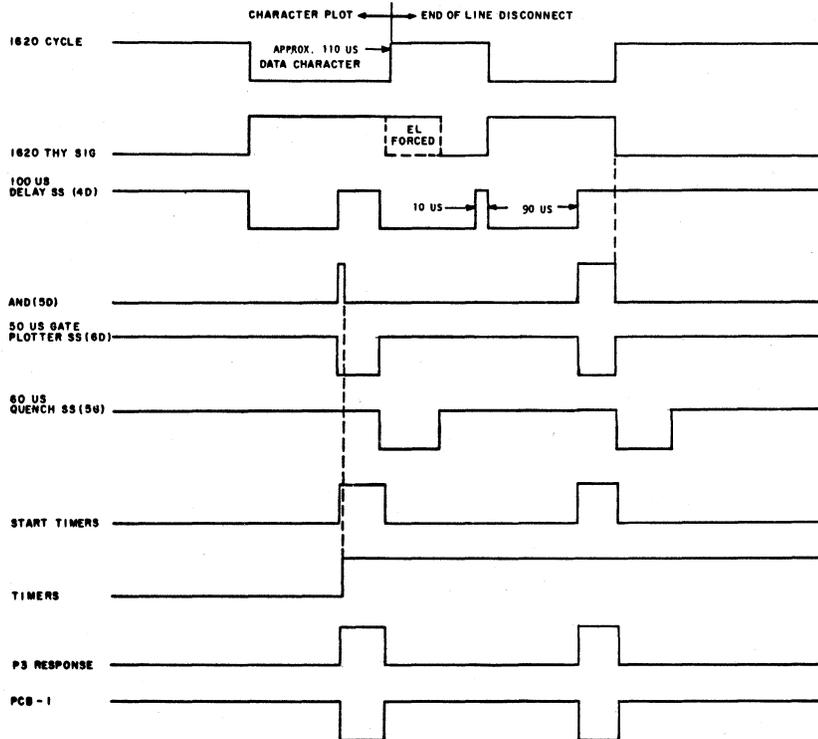
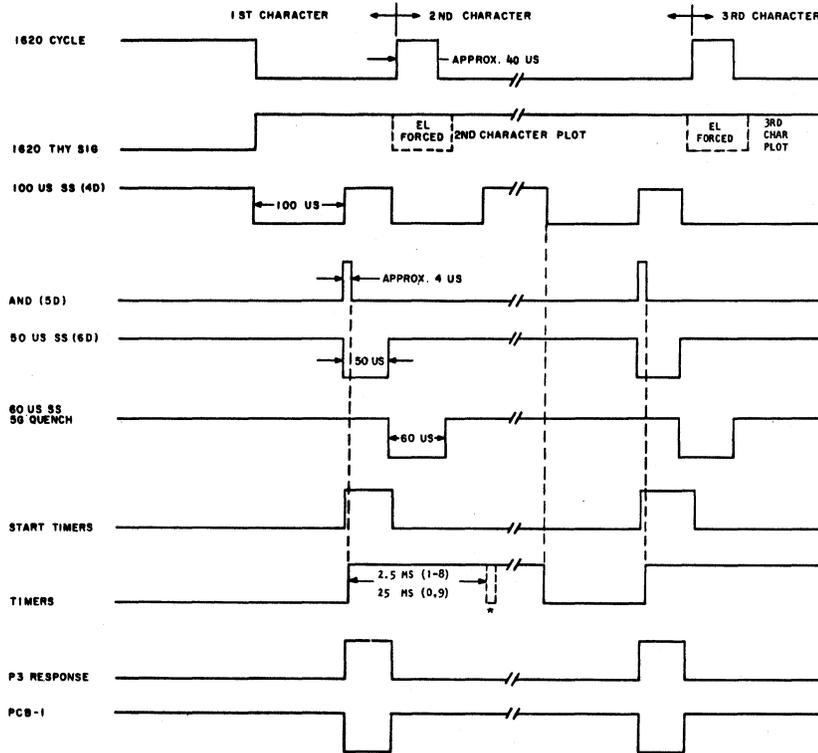
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SHEET 2 OF 2

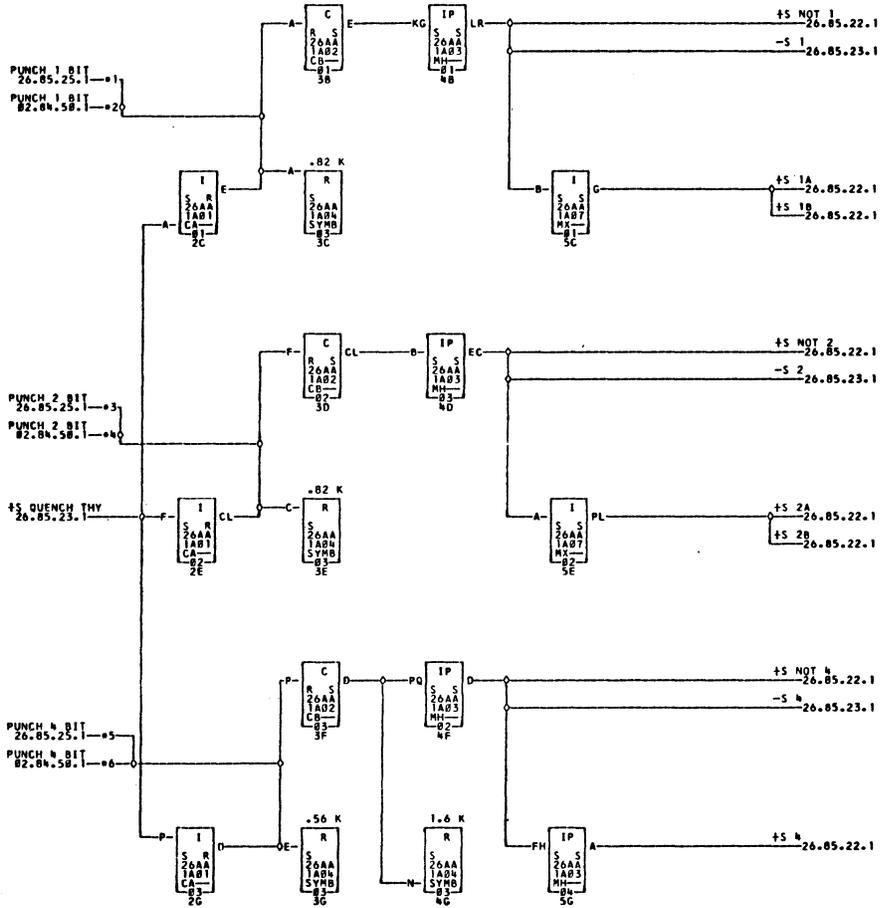
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16	MH- 371487 #3 26.05.22.1 26.05.22.1 26.05.22.1					
17	CD- 371829 #3 26.05.22.1 26.05.22.1 26.05.22.1					
18	MA- 371661 #4 26.05.22.1 26.05.22.1 26.05.22.1 26.05.22.1					
19	DHE- 8378262 #2 26.05.23.1					
20	#2 DHE- 8378262 #2 26.05.23.1					
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25	#2 DHE- 8378262 #2 26.05.24.1					
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\* VOLT, SPIKE MAY CAUSE 100 US S.S. TO FIRE (50 US S.S. WILL NOT FIRE)

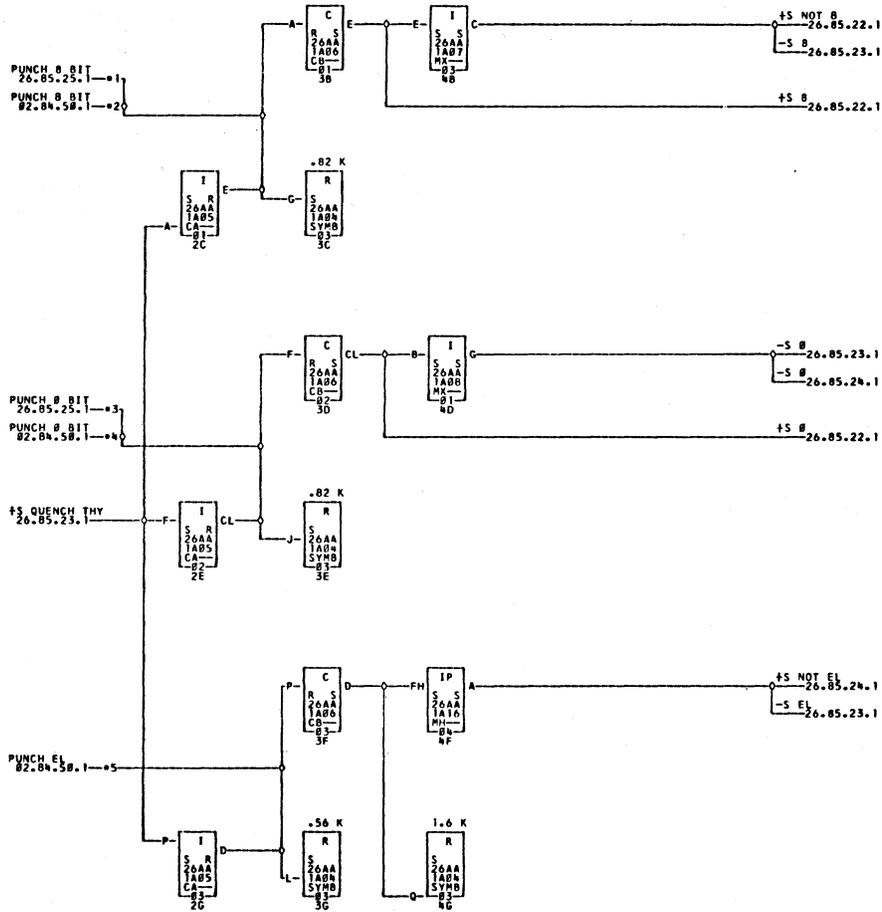


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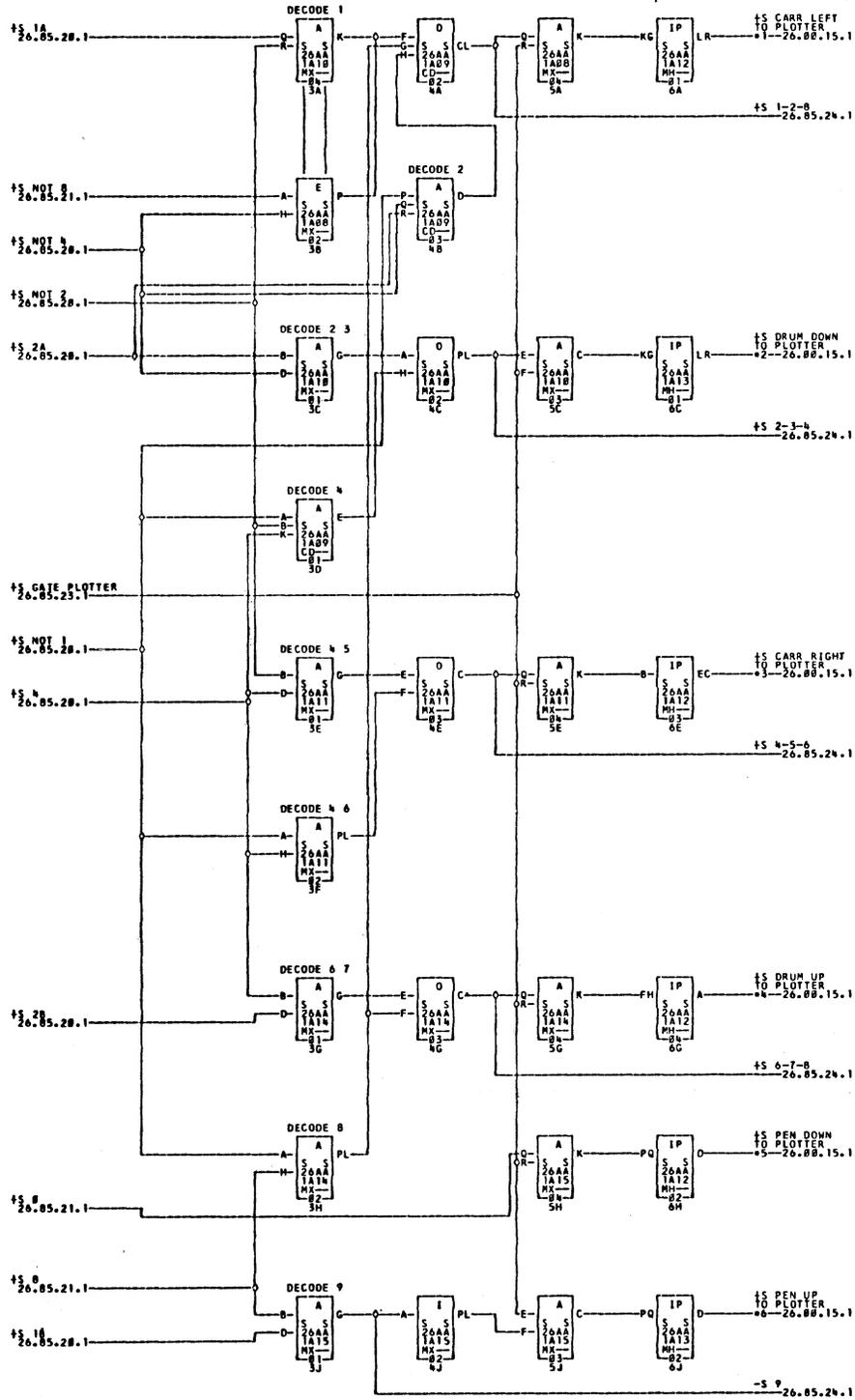
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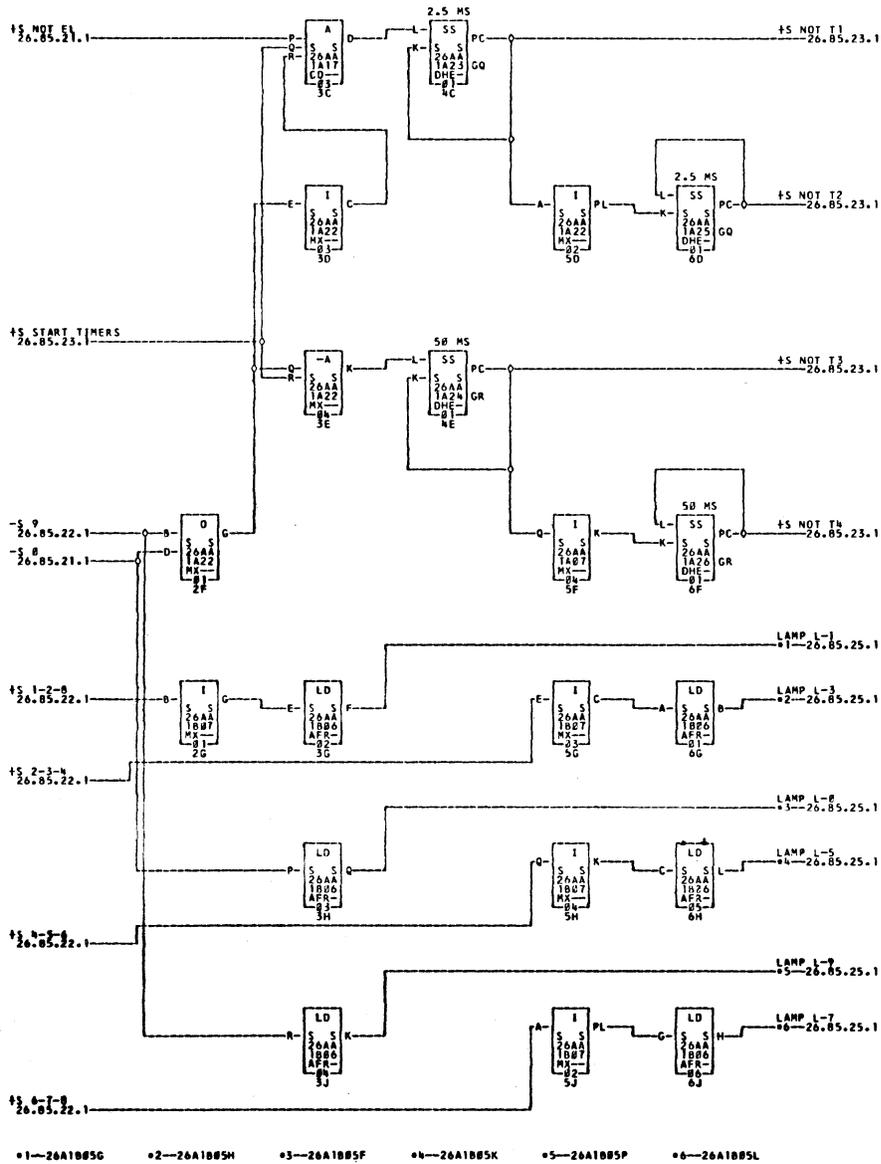


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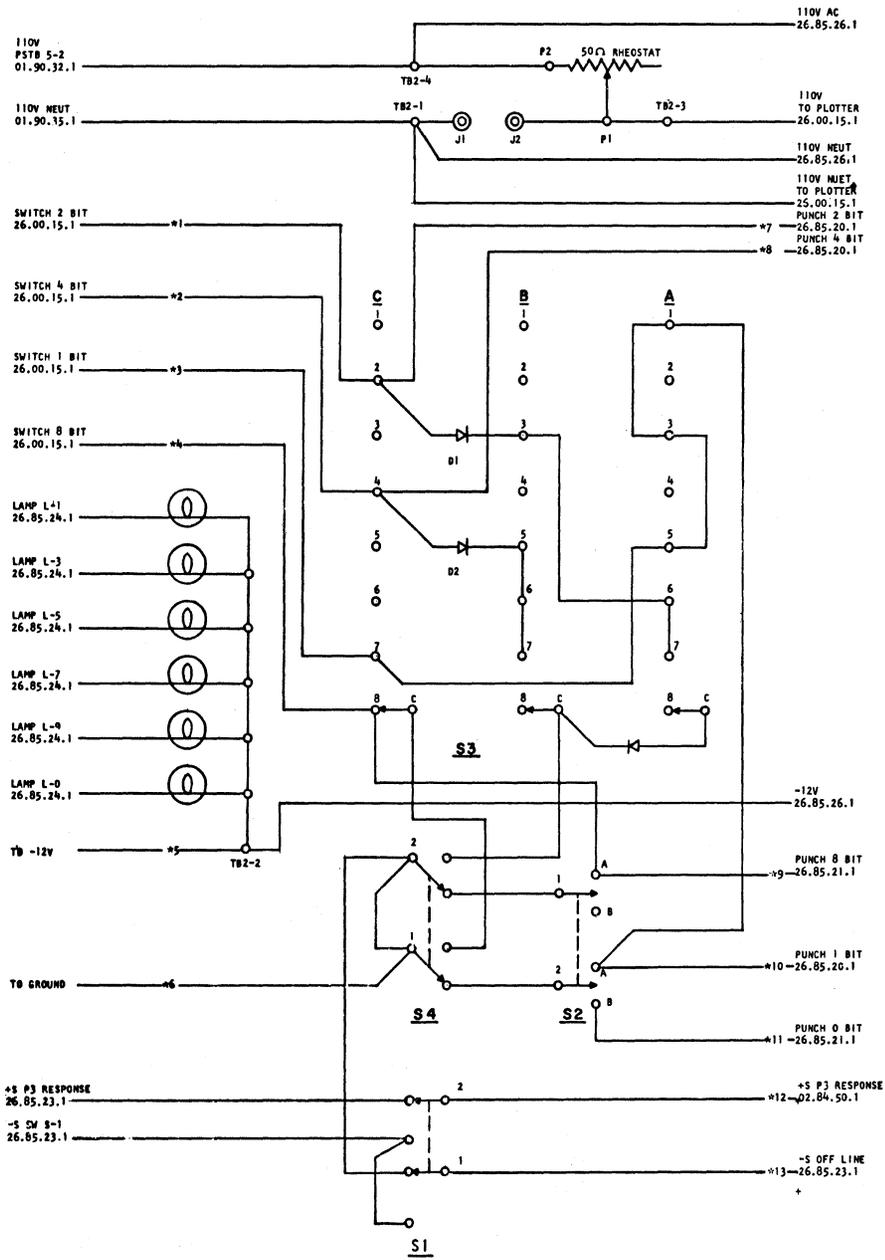
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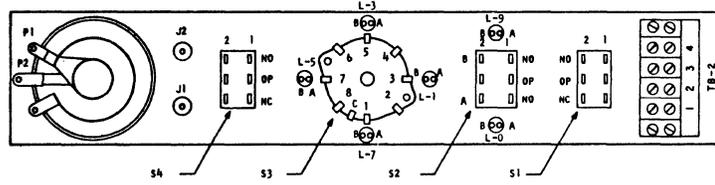
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- 5—26A1005P
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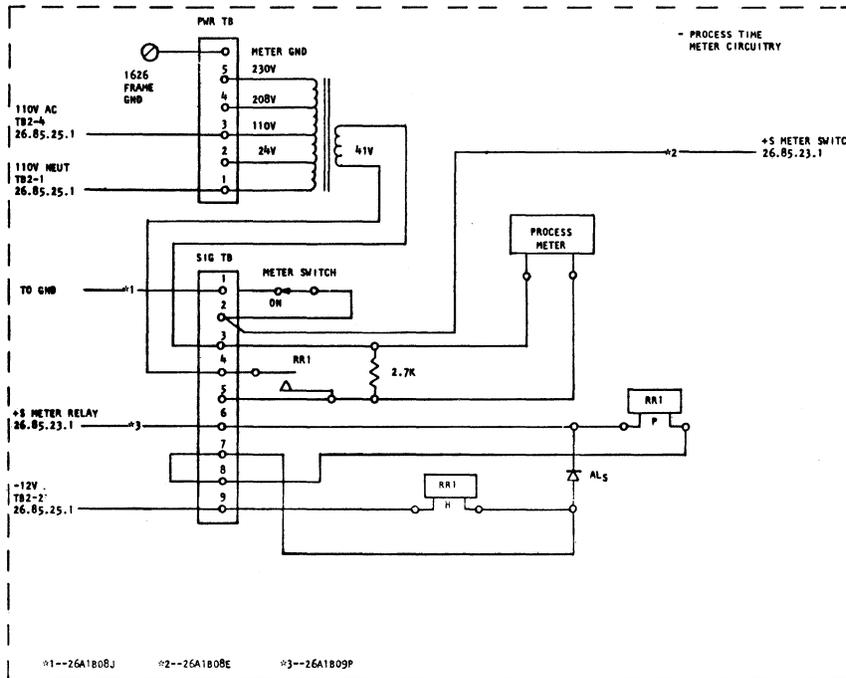
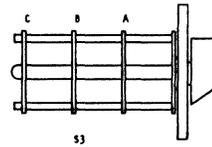
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- #11---26A1805A    #12---26A1805Q-26A1802C    #13---26A1805R

WIRING SIDE CE PANEL



SWITCH AND LAMP FUNCTIONS

NAME	FUNCTION
SWITCH S-1	ON LINE -OFF LINE
SWITCH S-2	PEN UP-PEN DOWN
SWITCH S-3	SELECT DIRECTION OF PLOTTER
SWITCH S-4	CE PLOT TO ACTIVATE PLOTTER
LAMP L-0	PEN DOWN
LAMP L-9	PEN UP
LAMP L-1	CARRIAGE LEFT
LAMP L-3	DRUM DOWN
LAMP L-5	CARRIAGE RIGHT
LAMP L-7	DRUM UP

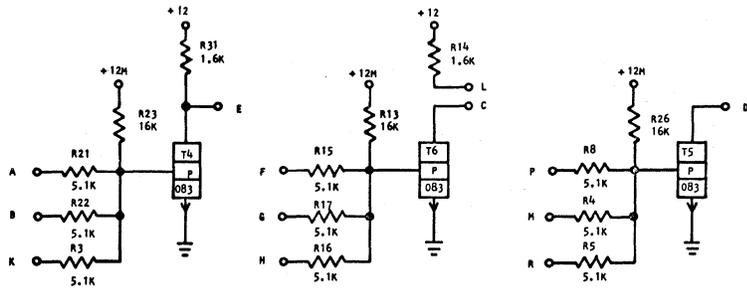


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CARD SCHEMATIC  
CTRL - "P" TYPE

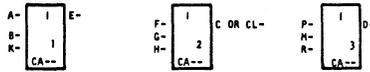
1626

C.00.02.0  
CA--



INPUT UP LEVEL -0.1V TO +0.4V  
DOWN LEVEL -5.56V TO -12.48V

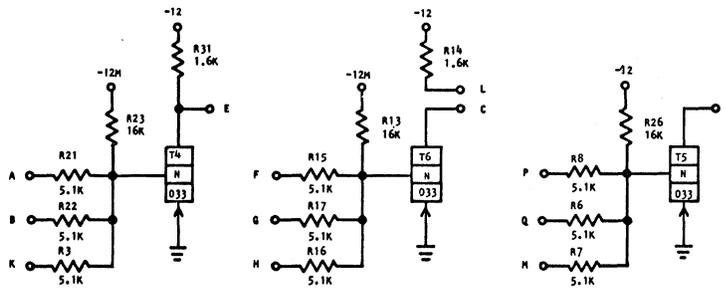
OUTPUT UP LEVEL +5.56V TO 12.48V  
DOWN LEVEL +0.1V TO +0.4V



371026 REF

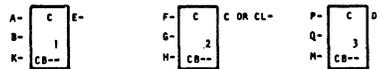
CTRL - "N" TYPE

CB--



INPUT UP LEVEL +5.56V TO +12.48V  
DOWN LEVEL +0.1V TO +0.4V

OUTPUT UP LEVEL -0.1V TO -0.4V  
DOWN LEVEL -5.56V TO -12.48V



371027 REF

Ec 404890-c 7-2-63

2162217

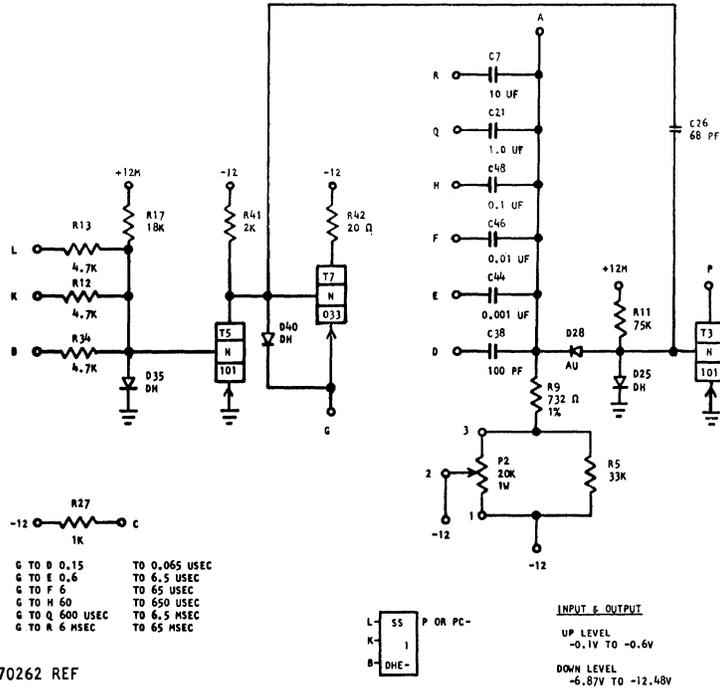
CARD SCHEMATIC

SOTRL - SINGLE SHOT  
0.15 USEC TO 65 MSEC

1626

C.00.03.0

DHE-



370262 REF

CONTENTS

- REAR OBLIQUE VIEW, COVER REMOVED, FIGURE 5-1
- FRONT OBLIQUE VIEW, COVER REMOVED, FIGURE 5-2
- REAR VIEW, PLUG-IN ASSEMBLIES REMOVED, FIGURE 5-3
- POWER SUPPLY, TOP VIEW, FIGURE 5-4
- POWER SUPPLY, BOTTOM VIEW, FIGURE 5-5

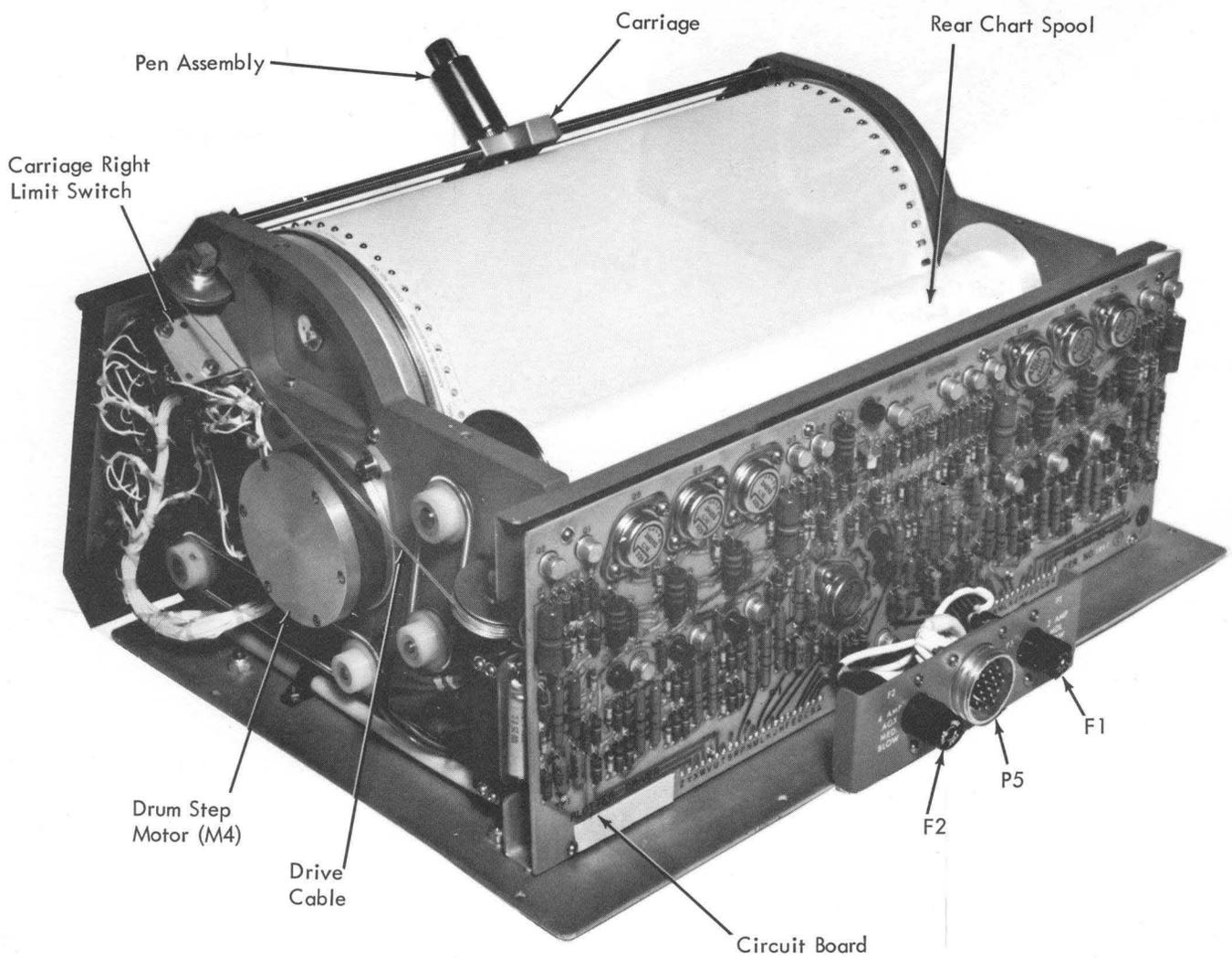


Figure 5-1, Rear Oblique View

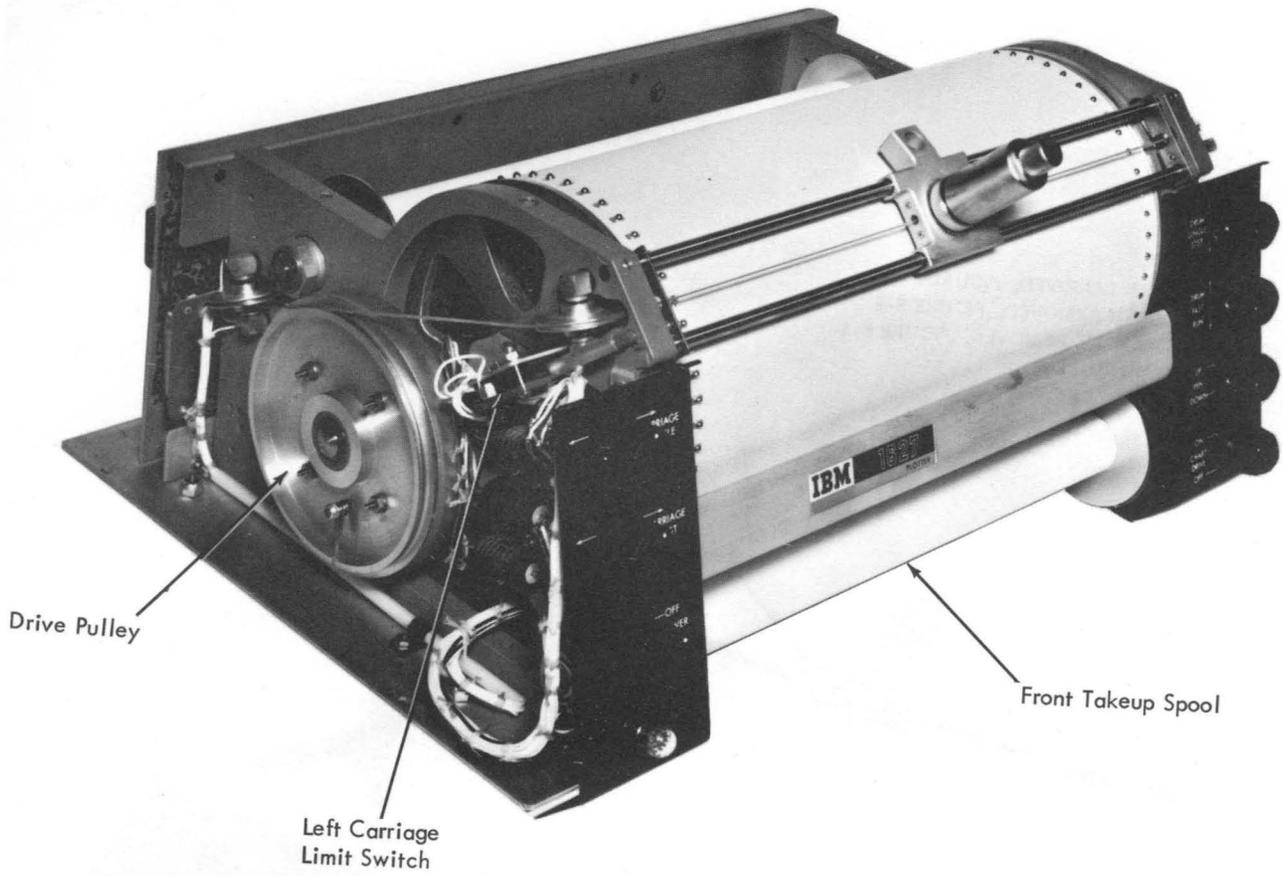


Figure 5-2. Front Oblique View

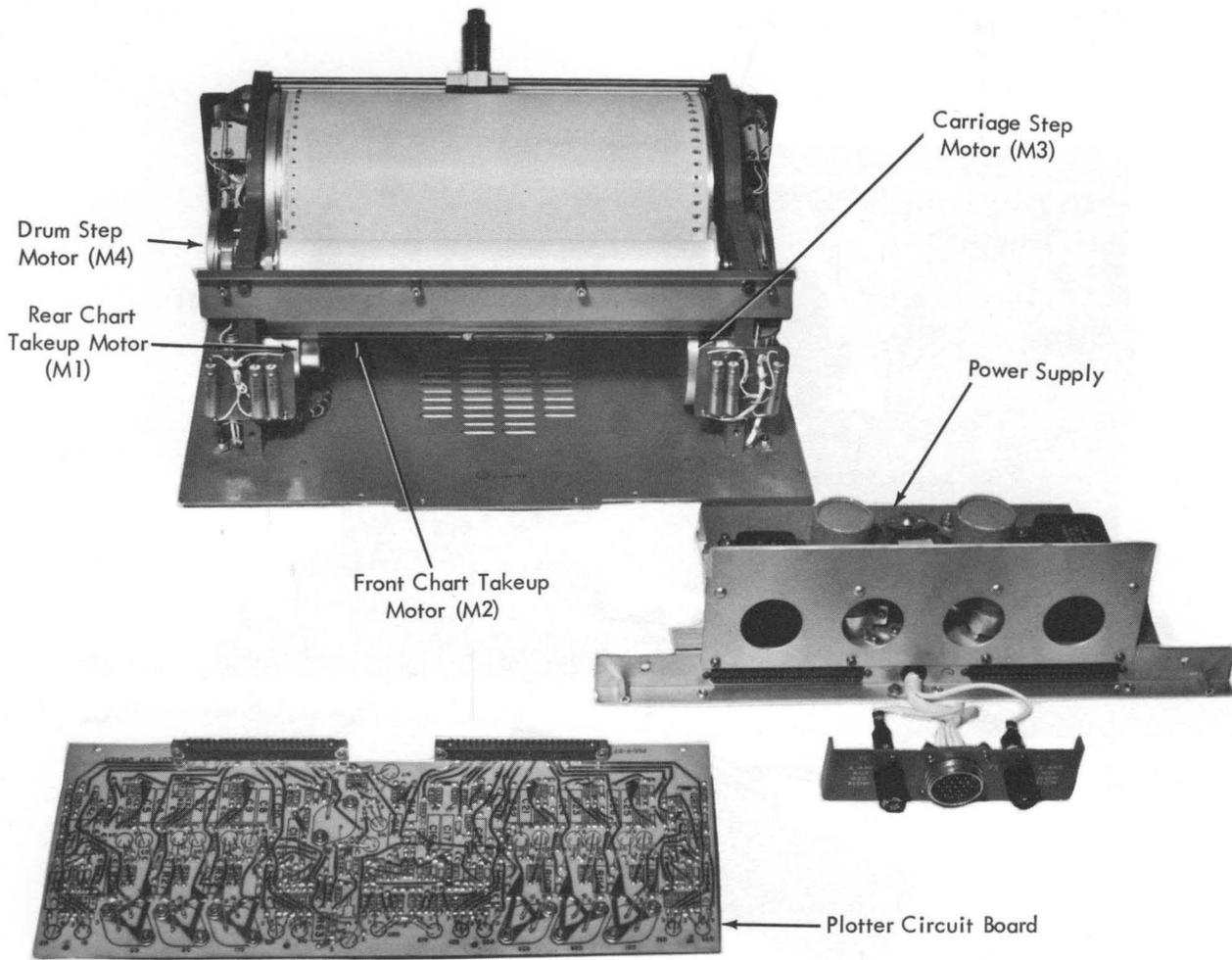


Figure 5-3. Rear View, Plug-in Assemblies Removed

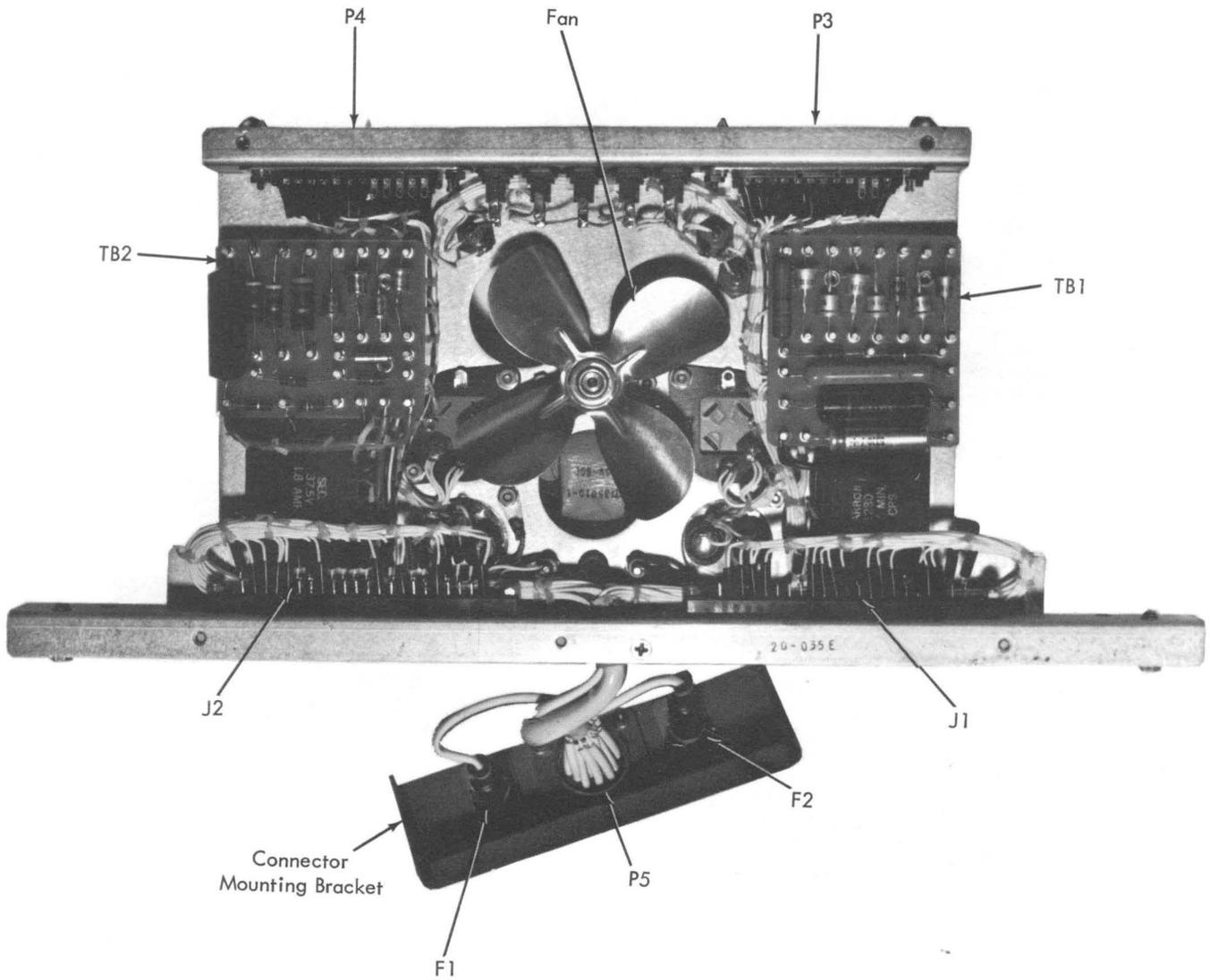


Figure 5-4. Power Supply

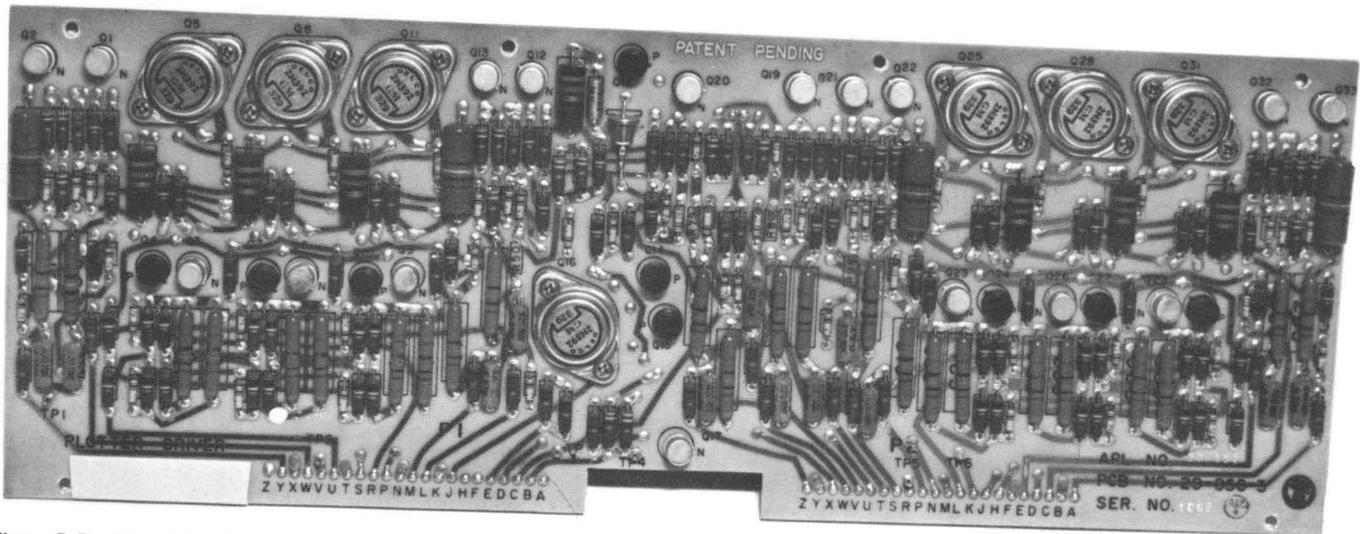


Figure 5-5. Circuit Board

SECTION 6 SPECIAL TOOLS AND SUPPLIES

SHIPPING GROUP - 1626

The following list calls out the special tools, parts, and supplies that are sent with the 1626 from the plant. Keep the tools at the installation.

<u>Item</u>	<u>P/N or Form No.</u>	<u>Qty.</u>
1627 Parts Catalog	127-0778-0	1
1626 Parts Catalog	127-0779-0	1
Instruction - Reference Manual	227-5721-0	1
DFT Manual	2161849	1
Screwdriver Kit	460258	1
Pliers	460622	1
Pliers	460966	1
Screwdriver, Adjust	461228	1
DFT Card Deck	2161850	1
Cable Assembly and Drawing (1626 to 1627)	2162206	1
Cable Assembly Power	2162207	1
Cable Assembly Signal	2162213	1

SHIPPING GROUP - 1627 MODELS 1 AND 2

A list of accessories accompanies the accessories shipped with each machine. Check the accessories against the list.

OFFICE TOOLS

The following tools are normally located in the branch office and can be obtained when needed. Consult the General CEM for the latest information on SMS tools and supplies.

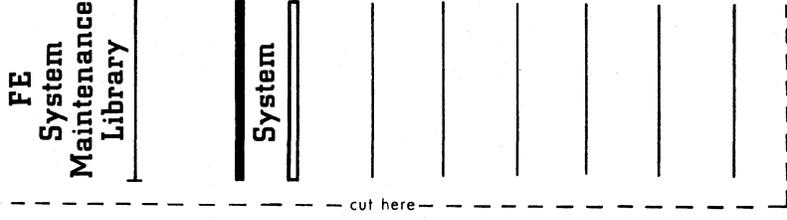
<u>Item</u>	<u>P/N</u>
Current probe	2108282
Current probe Adaptor	2108279

<u>Item</u>	<u>P/N</u>
Meter Simpson (See General CEM 57)	450497
Meter, 904 Weston, (or equivalent iron vane meter with low range voltage scale)	460880
Probe, additional attenuator (see General CEM 90)	451215
Probe, direct coaxial scope	461019
Probe, feed through termination	2108281
Probe tip	450778
Oscilloscope 310 Tektronix and accessories	450841
Probe attenuator	
Binder post adaptor	
Filter	
Instruction manual	
Viewing hood	
Test lead, black 10'	450840
Test lead, red 10'	450839

APPLICABLE CUSTOMER ENGINEERING MANUALS

The following is a list of CE manuals that contain information that can be of value in servicing the IBM 1626/1627.

Standard Modular System	Form 223-6900
Tektronix Oscilloscopes	Form 223-6725
Transistor Component Circuits	Form 223-6889
Transistor Theory Illustrated	Form 223-6794
Transistor Theory and Application	Form 223-6783



227-5721-0

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International Business Machines Corporation  
Field Engineering Division  
112 East Post Road, White Plains, N. Y. 10601