MODEL

IR-18M Multi-Speed Servo Chart Recorder

HEATHKIT®

ASSEMBLY MANUAL

HEATH COMPANY • BENTON HARBOR, MICHIGAN

HEATHKIT

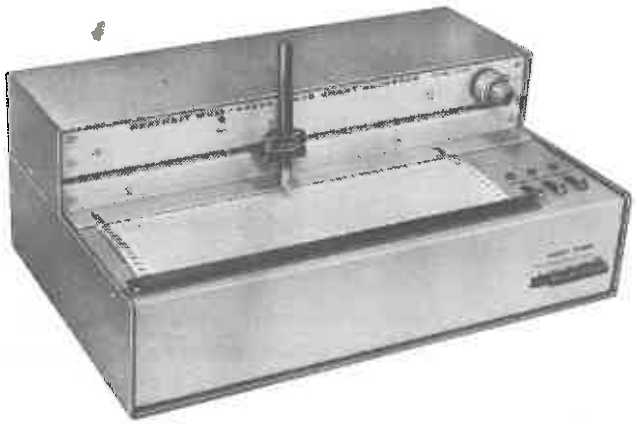
Price $2.00

595-1307-02

Assembly and Operation of the HEATHKIT

MULTI-SPEED SERVO CHART RECORDER

MODEL IR-18M



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OPERATION

The following information will help you understand how to properly use the Recorder for a wide range of applications. For any single application, the operation is quite simple. Study Figure 2 (fold-out from Page 48) to identify each switch and control to become familiar with their functions.

CHART SPEEDS

Five CHART SPEED pushbutton switches give you a choice of twelve different chart speeds. The switches marked 5, 10, and 20, are "or" pushbuttons. That is, only one button can be pushed at a time. The other two buttons marked X10 and MIN/INCH, are "and" pushbuttons. Either button may be pushed at any time, independently of the position of the other buttons.

The buttons that are pushed control the chart speed; you can determine the chart speed by "reading" the buttons. For instance, if the 10 button and the X10 button are pushed in, the chart speed is 10, X10, or 100 seconds per inch. NOTE: Both of the "and" buttons are multipliers. The MIN/INCH button can be considered a X60 button, but it is easier to consider that it changes seconds to minutes. When this button is pushed in, all speeds are read in minutes per inch instead of seconds per inch.

The following conversion chart will help you to make time base comparisons. Use the slowest speed that will give good results and conserve chart paper.

CHART SPEEDS

SEC/IN	5	10	20	50	100	200	300	600	1200	3000	6000	12000
MIN/IN	0.083	0.167	0.333	0.833	1.667	3.333	5	10	20	50	100	200
IN/MIN	12	6	3	1.2	0.6	0.3	0.2	0.1	0.05	0.02	0.01	0.005
IN/HR	720	360	180	72	36	18	12	6	3	1.2	0.6	0.3

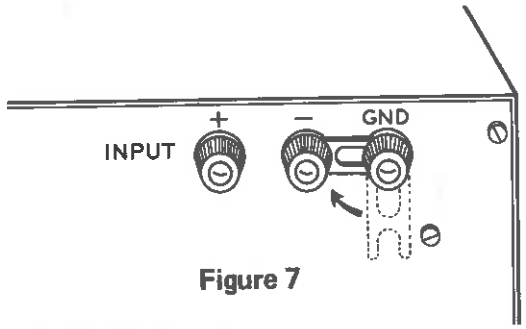


Figure 7

INPUT TERMINALS

Three terminals are available at the rear of the Recorder, as shown in Figure 7. The low or negative terminal (black) is connected with a shorting strap to the chassis terminal (green) for most operations. The chassis terminal is connected through the three-wire line cord to the power line ground.

At times, when recording or measuring from a grounded signal source, a floating input is desirable to prevent ground loop currents. A floating input can be obtained by removing the shorting strap from between the chassis terminal and the negative terminal. Then the input terminals can be operated at a maximum of plus or minus 100 Vdc with respect to the chassis terminal.

The floating input feature may also be necessary in order to reverse the direction of pen travel. A signal that causes the plus terminal (red) to go positive with respect to the minus terminal (black) will move the pen to the left. To reverse the direction of the pen travel, reverse the leads to the INPUT terminals.

RANGES

The Recorder has two input ranges: one millivolt and ten millivolt. The 10 millivolt range is adequately sensitive for most uses. Especially, when the voltage to be measured must be reduced by means of a voltage divider. The 1 millivolt range is very sensitive and should be used only when the transducer or signal source does not supply sufficient voltage to operate on the 10 millivolt range. Devices such as thermocouples, some temperature measuring bridges, and gas chromatography applications are suited for the 1 millivolt range.

Figure 8 shows the 10 millivolt jumper wire that must be cut for 10 millivolt operation or soldered together for 1 millivolt operation.

When working with such small voltages, especially on the 1 millivolt range, it is important that you make good connections to prevent "drifting pen" (recording errors). Poor connections, or connections made with dissimilar wires or metals, can cause voltages (due to a thermoelectric effect) large enough to cause the measurements being made to be invalid. The internal Recorder noise, external noise, and thermoelectric effect are more likely to cause recording errors on the 1 millivolt range than on the 10 millivolt range.

PAPER INSTALLATION

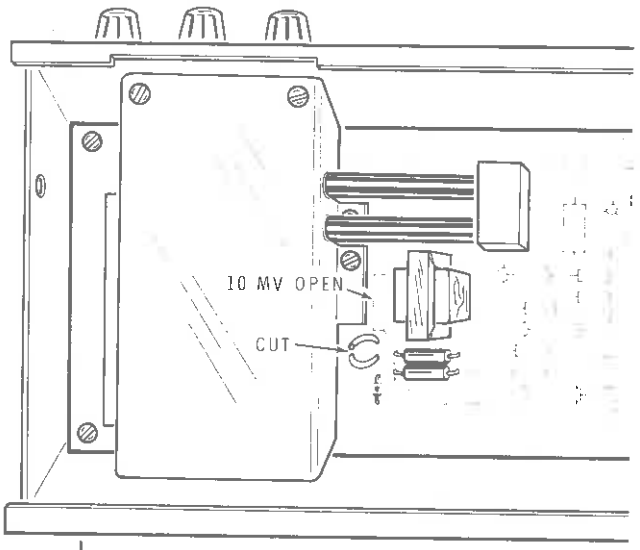
Install the roll as follows: Refer to Figure 9 (fold-out from Page 52).

1. Raise or tilt the servo chassis against the stop.
2. Remove the chart roll spindle from the recorder and place it through the center of the chart paper roll.
3. Replace the chart roll spindle in the chart roll brackets with the paper positioned so it comes off the bottom of the roll.
4. Route the paper over the sprockets and under the tear sheet, making sure the paper holes engage with the sprockets properly.
5. Lower the servo chassis.

NOTE: The paper can be positioned rapidly by lifting the servo chassis to free the paper from the sprockets and then positioning the paper by hand. A clutch is provided to allow the sprockets to be rotated for minor positioning of the paper. Also you can turn the CHART switch on and off to help align the pen with the grid lines.

PEN INSTALLATION

The universal design of the pen carriage allows it to accept most any type of pen. It also allows pens to be stored upside



OPEN JUMPER FOR 10 MILLIVOLT RANGE

Figure 8

down with the cap on, when not in use. This will keep the ink from drying on the pen point and will protect the point from damage.

The pen supplied with the Recorder is a standard fine point cartridge-type fountain pen. To install the pen, remove the cap and insert the pen point end into the carriage until the point touches the paper and the pen carriage is centered (up and down) in its operating slot.

The first time you use a new pen the ink may flow excessively from the tip (bleeding). To cure this problem, age the tip by leaving it uncapped for about a half hour. This will allow the ink in the tip to dry out. The dried ink deposited in the tip will reduce the flow of fresh ink. After the ink is dry, prime the tip by holding the pen in a vertical position and lightly tapping the tip on a piece of paper. Now, ink should flow properly.

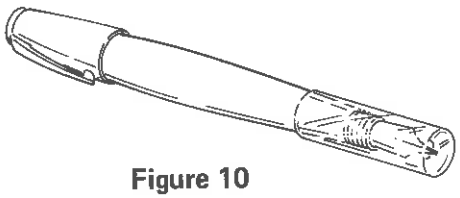


Figure 10

The pen tip may also dry out when recording with slow chart speeds for long periods of time. This can be remedied by improvising a shield which covers the pen tip area and exposes just the writing nib. See Figure 10. The shield may be made from a piece of plastic tubing, tape or even a modified pen cap. The shield keeps the air away and the tip from drying out. If it does dry out and becomes clogged, the tip can be cleaned by rinsing it out in plain water. Plain water can also be used to clean off the writing panel.

Standard cartridge-type pens make it possible to obtain multi-colored plots by merely changing the pen. Felt or porous tip pens offer additional variations of color or trace widths. The chart can be rerolled and the pen can be changed for "parallel" comparison recordings.

Ball point pens are not desirable because the extra pressure they require could overload the servo system and cause excess dead zone.

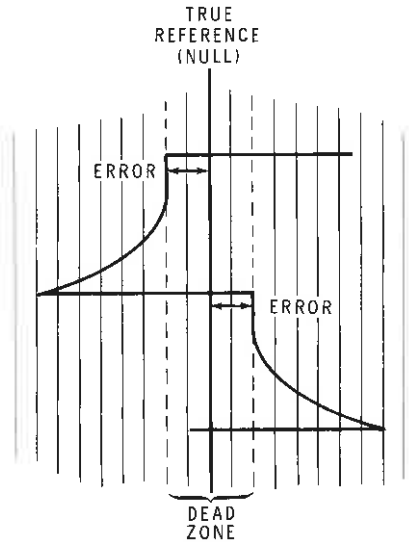


Figure 11

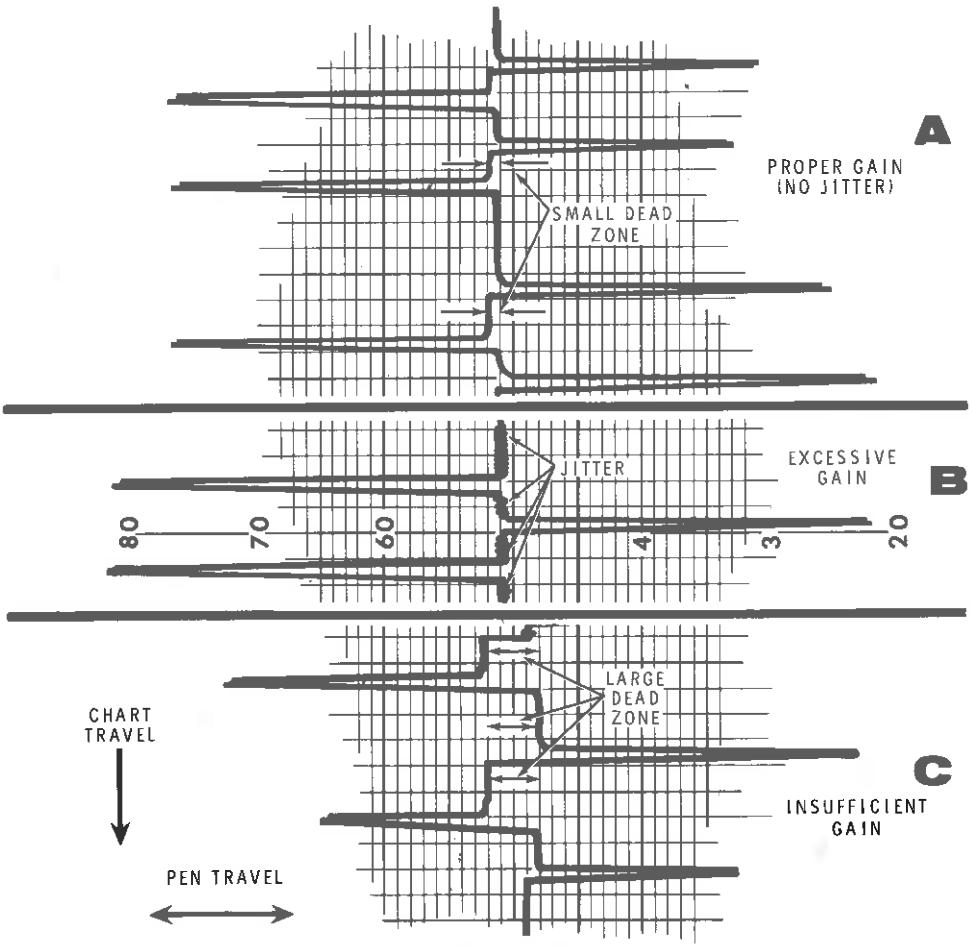


Figure 12

GAIN ADJUSTMENT

Figure 11 shows that as the pen moves toward the true reference line (null), from either the right or the left, it does not reach the true reference line. An error, the distance between the indicated reference (where the pen actually is) and the true reference line, appears in each direction. This error can be caused by low amplifier gain and/or mechanical resistance. The sum of these errors is called dead zone.

The GAIN control normally is set for your preference and is changed only as necessary to suit Recorder application variables. The GAIN control helps compensate for minor noise at the input. The pen will not jitter and the dead zone will be small when the gain is properly adjusted as shown in Part A of Figure 12. Part B shows that excessive gain causes jitter due to an over-sensitive servo. This can cause the servo motor to heat up due to overactivity (jitter). Sluggish response and a large dead zone due to insufficient gain is shown in Part C.

An example of the dead zone and one means of checking its size is given in the following steps. Refer to the "Electrical Adjustments" (on Page 65) section for the preferred method of dead zone checking.

1. Press the POWER, SERVO, and CHART switches to the on position.
2. Short the INPUT terminals.
3. Use the ZERO POSITION control and position the pen on a line near the chart center.
4. Press the SERVO switch to the off position.
5. Manually pull the pen carriage to the right a short distance and release it.
6. Press the SERVO switch to the on position.
7. Repeat steps 4, 5 and 6, except pull the pen carriage to the left.
8. Press the POWER, SERVO, and CHART switches to the off position.

If the pen did not return to the original position on the line, the resulting gap is the error. The sum of the errors is the dead zone.

TYPICAL OPERATING SEQUENCE

1. Press the Power switch to the on position and allow a few minutes for warm-up. (Allow more time if large ambient temperature changes are likely; air conditioner cycles and indoor and outdoor variations are conditions to consider. This allows the connections to stabilize, especially on the 1 millivolt range.)
2. Install the chart paper in the Recorder.
3. Position the pen properly in the pen carriage and be sure it is marking on the chart paper.
4. Press the SERVO switch to the on position.
5. Adjust the ZERO POSITION control for the desired reference point with the input shorted.
6. Select a suitable chart speed.
7. Connect the dc signal source to the INPUT terminals and check your connections. NOTE: It may be desirable to adjust the GAIN control at this time.
8. Press the CHART switch to the on position.

The Recorder is now recording the input signal.

APPLICATIONS

Since the Recorder can be used for many applications, it is obviously impossible to explain each application in detail. However, the following circuits are provided to give examples of some of the possible uses. These circuits convert various phenomena, such as line voltage variations, temperature changes, and frequency variations, to a 0-10 millivolt dc voltage. Also, each of the circuits may be premanently constructed in a small box and used as accessories for your Recorder.

Additional circuits, which might include a digital-to-anolog converter or a logarithmic-to-linear converter, are available from electronic publications and application notes of many manufacturers.

A 60 Hz filter circuit is also shown. This circuit is used to filter out unwanted 60 Hz signals from the input of the Recorder.

NOTE: Before connecting any of the following circuits to your Recorder, be sure it is operating on the 10-millivolt range. See Figure 8 on Page 53.

LINEAR RESISTANCE MEASUREMENT

The Recorder can be used to make and record linear resistance measurements. This is useful for monitoring such things as resistance versus temperature. Figures 13 and 14 show circuits that can be built to convert the Recorder into a linear ohmmeter. Either circuit can be used, depending on the type of voltage supply you have available.

If you wish to make an ohmmeter with a 10-volt supply, refer to the "10-Volt Supply" section. If you wish to use a supply other than 10 volts, refer to the "Optional Voltage Supply" section.

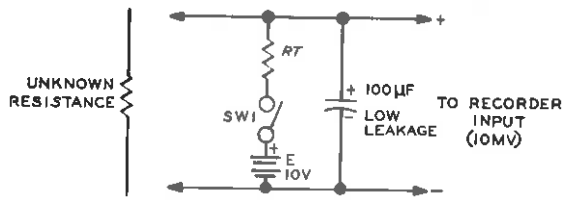


Figure 13

10-Volt Supply

To use a 10-volt supply and the circuit shown in Figure 13, proceed as follows:

1. Select the resistance range to be used and determine the range resistor value (R_t) from the formula or the following chart. The chart contains ranges that correspond to the chart paper divisions (0-100) and the corresponding range resistor values (R_t).

$$R_t = fs \times 100 \times E$$

where

fs = full scale range in ohms
E = supply voltage in volts

RANGE	RANGE RESISTOR (R_t)
0-100 Ω	100,000 Ω or 100 kΩ
0-1000 Ω	1,000,000 Ω or 1 MΩ
0-10,000 Ω	10,000,000 Ω or 10 MΩ
0-100,000 Ω	100,000,000 Ω or 100 MΩ

2. Construct the circuit shown in Figure 13.
3. Connect the unknown resistance to the circuit.
4. Connect the circuit to the INPUT terminals of the Recorder.
5. Be sure the Recorder is operating on the 10-millivolt range, and turn the Recorder on.
6. Short the leads together and adjust the ZERO POSITION controls to place the pen on the 0 line of the chart paper.
7. Close switch SW1.
8. Read the resistance value directly from the chart paper.

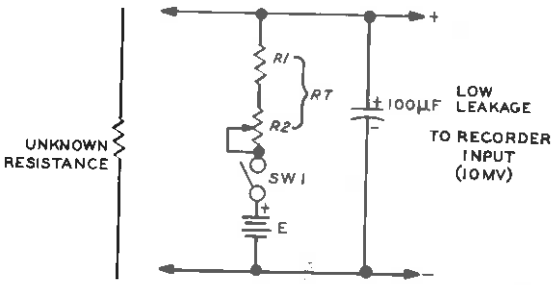


Figure 14

Optional Voltage Supply

To use a voltage source other than a 10-volt supply and the circuit shown in Figure 14, proceed as follows:

1. Select the resistance range to be used.

2. Decide the value of the source voltage.

3. Determine the value of R_t, which is the total resistance of resistor (R_1) plus control (R_2), from the following formula:

$$R_t = fs \times 100 \times E$$

where

fs = full scale range

E = supply voltage

For example, select: 0 - 10,000 Ω range, and a 9-volt battery.

Then:

$$R_t = 10{,}000 \times 100 \times 9V$$

$$R_t = 9{,}000{,}000\ \Omega \text{ or } 9\ M\Omega$$

$$R_1 = .9\ R_t = .9 \times 9\ M = 8.1\ M\Omega$$

$$R_2 = .2\ R_t = .2 \times 9\ M = 1.8\ M\Omega$$

4. Construct the circuit shown in Figure 14 using the values just determined.

5. Connect the circuit to the INPUT terminals of the Recorder.

6. Be sure the Recorder is operating on the 10-millivolt range.

7. Turn the Recorder on.

8. Short the leads together and adjust the ZERO POSITION controls to place the pen on the 0 line of the chart paper.

9. Connect a precision resistor equal to the full-scale value (10,000 Ω in the example) to the circuit.

10. Adjust control R_2 for full-scale pen movement.

11. Remove the precision resistor.

12. Place the unknown resistance in the circuit and read the resistance from the chart paper.

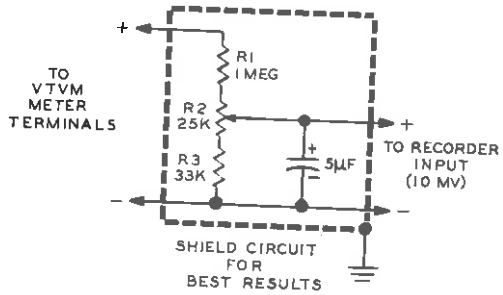


Figure 15

METER MONITOR

You can permanently record the meter indication of a VTVM using the circuit shown in Figure 15. This circuit couples a portion of the voltage applied to the meter terminals, by the VTVM circuitry, to the input of the Recorder. Thus, any function or voltage within the capability of your VTVM can be recorded. You may wish to permanently mount the circuit, shown in Figure 15, in your VTVM.

To record a meter indication, proceed as follows:

1. Construct the circuit shown in Figure 15.

2. Connect the circuit to the meter terminals and to the INPUT terminals of the Recorder.

3. Be sure your Recorder is on the 10-millivolt range.

4. Turn the Recorder on.

5. Be sure the meter pointer is at zero.

6. Position the pen at zero with the ZERO POSITION control.

7. Switch the VTVM to the ohms function and adjust the meter pointer for a full-scale meter deflection.

8. Adjust the circuit control (R2) for full-scale pen movement.

9. Set the meter to the function and range for your application.

10. Read the results from the chart paper.

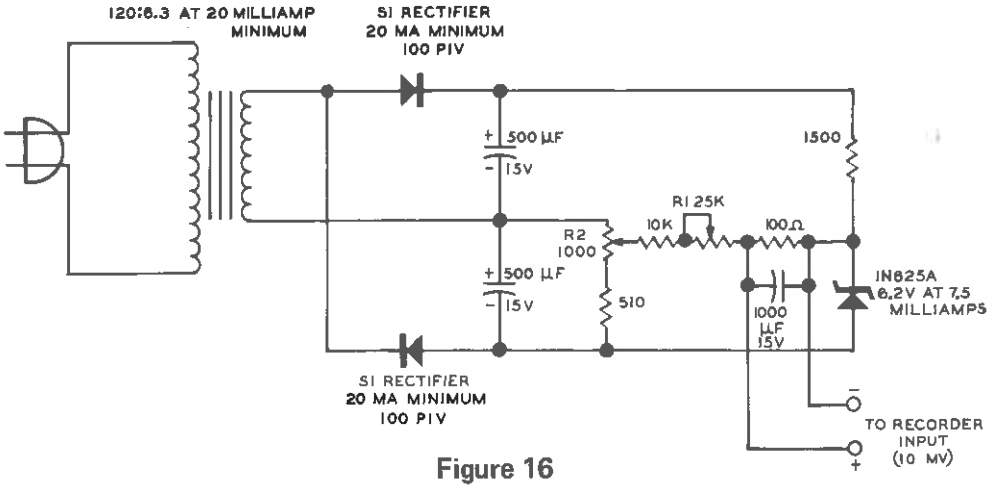


Figure 16

LINE VOLTAGE MONITOR

Line voltage variations can be monitored with the bridge circuit shown in Figure 16. You will need an ac voltage source that can be varied from 95 volts to 145 volts.

One leg of the bridge is held constant by a zener diode, which serves as a reference. Line voltage variations are compared to this standard and plotted by the Recorder. Each major division on the chart represents 5 volts ac.

To monitor the line voltage with the Recorder, proceed as follows:

1. Construct the circuit shown in Figure 16.
2. Connect the circuit to the INPUT terminals of the Recorder.
3. Be sure your Recorder is operating on the 10-millivolt range.
4. Turn the Recorder on.
5. Short the input terminals together and then place the pen on the center line (50) with the ZERO POSITION control.
6. Connect the voltage source to the circuit.

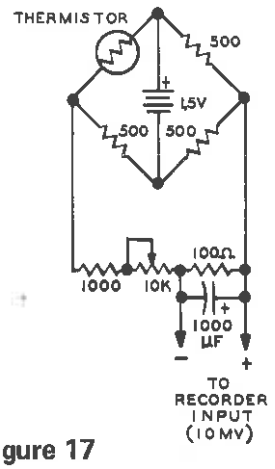


Figure 17

7. Adjust the voltage source to 120 volts.
8. Adjust R_2 to position the pen on the center line (50).
9. Adjust the voltage source to 145 volts.
10. Adjust R_1 to move the pen full scale (100) on the chart paper.
11. Remove the voltage source and connect the circuit to the line you wish to monitor.

TEMPERATURE MONITOR

The bridge circuit shown in Figure 17 is designed to convert temperature variations for the Recorder. Temperature changes vary the resistance of a thermistor in one leg of a bridge. The varying resistance is compared to a fixed resistance and recorded. Many other circuit values are practical to use.

Calibrate the circuit to a range near the temperatures to be recorded. This will minimize the non-linear thermistor effects.

To monitor temperature with the Recorder, proceed as follows:

1. Construct the circuit shown in Figure 17.
2. Connect the circuit to the Recorder.
3. Be sure the Recorder is set on the 10-millivolt range.

NOTE: Use a thermometer to calibrate the circuit in the following steps. If you do not have a thermometer, work out a temperature range from known values such as body temperature and an ice cube. Be careful not to short the thermistor leads.

4. Turn the Recorder on.
5. Adjust the ZERO POSITION control on the Recorder for the low temperature reading with the thermistor at the low temperature limit.
6. Adjust the circuit control for the high reading with the thermistor at the high temperature limit. Then repeat the previous step and this step.
7. Place the thermistor where it will be exposed to the temperatures you want to measure.

NOTE: For accurate measurements using nonlinear devices such as a thermistor, remark the chart paper to correspond to known measurements over the range to be measured.

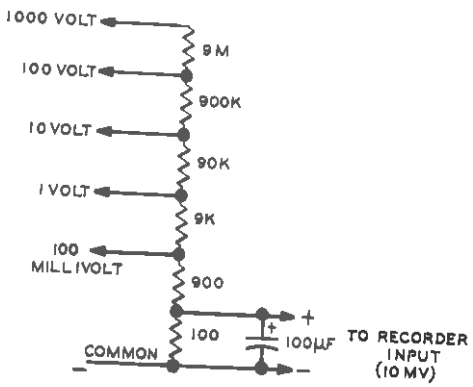


Figure 18

VOLTAGE DIVIDER

Figure 18 shows a multi-range voltage divider circuit that will scale dc voltages to the 10-millivolt Recorder input. This circuit presents only a 10 k ohm-per-volt load to the source. Build the circuit on a range switch in a box for a permanent accessory.

To build and use the voltage divider, proceed as follows:

1. Construct the circuit shown in Figure 18.
2. Be sure the Recorder is operating on the 10-millivolt range.
3. Connect the circuit to the Recorder.
4. Connect the source to the proper circuit input.
5. Turn the Recorder on and position the pen at zero with the ZERO POSITION control.
6. Turn the source on.
7. Read the voltage from the chart paper directly.

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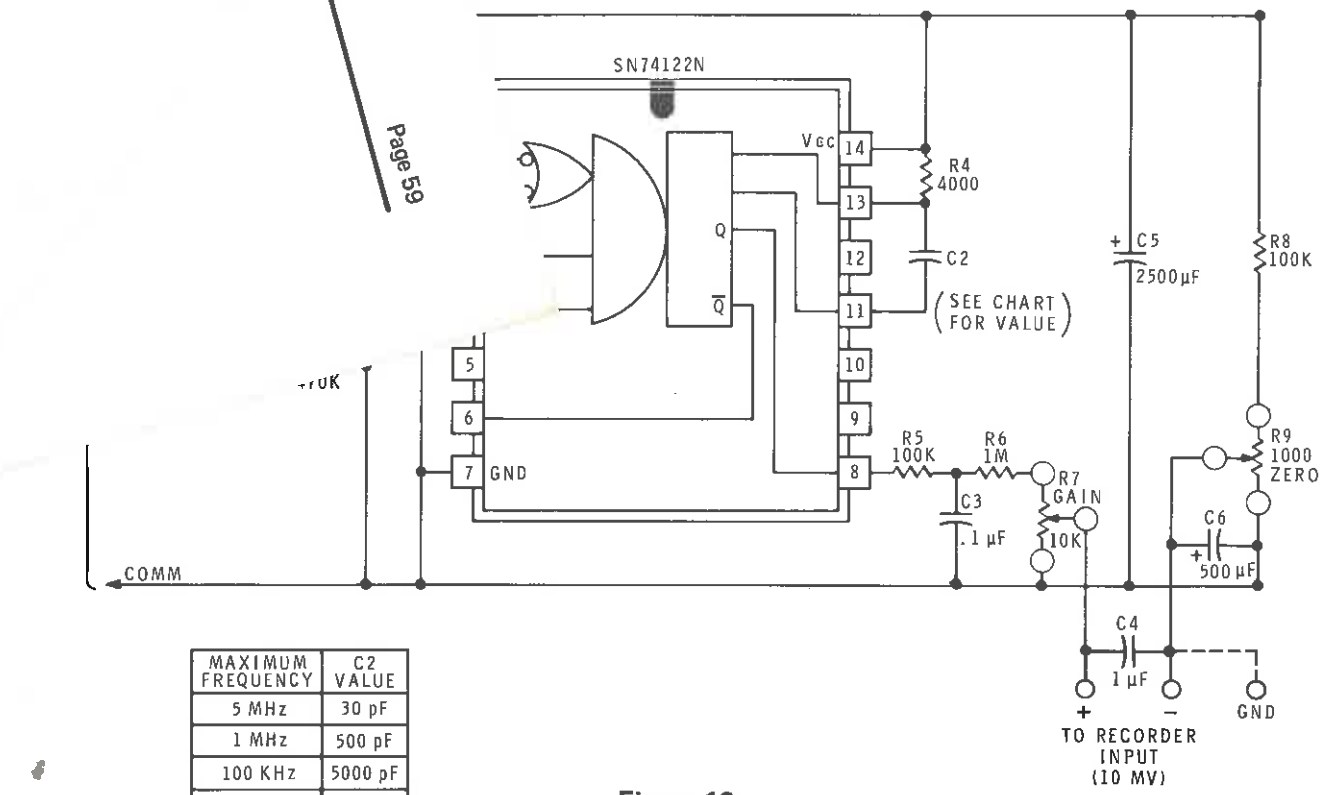


MAXIMUM FREQUENCY	C2 VALUE
5 MHz	30 pF
1 MHz	500 pF
100 KHz	5000 pF
10 KHz	.05 µF
1 KHz	.5 µF

Figure 19

FREQUENCY MONITOR

The circuit shown in Figure 19 will measure and record frequencies up to 5 MHz. Unknown frequencies are connected to the input of Q1. Q1 amplifies the input and provides low impedance drive to the integrated circuit.

The integrated circuit monostable oscillator produces an output pulse each time the input signal goes negative. The width of the output pulse is controlled by resistor R4 and capacitor C2. The value of C2 is determined by the maximum frequency of the desired range as shown in the chart.

Resistor R5 and capacitor C3 integrate the output pulse to produce direct current. This voltage is divided by R6 and R7 to the 10 millivolt Recorder range.

To monitor frequency with the Recorder, proceed as follows:

1. Construct the circuit shown in Figure 19.

2. Be sure the Recorder is on the 10-millivolt range and is calibrated.

3. Short the Recorder INPUT terminals and place the pen at zero on the chart paper with the ZERO POSITION control.

4. Remove the shorting device and connect the circuit to the Recorder INPUT terminals.

5. Apply the lowest desired frequency signal to the circuit input.

6. Adjust the circuit zero control (R9) for the low end of the range you selected. This is usually zero.

7. Connect the highest desired frequency signal to the input and adjust the circuit gain control (R7) for the high reading. This is usually full scale. Repeat steps 5, 6, and 7 three or four times.

8. Connect the signal you want to monitor to the circuit input.

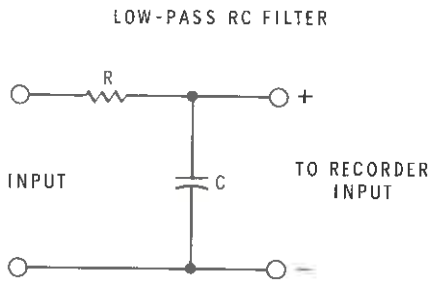


Figure 20

60 Hz FILTER

The output of some equipment will inject excessive 60 Hz noise into the Recorder INPUT terminals. This will increase the dead zone. To minimize this problem, it is necessary to use a 60 Hz rejection filter at the Recorder input.

Shown in Figures 20 and 21 are two filters which can be made from discrete components and connected directly to the INPUT terminals. The lead lengths of each component should be kept at a minimum for best results.

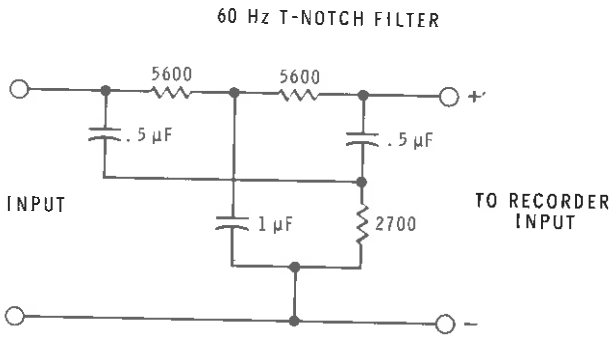


Figure 21

The component values of the low-pass RC circuit depend upon the application of the Recorder and the type of information being recorded. Although a large RC time constant will not affect the accuracy of the Recorder, it will increase the time it takes for the Recorder to reach a null.

Therefore, fast-changing signals will appear distorted when recorded. The values of the resistor and capacitor should be chosen to give sufficient amount of filtering with a minimum amount of signal distortion. The 60 Hz T-notch filter will reject a larger amount of 60 Hz noise without affecting the time required for the Recorder to reach null.

MAINTENANCE

This section of the Manual contains various checks and adjustments that will help you to keep your Recorder in top operating condition.

ROUTINE CARE

Your Recorder deserves the same care that you would give any electronic instrument. The only additional care required is to wipe the ink off the writing panel with a damp cloth. The pen carriage shaft must be kept clean and lightly lubricated with a thin film of grease.

MECHANICAL ADJUSTMENTS

Chart Drive Clutch Check and Adjustment

If it is necessary to adjust the clutch, complete the following steps.

1. Refer to the "Writing Panel Removal" section (Page 65) and remove the writing panel. WARNING: 120 volts ac is present at several points under the writing panel. Disconnect the line cord before you open the writing panel.

Refer to Figure 22 for the following steps.

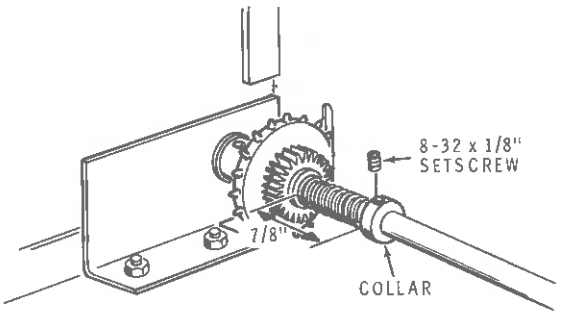


Figure 22

2. If the sprockets slip too freely, or if the chart motor failed to drive the chart, loosen the setscrew on the collar and increase the tension on the clutch spring slightly. Then retighten the setscrew.
3. Check the clutch tension again and repeat the previous step if necessary.
4. Refer to the "Writing Panel Installation" section (Page 65) and replace the writing panel.

Chart Drive Motor Adjustment

Tip up the servo chassis and rotate the drive sprockets forward and backward as shown in Figure 23. If there is no noticeable rotational play, or if the gears slip, adjust the chart drive motor in the following manner.

NOTE: Proper clearance is a point approximately halfway between the following extremes:

A. When all clearance is eliminated, binding may occur.

B. When excessive clearance between the gears exists, the gears may slip.

1. Adjust the clearance between the gear on the chart drive shaft and the gear on the chart motor as follows:

A. Refer to Figure 24 and loosen the chart motor bracket screws.

B. Slide the chart motor bracket toward the rear of the Recorder while rotating the drive sprocket to engage the gears. Note this position of the chart motor bracket.

C. Now, slide the chart motor bracket toward the front of the Recorder until the gears just disengage (slip) as the drive sprockets are rotated. Again note the position of the chart motor bracket.

D. Place the chart motor bracket halfway between the two previously noted positions. Then tighten the four chart motor bracket mounting screws.

2. Rotate the drive sprocket forward and backward. The gears must not disengage (slip), although a noticeable clearance between them must exist.

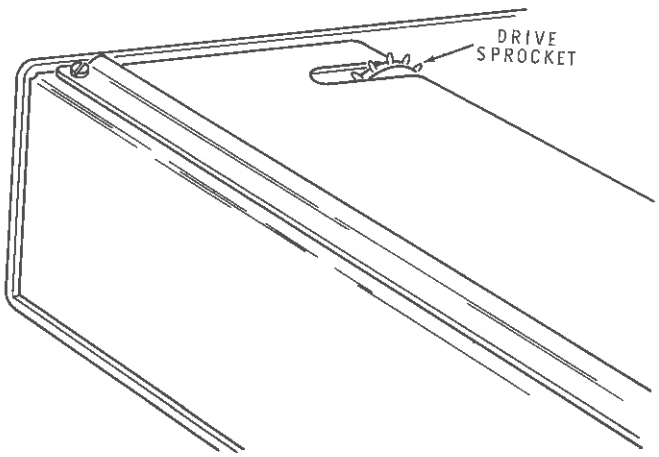


Figure 23

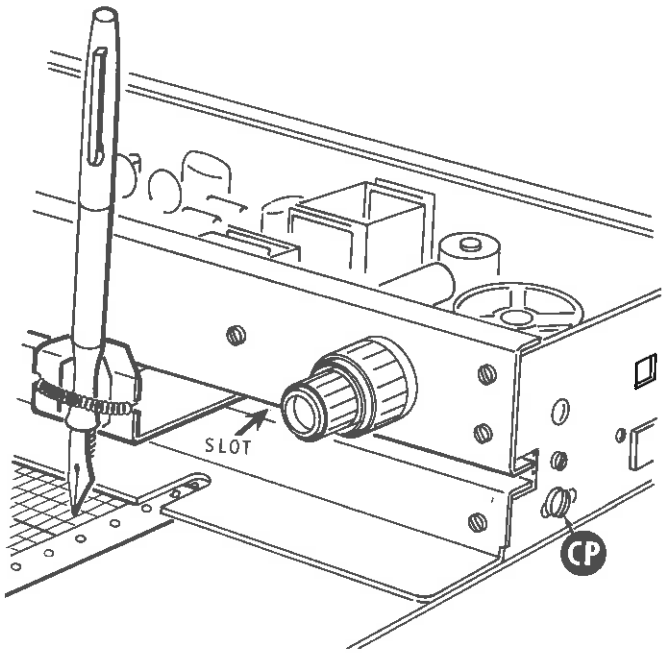


Figure 25

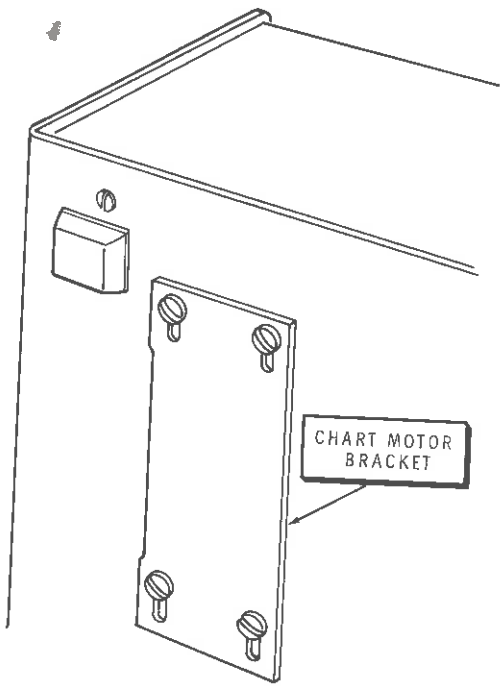


Figure 24

Pen Carriage Shaft Adjustment

Press the POWER, SERVO, and CHART switches to the on position and position the pen point on a horizontal line. Press the CHART switch to the off position. Connect a shorting wire between the input terminals. Adjust the ZERO POSITION control to move the pen from 0 to 100 on the chart paper. If the line drawn does not remain exactly on the chart line, align the pen carriage shaft in the following manner.

1. Refer to Figure 25 and loosen screw CP in the end of the pen carriage shaft.
2. Determine the distance and the direction the carriage shaft must be moved to make the pen draw a line parallel with the chart line.
3. Move the end of the pen carriage shaft the same distance in the same direction.
4. Tighten screw CP in the end of the shaft. Be careful not to move the shaft.
5. Advance the chart paper and repeat the check above to be sure the shaft is now correctly set.

Drive Cord Tension

The eyelet of the end of the drive cord should be 1/32" from the right side of the pen carriage as shown in Figure 26. Loosen screw CH and adjust the other end of the drive cord as necessary and tighten screw CH.

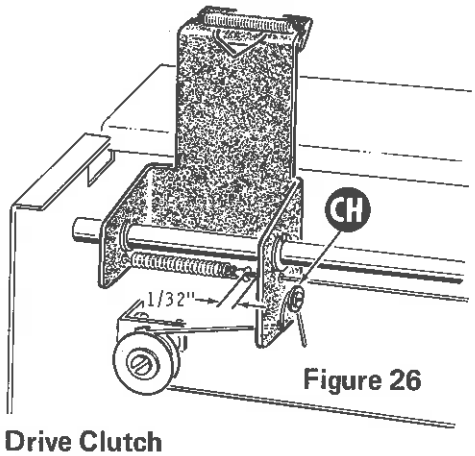


Figure 26

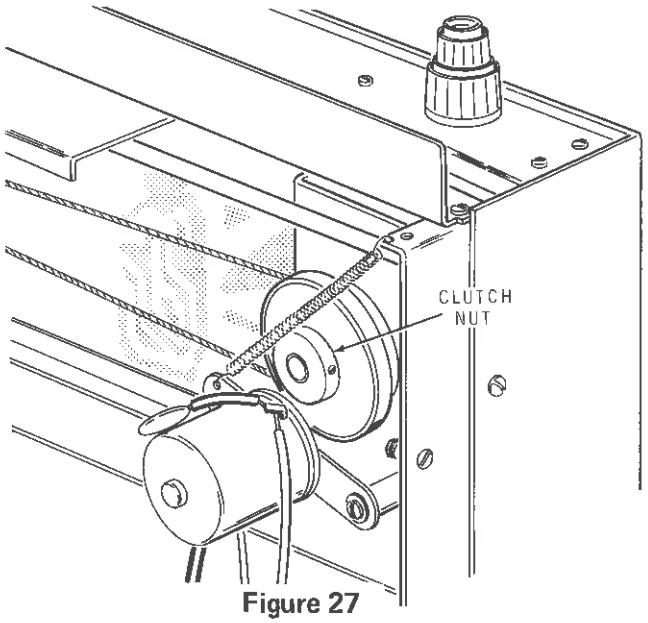


Figure 27

Pen Drive Clutch

The pen drive clutch must allow the servo motor to run when the pen carriage is held or stopped, yet it must not slip or jerk during normal operation.

If necessary, refer to Figure 27 and adjust the pen drive clutch as follows:

1. Short the INPUT terminals.

2. Center the pen with the ZERO POSITION control.

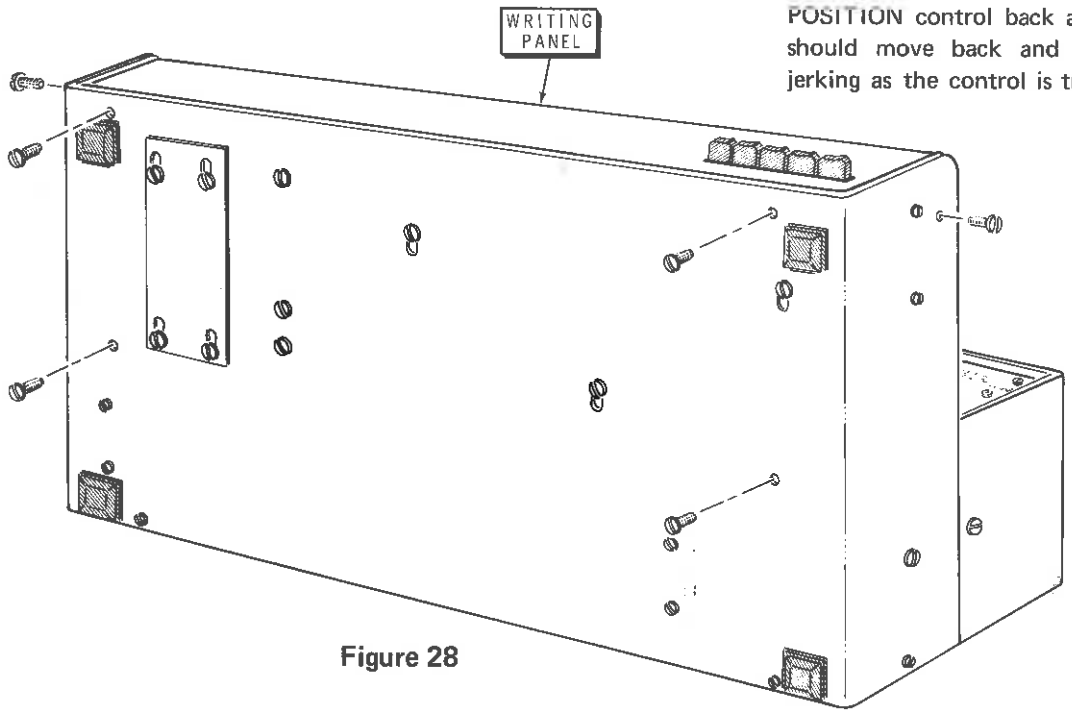


Figure 28

NOTE: The setscrew in the clutch nut should be tight enough to prevent the nut from loosening, but not too tight to prevent you from turning the nut by hand.

3. Hold the pen carriage and rotate the coarse positioning knob of the ZERO POSITION control in either direction. The servo motor should run and the pen drive clutch should slip. If the clutch does not slip, turn the clutch nut counterclockwise one-fourth turn at a time until the clutch slips. Then release the pen carriage.

4. Rotate the coarse positioning knob of the ZERO POSITION control back and forth. The pen carriage should move back and forth without slipping or jerking as the control is turned. If the clutch slips or jerks, tighten the clutch nut clockwise one-fourth turn at a time until the clutch does not slip. Then repeat the previous step and this step.

NOTE: Be sure the pen carriage shaft is clean and lightly lubricated with a thin film of grease. Also see that the motor mounting plate pivots freely and the tension spring holds the motor so its shaft is against the drive wheel.

WRITING PANEL REMOVAL

1. Press the POWER switch to the off position and unplug the line cord (disconnect all input connections).

2. Depress the five CHART SPEED buttons. The 5, 10, and 20 (OR) buttons must be pressed and released simultaneously.

3. Refer to Figure 28 and remove the six screws that hold the writing panel.

4. Place the Recorder in an upright position and tip back the servo chassis.

5. Raise the rear of the writing panel and simultaneously pull the panel forward and up.

WRITING PANEL INSTALLATION

1. Place the front lower edge of the writing panel in position.

2. Position the line cord under the circuit board edge and with the three other loose wires through the slot in the rear of the panel.

3. Align the switch slots with the switches and press the panel straight down. Turn the sprockets slightly to engage the drive gears.

4. Replace the six writing panel screws.

5. Check each switch to be sure it operates freely.

6. Release the CHART SPEED pushbuttons.

ELECTRICAL ADJUSTMENTS

Gain Control

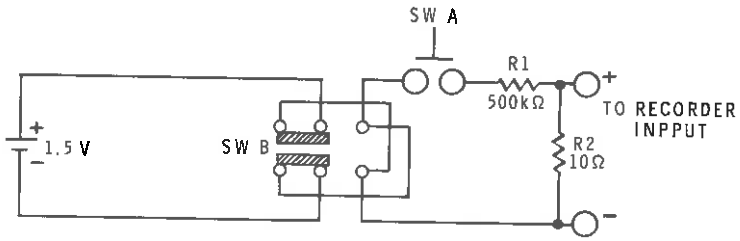
A high GAIN setting will give some jitter as evidence that the Recorder is working properly and that there is no excess dead zone. A lower GAIN setting will give a sharp clean line and some dead zone. Your personal preference will determine the exact setting, but the general area is defined as follows:

1. Turn the Recorder on and connect the source you will be using to the INPUT terminals.

2. Increase the GAIN control (clockwise) until the pen jitters.

3. Decrease the GAIN control (counterclockwise) to a point just below where the pen ceases to jitter.

NOTE: As you progress to a high GAIN setting, increased servo activity can be heard as an erratic vibration (motor noise). The servo motor may overheat if it is operated at this level. Reduce the GAIN just below the noise for the best setting.



DEAD ZONE CHECKER

Figure 29

Dead Zone Check

To properly check the amount of dead zone, construct the simple circuit shown in Figure 29 and connect it to the INPUT terminals. Then complete the following steps.

1. Apply the power and set the pen near the chart center.

2. Press the switch A on for several seconds and release the switch.

3. Repeat step 2 several times, move switch B and repeat step 2 several more times.

4. The sum of the error on each side of the true reference line is the dead zone.

ZENER CURRENT ADJUSTMENT

The ZENER CURRENT control adjusts the zener current level for maximum temperature stability. For greatest accuracy, an accurate milliammeter with less than twenty ohms internal resistance is required. The following steps explain how to make the zener current adjustment using a milliammeter. However, if you do not have a milliammeter, or if extreme accuracy is not necessary, position the ZENER CURRENT control to the center of its rotation.

Refer to Figure 30 for the following steps.

1. Cut the zener current jumper wire.
2. Connect a milliammeter in series with the jumper.
3. Adjust the ZENER CURRENT control for a 10 milliampere meter indication. NOTE: Allow 1% for every 5 ohms of meter resistance. For example, if your meter has a resistance of 16 ohms, allow .3 milliamperes for the meter and set the control to give a meter reading of 9.7 milliamperes.
4. Disconnect the milliammeter and solder the ends of the jumper wire together.

CALIBRATION

The CAL control adjusts the full-scale sensitivity of the Recorder. An accurate 1-millivolt (or 10-millivolt) source is required to make this adjustment. If you do not have an accurate source, position the CAL control in the center of its range. If you do have an accurate source, complete the following steps to calibrate the Recorder.

1. Turn the Recorder on and short the INPUT terminals.
2. Adjust the GAIN control for proper operation.
3. Use the SERVO POSITION control and position the pen on the chart zero line.
4. Remove the input short and connect a 1-millivolt source to the INPUT terminals.
5. Adjust the CAL control for full-scale pen travel.
6. Remove the 1-millivolt source and short the INPUT terminals.

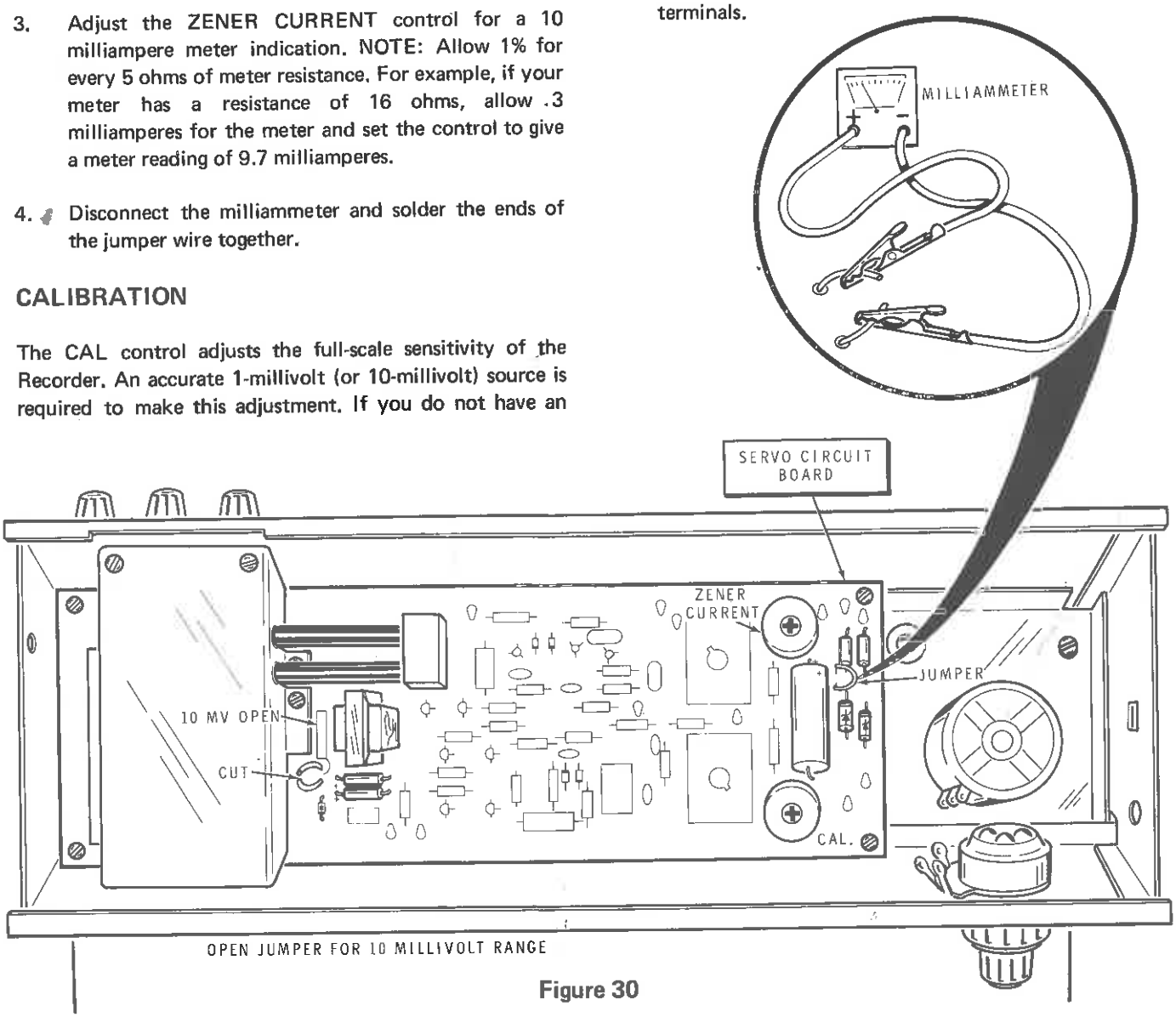


Figure 30

7. Check the pen position and place it on the zero line with the ZERO POSITION control if necessary.

8. Repeat steps 3 and 4 above and check the zero position again.

NOTE: If the zener current has been finely adjusted, repeat both the "Zener Current" and "Calibration" steps again.

IN CASE OF DIFFICULTY

Begin your search for any trouble that occurs after assembly by carefully following the steps listed in the "Visual Tests" section. After visual tests are completed, refer to the "Troubleshooting Chart."

NOTE: Refer to the "Circuit Board X-Ray Views" on Page 79 for the physical location of parts on the circuit board.

VISUAL TEST

1. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the kit builder.

2. About 90% of the kits that are returned to the Heath Company for repair do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections in the "Soldering" section of the "Kit Builders Guide."

3. Check to be sure that all transistors are in their proper locations. Make sure each lead is connected to the proper point.

4. Check that each of the IC pins are properly installed in their connectors, and not bent out or under the IC. Also be sure the IC's are installed in their correct positions.

5. Check the values of the parts. Be sure in each step that the proper part has been wired into the circuit, as shown in the Pictorial diagrams. It would be easy, for example, to install a 220 Ω (red-red-brown) resistor where a 2200 Ω (red-red-red) resistor should have been installed.

6. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring.

7. A review of the Circuit Description may also help you determine where the trouble is.

If the trouble is still not located after the "Visual Tests" are completed and a voltmeter is available, check voltage readings against those shown on the Schematic Diagram (fold-out from Page 77). Read the "Precautions for Troubleshooting" before making any measurements. NOTE: All voltage readings were taken with a high impedance voltmeter. Voltages may vary as much as ±20%.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the "Service" section and Warranty of the "Kit Builders Guide" and to the "Factory Repair Service" information on Page 69 of this Manual.

PRECAUTIONS FOR TROUBLESHOOTING

1. Be cautious when testing IC and transistor circuits. Although they have almost unlimited life when used properly, they are much more vulnerable to damage from excessive voltage or current than tubes.

2. Be sure you do not short any terminals to ground when making voltage measurements. If the probe should slip, for example, and short out a bias or supply point, it will very likely damage one or more IC's, transistors, or diodes.

Troubleshooting Chart

The chart lists the symptom, possible cause, and remedy of the malfunction. If a particular part or parts are mentioned (transistor Q206 for example, or resistor R105 as a possible cause, check these parts to see if they are incorrectly installed or wired incorectly. Also check to see if an improper part was installed at that location. It is also possible, on rare occasions, for a part to be faulty.

NOTE: Many integrated circuits have identical devices used in the Recorder. A faulty IC can be discovered by interchanging it with a good one.

SYMPTOM	POSSIBLE CAUSE	REMEDY
Pen will not jitter when the GAIN control is turned full clockwise.	1. Low amplifier gain.	1. Check servo amplifier circuit.
Nonuniform pen speed through full range of travel.	1. Pen carriage binding on shaft. 2. Drive cord tension insufficient or too great. 3. Bind in mechanical system. 4. Clutch slipping.	1. Clean shaft. 2. Adjust tension. 3. Eliminate bind by cleaning, adjusting. 4. Adjust clutch.
Servo mechanism inoperative (only one neon modulator lamp lights).	1. Flip-flop circuit (Q202 and Q203) defective if same lamp always lights when power is turned off and then on. 2. Unijunction oscillator circuit (Q201) is defective if either lamp lights when power is turned off and then on.	1. Check flip-flop circuits. 2. Check unijunction oscillator circuit.
Poor sensitivity, large dead zone.	1. Low amplifier gain. 2. Stray ac pickup or excessive 60 Hz in signal source. 3. Drive cord tension excessive. 4. Bind in mechanical system. 5. Excessive source resistance. 6. Servo motor defective.	1. Adjust Gain control properly. 2. Check for improper grounding. AC on input terminals. Eliminate 60 Hz noise in signal source. 3. Adjust the tension. Refer to Page 64 for information. 4. Eliminate bind by cleaning, adjusting, and lubricating. 5. Be sure source resistance is less than 100 kΩ. 6. Replace motor.
Calibration drifts, instrument will not calibrate.	1. Defective reference supply.	1. Check zener diodes and precision resistors.

SYMPTOM	POSSIBLE CAUSE	REMEDY
Pen moves to extreme position of pen travel and stays there.	1. Open circuit in input system. 2. Modulator malfunction. 3. Connection to motor reversed.	1. Check external connections. 2. Check modulator circuit. 3. Reverse connections.
Servo motor gets hot.	1. Excessive gain. 2. Excessive noise (ac signal) at input.	1. Reduce gain control setting. 2. Eliminate noise signal. Use input filter (Page 61).
Pen drifts.	1. Poor connections between signal source and Recorder. 2. Temperature of internal or external connections varying.	1. Tighten connections 2. Use 10 millivolt range or stabilize temperature.

FACTORY REPAIR SERVICE

You can return your completed kit to the Heath Company Service Department to have it repaired for a minimum service fee. (Kits that have been modified will not be accepted for repair.) Or, if you wish, you can deliver your kit to a nearby Heathkit Electronic Center. These centers are listed in your Heathkit catalog. NOTE: Do not include chart paper, chart shaft, or pen when returning equipment for service.

To be eligible for replacement parts under the terms of the warranty, equipment returned for factory repair service, or delivered to a Heathkit Electronic Center, must be accompanied by the invoice or the sales slip, or a copy of either. If you send the original invoice or sales slip, it will be returned to you.

If it is not convenient to deliver your kit to a Heathkit Electronic Center, please ship it to the factory at Benton Harbor, Michigan and observe the following shipping instructions:

Prepare a letter in duplicate, containing the following information:

- Your name and return address.
- Date of purchase.
- A brief description of the difficulty.
- The invoice or sales slip, or a copy of either.
- Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the warranty.

Attach the envelope containing one copy of this letter directly to the unit before packaging, so that we do not overlook this important information. Send the second copy of the letter by separate mail to Heath Company, Attention: Service Department, Benton Harbor, Michigan 49022.

Check the equipment to see that all parts and screws are in place. Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least THREE INCHES of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton. Seal the carton with gummed paper tape, and tie it with a strong cord. Ship it by prepaid express, United Parcel Service, or insured parcel post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022