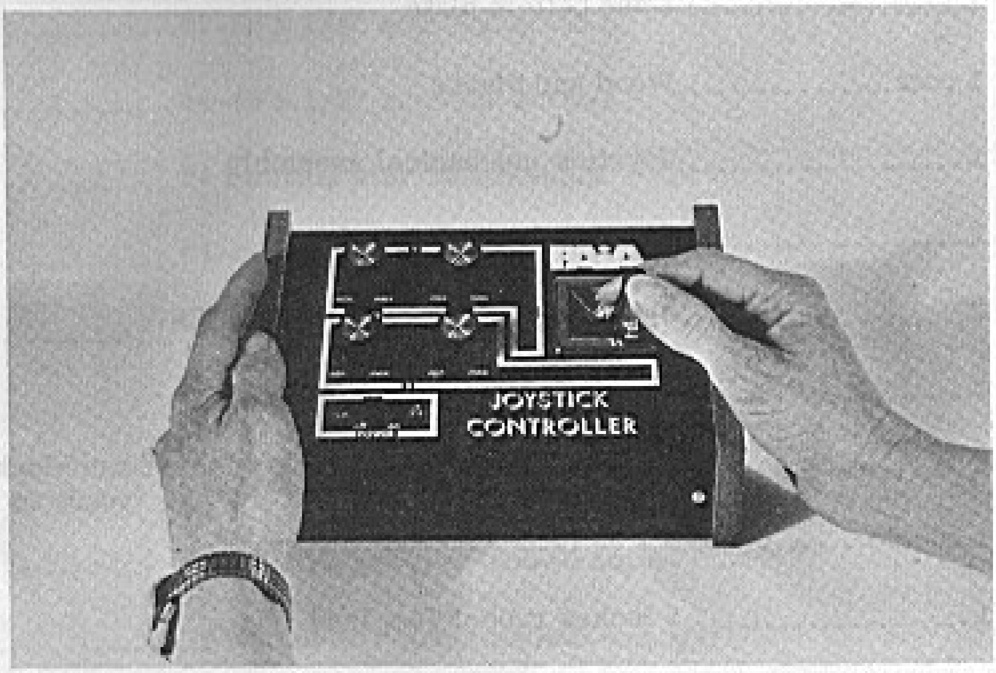
PAiA

ELECTRONICS, INC.

4783

JOY STICK CONTROLLER



The PAIA 4783 Joystick Controller is a versatile, yet compact, method to control up to three simultaneous parameters on a voltage controlled music synthesizer. Motion on both the X and Y axes produces separate outputs, with RANGE and BIAS adjustments for each axis. Additionally, the metal joystick shaft serves as a touch activated trigger source to initiate a variety of preprogrammed effects on command. Switch selectable multiplier function allows processing of remotely generated control waveforms.

SPECIFICATIONS

Power Source:	two 9 volt batteries
Control Voltage Output:	$\pm$4 volts
Trigger Output:	+8 volts
Control Voltage Input:	up to $\pm$5 volts

Prior to beginning assembly, check the supplied parts against the following parts list.

QUANTITY	ITEM
1	4783 Circuit Board
1	4783 Case Top
1	Case bottom plate
1 pair	Wood end blocks
1	Joystick mechanical assembly
1	Chrome Joystick bezel
2	748, 201, or 301 type op-amp ICs
2	1N914 or 1N4148 signal diode
1	CD4001 IC (DO NOT remove from foam block until ready to install)
1 bundle	4 x 30 inches hookup wire
1	5 inches rubber flex lead
2	5K potentiometers
2	100K potentiometers
2	SPDT slide switches
1	DPDT slide switch
1	9 lug terminal strip
3	Red pin jacks
3	Black pin jacks
6	Tinnerman nuts (see Fig. 4)
2	9 volt battery connectors

1 .... Solder lug

1 .... Wire tie

2 .... Threaded "L" hooks

4 .... Rubber feet

4 .... Push-on Knobs

8 .... Potentiometer mounting nuts

8 .... #4 x 3/8" self-tap screws

4 .... #2-56 x 1/4" machine screws

5 .... #4-40 x 1/2" machine screws

10 .... #4 internal star lockwashers

10 .... #4-40 nuts

5 .... 5/16" spacers

6 .... #4-40 x 1/4" machine screws

2 .... 330K resistors (orange-orange-yellow)

2 .... 82K resistors (grey-red-orange)

4 .... 10K resistors (brown-black-orange)

2 .... 680K resistors (blue-gray-yellow)

1 .... 4.7K resistor (yellow-violet-red)

2 .... 100 pf disk capacitors

2 .... .01 mfd disk capacitors

1 .... .001 mfd disk capacitor

1 .... .005 mfd disk capacitor

If you should find any parts missing, damaged, or otherwise unusable, contact PAIA Electronics Tech Services for replacement. Along with your request, we must have the packer number from the parts bag, and the order number which contained this kit.

( ) Rotate all control shafts fully counter-clockwise and push the knobs firmly into place so that their pointers point to the seven o'clock position of an imaginary clock face.

THIS COMPLETES THE ASSEMBLY SECTION. PROCEED TO THE TESTING AND CALIBRATION SECTION.

TESTING

All that is required for testing the Joystick is a voltmeter or similar basic test meter. First, connect the negative lead of the meter to the GROUND jack on the rear of the Joystick case. Connect the positive lead to the output jack labeled TRIGGER. Set the voltmeter to a range which will conveniently measure 10 volts. Slide the Joystick Power switch to ON. The meter should initially read 0 volts. Touch the metal shaft of the Joystick. The trigger output voltage will now jump to positive 9 volts. If not, check the circuitry based around IC3. Double check D1 and D2 to make sure they are installed with the correct polarity. You may also wish to check these diodes to make sure they were not blown out when soldered into the circuit. Of course, IC3 itself is the most important part of the touch switch circuitry. Improper operation of the touch switch may be traced to static or installation damage to the IC.

Move the positive meter lead to the "X" output jack. With the "X" section's RANGE and BIAS controls fully counterclockwise, you may note a slight negative deflection of the meter. Advancing the BIAS control approximately 50% should bring the meter reading to 0 volts. Further advancement of the BIAS control should deflect the meter to positive 4 volts or more. After this is confirmed, return the BIAS control to the mid-rotation point that provides 0 volts output. Set the meter to a range which will conveniently measure one volt or less. Advance the BIAS control slightly, until the meter shows 1/2 of full scale deflection. In other words, the meter should be pointing straight up. Move the Joystick shaft to the right and to the left. As the Joystick is moved to the right, the meter should move several tenths of a volt more positive. Movement of the stick to the left will produce a slight decrease in the output voltage. Return the meter range switch to a scale which will measure 5 to 10 volts. Increase the Joystick RANGE control to approximate mid-rotation. Reset the BIAS control to provide 1/2 of a full scale reading on the meter. Now move the Joystick shaft to the left and right and note that the output deflection is increased to several VOLTS of deviation. At maximum RANGE, the output swing will be about plus/minus 4 volts. Likewise, at minimum RANGE setting, the BIAS control should produce about plus/minus 4 volts deviation or more.

Move the positive meter lead to the "Y" section output jack. Repeat the test procedure which was used for the "X" section, this time using the RANGE and BIAS controls in the "Y" section and substituting upwards and downwards Joystick motion for the right and left motion previously used. NOTE: In our prototypes, we have noticed that usually the "Y" BIAS control can not be decreased far enough to provide 0 volt output when the "Y" RANGE control is fully advanced. To correct for this, the internal Joystick trimmer must be decreased. Push the trimmer lever of R-4 all the way to the position indicated by the asterisk in Figure 5. This should cause the R-4 trimmer lever to now be pointing towards the front lip of the case top. Now, repeat the test procedure for the "Y" section to make sure the RANGE and BIAS controls operate in the proper manner.

USING THE JOYSTICK

Before getting deeply involved with some sample applications for the Joystick, it is important to understand that the Joystick is a much more versatile and wide range controller than the more common AGO keyboard. The musical keyboard offers precision repeatability of a limited set of musical notes. But, the Joystick has a much wider range of outputs, with capability to generate an infinite number of outputs across its range. Additionally, it has the capability to generate TWO variable outputs PLUS a third trigger output. With all this increased capability comes an increase in operational subtlety and lack of applications comprehension. The point is that you must be prepared to experiment and PRACTICE in order to LEARN how to get the most from this new controller system, just like you had to LEARN how to play the AGO keyboard. The reward will be the ability to do some very complex control of a large assortment of synthesizer equipment from one efficient controller device.

PANEL LAYOUT AND CONTROL OPERATION

Note that the front panel graphics are arranged to depict the interaction of the rotary controls with the Joystick. The "X" and "Y" designations are derived from standard notation for designating a point in a two-dimensional graph. The X axis refers to horizontal, or side-to-side Joystick motion. The Y axis refers to vertical, or up-and-down Joystick motion.

The controls in the X section operate exactly like the Y controls, except they affect a different axis of motion.

RANGE - This control determines the amount of output voltage change for a given amount of Joystick motion. Clockwise rotation will give increased output changes.

BIAS - This control determines the amount of initial voltage at the output; or in other words, the center voltage of the Joystick at rest. Any movement of the Joystick will then cause an increase or decrease in this center bias setting. Minimum settings of the BIAS controls represents an output of approximately -4 volts. Clockwise rotation will increase the output voltage to a maximum of about +4 volts.

TRIMMERS - The ribbed, thumbwheel sliders adjacent to the joystick mechanism act as fine tuners for the setting of the Joystick.

POWER - Sliding this switch to the right applies power to the internal circuitry. Be sure to switch off the power when not in use to help prolong battery life.

On the rear panel:

GND - This jack should be patched to a common ground point on the equipment which the Joystick is to be controlling. This connection is REQUIRED for proper operation of the Joystick.

TRIG - This output jack provides a trigger output of approximately +8 volts when the metal section of the Joystick shaft is touched. The output will remain high as long as the shaft is touched.

As with the front panel controls, the operation of the rear panel is similar for both the X and Y sections.

OUTPUT- The voltage which is the resulting summation of Joystick location, control setting, and so on, appears at this jack. This jack will be patched to the module you wish to control with the Joystick.

INPUT - This jack allows for input of complex control waveforms which can then be selected, processed, and outputted from the Joystick. This jack is used for some very special modes of operation, and will be discussed in detail in a later section.

CV/MULT- This switch selects the normal variable voltage mode of operation (CV), or the multiplier mode of operation (MULT) which uses the previously mentioned INPUT jacks.

This seems the appropriate time to talk about two other "controls" which aren't attainable from the outside of the case. On the rear of the Joystick mechanical assembly, you will find two protruding plastic "pillars" with an Allen-type hex screw in the end. These screws adjust the tension of the Joystick "spring return" action. Screwing these adjustments further into the pillar will cause a faster, tighter spring return action. Similarly, backing these screws out of the pillars will cause the spring action to get weaker until, just before the screws begin to leave the pillar, the Joystick has no spring return action at all. At this position, the Joystick should stay anywhere along the axis that you put it. This could be useful for some applications, and you may wish to readjust one or both axes of your Joystick to operate in this manner. NOTE that the adjustment screws should not be completely removed from the pillars, as this will allow several small springs and pivot arms an opportunity to fall out and be lost. Chances are that you may want to readjust the tension again in the future, so try to avoid the loss of these parts.

APPLICATIONS

Now that we have all the details out of the way, let's get down to patching the Joystick into a system and putting it to use. One of the first things that comes to mind when you set a knob, lever, or thumbwheel next to a keyboard is pitch bending. Since you will be bending the pitch up and down, it makes sense to use the "Y" (vertical) axis for this application. First, MAKE SURE that you have a patch cord connected from the Joystick GROUND jack to a ground jack on your 4761 Wing (or to the chassis of the unit to be controlled, if it is from another system). The Y output should be patched into the VCO(s) to be controlled IN ADDITION TO the normal control voltage from the keyboard, sequencer, etc. (See Figure 10). The front panel Y RANGE should be set to minimum. We do not want any control voltage at the output when the Joystick is at its resting center position, so the Y BIAS should be set to approximate mid-position. While inserting and removing the patchcord from the output jack, make slight adjustments to the Y BIAS control until there is NO pitch offset when the Joystick is connected to the VCO. This is the point where there is 0 volts bias at the Joystick output. If you can get close with the BIAS control, then you can fine tune the zero setting with the Joystick trimmers. Now, you should be able to play up and down your keyboard and selectively add upwards or downwards pitch bends of up to a musical fifth or so. If you prefer more dramatic, wide-range pitch sweeps, the RANGE control can be advanced as desired. NOTE, though, that the BIAS control will need to be reset to provide the initial 0 volt output.

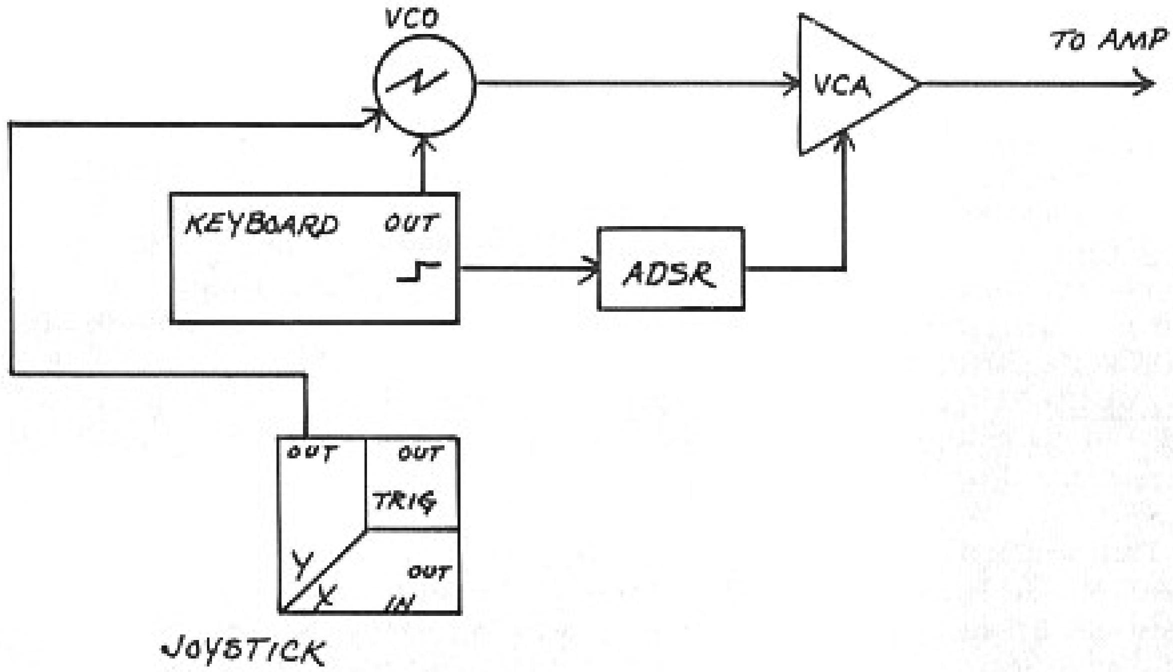


FIG. 10: PITCH BENDING PATCH

Those of you who are involved with experiments in microtonal or macrotonal tunings can use the front panel BIAS control to generate the positive (for microtones) or negative (for macrotones) voltage offset required. The wide range of the BIAS control should provide for a world of new tonalities to be explored.

Now let's take the basic patch a step further. Let's add variable filter sweep which is controlled by horizontal (X axis) motion of the Joystick. (See Figure 11). Use an additional patch cord to connect the X output to the control input of a VCF. For now, use the Joystick as the only input to the filter. With this patch, moving the Joystick up and down while playing the keyboard will produce pitch bends, while moving the Joystick from side to side will act as a tone control.

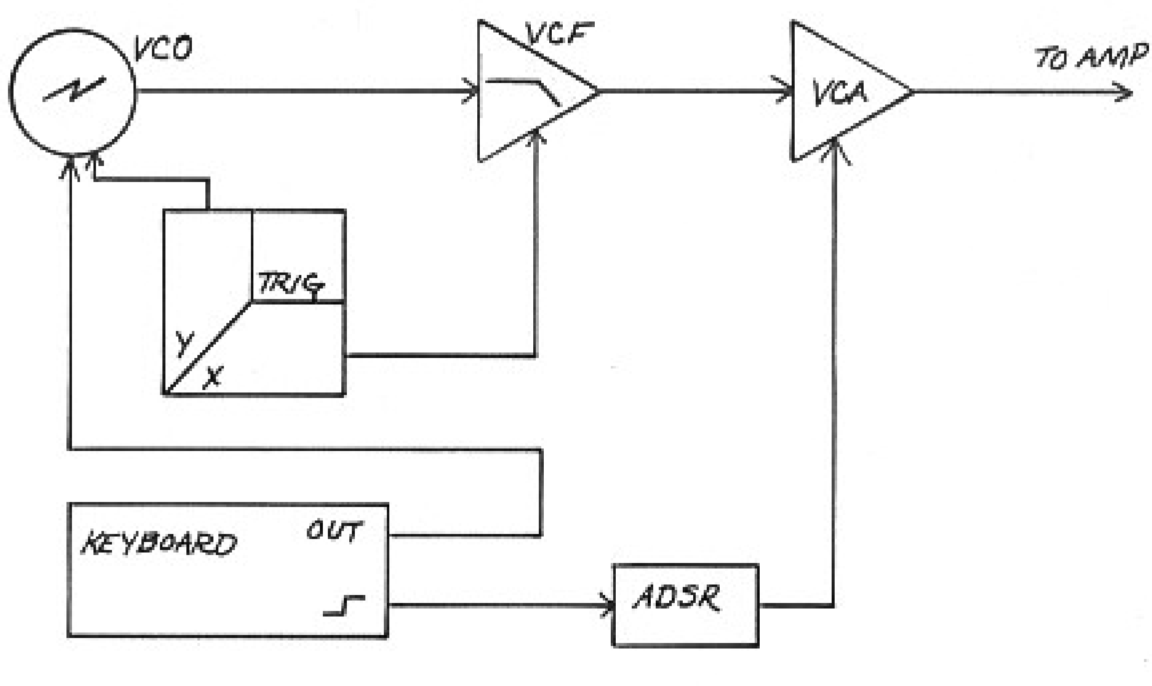


FIG. 11: PITCH BEND/TONE CONTROL PATCH

When using this patch you will probably find it most useful to have the X RANGE set between midpoint and maximum for the widest range of tonal changes. This demonstrates a very important design concept--instead of using one set of master controls to adjust range and bias of both Joystick axes simultaneously, we chose to retain separate control for each axis to allow for the widest range of possible applications. On Joysticks which have only one master range control, you would never be able to execute the preceding patch without having either an extremely narrow (thus ineffective) filter sweep range or a very wide pitch bend range (thus difficult to use for bends of a few semitones only).

To add a third dimension of control to our expanding patch, connect the TRIGGER output to the input of an envelope generator. (See Figure 12.) Then, patch the output of the envelope generator into the control input of the VCF which is being used as a tone control for the X axis. With these connections completed, you will be able to bend pitch, change the tone manually, AND touch the metal shaft of the Joystick to get an automatic sweep of the filter. NOTE that when using the touch TRIGGER function, all Joystick movement must be done by holding the <u>end</u> of the shaft.

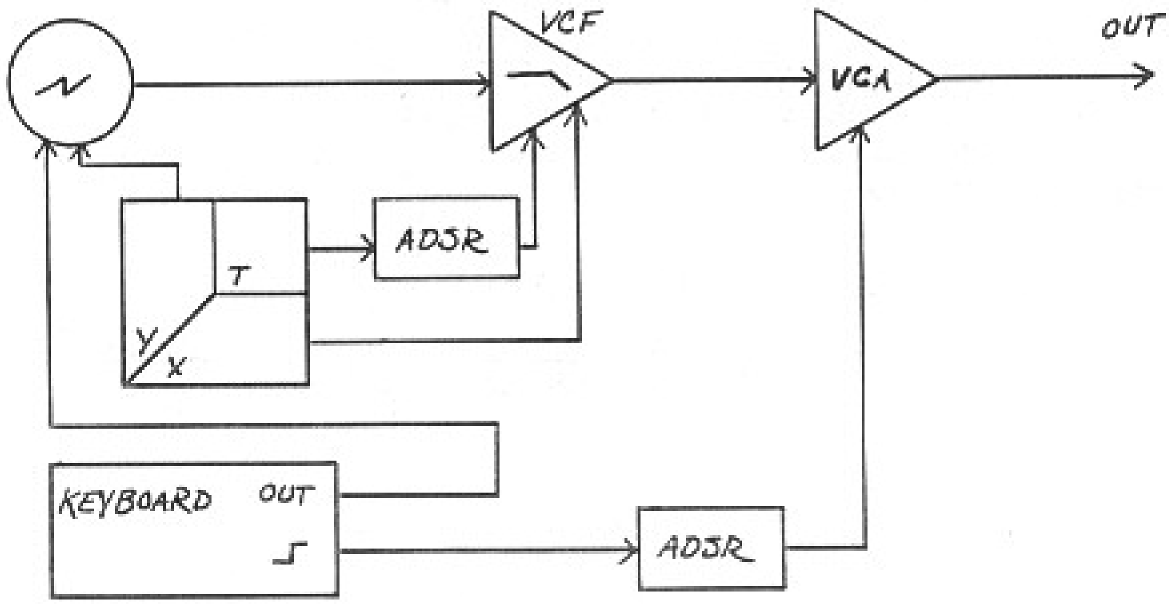


FIG. 12: ADDING TRIGGER CONTROL

From these basic applications, we can expand to using the Joystick trigger output to initiate a sequenced pattern, or better yet--to single step through a sequenced pattern. This way, you could have a number of preset voltages for a tonal sequence, a chord progression, or perhaps just use the sequencer gate outputs to enable various patches through a number of VCAs. Now, whenever you touch the Joystick shaft, the sequencer will advance one stage, and the next preset "patch" will be heard. By now your creative instincts should be getting a few ideas worth experimenting with. TRY THEM ALL. Experiment with having the Joystick control every module in your system. This will help you derive or stumble upon some good control combinations which you may not have thought of yet.

The Joystick can be used as a range determinant for control signals in several ways. Probably the most obvious is to use the Joystick as a bias voltage generator, with the front panel BIAS control set to the lower 50% of its range. This will cause a negative voltage output from the Joystick which, when summed with the control signal you wish to process, will provide enough negative bias to keep the other control signal from having any effect. However, as the Joystick is moved to sweep the output voltage up to 0 volts or greater, the other control signal will have more and more potential for forward biasing the module it has been attempting to control. Finally, when the Joystick is outputting 0 volts, it is as if there is no Joystick patched into the circuit, and the control signal will have its full sweep range applied to the module. Let's apply this technique in a situation where we want to have a variable amount of repeating sweep on a filter. (See Figure 13.) Patch an oscillator signal through a low-pass or band-pass type VCF, and out to your amp. Select the variable output of a control oscillator, and patch into the control input of the VCF. Set the variable output of the control oscillator to produce about 2 to 3 volts output. Patch a Joystick output into the VCF along with the control oscillator. If you can hear the Low Frequency Oscillator (LFO) sweeping the filter a bit, decrease the setting of the Joystick Bias control to sum in a bit more negative voltage. Now, when the Joystick is moved, the sweeping oscillation of the filter should become increasingly predominant. With a bit of practice, this type of Joystick operation can add a significant amount of expression to your playing by providing fade-in vibrato, left hand modulation depth, or envelope range or emphasis control for doing accents, etc.

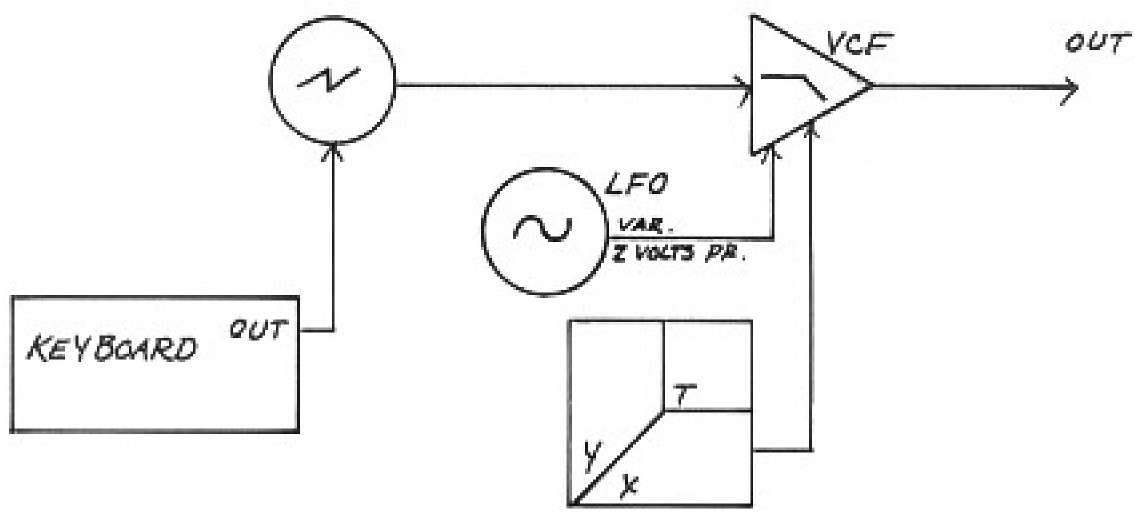


FIG. 13: FILTER SWEEP RANGE CONTROL

A slightly different method of control waveform range processing is through the use of the MULTIPLIER function which is accessible from the rear panel of the Joystick. In this mode of operation, the fixed joystick bias voltage is switched out, and an input is provided so the Joystick mechanism can be used to select variable amounts of a control waveform of your choice. This will provide a smoother variation in amplitude than the previous method, as we no longer need to bring the control waveform above a certain threshold before the control signal can take effect. Now, the Joystick will cause a true amplitude control of the input waveform. Additionally, a bias offset can be added to the output, if desired, through the use of the front panel BIAS control. This could serve as an inititial range setting before the Joystick introduces the various amounts of the modulating waveform. As an example, let's use the Joystick for envelope amplitude control. See Figure 14. We will use a signal from an ADSR to be fed into the Joystick. Patch the ADSR output into the Y INPUT jack on the rear of the Joystick. Slide the Y selector switch to the MULT position. Patch the Y OUTPUT to the module you wish to control--let's use a filter again. In the MULTIPLIER mode of operation, you will probably find it easiest to have the RANGE control set in the 50% to 100% area.

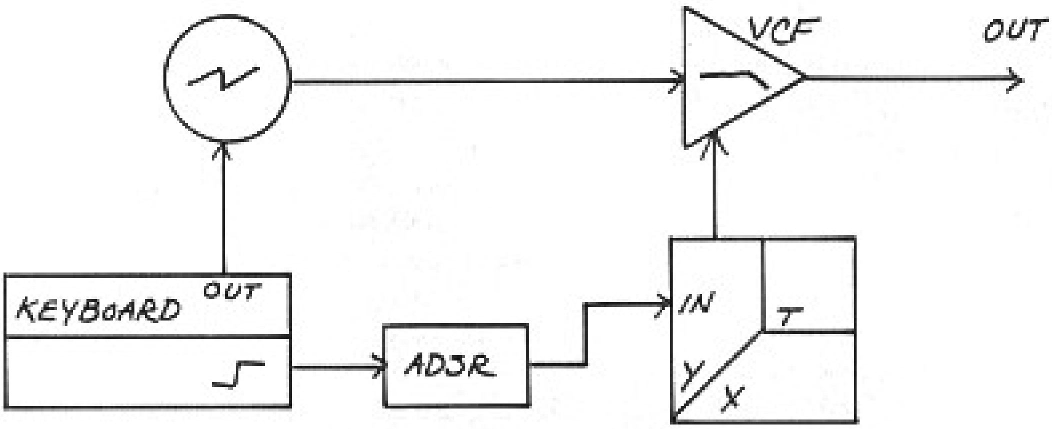


FIG. 14: EXTERNAL SIGNAL MULTIPLIER PATCH

This will provide the widest range of Joystick action. Initially, set the Y BIAS control to approximate mid-position. While playing the keyboard, the Joystick can be moved up or down to cause an increase or decrease in the deflection range of the filter. Experiment with different RANGE and BIAS settings, as there are limitless possibilities with this mode of operation. How about having the Joystick trigger the module it is processing? In figure 14, remove the ADSR trigger from the keyboard and connect to the Joystick trigger output.

If you are ready to move up to some VERY subtle and tricky control configurations, you can try complete system control with the Joystick. At first, this type of patch is frustrating, as it is hard to get the degree of control required to produce "musical" sequences. A typical system control patch would be similar to that shown in figure 15. Once you have refined this type of Joystick operation, you will have gained a very powerful new tool for the expression of the extreme subtleties of your music.

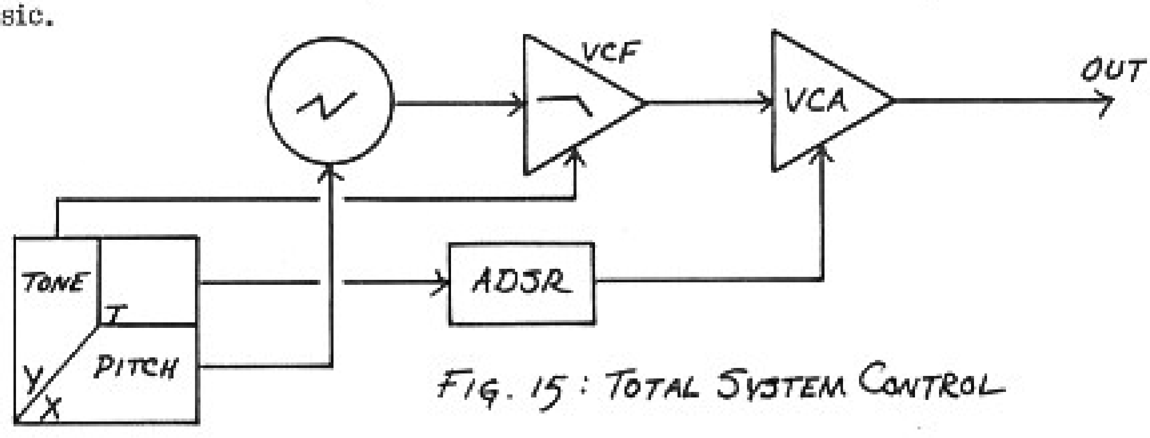


FIG. 15: TOTAL SYSTEM CONTROL

DESIGN ANALYSIS

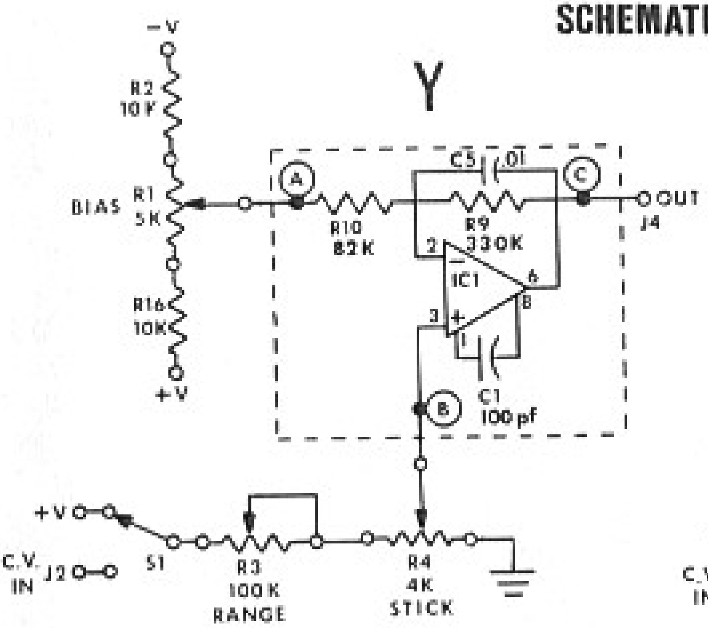
The basic circuit of the Joystick is a DC voltage amplifier consisting of IC1 for the Y section, and IC2 for the X section. A small variable positive/negative voltage is selected by the BIAS control and fed through the IC in an inverting mode which has a gain of about 4. A variable positive voltage is selected by the Joystick and applied to the IC in a noninverting mode. RANGE controls allow for dropping the amount of voltage appearing across the Joystick potentiometer. Slide switches S1 and S2 allow for selecting fixed voltage input to the Joystick or control waveforms applied to the input jacks, J1 and J2.

The touch switch section requires a high frequency clock which is generated by IC3A and IC3B. Under normal conditions, identical clock signals are applied to both inputs of NOR-gate IC3C. Thus, this gate acts as an inverter and the clock signal reappears at D1. The high states of the clock signal serve to charge C4 to an equivalent peak voltage. With the values selected, D1 becomes reverse biased when the clock signal goes low, so the only discharge path for C4 is through R13. (The input impedance of the following inverter, IC3D, is very high and presents negligible leakage paths.) R13 is selected to have a discharge time slightly longer than the period of the clock signal, thus maintaining a high logic level going into inverter IC3D. In this condition, a low (grounded) output occurs at the trigger output.

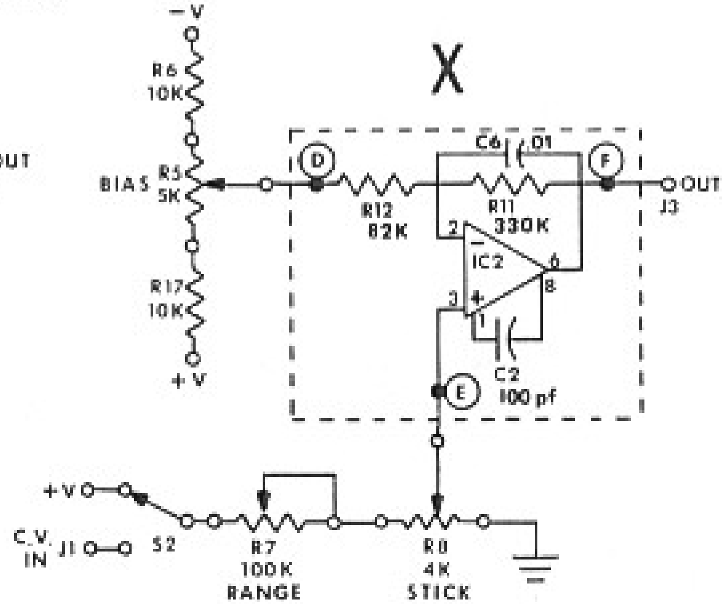
When the capacitance of a human body is applied to the Joystick shaft, it is enough to charge up to the peak value of the clock signal at G. When the clock output goes low, D2 becomes reverse biased and R15 presents the only discharge path for the body capacitance. Therefore, the logic input to pin 6 of IC3C stays high while the other input goes low. As long as the high logic level is maintained across the body capacitance, the output of IC3C will be low. If this point stays low for more than a few clock cycles, C4 will have time to discharge through R13 causing a low logic signal to be applied to output inverter IC3D. After inversion, the high trigger output is made available at point H.

SCHEMATIC

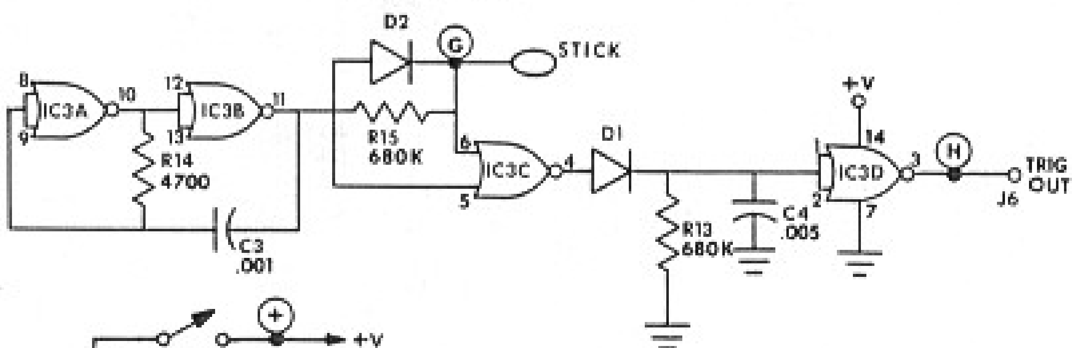
Y

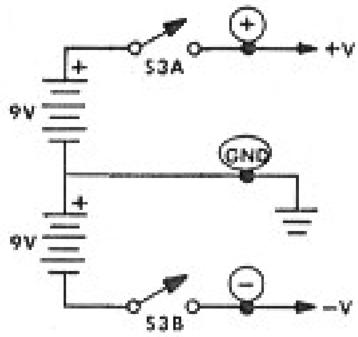


X



TOUCH





ASSEMBLY DRAWINGS

Remove this section for easy reference

during assembly.

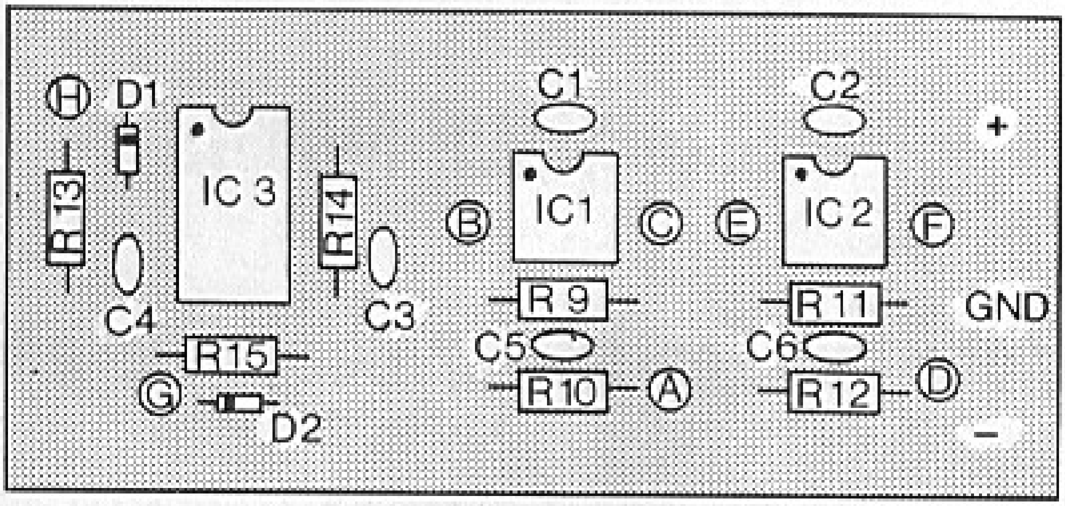


Figure 1

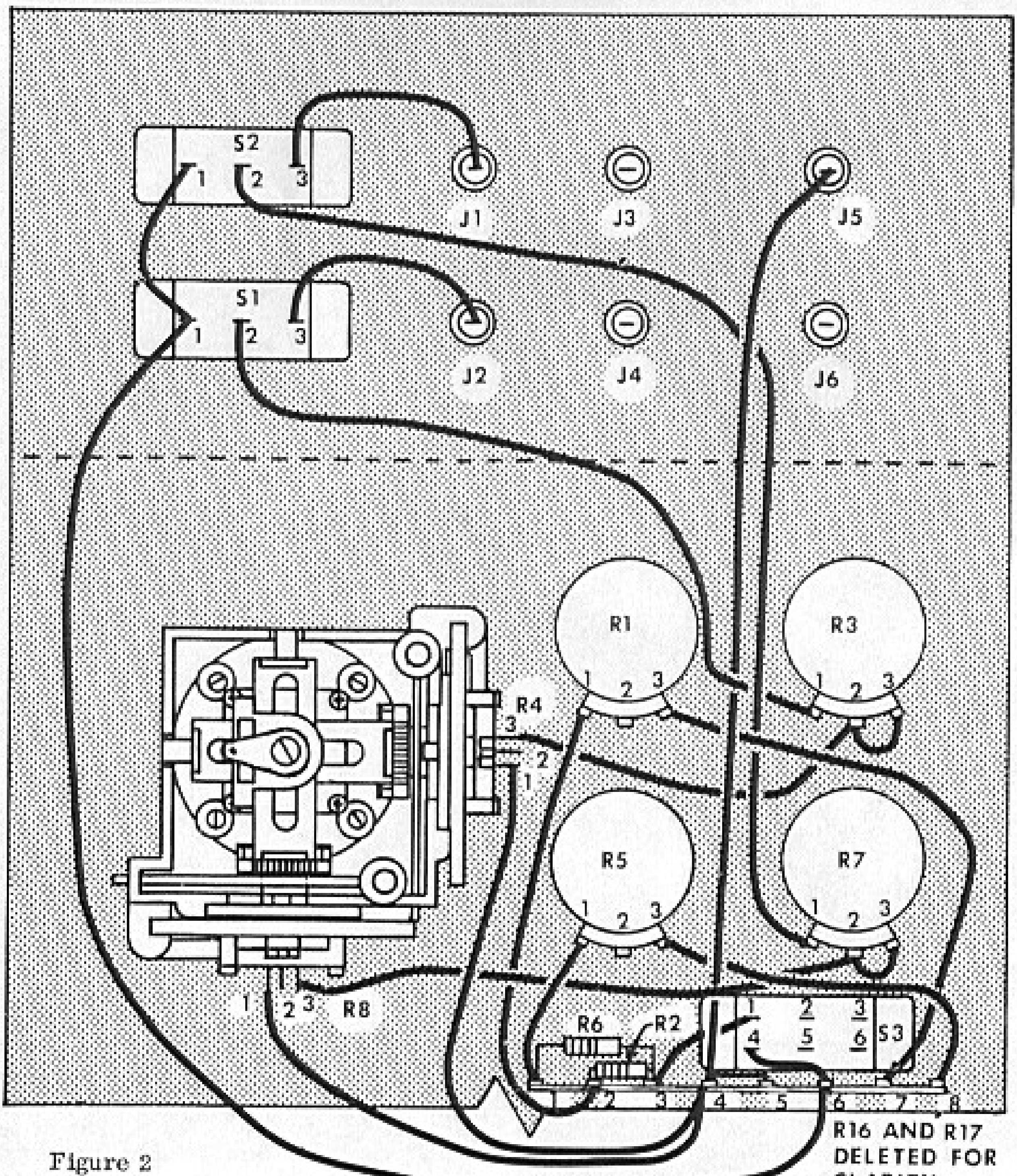


Figure 2

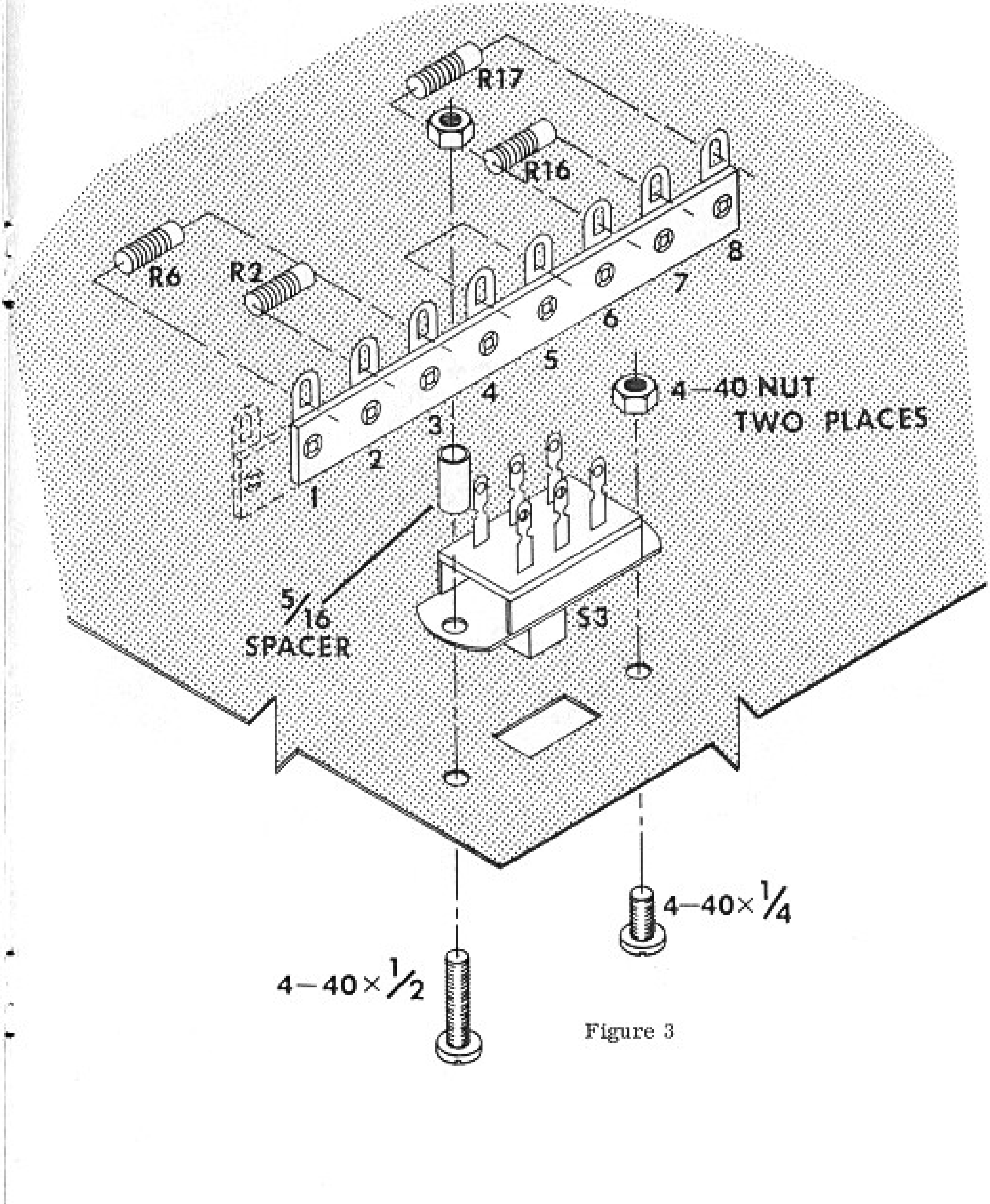

R17
R16
R6
R2
1
2
3
4
5
6
7
8
4-40 NUT
TWO PLACES
5/16
SPACER
S3
4-40×1/4
4-40×1/2

Figure 3

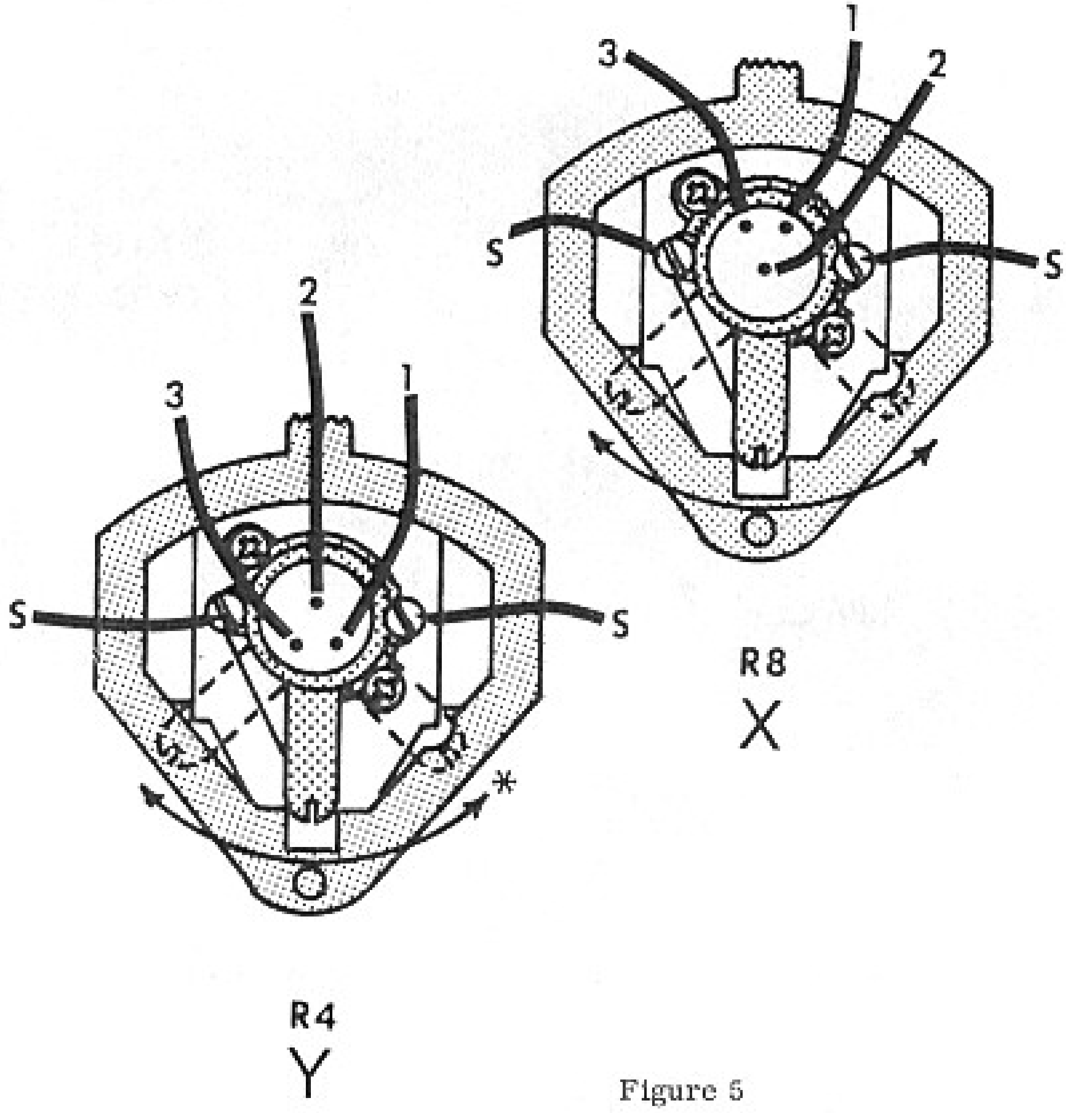


Figure 5

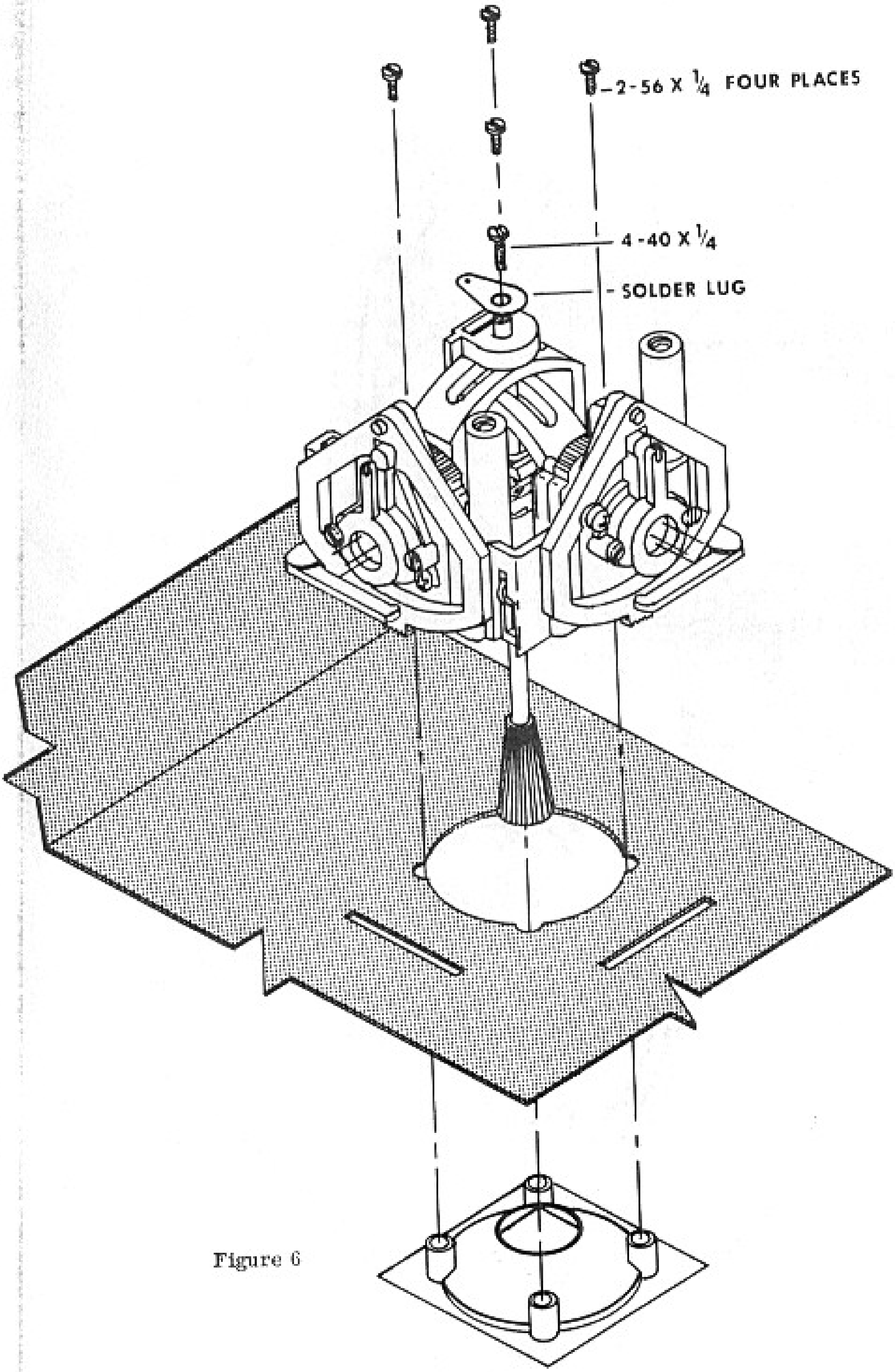
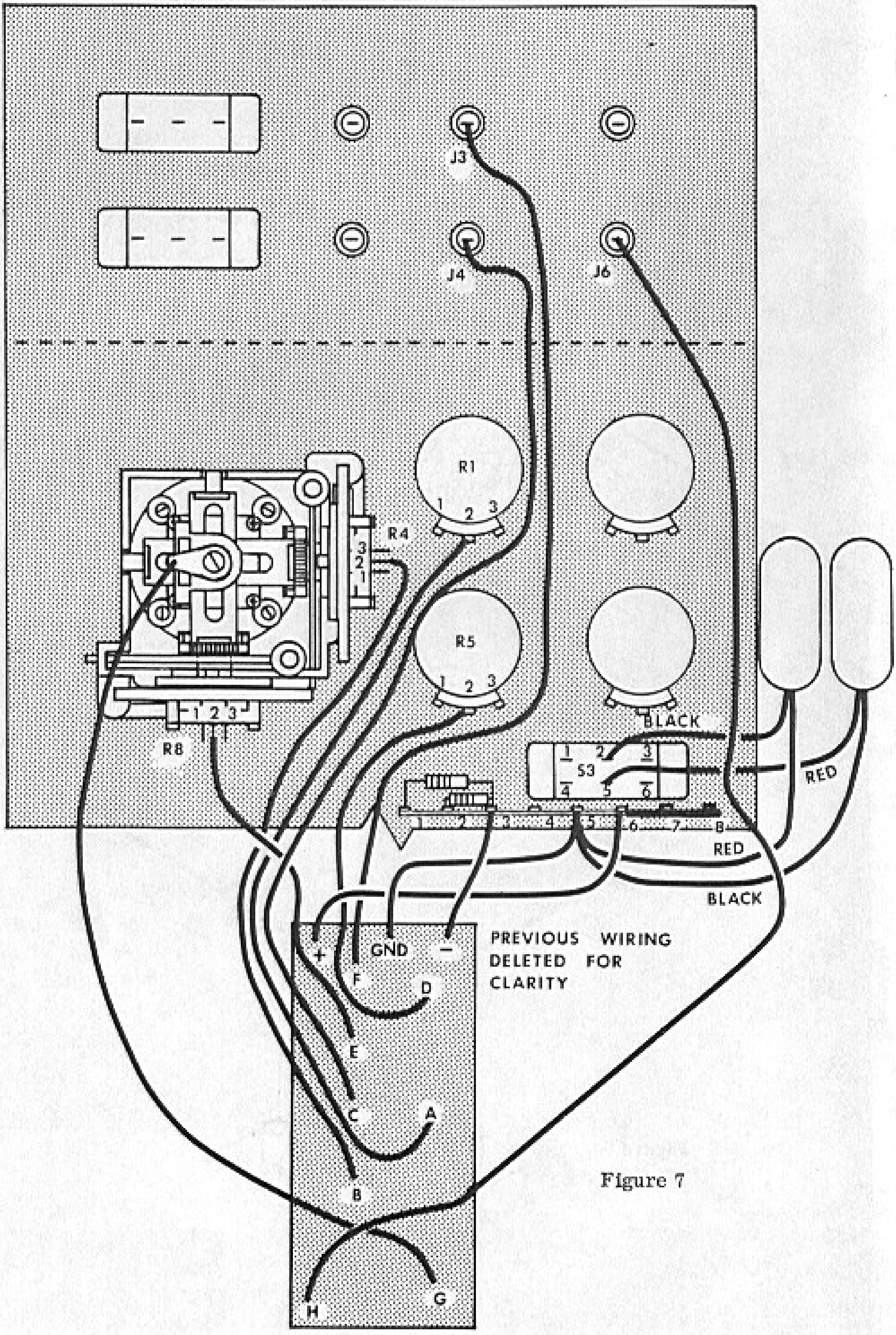


Figure 6



J3
J4
J6
R1
R5
R4
R8
S3
BLACK
RED
RED
BLACK
+
GND
−
F
D
E
C
A
B
H
G
PREVIOUS WIRING DELETED FOR CLARITY

Figure 7

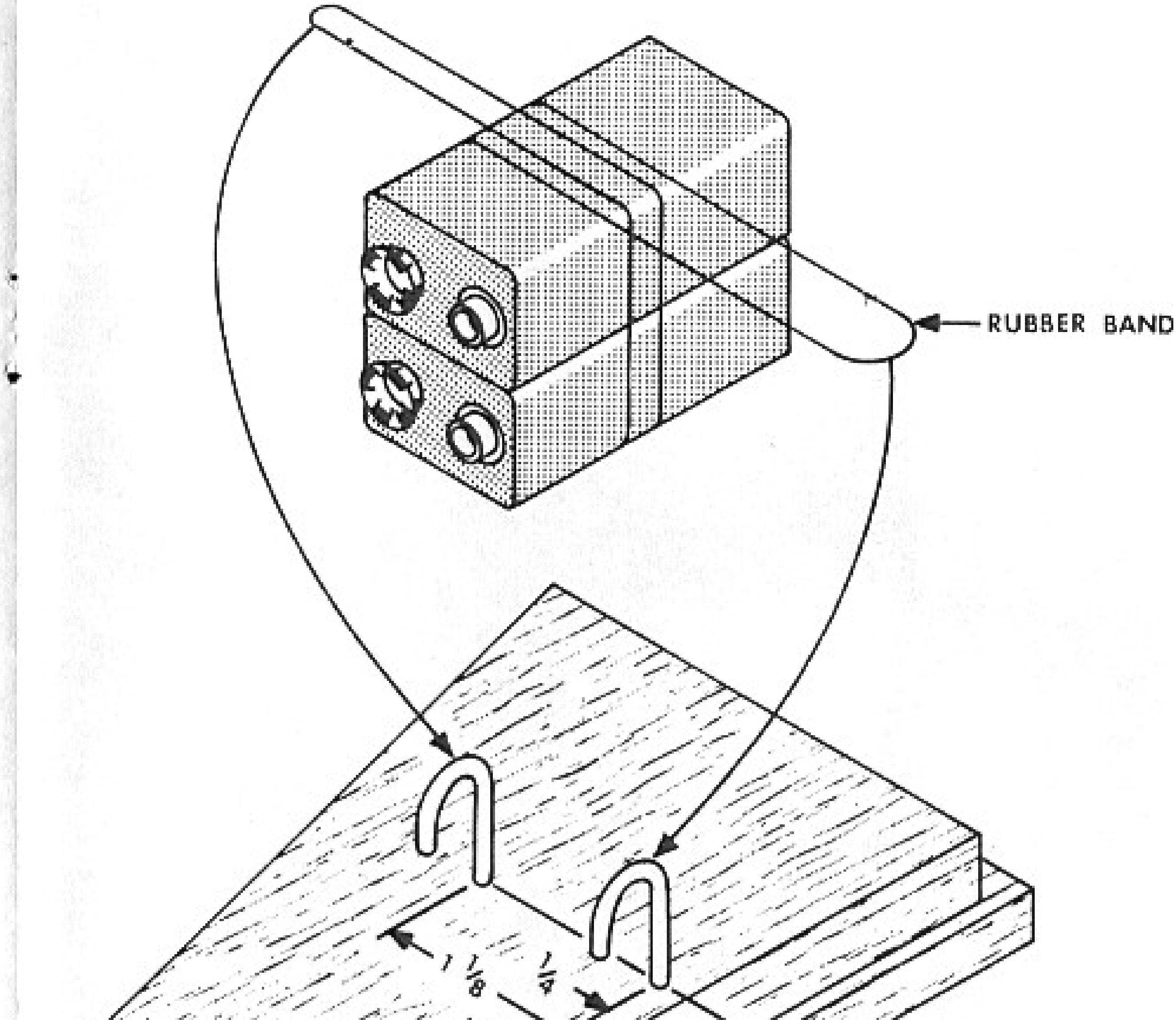


Figure 8

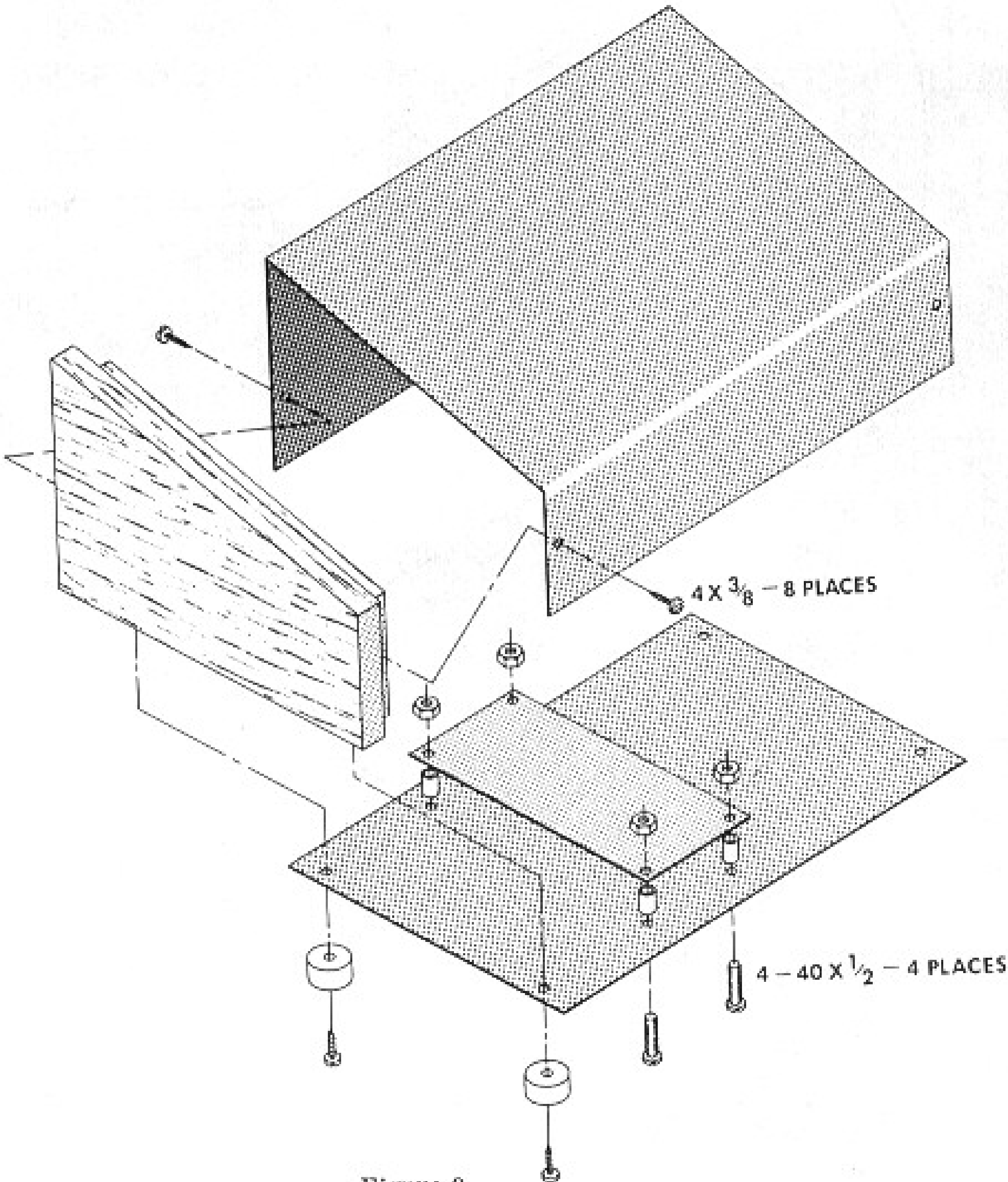


Figure 9