IMSAI IKB-1

INTELLIGENT KEYBOARD

January, 1978

CAUTION

FAILURE TO OBSERVE THESE IMPORTANT PRECAUTIONS WILL VOID WARRANTY

1. Read all material before beginning construction.
2. Use ONLY electronic quality rosin core solder.
3. Use extreme care with static-sensitive chips to prevent static discharge damage. (These chips are inserted in black conductive foam material in your kit.)
4. Do NOT plug or unplug boards while power is on.
5. Do NOT apply power to any board or circuit before checking each component and each trace.
6. Do NOT insert chips in socket before all soldering on the board is completed.
7. Do NOT use nonstandard parts such as fuses of a higher current rating.
8. Do NOT leave out any construction step.
9. Use only specified AC power.
10. Prevent flat cable end from touching areas of the system that may be carrying current.
11. Clean unit with soap and water or isopropyl alcohol only to prevent damage to plastic components.
12. Some repair operations are quite demanding. Do not attempt repairs beyond your level of skill to prevent damage to the board or the components.
13. Use ONLY a 25 watt electronic soldering iron for assembly of your IMSAI kit.
14. Do NOT perform any solder work on a board while power is applied.
15. Do NOT plug or unplug a chip from a socket while power is applied.
16. Check power supply voltages BEFORE inserting any boards into chassis.
17. For all assembled units, read USER GUIDE section for jumpering instructions.
18. To register your kit for warranty protection, fill out warranty cards and mail to IMSAI. Kits without warranty cards on file are NOT covered by warranty.

KEYBOARD FUNCTIONAL DESCRIPTION

The IMSAI Intelligent Keyboard is a unique, programmable keyboard designed to be used as a parallel or serial computer input device. A number of keyboard functions may be programmed by the user through simple keyboard commands, or under direct control of the system CPU.

KEYBOARD: The IMSAI Intelligent Keyboard utilizes a high quality, 63 key mechanical contact keyboard for high reliability. All keys are fully debounced, and the keyboard provides full N-KEY ROLLOVER. Continuous depression of a key will invoke an auto repeat function, causing a character to be output continuously until the key is released. Standard alphanumeric and control keys are arranged in a typewriter type layout.

SERIAL/PARALLEL OPERATION: The keyboard may be configured to operate as a parallel OR serial input device. The parallel mode supports a full 8 bit parallel format with RDY and ACK handshaking. The serial mode supports both EIA and TTL levels. Serial baud rates are selectable by keyboard commands and allow for the selection of seven separate rates from 110 - 2400 baud.

ENCODED/UNENCODED MODES: User or system CPU programming allows the keyboard to operate in encoded or unencoded modes. Selection of the encoded mode allows the keyboard to output standard USASCII code, while the unencoded mode gives the user a raw map of the keyboard array allowing multiple key depressions to be used for games, music, etc.

KEY PROGRAMMING: Any individual key may be reprogrammed to output any given ASCII character.

UPPER/LOWER CASE: The keyboard may be programmed to operate in upper case only or in upper and lower case.

CABINET: The cabinet is constructed of high quality aluminum and is finished in an IMSAI System compatible blue. The cabinet houses the keyboard, an audible beep tone speaker and 3 LED indicators. The LED display indicates entry into the program mode, shift, and upper case.

EXTERNAL CONNECTIONS: A 25 pin D-type connector provides for the +5V power and computer interface connection. Interface lines are compatible with the IMSAI MIO and SIO interface boards. An additional 15 pin D-type connector allows an external keypad to be used.

The Intelligent Keyboard (IKB-1)

REVISIONS			
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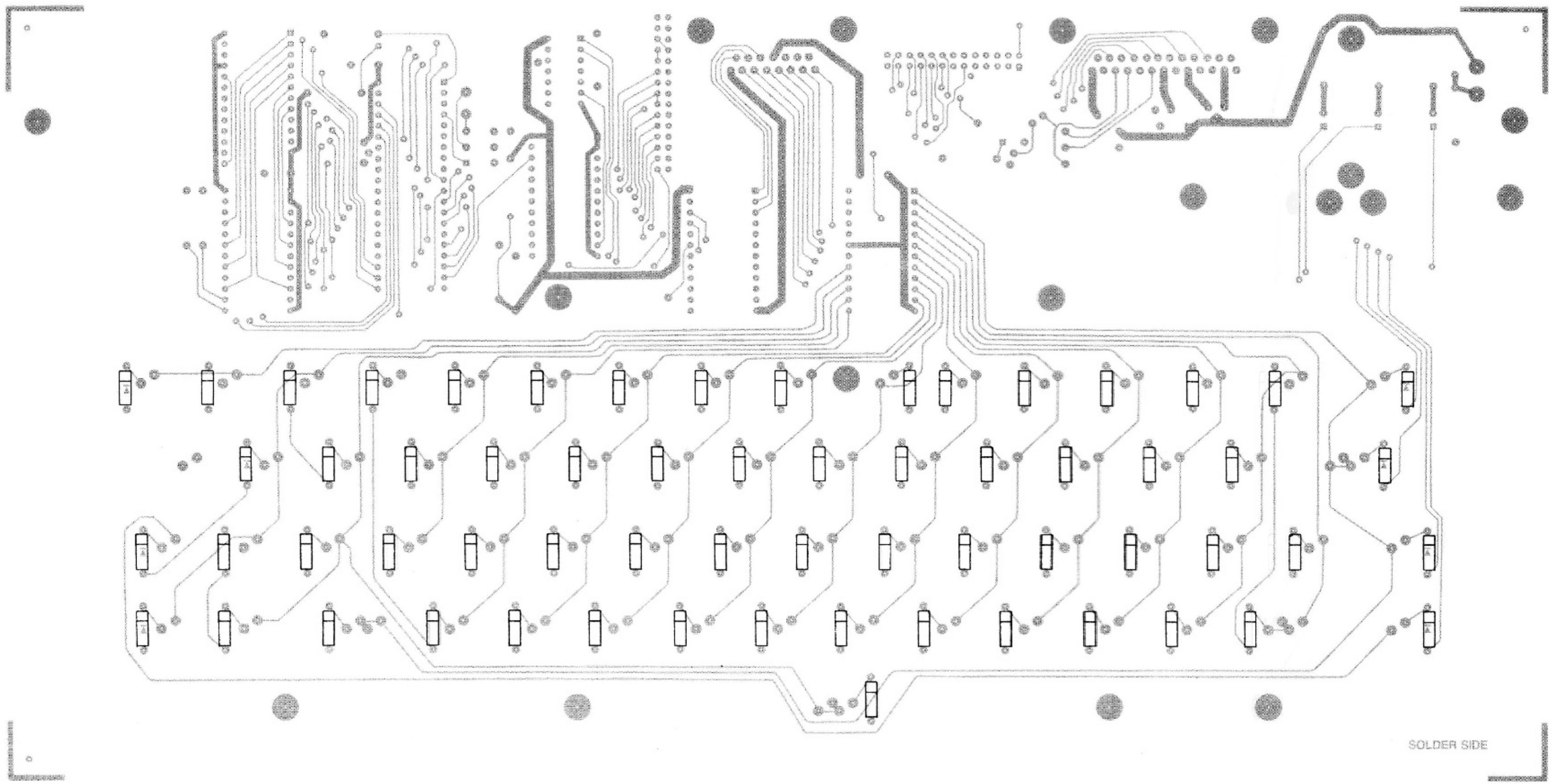

TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS	DEC.	ANGLES
±	±	±

APPROVALS	DATE
DRAWN	
CHECKED	

IMSAI SYSTEM
IKB–1 REV. 1
DIODE PLACEMENT DIAGRAM

SCALE	SIZE	DRAWING NO.
	B	

DO NOT SCALE DRAWING | SHEET 1 OF 1

LTR	DESCRIPTION	DATE	APPROVED
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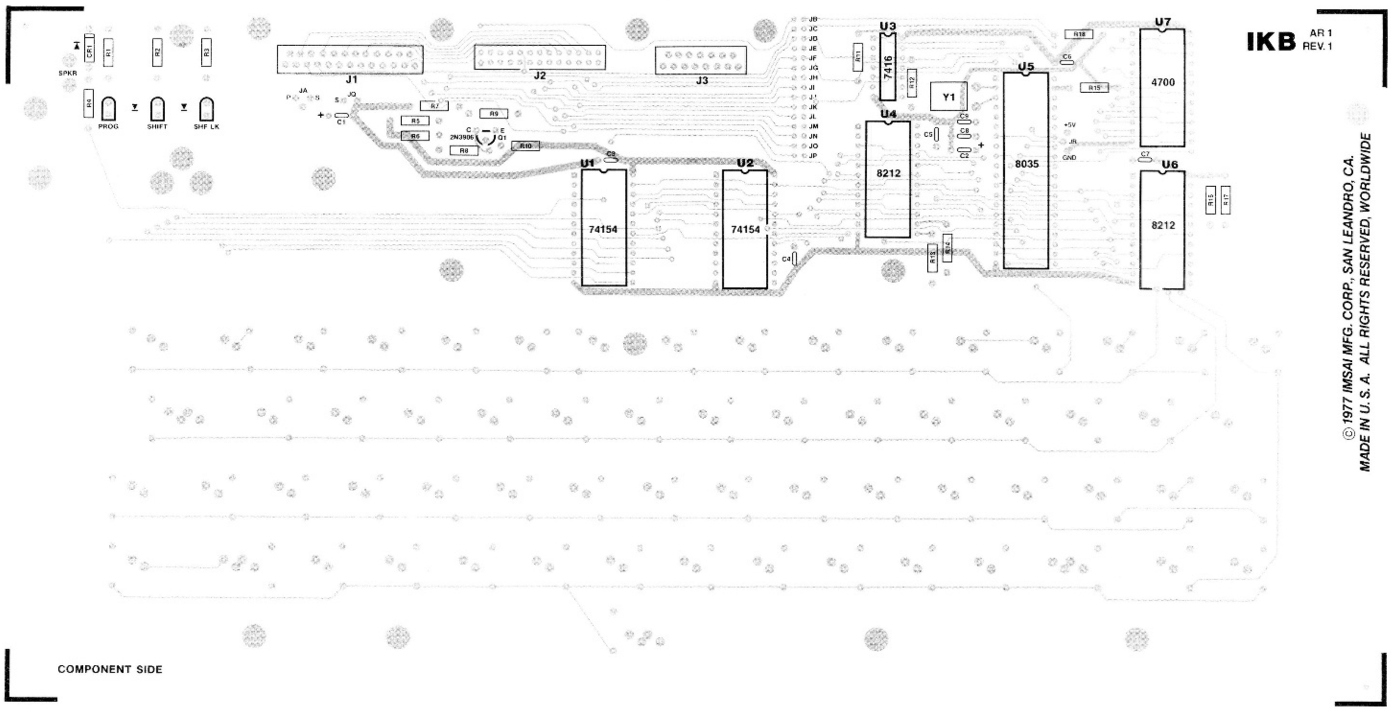
1	MODIFY REV. 1.3	8/77	



U1, U2	74154
U3	7404
U4, U6	8212
U5	8035
U7	4700 WITH 'KEY 1 REV. 1'
C1	33 uF
C2	2.2 uF
C3 THRU C7	.1 uF
C8, C9	20 pF
CR1 62 DIODES	1N4148
J1	25 PIN CONNECTOR
J2	26 PIN CONNECTOR (NOT PROVIDED)
J3	15 PIN CONNECTOR
Q1	2N3906
R1 THRU R3	82 OHM ¼W
R4	100 OHM ¼W
R5 THRU R7	1K ¼W
R9	4.7K ¼W
R8	150 OHM ¼W
R10	
R11, R12, R15, R18	10K ¼W
R13, R14, R16, R17	1K¼W

TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS ± DEC. ± ANGLES ±	
APPROVALS / DATE; DRAWN; CHECKED	IMSAI SYSTEM IKB – 1 REV. 1 6/77 ASSEMBLY DIAGRAM
	SCALE / SIZE B / DRAWING NO.
	DO NOT SCALE DRAWING / SHEET

REVISIONS			
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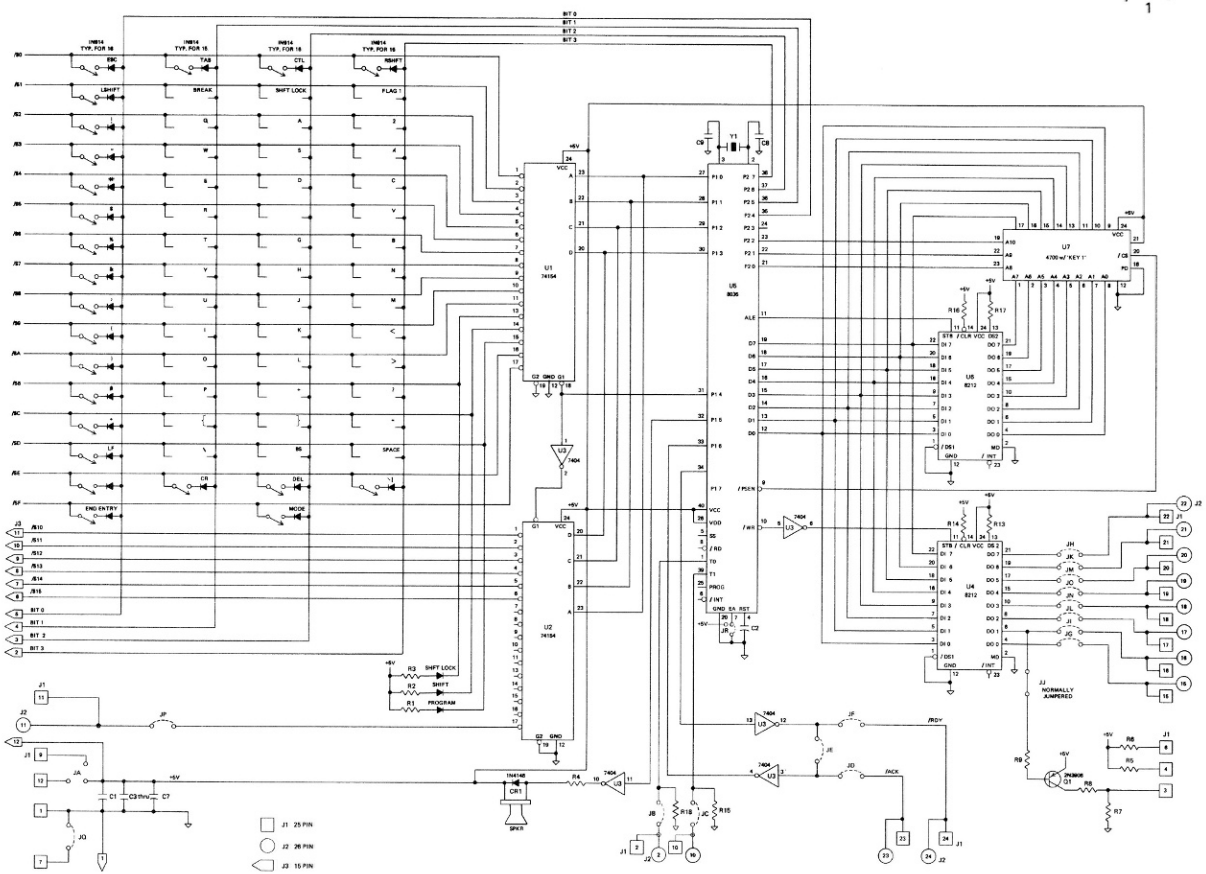
1	REV. 1.3	8/77	



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R4	100 OHM ¼W
R5 THRU R7	1K ¼W
R9	4.7K ¼W
R8	150 OHM ¼W
R10	47 OHM ¼W
R11, R12, R15, R18	10K ¼W
R13, R14, R16, R17	1K ¼W

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC. ± ANGLES ±

APPROVALS	DATE
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IMSAI SYSTEM
IKB – 1 REV. 1 6/77
SCHEMATIC DIAGRAM

SCALE | SIZE B | DRAWING NO.

DO NOT SCALE DRAWING | SHEET

IKB-1 ASSEMBLY

BEFORE PROCEEDING

Unpack all keyboard parts and check each part against the parts list shown below. Do not disgard any of the packing materials until all of the parts are accounted for. In case of any discrepancies, contact your local IMSAI dealer or, if you purchased your kit directly from the factory, IMSAI Customer Service immediately.

IKB-1 CIRCUIT BOARD PARTS LIST

ITEM	IMSAI PART NO.	QUANTITY	DESCRIPTION
ELECTRICAL PARTS			
Resistor	30-2820462	3	82 Ohm, 1/4 W, 5% (gry-r-blk)
Resistor	30-3100362	1	100 Ohm, 1/4 W, 5% (br-blk-br)
Resistor	30-3150362	1	150 Ohm, 1/4 W, 5% (br-gn-br)
Resistor	30-4100362	6	1K Ohm, 1/4 W, 5% (br-blk-r)
Resistor	30-4470362	1	4.7K Ohm, 1/4 W, 5% (y-v-r)
Resistor	30-5100362	2	10K Ohm, 1/4 W, 5% (br-blk-o)
Capacitor	32-0220020	2	20 pF Disk
Capacitor	32-2010010	5	.1 uF Disk, 30V
Capacitor	32-2202270	1	2.2 uF Tant, 25V
Capacitor	32-2722070	1	33 uF Tant
Diode	35-1000012	63	1N4148 (ALT: 1N914)
Transistor	35-2000003	1	2N3906
LED	35-3000001	3	Red
Crystal	35-5000006	1	3.579545 MHz

ITEM	IMSAI PART NO.	QUANTITY	DESCRIPTION
HARDWARE			
Solder	15-0000001	5'	
Screw	20-3402001	3	6-32x3/8 Phillips Pan Head Machine
Nut	21-3120001	3	6-32 Hex
Lockwasher	21-3350001	3	#6 Internal Star
Washer	21-3390001	3	#6x1/16" Fiber, Black
INTEGRATED CIRCUITS (IC's)			
7404	36-0740401	1	Hex Inverter
8035	36-0803501	1	Processor
8212	36-0821201	2	8-Bit Latch
74154	36-7415401	2	4 to 16 Decoder
4751	88-0000035	1	Programmed "Key 1 Rev. 1"
METAL PARTS			
Keyboard	60-0500003	1	Hytek DS6300, w/ Custom Caps
Cabinet Ass'y	91-0100008(A) 91-1100008(K)	1	IKB-1 Cabinet Rev. A (Assembled or Kit)
SOCKETS			
IC Socket	23-0800002	1	24 Pin
IC Socket	23-0800004	1	40 Pin
IC Socket	23-0800009	1	14 Pin
TERMINAL STRIPS - CONNECTORS			
Connector	23-0400023	1	15 Pin EIA, Standard
Connector	23-0400024	1	25 Pin EIA, Standard

ITEM	IMSAI PART NO.	QUANTITY	DESCRIPTION
MISCELLANEOUS			
Spacer	21-3600002	3	7/16"x1/4" Nylon
Wire	22-0122005	3"	22AWG, Red
Tape	28-0600003	1	3M Magic Tape, 1/2" Sq.
Speaker	60-0000009	1	2 1/2" dia. Quam 24AQ728

IKB-1 CABINET ASSEMBLY PARTS LIST

HARDWARE			
Screw	20-3200001	6	#6-32x1/4" Allen, Button Head, Bl. Oxide
Screw	20-3916001	6	#6-32x1 1/2" Allen, Button Head, Bl. Oxide
Hardware Set	21-1100001	2	
Nut	21-3120001	6	6-32 Hex, CAD
Lockwasher	21-3350001	6	#6 Internal Star
METAL PARTS			
Cover	93-2100008	1	IKB-1
Digibezel	93-2100007	1	905-60 Red Polarized Filter w/ Silkscreen Legend
Cabinet Bottom	93-4100002	1	IKB-1 Rev. C
Cabinet Cover	93-4100003	1	IKB-1 Rev. H
MISCELLANEOUS			
Washer	21-3390001	1	#6x1/16" Fiber, Black
Spacer	21-3600005	6	#6x1 1/16" Round Nylon
Allen Wrench	27-0000001	1	5/64

TRACE CUTS

( ) 1. Refer to the diagrams below and to the right and locate the three (3) traces designated to be cut.

( ) 2. Cut the traces located in Step 1 with a sharp cutting tool; e.g., an XACTO knife.

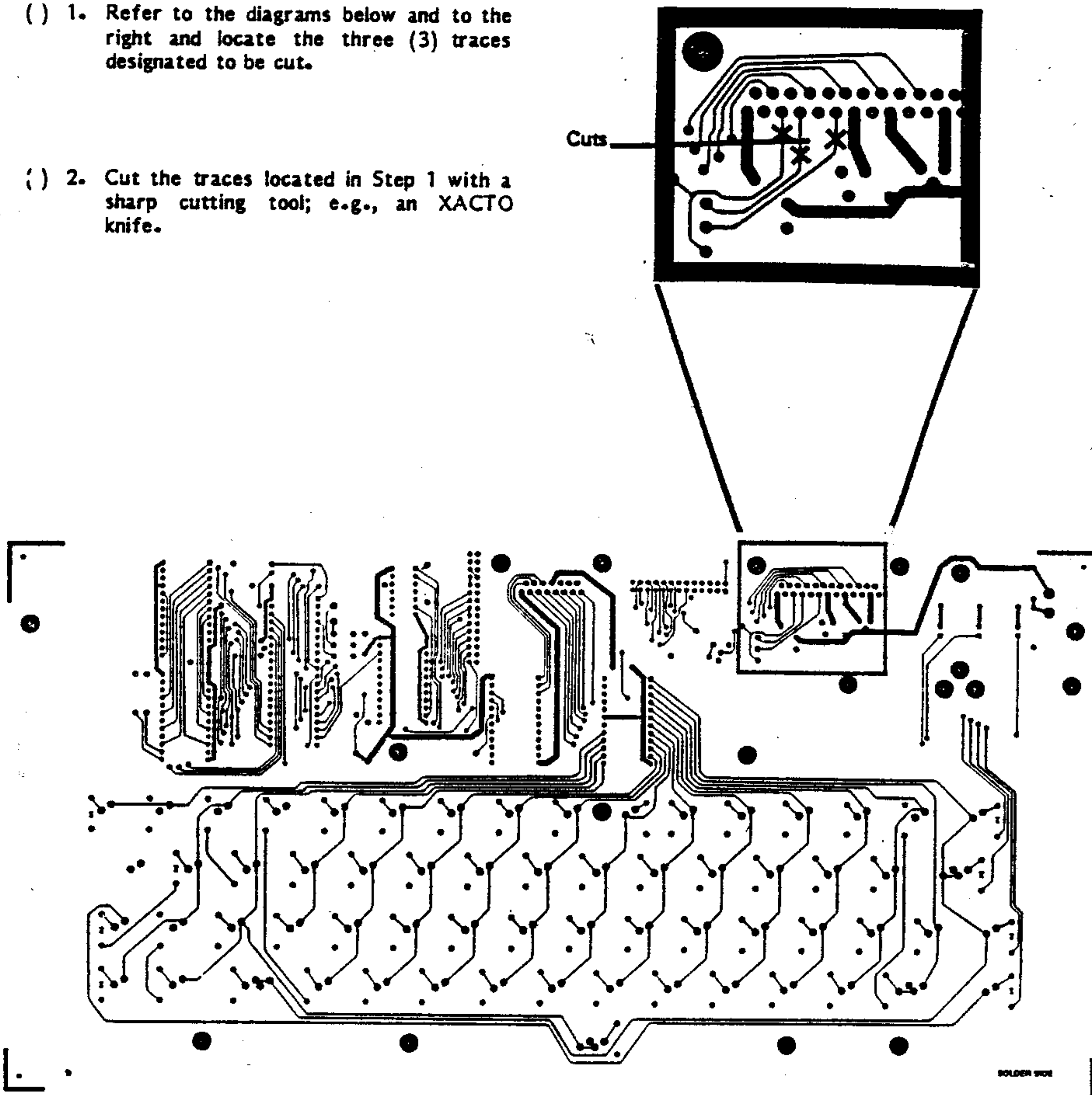


FIGURE 1: Trace Cuts

COMPONENT INSTALLATION

IC INSTALLATION

In the following steps, you will be directed to "install" an integrated circuit at a specified location. In this context, "install" means:

1) Insert the IC into the PC board. Ensure that the IC is oriented correctly.

2) Be sure that all pins are seated in the appropriate holes.

3) Solder pin 1 and the pin at the farthest corner from pin 1. This procedure is followed in order to hold the IC onto the board until the remaining pins are soldered.

You will be instructed when to solder the remaining pins.

The number of pins on a particular IC will be specified in the assembly instruction step (for instance, an 18-pin IC is called out as P18.)

( ) 3. Identify the top, or component, side of the keyboard PC board. All integrated circuits (IC's) will be mounted from this side of the board. Refer to the assembly diagram on this page in order to facilitate IC installation.

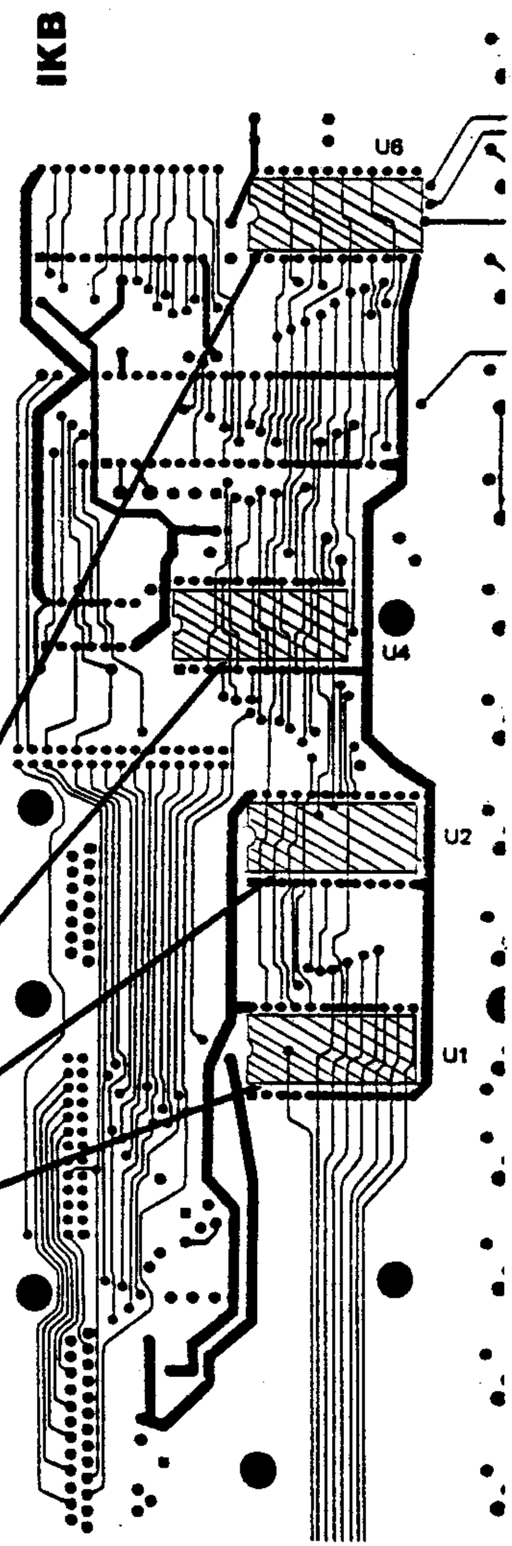
( ) 4. Install the specified IC's at the following locations:

( ) 8212 at U6 (P24)

( ) 8212 at U4 (P24)

( ) 74154 at U2 (P24)

( ) 74154 at U1 (P24)



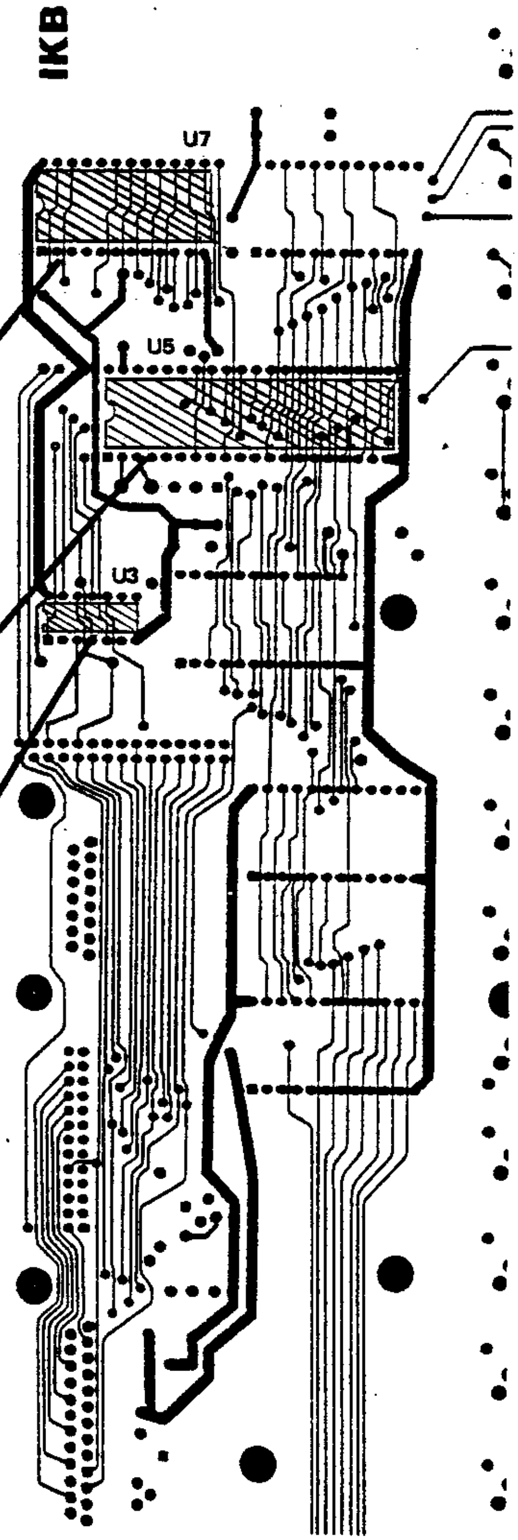
( ) 5. When you are satisfied that all IC's are positioned correctly, solder ALL of the remaining pins on the solder side of the board.

( ) 6. Locate the 24-pin socket and install at U7. Sockets may be braced against the component side of the PC board with a strip of masking tape. Ensure that all of the pins are seated in the appropriate holes. Note that the 4751 chip will be installed later.

( ) 7. Locate the 40-pin socket and install at U5. Note that the 8035 chip will be installed later.

( ) 8. Locate the 14-pin socket and install at U3. The 7404 chip will be installed later.

( ) 9. Ensure that all socket pins are seated in the appropriate holes. Solder ALL socket pins on the SOLDER side of the PC board. Remove the tape holding the sockets to the front of the board.



In the following steps you will be instructed to "install" a particular component. In this context, to install means to "insert the part into the circuit board and bend back the leads". You will be instructed when to solder the components.

RESISTOR INSTALLATION

( ) 10. Install a 1K ohm, 1/4 watt resistor (brown-black-red) at locations:

( ) R17
( ) R16

( ) 11. Install a 10K ohm, 1/4 watt resistor (brown-black-orange) at locations:

( ) R15
( ) R18

( ) 12. Install a 1K ohm, 1/4 watt resistor (brown-black-red) at locations:

( ) R14
( ) R13

( ) 13. Install a 4.7K ohm, 1/4 watt resistor (yellow-violet-red) at R9.

( ) 14. Install a 150 ohm, 1/4 watt resistor (brown-green-brown) at location R8.

( ) 15. Install a 1K ohm, 1/4 watt resistor (brown-black-red) at locations:

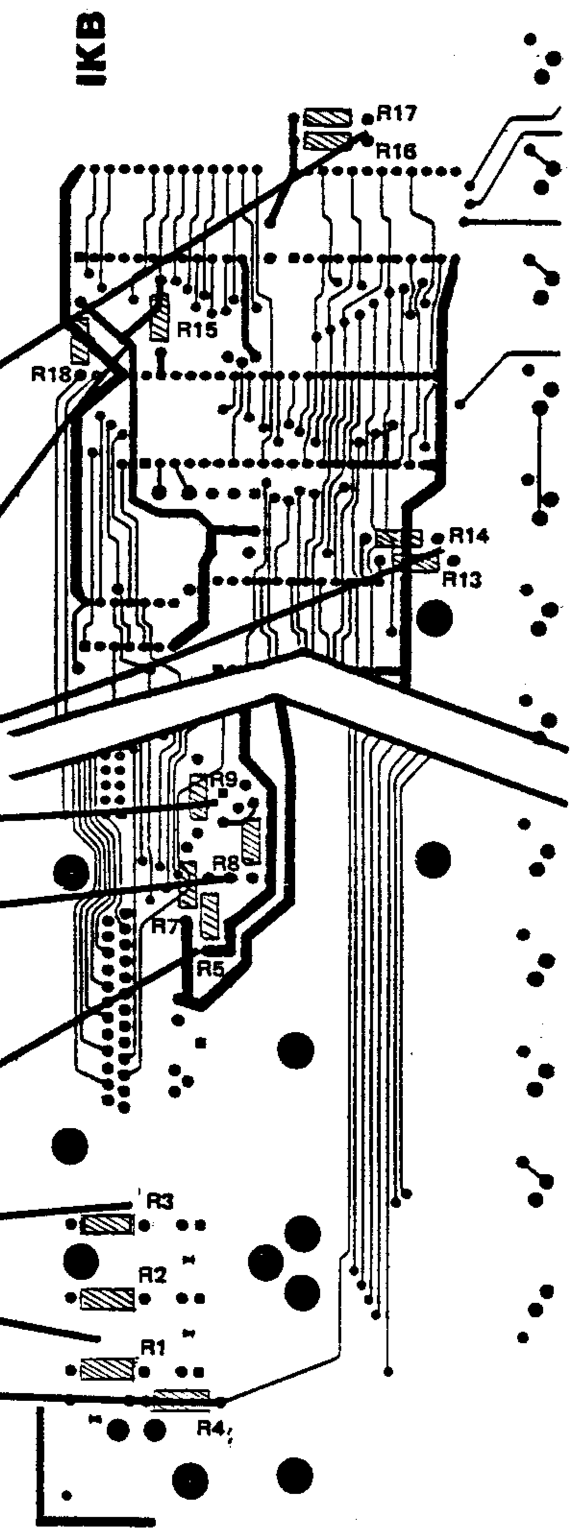
( ) R7
( ) R5

( ) 16. Install an 82 ohm, 1/4 watt resistor (grey-red-black) at locations:

( ) R3
( ) R2
( ) R1

( ) 17. Install a 100 ohm, 1/4 watt resistor (brown-black-brown) at location R4.

( ) 18. Solder all leads and cut off excess lengths.



CAPACITOR INSTALLATION

The tantalum capacitors installed in Steps 21 and 23 are POLARIZED and must be inserted in the correct orientation. The positive lead of the capacitor is marked as such ("+") and should be installed in the SQUARE pads on the PC board.

( ) 19. Locate two (2) 0.1 uF disk ceramic capacitors and install them at locations:

( ) C7
( ) C6

( ) 20. Locate two (2) 20 pF disk ceramic capacitors and install them at locations:

( ) C9
( ) C8

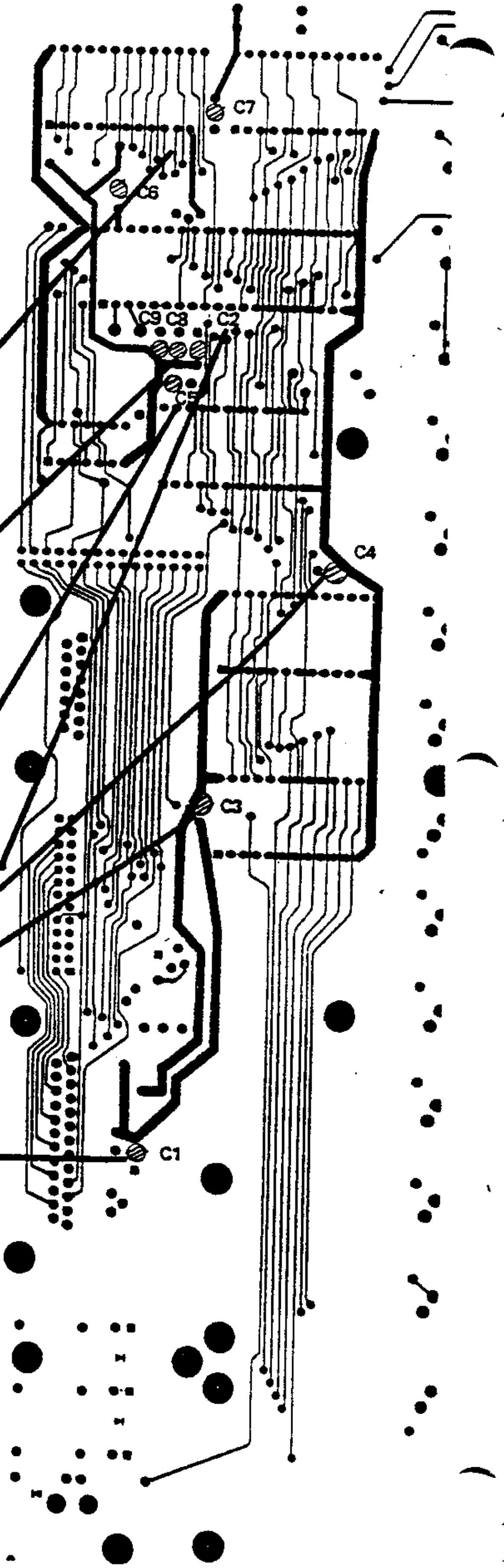
( ) 21. Install a 2.2 uF tantalum capacitor at location C2.

( ) 22. Locate three (3) 0.1 uF disk ceramic capacitors and install them at locations:

( ) C5
( ) C4
( ) C3

( ) 23. Install a 33 uF tantalum capacitor at location C1.

( ) 24. Solder all leads and clip off excess lead lengths. SAVE THE CAPACITOR LEADS; YOU WILL NEED TO USE THEM AS JUMPER WIRES LATER ON.



JUMPER INSTALLATION

Steps 25 - 28 apply ONLY for parallel interfacing (e.g., for the PCS-80/30). If you will be using a serial interface, refer to the jumper instructions in the User Guide of this manual, Section 3.1.2.

The excess lead lengths which you trimmed off the capacitors and resistors serve as jumper wires in the steps which follow. Cut the leads to appropriate lengths, and insert them at the specified locations from the COMPONENT side of the PC board.

( ) 25. Insert and solder a jumper at location JR (to the right of U5). The jumper should connect the center hole to the +5V hole. Clip excess leads.

( ) 26. Insert and solder thirteen (13) jumpers at the locations indicated:

( ) JB	( ) JK
( ) JC	( ) JL
( ) JE	( ) JM
( ) JF	( ) JN
( ) JG	( ) JO
( ) JH	( ) JP
( ) JI	

Clip excess leads.

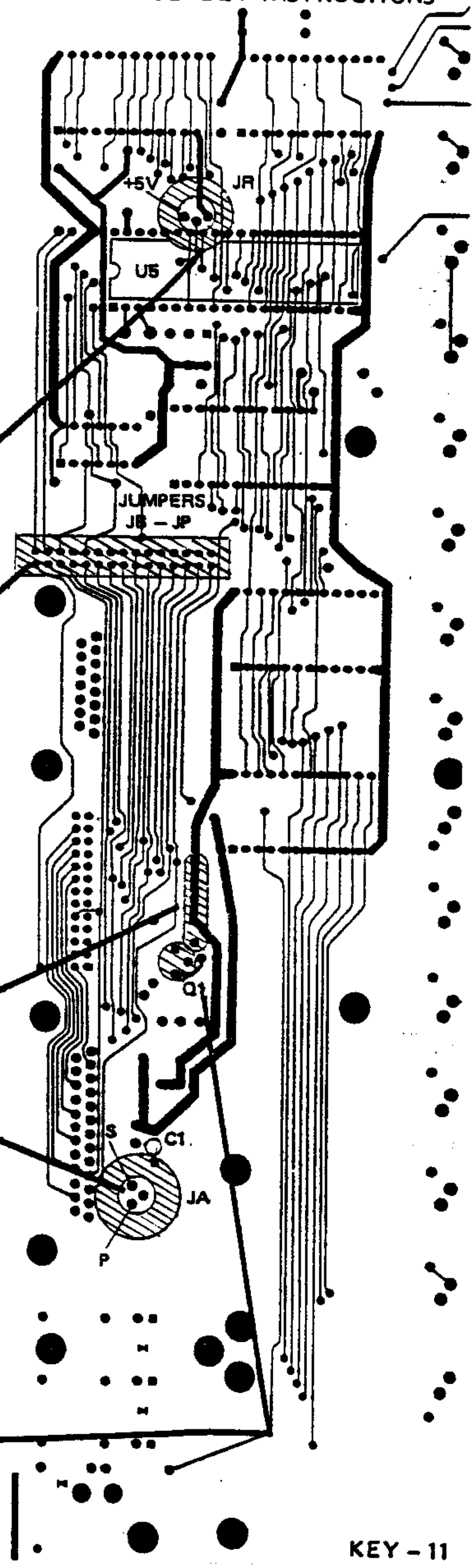
( ) 27. Insert and solder a jumper to the right of Q1, at the location indicated in the diagram to the right. Clip excess leads.

( ) 28. Insert and solder a jumper at location JA (above and to the left of the tantalum capacitor C1). The jumper originates at the plated-through hole in the middle and connects to the hole labeled P. Clip excess leads.

TRANSISTOR INSTALLATION

See Section II, Figure 2-3 for instructions concerning correct transistor orientation.

( ) 29. Insert and solder a 3906 transistor at location Q1. Trim excess leads.



LED INSTALLATION

Three (3) LEDs will be installed at the locations bearing the call-outs "PROG", "SHIFT" and "UC". Refer to Figure 2 to ensure correct LED orientation.

( ) 30. At each of the locations indicated, orient the LED as shown in the figure, slip a #6x7/16 white, nylon spacer over the LED leads and insert the leads into the PC board. The lead in front (directly below the flat face of the LED body) should be inserted into the SQUARE pad on the PC board.

( ) 31. Solder the leads on the SOLDER side of the board while holding the LED assembly in place from the component side of the PC board.

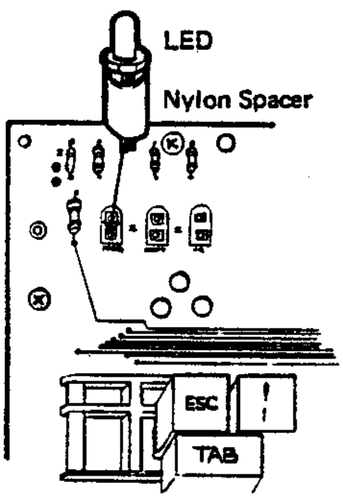


FIGURE 2: LED Installation

CRYSTAL INSTALLATION

( ) 32. Locate the 3M "Magic Tape" enclosed with your kit; cut out a square of tape whose size matches the box designated as "Y1" on the silk screen.

( ) 33. Refer to Figure 3 and trim the crystal leads to 1/2 inch. Bend the leads 1/8" from the body of the crystal.

( ) 34. Install the crystal at location Y1 - as shown in the figure - and solder the leads on the SOLDER side of the board.

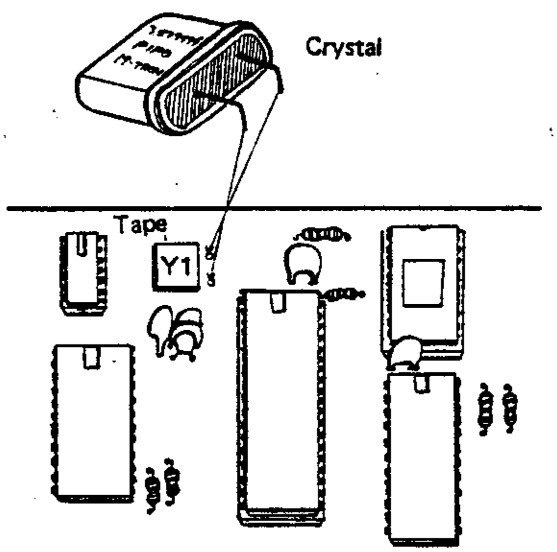


FIGURE 3: Crystal Installation

CONNECTOR INSTALLATION

( ) 35. Locate the 25-pin and 15-pin EIA connectors; check to see that none of the connector pins are bent.

( ) 36. Refer to Figure 4 and install the 25-pin connector at location J2 FROM THE SOLDER SIDE OF THE BOARD.

( ) 37. Install the 15-pin connector at location J3.

( ) 38. Check to see that all pins are seated in the appropriate eyelets, and secure each connector with two (2) phillips 6-32x3/8" screws FROM THE COMPONENT SIDE OF THE BOARD. (See Figure 4.)

( ) 39. Solder all pins (40) on the COMPONENT side of the board.

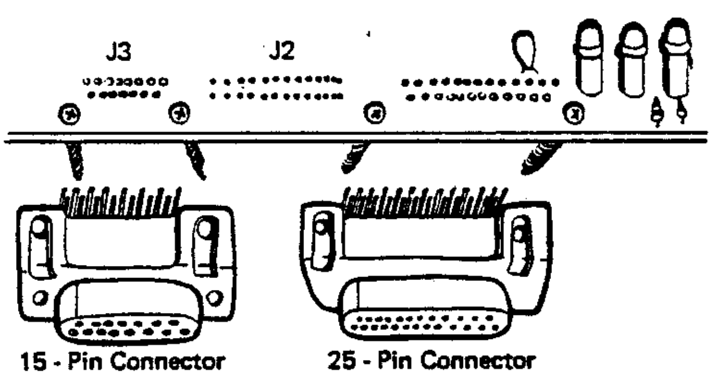
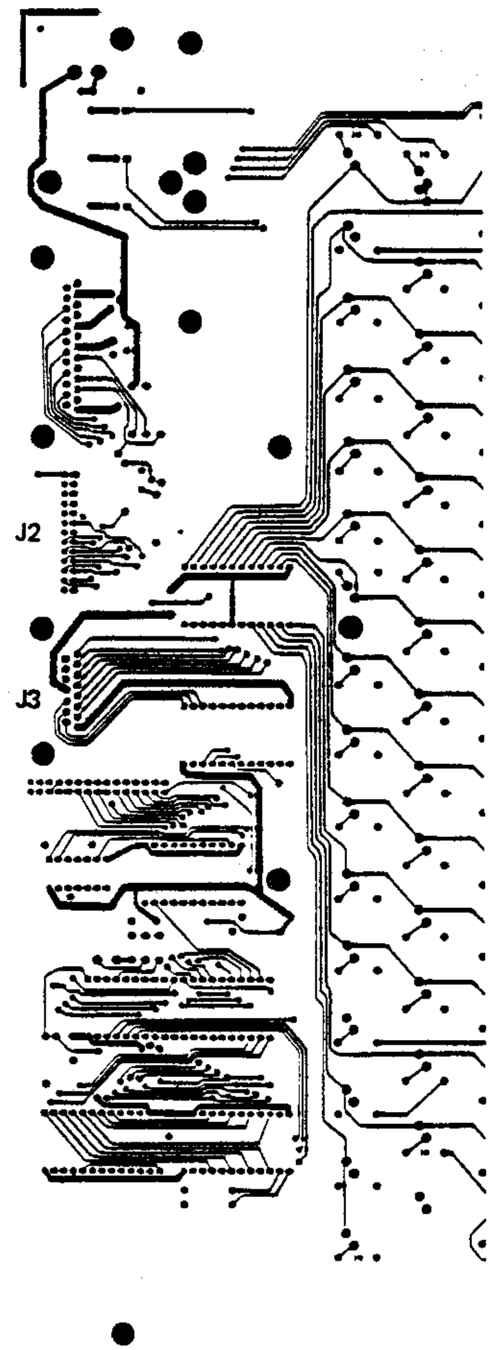


FIGURE 4: Connector Installation



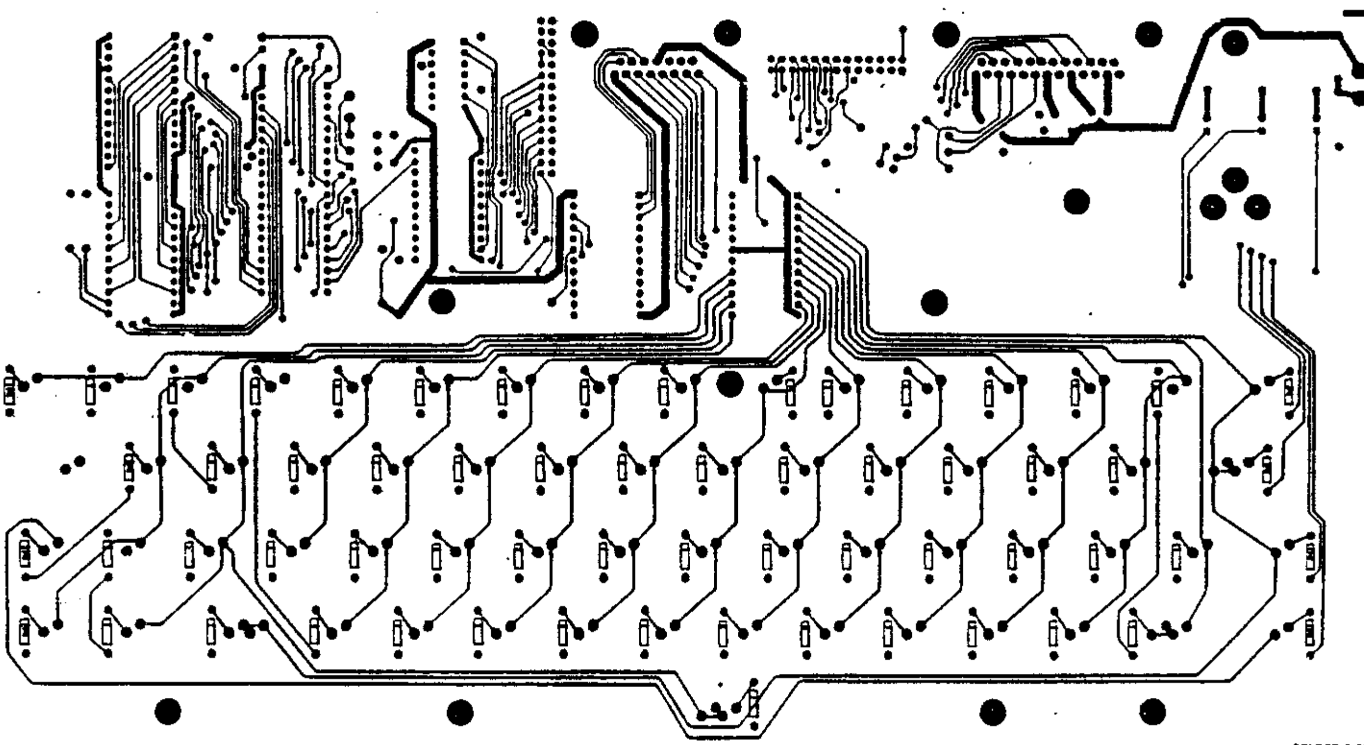
DIODE INSTALLATION

( ) 40. Locate a 1N4148 Diode and install it in the extreme upper left-hand corner of the board at location CR1. Insert the diode from the COMPONENT side of the board. Trim excess leads.

( ) 41. Identify the solder, or bottom„ side of the keyboard PC board. All remaining diodes will be mounted from the SOLDER side of the board. Refer to the Diode Placement Diagram in order to facilitate diode installation.

( ) 42. Insert sixty-two (62) 1N4148 diodes from the SOLDER side of the board, at the locations indicated in the Diode Placement Drawing. The diodes should be mounted flush against the PC board. SOLDER AND TRIM THE DIODE LEADS FLUSH AGAINST THE PC BOARD. MAKE YOUR SOLDER JOINTS AS SMOOTH AS POSSIBLE.

IMPORTANT: All diodes are polarized and installed in a specific orientation. The "cathode" end is marked with a colored band and is represented on the Diode Placement Diagram in the manner illustrated below. Note that in this instance, all the diodes are orientated in the same direction.



KEYBOARD INSTALLATION

( ) 43. Install the keyboard to the COMPONENT side of the PC board; ENSURE THAT ALL KEYBOARD PINS (124) PROTRUDE TO THE SOLDER SIDE OF THE BOARD. Align the keyboard so that the three (3) black plastic feet on the rear of the keyboard project through the metal-rimmed alignment holes on the solder side of the keyboard (see Figure 5). Solder the keyboard pins (124).

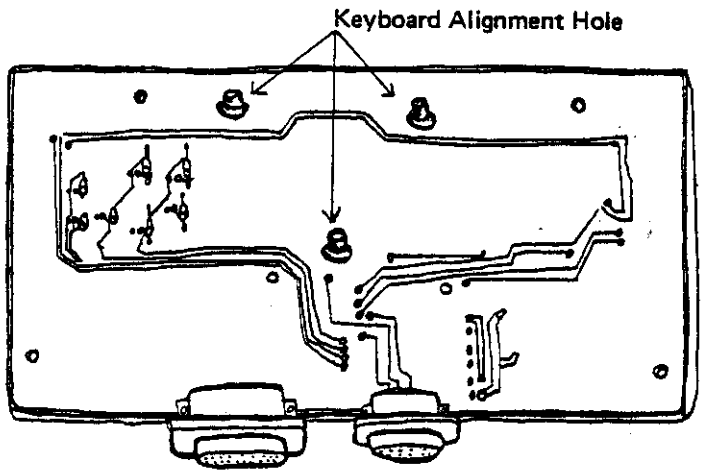


FIGURE 5: Keyboard Installation On PC Board

SPEAKER INSTALLATION

( ) 44. Solder a 1 1/2-inch length of orange wire onto each of the two crimp terminals on the speaker.

( ) 45. Position the speaker on the SOLDER side of the PC board as indicated in Figure 6. To install the speaker onto the board, insert a 6-32x3/8" screw in each of the three holes indicated in the figure. Each screw is inserted from the top (COMPONENT SIDE) of the board, through two fiber washers, through the speaker, and is secured with an internal star lockwasher and 6-32 nut. Tighten the speaker mounting screws.

( ) 46. Solder the free end of each wire installed in Step 44 onto the eyelets indicated in Figure 6.

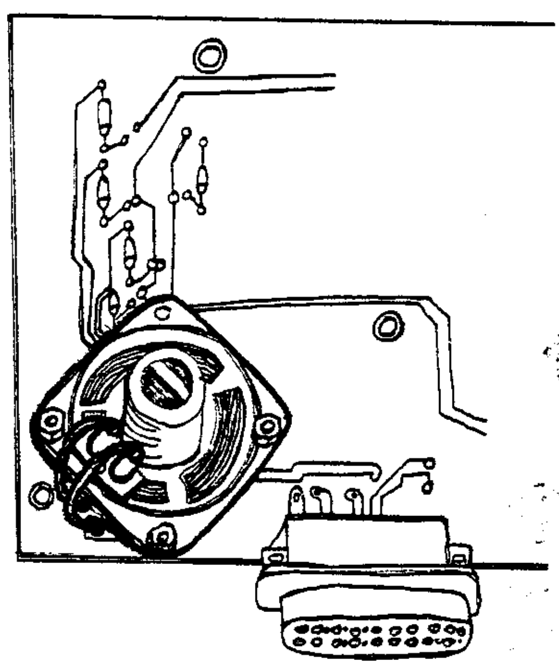


FIGURE 6: Speaker Installation

INTEGRATED CIRCUIT INSTALLATION

( ) 47. Insert the specified IC's into the appropriate sockets at the locations indicated. Take care to orient the chips correctly prior to insertion; i.e., pin 1 is in the upper left hand corner.

( ) Install the 4751 chip at U7
( ) Install the 8035 chip at U5
( ) Install the 7404 chip at U3

SET THE PC BOARD ASIDE AND PROCEED WITH CABINET ASSEMBLY

CABINET ASSEMBLY

( ) 48. Cover your work surface with a soft cloth so as not to scratch the paint on the keyboard cover plate.

( ) 49. Position the cover plate on your work surface with the lettering face-down.

( ) 50. Place the four green bezel pads, sticky side down, at each corner of the rectangular window cut-out, as indicated in Figure 7.

( ) 51. Locate the black plastic window frame, or BEZEL, and install the bezel around the window cut-out, inserting the four bezel feet from the outside of the cover plate so that they protrude to the inside of the plate.

( ) 52. Peel the sticky backing off both sides of the polarized filter, and position the filter face down at the window cut-out, centered on the bezel; the label should face the front of the cover panel.

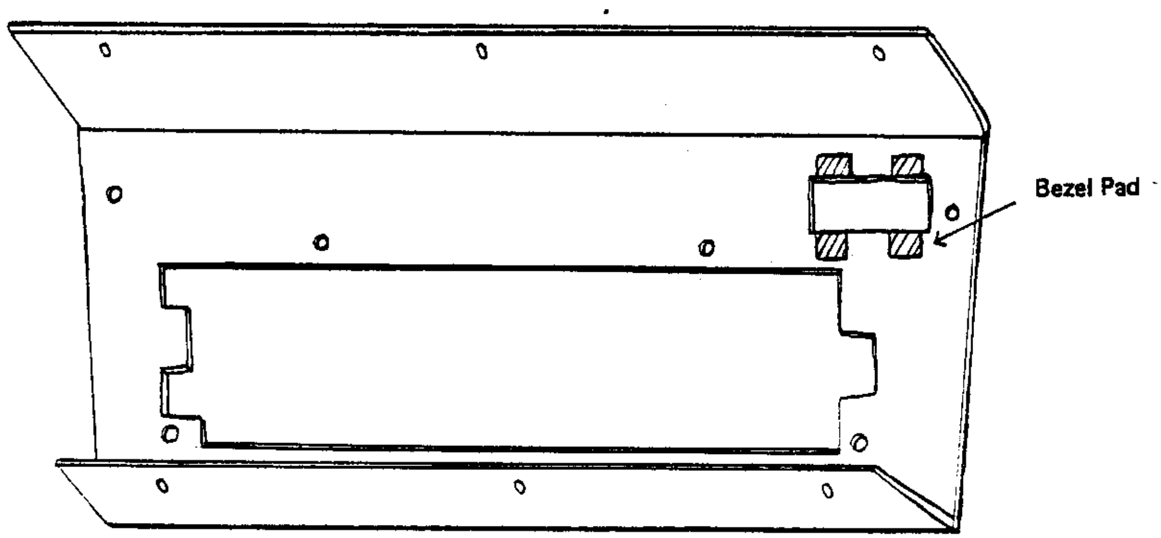


FIGURE 7: Front Panel Bezel Installation

( ) 53. Locate the black plastic bezel frame; slip the cover onto the bezel so that the four bezel pins project through the holes at the corners of the bezel frame. See Figure 8.

( ) 54. Locate four black curved plates, each containing a hole in its center. Press-fit one plate over each of the bezel pins until the plates snap onto the frame. See Figure 8.

( ) 55. Turn the keyboard cover plate face-up, and check to see that the window is installed securely.

( ) 56. Install six (6) 6-32x1 1/2" black screws from the front of the cover plate to the inside, at the positions indicated in Figure 8 (i.e., the screws designated as A, B, C, D, E, and F).

( ) 57. Slip six (6) white plastic spacers over the screws installed in Step 56.

( ) 58. Stand the keyboard cover panel on end to maintain the screws and spacers in place.

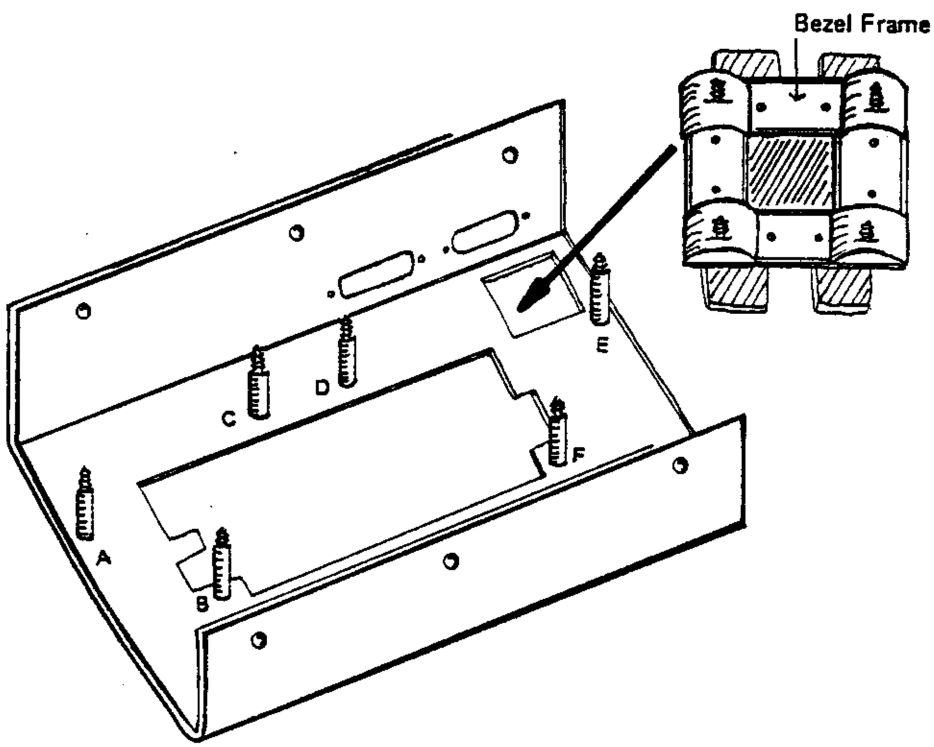


FIGURE 8: Filter Window Assembly

( ) 59. Refer to Figure 9; align the PC board and cover plate as indicated in the figure, and press the cover plate screws designated as C and D into the corresponding metal-rimmed eyelets on the PC board. Press-fit the four (4) remaining screws from the cover plate into the appropriate holes on the PC board.

( ) 60. Locate the screw designated as C and, on the solder side of the board, install a black nylon washer at this location (to prevent scratching the solder traces surrounding this screw). Add an internal star lockwasher and secure with a 6-32 nut.

Tighten the nut by securing the head of the screw (on the outside of the cover plate) with the Allen wrench supplied in your kit; tighten the nut (on the SOLDER side of the PC board) with a SPIN-TIE wrench.

( ) 61. To the five remaining screws (A, B, D, E and F), add ONLY an internal star lockwasher; secure these five screw assemblies with a 6-32 nut. Tighten the nut as described in Step 60.

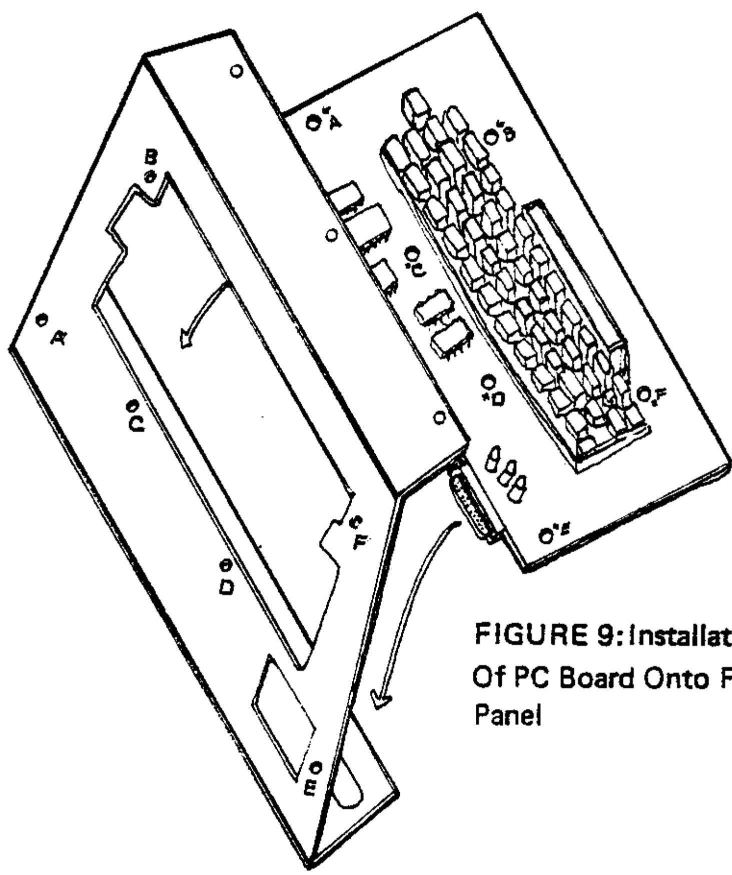


FIGURE 9: Installation Of PC Board Onto Front Panel

( ) 62. Locate the black plastic 25- and 15-pin connectors protruding through the cover panel. Insert, from the outside of the panel, four (4) 6-32x1/4" Allen screws on both sides of the two connectors. See Figure 10.

( ) 63. Install, from the inside of the cover panel, a small, gold, split-ring washer and a 6-32 hex nut on each screw installed in Step 62.

Hold the nut in place (from the inside of the panel) with a pair of pliers; tighten with a spin-tie wrench from the outside.

( ) 64. Locate the bottom of the keyboard chassis assembly and fit this piece under the top of the cover assembly as illustrated in Figure 11. Secure the frame with six (6) 6-32x1/4" Allen screws placed in the available holes. Tighten the screws with the Allen wrench.

( ) 65. Locate the four (4) rubber feet, and snap them into place at the four corners of the chassis bottom.

ASSEMBLY OF YOUR KEYBOARD IS COMPLETED.

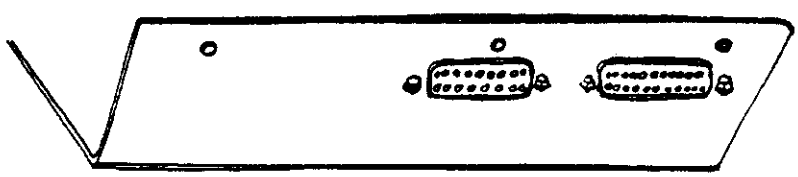


FIGURE 10: Installation Of Screws At Connectors

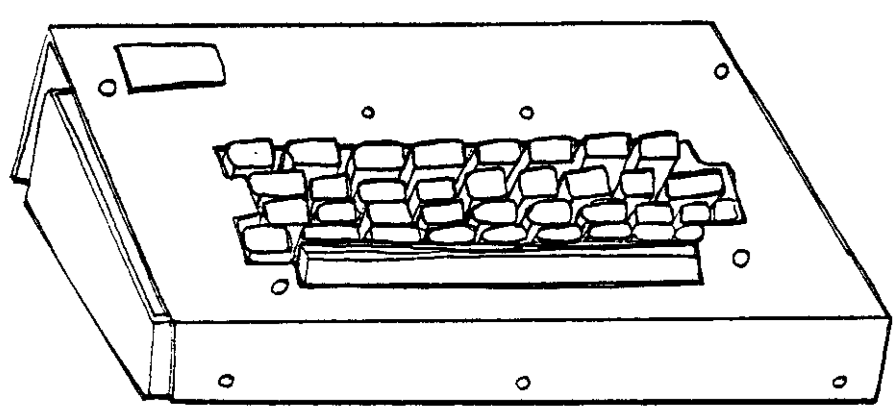


FIGURE 11: Chassis Assembly

KEYBOARD USER GUIDE

3.1 BOARD CONFIGURATION

Since the keyboard may be used as a serial or parallel device, it is important that the circuit board jumpers be properly configured for the type of hardware interface to be used. The jumper areas are located on the printed circuit board above the keyboard assembly. Each area is clearly marked on the board.

3.1.1 Parallel Port Configuration

If the keyboard is to be used as a parallel input device, the following jumper configuration instructions apply. Figure 3-1 shows the proper configuration when using the IMSAI MIO parallel port. Assembled units are shipped already jumpered for an MIO parallel port.

1) Install a jumper in each of the position JG, JH, JI, JK, JL, JM, JN, and JO, to set-up the eight parallel data lines.

2) If an IMSAI MIO parallel port is used, install a jumper at locations JE and JF to configure the handshake lines.

   When other types of parallel interface boards are used, it will be necessary to determine the type of handshake signals required. Refer to Appendix A for the configuration of the handshake lines before continuing.

3) Install a jumper in location JA from the bottom, center pad to the pad marked "P" (left).

4) Install a jumper in location JR from the center pad to the pad marked "+5V" (top).

5) If an IMSAI MIO parallel port is to be used, install jumpers in locations JB and JC.

   When other types of parallel interface boards are used and it is desired to allow the keyboard to be programmed from an output port, refer to Appendix B to configure the keyboard's control port lines before continuing.

6) Make certain that all jumpers are correctly configured and proceed with Section 3.2.

3.1.2 Serial Port Configuration

If the keyboard is to be used as a serial input device, the following jumper configuration instructions apply. Figure 3-2 shows the proper configuration when using the IMSAI SIO board or the IMSAI MIO serial port.

1) Install a jumper in location JQ.

2) Install a jumper in location JR from the center pad to the pad marked "+5V" (top).

3) Install a jumper in location JA from the bottom, center pad to the pad marked "S" (right).

4) Install two jumpers as shown in Figure 3-3.

5) If the IMSAI MIO serial port is used, no other jumpers are required. Make certain all jumpers are correctly configured and proceed with Section 3.2. If the SIO is used, a jumper must be installed and a trace cut on the SIO as shown in Figure 3-4.

   If the TTL level serial output is to be used, install a jumper at location JI.

3.2 EXTERNAL INTERFACE CONNECTION

Once the circuit board has been properly configured for serial or parallel operation, the external interface connections can be made.

NOTE: Do not attach the keyboard to an interface for which it has not been configured or damage to the circuit may result.

3.2.1 IMSAI Parallel/Serial Interface (IMSAI MIO, SIO)

If an IMSAI MIO or SIO interface board is used, an IMSAI cable A and an IMSAI cable C will make interface connection straightforward.

1) Attach one 25 pin male end of Cable C to the 25 pin J1 connector at the rear of the keyboard cabinet.

2) Attach the remaining end of Cable C to the 25 pin connector of Cable A.

3) If the keyboard is configured for parallel operation, attach the remaining end of Cable A to the PIO1 or PIO2 connector on the MIO board to complete the parallel interface connection.

   If the keyboard is configured for serial operation, attach the remaining end of Cable A to the serial connector of the MIO or SIO board to complete the serial interface connection.

4) The keyboard is now ready to be used. Proceed with Section 3.3.

3.2.2 Parallel Interface (General)

If the IMSAI MIO parallel port is not used, the keyboard's parallel interface signals will have to be mapped to the appropriate lines of the interface board. Table 3-1 lists the signal lines used in the parallel mode. All signals are available at the 25 pin J1 connector at the rear of the keyboard cabinet.

TABLE 3-1
Parallel Mode Signals (J1 Connector)

Pin #	Signal Name	Description
22	DO7	Data bit 7
21	DO6	Data bit 6
20	DO5	Data bit 5
19	DO4	Data bit 4
18	DO3	Data bit 3
17	D02	Data bit 2
16	DO1	Data bit 1
15	DOO	Data bit 0
24	/RDY	Ready (active low)
23	/ACK	Acknowledge (active low)

3.2.3 Serial Interface (General)

If the IMSAI SIO or MIO serial port is not used, the keyboard's serial interface signals will have to be mapped to the appropriate lines of the interface board. Table 3-2 lists the signal lines used in the serial mode. All signals are available at the 25 pin J1 connector at the rear of the keyboard cabinet.

TABLE 3-2
Serial Mode Signals (J1 Connector)

Pin #	Signal Name	Description
16	DO1	TTL Data Out
2	EIA Data Out	Data Out EIA level
20	+5V Pullup	

3.3 KEYBOARD OPERATION

The keyboard will operate in two basic modes of operation: program mode and data entry mode. The program mode allows the keyboard options to be programmed either directly from keyboard commands or from an output port. The data entry mode is the standard data input mode of operation and allows data to be entered to the computer. Keyboard operation in the data entry mode is determined by the option selected in the program mode.

3.3.1 Program Mode (from Keyboard)

The keyboard options may be programmed directly from keyboard commands. Programming is initiated by depressing the "PROG" key located in the upper right corner. The keyboard will verify entry into the program mode with an audible beep and the PROG LED lit.

Once the keyboard is in the PROGRAM mode, a valid command typed on the keyboard will select a particular keyboard option. A number of commands may be typed in sequence to select more than one keyboard option where applicable. The last character of each valid command will be confirmed with an audible beep.

When all features have been selected, the program made is terminated by pressing the "END MODE" key, located to the left of the "PROG" key.

Valid commands are as follows:

RQ	places the keyboard in parallel mode
R1	selects 110 baud serial output
R2	selects 150 baud serial output
R3	selects 300 baud serial output
R4	selects 600 baud serial output
R5	Selects 1200 baud serial output
R6	Selects 1800 baud serial output
R7	Selects 2400 baud serial output
D	selects DEFAULT MODE ... Parallel outputs upper case only, encoded outputs
U	selects UPPER CASE ONLY mode. Operation is similar to TTY keyboard. All alpha character output in upper case. Shift key controls upper case for all non-alpha characters.
L	enables LOWER CASE characters. Operation is similar to typewriter keyboard. Shift key control upper case for all characters. SHIFTLOCK key will lock all alpha characters to upper case. SHIFTLOCK may be released by depressing the SHIFT key.

SAB	substitutes any ASCII character, B, for any other ASCII character, A. The keyboard will output the character, B, whenever the key, A, is typed. The resulting character, B, is unaffected by "CTRL", "SHIFT" or "FLAG". To cancel the current substitution, type "S" followed by two blank spaces.
E	sets the keyboard in normal ENCODED mode. In this mode, the keyboard is scanned using a N-key Rollover algorithm and characters are output in Standard ASCII format. The state of the flag key is encoded as the high order bit of any character sent.
V	places the keyboard in verbatim or unencoded mode. When the END-MODE key is depressed, the keyboard will start outputting a continuous stream of bytes indicating the complete state of the keyboard. This may be used to transmit multiple key depression information for music or games. For details of the unencoded format reference Section 3.3.3

3.3.2 Program Mode (from Computer)

A number of the basic keyboard options may be programmed from an 8212-type parallel output port.

When the keyboard is configured for parallel operation with the IMSAI MIO parallel port, the keyboard may be programmed from the MIO's PIO1 or PIO2 output ports.

Programming is achieved by outputting a series of bytes to the keyboard. Only one bit per byte is taken as part of the command string. When an MIO parallel port is used, only output bit 0 is taken as the valid command bit.

A command string consists of from one to four bits and always terminates with a 0. Valid command strings for use with the MIO output port are (X's are "don't cares"):

XXXX XXX0	beep the speaker
XXXX XXX1 XXXX XXX0	place keyboard in default mode
XXXX XXX1 XXXX XXX1 XXXX XXX0	set lower case mode
XXXX XXX1 XXXX XXX1 XXXX XXX1 XXXX XXX0	select unencoded (verbatim mode)

Once a byte is output to the keyboard, the next byte of sequence must be output within 4 milliseconds, or the input routine will time-out and return, making no programming changes.

3.3.3 Data Entry Mode

Once the keyboard options have been selected and the END MODE key has been depressed, the keyboard will operate in the Data ENTRY MODE.

ENCODED: If the "E", encoded, option is selected, any key or sequence of keys typed on the keyboard or external keypad (optional) will cause the correspondign ASCII code to be sent to the computer.

In the encoded mode, continuous depression of a key will invoke the AUTO REPEAT function, causing the character to be output continuously until the key is released.

Selection of the "U", upper case only option, will cause the SHIFTLOCK LED to light.

UNENCODED: If th "V" unencoded option is selected, the keyboard will output a continuous series of bytes which will provide the user with a continuously updated map, indicating the state of the keyboard array. (The state of the external keypad is excluded from the map.)

Each byte which is output from the keyboard is in the following form:

D7 D6 D5 D4	D3 D2 D1 D0
Row State	Row Number

The low order four bits contain a binary encoded row number (0 - 15 decimal), and the high order four bits indicate the state of that row.

A "0" in any of the bit positions D7 - D4 indicate that the corresponding key(s) of that row are depressed. Likewise, a "1" indicates that the key(s) is in the up position.

Table 3-3 lists the keyboard array by row number and bit position (D7 - D4).

The keyboard will successively output the state of each row in the above format as long as the "V" unencoded mode is selected.

TABLE 3-3
Unencoded Mode

Row #	D7	D6	D5	D4
	Row State			
0	RSHFT	CTL	TAB	ESC
1	FLAG1	SHFTLK	BRK	LSHFT
2	2	A	Q	!
3	R	S	W	"
4	C	D	E	#
5	V	F	R	$
6	B	G	t	%
7	N	HI	Y	&
8	M	J	U	'
9	<	K	I	(
10	>	L	O	)
11	?	+	P	0
12	=	†	§	.
13	SPACE	BS	?	LF
14		DEL	CR	
15		MODE		ENDENTRY

3.4 EXTERNAL KEYPAD

Provision is made for an external cursor control keypad and a numeric entry keypad. The scan lines for these keypads are brought out to connector J3. The connections for each key are shown in Table 3-4. To retain N-key rollover, it in necessary to place a diode in series with each switch with the cathode connecting to the scan line (/S10 thru /S15). Therefore, each key will consist of a connection from one of the scan lines, /S10 thru /S15, then to the cathode of a small signal diode. The anode is then connected to one side of the switch and the other side of the switch connects to the appropriate bit line, bit 0 thru bit 3.

TABLE 3-4

	Bit 0	Bit 1	Bit 2	Bit 3
/S10	9	8	7	K=Cursor Up
/S11	6	5	4	H=BS (Cursor Left)
/S12	3	2	1	L=Cursor Right
/S13	0	Tab	(home)	Line Feed (Cursor Down)
/S14	.	U	T	E
/S15	,	N(XMIT)	Del	D

KEYBOARD THEORY OF OPERATION

4.1 KEYBOARD HARDWARE

The IMSAI keyboard uses an on-board 8035 processor to handle all keyboard control functions. The keyboard control firmware is resident in the 4751 ROM at U7.

The control sequence is completely dependent on the firmware program, described in Section 4.2. The 8212 at U6 serves as an address latch during instruction fetch cycles from the 4751 ROM.

The two 74154, 4-line to 16-line decoders, at locations U1 and U2 allow the processor to scan the keyboard array and optional external keypad. Keyboard data is output to the parallel interface through the 8212 latch at U4.

4.1.1 Instruction Fetch

The 8035 processor executes those instructions stored in the 4751 PROM at U7. During an instruction fetch cycle, the 8035 outputs the 12 bit address of the next instruction to be executed on its Bus Lines (D0 - D7), and Port 2 (bits 0 - 3). The high order address bits A8 - A11 are internally latched and remain stable on the output lines of Port 2 (bits 0 - 3). The low order address bits are latched into the 8212 at U6 using the ALE strobe from the 8035 processor.

Once the address is present and stable at the address inputs of the 4751 ROM, the processor will drive its /PSEN strobe active low to enable the outputs of the 4751 ROM. Data is then input to the processor through its Bus lines D0 - D7 on the rising edge of /PSEN.

4.1.2 Keyboard Scan

The keyboard array consists of a diode matrix, 16 columns wide and 4 key positions (rows) to a column. To identify a key closure, the 8035 processor will output a column number to the 74154 at U1 through port P1, bits 0 - 3. The column number is decoded by the 74154 and will drive one of its 16 output lines active to place a low logic level along the selected column line of the keyboard array.

The 8035 processor then reads the state of the 4 row lines through port 2 bits 4 - 7. Any key closure in the selected column will appear as a "O" in one of the four bit positions (rows).

By successively scanning each column in this manner, the 8035 processor can key closures in the entire keyboard array.

If an external keypad is used, the same scanning technique is used with the 74154 at U2.

4.1.3 Display LED's

Each of the three display LED's are turned on by the 8035 processor by outputting one of three column select codes to the 74154 at U1. The corresponding output of the 74154 are used to drive the three LED's. Note that for a LED to appear lit to the user, it only has to be on for a brief interval since the period between successive "on" times cannot be detected by the user.

4.1.4 Speaker

An audible speaker beep is created by the 8035 processor by successively outputting a series of 1's and 0's to the speaker through output port one, bit 5. The pitch or frequency of the tone is determined by the rate of repetition.

4.1.5 Character Output

Characters to be output from the keyboard are latched into the 8212 at U4 from the 8035's Bus Lines on the rising edge of the processor's /WR strobe. The outputs of the 8212 directly interface to the external input port when the keyboard is operating in parallel mode. Parallel handshaking is achieved using the 8035 port 1, bits 6 and 7, as /ACK and /RDY. The 8035 outputs a "1" to bit 7 of port 1 when a character is ready to be input to the computer. Bit 6 of Port 1 is then polled to determine when the computer has read the character.

When the keyboard is used in the serial mode, the serial data appears on bit D0 of the 8035's Bus and is latched into the 8212 at U4. The DO0 output of the 8212 is then used to provide the TTL serial data line out to the interface. The DO0 line of the 8212 2II also drives the base of Q1 so that EIA level serial data appears at the collector of Q1 (J1 pin 2).

4.1.6 Program Lines

When an output port is used to program the keyboard, the data appears at the T0 input of the 8035. T0 is a general purpose test input and in this case allows the 8035 to input the sequence of tests which comprises the command strings.

Handshaking is achieved by using the T1 input of the 8035 as a ready line from the interface. An acknowledge signal is generated with an output line from the 74154 at U2. The processor will place a IFH on Port 1 bits 0 - 4, then, on the next cycle, will place a 00 H on these same bits. This causes U2 - 17 to toggle resulting in the desired acknowledge signal (J1 - 11).

4.2 KEYBOARD SOFTWARE

4.2.1 Initialization

On startup of the 8035, all interrupts are disabled and the chip is started at location 0. The program then clears most of RAM, initializes the timer, turns on the timer interrupt, and enters a wait loop which performs various functions, such as turning on the LED's, while waiting for a signal from the interrupt routine to initiate keyboard scans. I/O routines handling communication with the computer are called from the main loop.

4.2.2 Timer

The timer interrupt is based on a resettable 134.1 microsecond timer clock which is derived from the 3.58 MHz system crystal. Three processes are timed by the interrupt routine: (1) keyboard scans, which are initiated every 10 to 14 milliseconds after the interrupt routine sets the byte SCANFLAG; (2) serial output, which is handled directly by the interrupt routine; and (3) the loudspeaker beeps, which are also handled directly by the interrupt routine. The principal function of the interrupt routine is to time serial output accurately; for this reason, each interrupt begins with a delay loop (FUGLUP) which precisely times the resetting of the timer clock. The length of the delay is looked up in a table CKFUDGE which is indexed by the baud rate index RATE. Likewise, the timer is set to a value looked up in the table CKDIV, again indexed by RATE. This sets up the basic interrupt rate. Serial output is initiated by the HANDSHAKE routine by putting a data byte in RSERCHAR and setting RBITNUMBER to 11. The interrupt routine, upon seeing a non-zero value in RBITNUMBER, starts counting down from the main interrupt rate to the baud rate (by a value in CKBIT). Each time the counter goes to zero, the rightmost bit of RSERCHAR, shifted right, or a stop or start bit, is placed on the BUS outputs of the 8035, RBITNUMBER is decremented, and the clock divider is re-initialized.

4.2.3 Speaker

The loudspeaker beep is initialized from several places in the program by setting RBEEP to some nonzero value. Each time the initial timer routine sees a nonzero value of RBEEP, it complements bit 5 of P1 and decrements RBEEP. Since the basic timing rate varies for higher baud rates, the beep is higher in pitch when the baud rate is 1800 or 2400 baud, and slightly lower when for parallel output.

4.2.4 Main Loop

The main loop of the program alternately checks various conditions which turn the indicator lights on, and calls a series of routines which handle keyboard encoding and data communications. It should be noted that whenever a LED is flashed, the program enters a wait loop so that the light is long enough that it can be seen. This has an effect on the timing of non-interrupt driven processes, such as unencoded scans and RDY-ACK handshaking with the computer. The other processes in the main loop are HANDSHAKE, which initiates transmission of a byte to the computer, CHECKT1, which handles control (programming) information coming from the computer, CHECKPROG, which looks at the PROG/END-ENTRY keys to set or clear PROGFLAG, and CHECKSCAN, which will initiate a scan of the keyboard when the interrupt routine has set SCANFLAG.

4.2.5 Handshake

HANDSHAKE functions entirely differently in serial and parallel mode. In serial mode, it looks for the FULL flag, which is set by SCAN or DOUNENC to indicated that a byte to be transmitted is in BUFF. If FULL is set, it clears FULL, transfers the data byte from FUFF to RSERCHAR, and sets RBITNUMBER to 11 to signal the interrupt routine to start transmitting the character. In parallel mode, on the other hand, the routine places the data byte on the BUS, sets P1 bit 7, which is the RDY line going to the computer, and waits for P1 bit 6, the ACK line, to become true. When ACK becomes true, RDY is turned off. In the current routine, the situation is actually a little more complicated; after a timeout delay, RDY is turned off whether ACK appears or not. Also, an extra check for ACK going away immediately after RDY is turned off speeds up handshaking if the computer responds quickly or if RDY is jumpered to ACK.

4.2.6 CHECKT1

CHECKT1 checks for programming signals coming from the computer. The T1 input to the 8035 chip is used as a RDY input, T0 is used as a data bit, and an acknowledge is generated using one of the multiplexer outputs. The program works by counting 1's on the T0 line when T1 goes true. It exits without doing anything if too many (more than 3) 1's are seen in a row or if more than about 3 milliseconds elapse between 1's. A normal control message ends with 0. The meanings of the various legal sequences are defined in the programming page of the manual.

4.2.7 CHECKPROG

CHECKPROG sets PROGFLAG to 1 when the PROG key is depressed, if PROGFLAG is currently 0. The effect of this is to cause a branch from the scan routine to PROGRAMMIT, which uses input characters to setup other values for PROGFLAG. On subsequent entries to PROGRAMMIT, a 4-way branch on the value of PROGFLAG will be used to interpret subsequent characters in a command string. Note that at the point of entry to PROGRAMMIT, a character is freshly encoded, that is, shift, control and flag do not effect its value. If PROGFLAG is 4, the current mode is "enter character which will be substituted for some key", which has to be handled by a special routine later in SCAN. When a particular command sequence is completed, PROGFLAG is reset to 1 and the speaker is beeped. Note that some of the programming routines are also used by the external-programming routine CHECKT1, which calls REMOTESEL. In this case, if PROGFLAG is already 0, it is not set to 1.

4.2.8 CHECKSCAN

CHECKSCAN works by evoking the N-key rollover encoding routine SCAN whenever SCANFLAG is set and VERBFLAG is false. SCAN works as follows: A map of keys which are currently believed to be depressed is maintained in the array OLDKEYS. Scanning consists of reading in succession all 22 4-bit scan rows of the keyboard matrix (including the external keypad), packing the nibbles into 8-bit bytes, and comparing the input bytes with the corresponding entry in OLDKEYS. If a transition is seen, scanning stops, the row of the matrix, the bit number of the rightmost different bit, and whether the change is up or down are recorded. On the next scan, the resulting flags ONBIT and OFFBIT are checked. If the corresponding key is STILL down, or still up, respectively, the transition is considered debounced. In the case of a downward transition, the bit for the corresponding key is cleared (down keys are 0's) and encoding begins. In the case of an upward transition, the bit for the corresponding key is set in OLDKEYS. In this way, only transitions in the keyboard matrix initiate encoding and transmission of characters — any number of keys can be down, and a new depression will transmit a new character.

4.2.9 Encoding

Encoding is straightforward. An index to an ASCII table ASCTABLE on page 3 of the program is computed, and the basic ASCII code corresponding to the key is looked up. At this point PROGFLAG is checked to see if the character is to be input to the programming routine rather than to be transmitted. After that, if it is to be transmitted, the shift key and the shiftlock bit of MODE (set or cleared earlier) are checked to determine if the character is to be shifted. Likewise, the control key is checked if appropriate to determine if the character is to be turned into a control character. At this point, if PROGFLAG is equal to 4, the character is saved as a substitute character, and not transmitted. Otherwise, the character is placed in BUFF, FULL is set to tell HANDSHAKE to send the character, and REPCOUNT is set to -50 to time the delay to the first repeat of the character. Subsequent scans check to see if the last character to be encoded has its corresponding key still down. If so, REPCOUNT is incremented; if it goes to 0, the character is re-transmitted and REPCOUNT set to -5. This results in a delay of about .8 second before the first repeat and about .08 seconds between subsequent repeats.

4.2.10 Unencoded Output

Unencoded output is handled as follows: When the CHECKSCAN routine sees that VERBFLAG is set, it calls the routine DOUNENC. This routine reads a row (4 bits in the left half of the input byte) of the keyboard matrix, packs the row number into the right half of the byte, and transmits the byte to the computer, incrementing the row number for the next call to DOUNENC. Note that (1) 1 means a key is UP, 0 means the key is DOWN, and (2) only the keys on the basic keyboard can be read in this mode — the external keypad is ignored, because only 16 rows can be encoded in this manner.

APPENDIX A: PARALLEL HANDSHAKING

When the keyboard is configured for parallel operation, the /RDY and /ACK lines are used for handshaking.

The keyboard will assert /RDY (active low) when data is stable and is ready to be latched by the interface port. If it is desired to use /RDY, install a jumper in location JF. This timing is shown in Figure A-1 (Case 1).

If it is desired to use an external acknowledge signal /ACK from the parallel input port, also install a jumper at location JD. In this configuration, once /RDY is asserted, the interface should respond by driving /ACK active low to indicate the reception of data.

This timing is shown in Figure A - 1 (Case 3). Note that if /ACK is not received within 11 ms following the leading edge of /RDY, /RDY will time-out and return to its cleared (high) state.

If it is desired to jumper the keyboard's /RDY output to the /ACK input, install a jumper at location JE. This configuration will result in a short /RDY pulse and does not require an external acknowledge signal from the interface. This timing is shown in Figure A - 1 (Case 2).

APPENDIX B: CONTROL (OUTPUT) DATA AND HANDSHAKING

If a parallel output port is used to program the keyboard, the data and handshake lines need to be configured for the type of output port used.

A jumper should be installed in location JB to enable the use of the data input line (J1, pin 2). This line will be driven by one bit of the output port used for keyboard programming.

Jumpers JC and JP allow the READY and ACKNOWLEDGE handshake lines to be used.

When it is desired to use a READY output from the interface, install a jumper in location JC. The interface should assert READY (J1, pin 10) when data is stable and is ready to be READ by the keyboard processor.

When it is desired to use an ACKNOWLEDGE output from the keyboard, install a jumper in location JP. The keyboard will assert ACKNOWLEDGE (J1, pin 11) following the receipt of the READY signal.

The READY and ACKNOWLEDGE handshaking is suitable for use with an output port having hardware handshake line., e.g. 8212 type ports. The use of software implemented handshake lines is not recommended due to timing constraints.