ESCON

ASSEMBLY AND OPERATING INSTRUCTIONS

MODEL E-C

COMPUTER INTERFACE CIRCUIT BOARD

ESCON PRODUCTS, INC.

171 Mayhew Way, Suite 204

Pleasant Hill, California 94523

ESCON

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The ESCON Model E-C interface circuit board is designed to be used with the Model E-A mechanical assembly installed on a Selectric* typewriter.

A driver amplifier for the typewriter magnets is required between the interface board and the typewriter. This can be the ESCON Model E-B driver amplifier and power supply. If any other amplifier is used, it must meet the requirements specified in the instruction book for the typewriter assembly, ESCON Model E-A.

*IBM trademark

PARTS LIST

DEVICE TYPE	QUANTITY	DESCRIPTION	CIRCUIT NO./ LOCATION
CIRCUIT BOARD	1	ESCON Part No. 31D190C	-
INTEGRATED CIRCUITS	2	7805 +5V REG	A1/1E A2/2E
	1	7912C -12V REG	A3/2C
	1	74LS08 AND	A29/10E
	1	74S471 Prom	A6/2B
	5	75453 Dual Positive or Drivers	A7/3D A8/3C A10/4D A11/4C AB/5D
	2*	AM3341PC Fifo Buffer	A15/4B A20/6B
	1	74S287 Prom	A18/7E
	2	74LS266 Open Collector Exclusive NOR	A19/7D A16/6D
	1	74LS161A Synchronous Counter	A21/7E
	1	74LS86 Exclusive OR	A22/7D
	1	NE555 Oscillator	A23/8E
	1	74LS138 Decoder	A24/8D
	1	74LS240 Octal Buffer/Line Driver	A25/8B
	1	74LS393 Dual Counter	A26/9E
	1	74LS74A Dual Type-D Flip Flop	A27/9D
	1	74LS00 NAND	A30/10D

*Provision is made for up to 2 additional (4 in all) Fifo buffers—see circuit description.

Rev. 6/15/78

PARTS LIST (Con't)

DEVICE TYPE	QUANTITY	DESCRIPTION	CIRCUIT NO./ LOCATION	
CAPACITORS	5	1.5 mf Tantalum Electrolytic	C1/1A	C3/2A
			C4/2C	C6/3E
			C7/3D	
	21	.01 mf Ceramic	C5/3C	
			C9/4C	
			C14/5C	C12/5C
			C16/6D	C18/6E
			C20/7C	C21/7D
			C22/8E	C23/6B
			C25/8D	C26/9E
			C27/9D	C28/9C
			C29/9C	C30/9E
			C31/10D	C33/10D
			C13/4B	C15/5B
			C34/10E	
	1	.001 mf 1% Ceramic	C24/8D	
FIXED RESISTORS	1	1 K, 5%, ¼W	R1/5E	
	8	51K, 5%, ¼W	R2/5E	R3/5E
			R4/5E	R5/5E
			R6/5E	R7/5E
			R8/5E	R9/5E
	1	154K 1%	R10/9E	
	1	12K, 5%, ¼W	R11/9D	
	1	10K, 5%, ¼W	R12/5B	
POTENTOMETER	1	100K	R12/8E	
SWITCH	1	8 Circuit	S1/6D	
DIP SOCKETS	1	8-pin		
	7	14-pin		
	9	16-pin		

PARTS LIST (Con't)

DEVICE TYPE	QUANTITY	DESCRIPTION	CIRCUIT NO./ LOCATION
DIP SOCKETS	2	20-pin	
HARDWARE	3	6-32 x 1/2 RH Mach Screw	H1/E1 H2/E2 H3/C2
	3	6-32 Hex Nut with Lock Washer	N1/E1 N2/E2 N3/E3
	1	Heatsink, Part 211 1 hole	HS2/C1
	1	Heatsink, Part 212 2 holes	HS1/E1

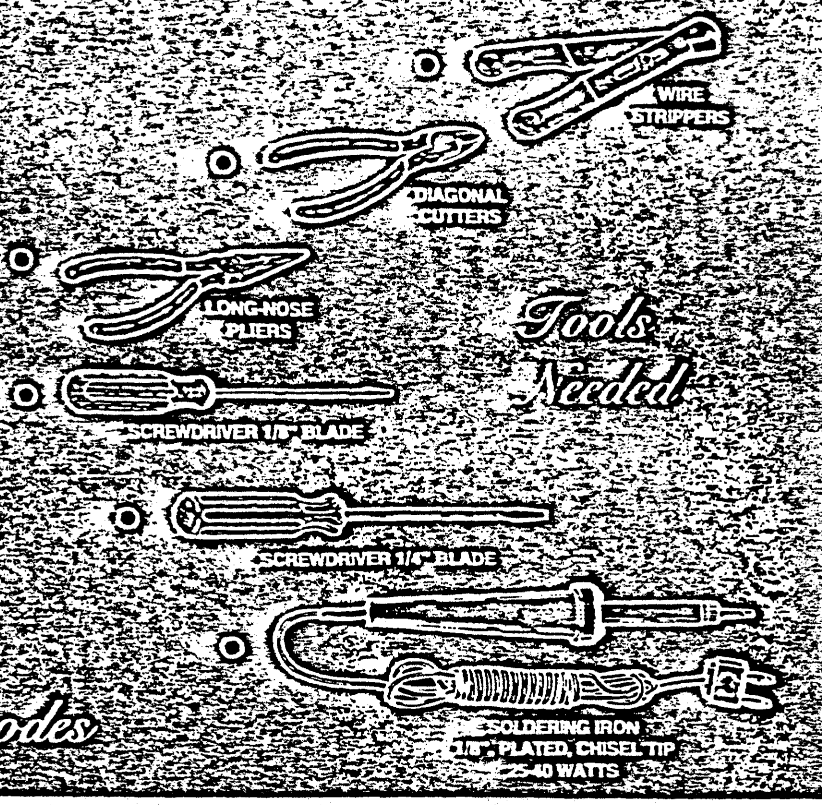
SUPPLIES FURNISHED WITH KIT

3 ft.	Rosin core solder wire
6 in.	Solder wick
20 in.	20 ga. wire

Rev. 4/14/78

The ESCON Kit Builder's Guide To:

Installing parts
Proper soldering
Resistor & capacitor codes



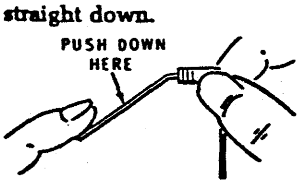
CIRCUIT BOARDS

To Install a Part:

The following example uses a resistor, since resistors are usually installed first.

1. Position the circuit board as shown in the Manual with the printed side (not the foil side) up.

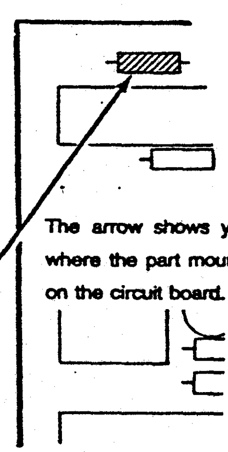
2. Hold the resistor by the body as shown and bend the leads straight down.



3. Push the leads through the holes at the proper location on the circuit board. The end with color bands may be positioned either way.

4. Press the resistor against the circuit board. Then bend the leads outward slightly to hold the resistor in place.

EXAMPLE CIRCUIT BOARD

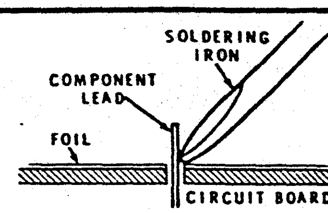


The arrow shows you where the part mounts on the circuit board.

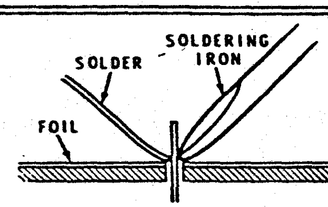
NOTE: A pencil-type soldering iron, as shown above, will give the best results.

To Solder a Connection:

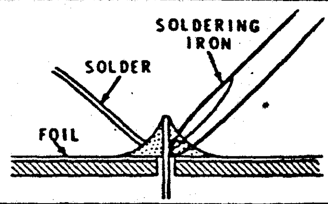
1. Place the soldering iron tip against both the lead and the circuit board foil. Heat both for 2 or 3 seconds.



2. Then apply solder to the other side of the connection. IMPORTANT: Let the heated lead and the circuit board foil melt the solder.



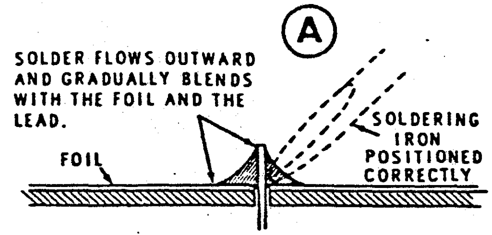
3. As the solder begins to melt, allow it to flow around the connection. Then remove the solder and the iron and let the connection cool.



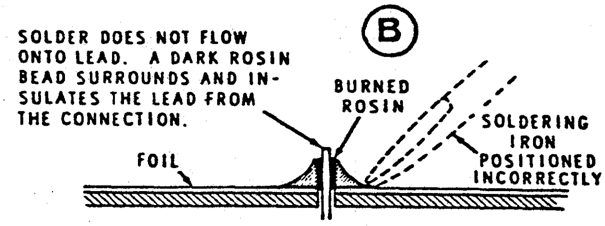
4. Hold the lead with one hand while you cut off the excess lead length close to the connection. This will keep you from being hit in the eye by the flying lead.

To Check a Connection:

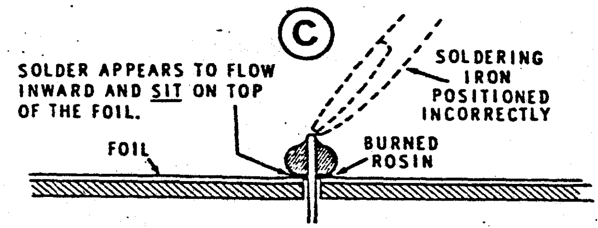
Be sure the solder made a good electrical connection. When both the lead and the circuit board foil are heated at the same time, the solder will flow onto the lead and the foil evenly. See Illustration A. The solder will then make a good electrical connection between the lead and the foil.



When the lead is not heated sufficiently, the solder will not flow onto the lead as shown at B. Reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection as shown at A.



When the foil is not heated sufficiently, the solder will blob on the circuit board as shown at C. Reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection as shown at A.



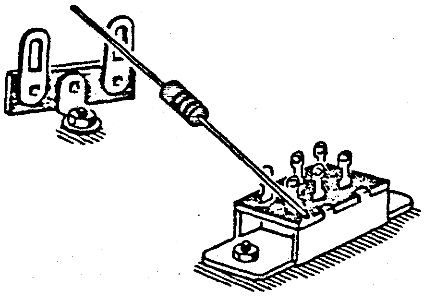
A solder bridge between two adjacent foils .... How the connection should appear.

Be sure you did not make any solder bridges. Due to the small foil area around the circuit board holes and the small areas between foils, you must use the utmost care to prevent solder bridges between adjacent foil areas.

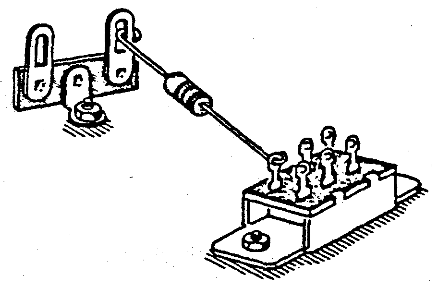
A solder bridge may occur if you accidentally touch an adjacent connection, if you use too much solder, or if you "drag" the soldering iron across other foils as you remove it from the connection. Always take a good look at the foil area around each lead before you solder it. Then, when you solder the connection, make sure the solder remains in this area and does not bridge to another foil. This is especially important when the foils are small and close together.

CHASSIS WIRING

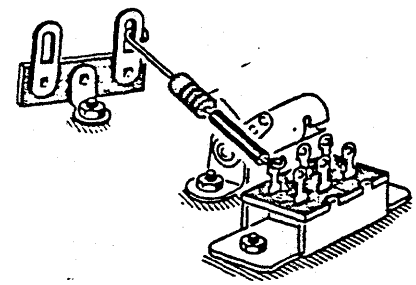
To Install a Part:



1. Cut the leads to the proper length.



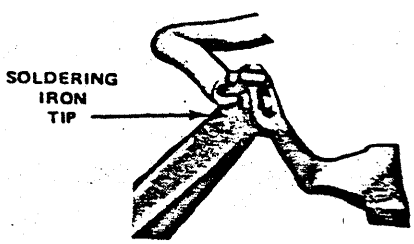
2. Fasten the lead ends.



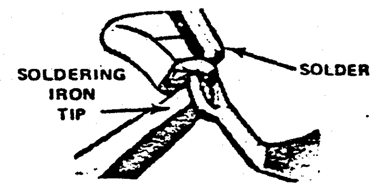
NOTE: Use sleeving when it is called for to provide insulation.

To Solder a Connection:

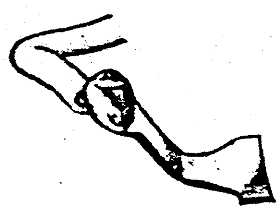
1. Heat both the wire and the connection point; do not burn the insulation on the wire.



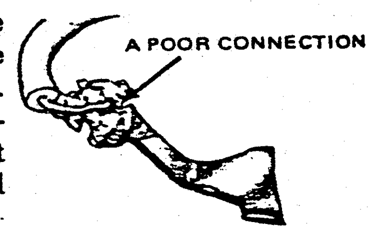
2. Apply only enough solder to thoroughly wet both the tip and the connection.



3. Let the connection harden before moving the wire. The connection should be smooth and bright.



4. Check the connection. Poor connections look crystalline and grainy, or the solder tends to blob. Reheat the connection if it does not look smooth and bright.



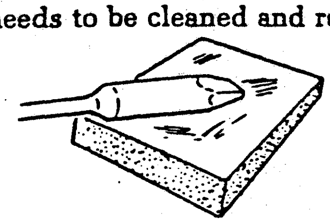
Remember:

Soldering abbreviations are given in the steps. (NS) means not to solder because other wires will be added later. "S-" with a number, such as (S-3), means to solder the connection. The number following the "S" tells how many wires are at the connection. (Where a wire passes through a connection and goes on to another point, it counts as two wires...S-2).

When there are several wires at a connection, be sure all of them are soldered.

Good solder connections are MOST IMPORTANT: 90 percent of all service problems are caused by poor soldering.

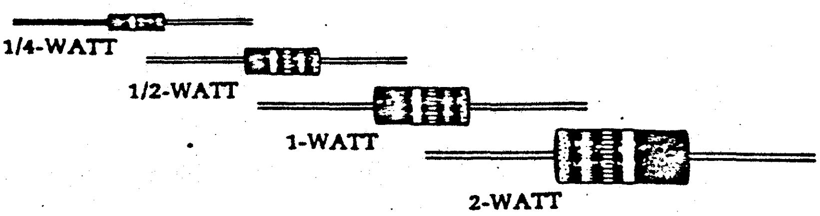
Keep the soldering iron tip clean. Wipe it often on a wet sponge or cloth; then apply solder to it to give the entire tip a wet look. This "tinning" process will protect the tip and enable you to make good connections. When the solder tends to "ball" or not stick to the tip, the tip needs to be cleaned and retinned.



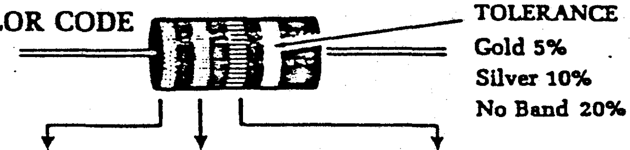
Use rosin core, radio-type solder (60:40 or 50:50 tin-lead content) for all soldering in the kit. The Warranty will be void and we will not service any kit in which acid core solder or paste fluxes have been used.

RESISTORS

Resistors come in several sizes and shapes, each one with its color code or value printed on it. The Manual calls out the value, and color code when used, of each resistor at the time it is installed.

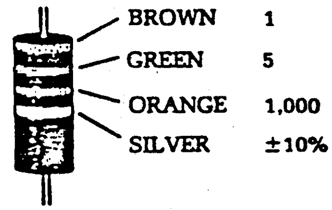


RESISTOR COLOR CODE

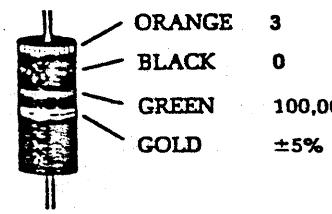


COLOR	1st DIGIT	2nd DIGIT	MULTIPLY BY
BLACK	0	0	1
BROWN	1	1	10
RED	2	2	100
ORANGE	3	3	1,000
YELLOW	4	4	10,000
GREEN	5	5	100,000
BLUE	6	6	1,000,000
VIOLET	7	7	10,000,000
GRAY	8	8	100,000,000
WHITE	9	9	1,000,000,000
GOLD			.1
SILVER			.01

EXAMPLES:



15 × 1,000 = 15,000 Ω (15,000 OHMS), or "15 k"



30 × 100,000 = 3,000,000 Ω (OR 3 MΩ)
3 MΩ = 3 MEGOHMS

CAPACITORS

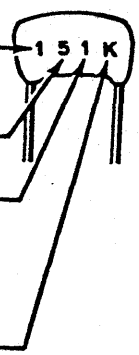
Capacitors come in many sizes and types. The Manual will tell the type and value of each one, and show what it looks like. This page shows how you can read the code printed on some capacitors.

First digit of capacitor's value: 1

Second digit of capacitor's value: 5

Multiplier: Multiply the first & second digits by the proper value from the Multiplier Chart.

To find the tolerance of the capacitor, look up this letter in the Tolerance columns.



EXAMPLES:

151K = 15 × 10 = 150 pF
759 = 75 × 0.1 = 7.5 pF

NOTE: The letter "R" may be used at times to signify a decimal point; as in: 2R2 = 2.2 (pF or μF).

pF = picofarads
μF = microfarads

MULTIPLIER		TOLERANCE OF CAPACITOR		
FOR THE NUMBER:	MULTIPLY BY:	10pF OR LESS	LETTER	OVER 10pF
0	1	±0.1pF	B	
1	10	±0.25pF	C	
2	100	±0.5pF	D	
3	1000	±1.0pF	F	±1%
4	10,000	±2.0pF	G	±2%
5	100,000		H	±3%
			J	±5%
8	0.01		K	±10%
9	0.1		M	±20%

ELECTROLYTIC CAPACITORS

Many capacitors must be connected in the proper direction. These capacitors are marked by "+" or "-" signs to indicate one of the wires. This polarity must correspond to the marking on the circuit board where they are installed. For example, if one lead is marked "-" and one hole in the board is marked "+", do not solder the "-" lead in the "+" hole.

DIODES

Diodes must be installed in the proper direction. Diodes are marked with an arrow touching a line, →|—. On small diodes only the line is marked. The end of the diode closest to the line is the end toward which the arrow would point:

The direction of the arrow must match the arrow on the circuit board or must point toward the hole marked "-".

CABLE CONNECTORS

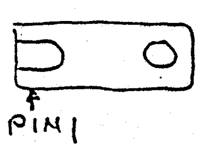
It is convenient for trouble-shooting to mark pin 1 on all connectors, plugs and receptacles and on both sides. This can be done by painting a dot near the pin using typewriter "whiting out" paint.

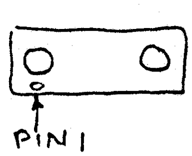
SOLDERING TRANSISTORS AND DIODES

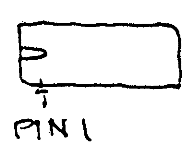
When soldering transistors and diodes avoid heating the leads longer than necessary. If you don't get a good looking joint after about a second of heating, let the joint cool before touching it up. After soldering one lead move to another component to allow the first to cool before going back to it.

INTEGRATED CIRCUITS

The pin numbering of integrated circuits starts with pin 1 at one corner and proceeds counterclockwise. Pin 1 is usually marked with a dot. Sometimes the end that has pin 1 is marked with a notch or a dot. Pin 2 is always on the same side as pin 1. Pin 1 of the circuit must correspond to the location marked on the circuit board by a dot or otherwise.







REMOVING SOLDER

If you put too much solder on a joint or if you need to remove a component already soldered to the board, the solder can be removed by use of the solder wick braid. Place the braid against the solder and place the iron against the braid. When the braid heats up, it will soak up the solder. Cut off the end of the braid after it is filled with solder.

CUTTING TRACES

In some cases, the instructions call for cutting traces on the circuit board. This is best done by cutting the traces with a sharp knife. Remove a piece of the trace about 1/16 inch long to be sure the trace is open. If the ends of the open trace have lifted off the board, cut them back to a point where they are firmly attached. Remove the cut pieces of the trace; don't leave them on the board where they might cause a short.

SAFETY

Always wear glasses when cutting wires or soldering. Small pieces of wire can easily get in the eye.

ASSEMBLY INSTRUCTIONS

1. Read this instruction book all the way through.

2. Work in a well-lighted place.

3. Don't hurry.

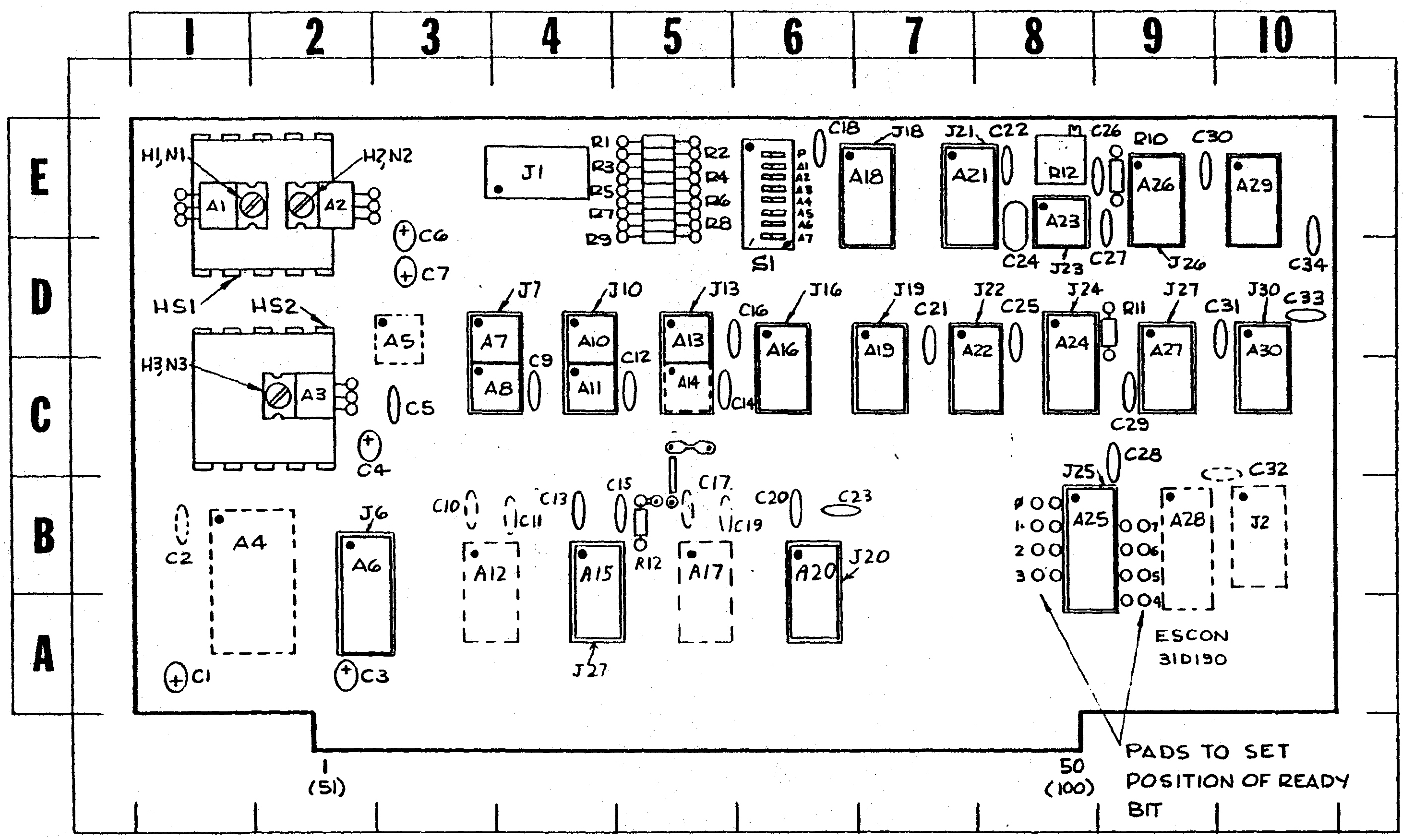
4. Check all the parts against the parts list.

5. Form and cut the resistor leads as shown in the instructions.

6. Load the parts on the board one at a time following the loading diagram. Solder the components as you go. Keep the soldering iron clean.

7. After the board is completely loaded and soldered, examine each joint carefully, with a magnifying glass if possible. Also, examine the board for bridges or drops of solder. It is much quicker and easier to find defects visually than electrically.

8. With the board plugged into a computer programmed to drive it, with a driver-amplifier power supply and an ESCON-converted typewriter, perform the typewriter operation test as instructed in the following section.



POSITIONS FOR FUTURE OPTIONS SHOWN IN DASHED LINES
NO SOCKETS OR COMPONENTS ARE REQUIRED IN THESE POSITIONS
FOR KIT E-C

ESCON MODEL E-C
CIRCUIT BOARD
LOADING DIAGRAM

2-1-78

TYPEWRITER OPERATION TEST

This test procedure must be followed to avoid the possibility of damage to the typewriter that might result from a defect in the interface board.

1. Remove the print ball.
2. Take the cover off the typewriter and set the mechanism on end so that the magnets can be observed. (See assembly instruction for Kit E-A.)
3. Connect the typewriter to the power supply and the power supply to the computer.
4. Check that none of the ten magnets are energized.
5. Plug in the typewriter and turn it on.
6. Send the following characters one at a time from the computer and observe that the corresponding magnets set and release:

CHARACTER	MAGNET
Q	R2
B	T2
W	T1
Y	R1
=	R2 & R2A
,	R2 & R5

Shift Space Return	Each should cause the corresponding operation.

7. Lay the typewriter down in the case.

8. Set the left margin stop at zero and the right margin stop at the extreme end of the line.

9. Return the carriage.

10. Send a line of 95 dashes to the typewriter.

Repeat the line measuring the time required for the 95 dashes with a stop watch or by watching a sweep second hand. The 95 dashes should take at least 7 seconds. Seven seconds corresponds to 13½ characters per second which is 10% below the absolute limit of 15 per second. Beyond 15 per second, the typewriter will be damaged if used for characters other than dashes. The damage consists of stretching or breaking the tape that rotates the ball. Repair requires an expert serviceman.

Adjust the potentometer R12 to obtain the time of seven seconds for 95 dashes before typing other characters.

OPERATION OF THE INTERFACE BOARD

Summary

The ESCON interface board provides for the operation of the ESCON Model E-C converted Selectric typewriter from any computer using the S100 bus structure. Using one bus slot, the board performs the conversion from the ASCII character set used by the computer to that used by the typewriter, and it performs all timing functions for the operation of the typewriter. With the single exception of testing for a ready status, the computer is freed of all detail associated with the typewriter operation. The board includes a first-in, first-out character buffer that allows the computer to send ASCII text in bursts of 64 characters at a time; the buffer size may be increased to a maximum of 128 characters at additional cost. In order to provide for the simplest implementation of the ESCON system, the board provides for accepting data from any of 128 odd numbered output ports by switch selection. It supplies the ready signal on the associated even input port. The parity of the ready signal is selectable by a switch and the bit position is selectable by a wired jumper. Power, address signals, data-in and data-out signals, and control signals are taken from the bus according to the S100 convention.*

*See for example: Interface Age 2 #7, p. 66 (June 1977)

Major Functions

The operation of the interface board comprises four basic functions, and the description of the operation is subdivided accordingly. These major functions are:

(1) recognition of the board address received from the computer and status output to the computer,

(2) latching and accumulation of ASCII characters and the translation into the Selectric bail code,

(3) timing logic, and

(4) actuation of the typewriter magnets.

There is a circuit diagram at the end of this description. The above groupings are shown on this diagram. Actual locations for the components are shown on the loading diagram.

The parts of the circuit implementing the above functions plus the voltage regulation function are indicated on the diagram by the heavy dashed lines.

Address Recognition

The 8080 and Z80 CPU's provide for 256 input ports and 256 output ports. The usual custom in the S100 computers is to group these ports into 128 groups with the odd numbered ports being used for the transfer of data and the even number ports being used for the transfer of status information. The ESCON board follows this custom, allowing the port group to be set by seven switches, designated by S1, at the top of the board. (The edge connection is at the bottom of the board.) The bottom switch sets Bit A7, the most significant address bit of the input and output ports; this switch is moved to the right for a one and the left for a zero. Bits A6 through A1 are similarly set by the adjacent six switches. The top switch is not used in the addressing of the board. For example, to address the board so that an output to port 7F will print a character, the bottom switch is set to the right, and the others are set to the left. In this case, the ready status may be determined by performing an input directed to port 7E and then testing the proper bit.

The switches are constantly compared to address bits 7--1 by by means of the open-collector exclusive-nor gates at A16 and A19. Because of the wired-or configuration, a failure to match any of these bits causes the input to the decoder A24 (pin 6) to be a zero. The remaining exclusive-nor gate is used to test for an input or output operation by comparing the SINP and SOUT signals from the bus. When such an operation occurs and the address match is made, and the decoder is enabled. The particular decoder output activated (pulled low) is determined by the least significant address Bit AØ and the control lines PDBIN and $\overline{\text{PWR}}$. The activated output will be one of the following: pin 7, $\overline{\text{DATA-IN}}$; pin 9, $\overline{\text{STATUS-IN}}$; pin 14, $\overline{\text{DATA-OUT}}$; or pin 15, $\overline{\text{STATUS-OUT}}$. Pin 15 is not connected.

The $\overline{\text{DATA-OUT}}$ signal strobes a character from the bus into the FIFO buffer. The $\overline{\text{STATUS-IN}}$ signal turns on the inverting octal buffer/line-driver A25, passing the ready status to the computer. The $\overline{\text{DATA-IN}}$ signal may be used to turn on an optional buffer for which space is provided at A28 in order to provide a parallel input port for an external device, such as a keyboard.

There is space on the board for the user to implement the status-out operation through the addition of an 8-bit latch such as a 74LS273.

ASCII Character Latching, Accumulation, and Translation

The first-in-first-out (FIFO) buffer latches the ASCII character received from the computer on the rising edge of the inverted $\overline{\text{DATA-OUT}}$ strobe. The character is moved internally in the buffer to the first empty position. When the buffer is ready to receive another character, it drops $\overline{\text{READY}}$ (pin 11 of A30) to zero. The top switch of S1 may be set by moving it to the left to invert this signal. The interface board is wired so that it will transmit this bit to the CPU as bit 0 during the $\overline{\text{STATUS-IN}}$ strobe. The READY bit may be moved to any other position by cutting the trace between the pads connected to pin 2 of A25 and connecting the desired bit by means of a jumper between the proper pair of pads around A25. Bit 0 is the upper left pair of pads. As shown on Figure 3, the other bits correspond to pairs of pads moving around A25 in the counter-clockwise direction with bit 7 being the uppermost pair to the right of A25.

A25 inverts the signal once again. Thus, if the parity-selection switch (the top switch at S1) is set to the left, the buffer is ready to accept a new character when the selected bit is a zero. If the parity-selection switch is set to the right, the buffer is ready when the selected bit is a 1.

If the selected bit is left as bit 0, then an easy test for the ready status is to input the status bit, rotate the accumulator to the right, and then test the carry bit. A new character may be output to the ESCON board only if the FIFO buffer is READY. Thus, if the parity-selection switch is set to the left, the rotate instruction should be followed by a jump back to the INPUT STATUS instruction on a non-zero carry bit. This loop is then followed by the instructions that output the new character to the FIFO buffer.

Let us now return to the progress of the character in the FIFO buffer. As soon as a character reaches the output of the buffer, the OUTPUT READY signals from the buffers cause the GO signal (pin 3 of A29) to go high. As soon as the typewriter completes its last operation, IDLE goes high and the $\overline{\text{START}}$ strobe is generated. The character remains at the FIFO output until the typewriter has completed typing the character. The falling inverted edge of the IDLE signal is the SHIFT OUT signal to the last pair of FIFO chips; SHIFT OUT moves a new character into position if another character is in the buffer.

It is necessary to translate the ASCII character into the bail code used by the Selectric typewriter. This is done by the PROM A6. The output of this PROM is as follows:

Bit 7 is $\overline{\text{SHIFT}}$; 1 sets lower case, and 0 sets upper case.

Bit 6 is PRINTABLE; it is 1 for a printable character and 0 for a space, return or other nonprinting operation.

If bit 6 is 1, then bits 5, 4, 3, 2, 1, and 0 are the bail code for the R5, R2A, R2, R1, T2, and T1 magnets, respectively; a zero for a bail code bit causes the corresponding solenoid to be turned on at the proper time.

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If bit 6 is 0, then bits 3, 2, 1, and 0 specify one of 16 nonprinting operations of which two—the space and carriage return—are presently implemented. Bits 5 and 4 are sent to the control PROM A18 where they determine the delay required after the selected operation is implemented.

The truth table for the bail code prom is shown in Table I. As there are 96 ASCII characters but only 88 positions on the Selectric ball, some compromises must be made. Also, there are several variations of the Selectric ball (for example, some have brackets, some do not). Bit 7 of the ASCII code is a don't-care bit for the bail code PROM.

There is a jumper on the board at PIN 19 of A6 to provide for connecting bit 7 to a permanent zero or to a permanent one, thereby providing for the expansion to two separate character sets.

TABLE I

ESCON BAIL CODE PROM

ASCII		BAIL CODE			ASCII		BAIL CODE		
octal	hex	hex	octal	char	octal	hex	hex	octal	char
000	00	BF	277	nul nop	026	16	BF	277	SYN nop
001	01	BF	277	SOH nop	027	17	BF	277	ETB nop
002	02	BF	277	STX nop	030	18	BF	277	CAN nop
003	03	BF	277	ETX nop	031	19	BF	277	EM nop
004	04	BF	277	EOT nop	032	1A	BF	277	SUB nop
005	05	BF	277	ENQ nop	033	1B	BF	277	ESC nop
006	06	BF	277	ACK nop	034	1C	BF	277	FS nop
007	07	BF	277	BEL nop	035	1D	BF	277	ES nop
010	08	B7	267	BS BLOCK SPACE	036	1E	BF	277	RS nop
011	09	8B	213	HT delay 8	037	1F	3D	075	US SHIFT SPACE
012	0A	8F	217	LF nop delay 8	040	20	BD	275	Space
013	0B	BF	277	VT nop	041	21	E2	342	!±
014	0C	BF	277	FF nop	042	22	72	162	"
015	0D	8E	216	CR delay 8	043	23	44	104	#
016	0E	BE	276	SO CR no delay	044	24	58	130	#
017	0F	BB	273	SI TAB no delay	045	25	70	160	%
020	10	BF	277	DLE nop	046	26	50	120	&
021	11	BF	277	DC1 X-on nop	047	27	F2	362	'
022	12	BF	277	DC2 TAPE nop	050	28	7C	174	(
023	13	BF	277	DC3 X-off nop	051	29	78	170	)
024	14	BF	277	DC4 ~~TAPE~~ nop	052	2A	54	124	*
025	15	BF	277	NAK nop	053	2B	67	147	+

TABLE I (Con't)

ASCII octal	ASCII hex	BAIL CODE hex	BAIL CODE octal	char
054	2C	D7	327	,
055	2D	FF	377	-
056	2E	E6	346	.
057	2F	D8	333	/
060	30	F8	370	0
061	31	C0	300	1
062	32	E4	344	2
063	33	C4	304	3
064	34	D8	330	4
065	35	F0	360	5
066	36	F4	364	6
067	37	D0	320	7
070	38	D4	324	8
071	39	FC	374	9
072	3A	53	123	:
073	3B	D3	323	;
074	3C	7C	174	<(
075	3D	E7	347	=
076	3E	78	170	>)
077	3F	5B	133	?
100	40	64	144	@
101	41	4E	116	A
102	42	7D	175	B
103	43	55	125	C
104	44	51	121	D
105	45	71	161	E
106	46	47	107	F
107	47	43	103	G
110	48	79	171	H
111	49	76	166	I
112	4A	63	143	J
113	4B	75	165	K
114	4C	59	131	L
115	4D	42	102	M
116	4E	65	145	N
117	4F	5A	132	O
120	50	73	163	P
121	51	77	167	Q
122	52	52	122	R
123	53	7A	172	S
124	54	61	141	T
125	55	45	105	U
126	56	46	106	V
127	57	7E	176	W
130	58	41	101	X
131	59	7B	173	Y
132	5A	60	140	Z
133	5B	7C	174	[(
134	5C	D3	323	\;
135	5D	78	170	])

TABLE I (Con't)

ASCII		BAIL CODE		
octal	hex	hex	octal	char
136	5E	71	161	↑E
137	5F	7F	177	_
140	60	F2	362	`'
141	61	CE	316	a
142	62	FD	375	b
143	63	D5	325	c
144	64	D1	321	d
145	65	F1	361	e
146	66	C7	307	f
147	67	C3	303	g
150	68	F9	371	h
151	69	F6	366	i
152	6A	E3	343	j
153	6B	F5	365	k
154	6C	D9	331	l
155	6D	C2	302	m
156	6E	E5	345	n

ASCII		BAIL CODE		
octal	hex	hex	octal	char
157	6F	DA	332	o
160	70	F3	363	p
161	71	F7	367	q
162	72	D2	322	r
163	73	FA	372	s
164	74	E1	341	t
165	75	C5	305	u
166	76	C6	306	v
167	77	FE	376	w
170	78	C1	301	x
171	79	FB	373	y
172	7A	E0	340	z
173	7B	7C	174	{(
174	7C	D9	331	|
175	7D	78	170	})
176	7E	BF	277	~ nop
177	7F	BF	277	rubout nop
(does not exist)		74	164	¢

BIT FUNCTION							
01	$\overline{T1}$	02	$\overline{T2}$	04	$\overline{R1}$	08	$\overline{R2}$
10	$\overline{R2A}(d_1)$	20	$\overline{R5}(d_2)$	40	PRINTABLE	80	SHIFT

Timing Logic

The interface board performs all of the timing functions required to operate the IBM Selectric typewriter using the ESCON kit. In contrast to the usual ASCII terminal (such as a teletype), the Selectric is unable to perform a shift operation and print a character simultaneously. Thus, the interface board must ascertain when a shift operation is required and delay the printing of the character until the shift operation has been completed. Another function of the board is to provide the additional delay required to complete certain non-printing operations such as the carriage return. Finally, the operation of the Selectric bail magnets requires careful timing in order to avoid damaging the typewriter.

The components of the timing logic comprise the following:

1. An astable oscillator (NE555) A23 that is set to run at 512 times the typewriter character rate or 6912 Hz.

2. A divide-by-256 circuit (74LS393) at A26 that functions to synchronize the oscillator output to the $\overline{\text{START}}$ signal. It also suppresses the system clock during the IDLE state.
   The output of A26 when inverted is the SYSTEM CLOCK. Its rate is twice the character rate.

OPERATION OF THE INTERFACE BOARD (Con't)

3. A four-bit counter (74LS161A) A21 whose output comprises the ESCON state count; it is located at A21 and is subsequently referred to as the state counter. This counter provides for a direct clear operation that is here used to start the printing cycle. With the exception of the clear operation, the counter is fully synchronous, advancing only on the rising edge of the $\overline{\text{STATE CLOCK}}$. It provides for a $\overline{\text{load}}$ operation in which case all four outputs of the counter are set to ones upon the next rising clock edge regardless of their previous value; this state (1111) is used to represent the idle state. The counter provides a carry-out bit at pin 15 which is high only during the 1111 count and thus provides a glich-free signal to denote the IDLE state.

4. A 256 X 4 PROM (74S287 or MMI 6301-1) A18 whose four low-order address bits are the count outputs of the 74LS161A state counter. This PROM determines the timing logic; its truth table appears in Table II. One output, named $\overline{\text{STOP}}$ is used as the load input to the state counter; when this signal is zero, the state counter advances to the IDLE state at the next positive clock. Two outputs are used to enable the various solenoid

TABLE II

ESCON CONTROL PROM OUTPUT TABLE

Start ↓ (state count Ø)

OPERATION SELECTION ADDRESS - High Order 4 Bits (rows); STATE COUNT ADDRESS - Low Order 4 Bits (columns)

	Ø	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Ø	(5)	F	F	F	F	F	F	F	F	F	F	F	F	F	F	B
1	(5)	F	F	F	F	F	B	3	3	3	3	3	3	3	3	3
2	(5)	F	F	B	3	3	3	3	3	3	3	3	3	3	3	3
3	(5)	B	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	(6)	B	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5	(6)	B	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6	(6)	B	3	3	3	3	3	3	3	3	3	3	3	3	3	3
7	(6)	B	3	3	3	3	3	3	3	3	3	3	3	3	3	3
8	(5)	F	F	F	F	F	F	F	F	F	F	F	F	F	F	B
9	(5)	F	F	F	F	F	B	3	3	3	3	3	3	3	3	3
A	(5)	F	F	B	3	3	3	3	3	3	3	3	3	3	3	3
B	(5)	7	B	3	3	3	3	3	3	3	3	3	3	3	3	3
C	7	7	7	(6)	B	3	3	3	3	3	3	3	3	3	3	3
D	7	7	7	(6)	B	3	3	3	3	3	3	3	3	3	3	3
E	7	7	7	(6)	B	3	3	3	3	3	3	3	3	3	3	3
F	7	7	7	(6)	B	3	3	3	3	3	3	3	3	3	3	3

Rows Ø–3: Non-printing operation with no shift change

Rows 4–7: Printable character with no shift change

Rows 8–B: Non-printing operation with shift change (nearly identical to non-print without shift change)

Rows C–F: Printable character with shift change (delay 3 states for shift)

t0 t1 t2 t3 t4 t5 t6 t7 t8 t9 t10 t11 t12 t13 t14 t15 (increments of ½ print cycle ~37 ms)

t15 ← IDLE STATE

Significance

Output

$d_Ø$ - pin 12 — PRINT ENABLE - $d_Ø$ = Ø enables tilt, rotate, print solenoids

d_1 - pin 11 — NONPRINT ENABLE - d_1 = Ø enables space, return, tab solenoids

d_2 - pin 10 — STOP - d_2 = Ø forces idle state on next positive clock edge

d_3 - pin 9 — FEEDBACK ENABLE - d_3 = 1 enables feedback from typewriter

Address

a_3, a_2, a_1, a_0 — State count: output from 74LS161A state counter bit

a_5, a_4 — Bits 5 and 4 from character decode prom - used to determine delay after nonprinting operations

a_6 — PRINTABLE - a_6 = 1 for a printable character; Ø for space, return

a_7 — ΔSHIFT - a_7 = 1 if shift status change with this character

The only entries where solenoids can be energized are circled. Shaded entries are delay states.

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magnets on the typewriter at the proper time. The fourth output is presently unused.

5. An edge-clocked type-D flipflop (74LS74A) A27, that is used to preserve the status of the shift magnet during the last character (OLD SHIFT), and an exclusive-or gate at A22 whose output, ΔSHIFT, is high whenever the shift status of the current character differs from that of the previous character. The rising edge of the IDLE signal is used to clock the 74LS74A thus preserving the status of SHIFT at the end of the print cycle.

Briefly, the timing logic functions as follows. When a character to be printed is available in the FIFO buffer, the GO signal goes high. At this time, providing the typewriter is IDLE, the $\overline{\text{START}}$ strobe is generated and the state counter A21 is cleared, thus setting the IDLE signal to a low state. The low state of the IDLE signal allows the counter A26 to output the STATE CLOCK to the state counter. Starting at a count of zero, the state counter advances at intervals of 37 milliseconds until the control PROM outputs a zero on the $\overline{\text{STOP}}$ line. At this point, the next STATE CLOCK forces the state counter to the idle state (1111). Upon entering the idle state, the IDLE signal goes high thereby latching the status of SHIFT and also strobing the next character, if it exists, to the FIFO output. The IDLE signal also blocks counts to the state counter. If, upon reaching the IDLE state, there is another character waiting in the FIFO buffer, the cycle immediately repeats. Otherwise, the IDLE state is maintained until another character is available.

This timing sequence is shown in Figure 1 for a situation where three characters are sent to the typewriter. The first character requires a shift change to upper case and the third character is a space. During the initial IDLE state, the state counter output is F_{16} (1111), STATE CLOCK is high and $\overline{\text{STOP}}$ is zero thus maintaining the idle state until the counter is cleared. At the arrival of the first character, the $\overline{\text{START}}$ strobe is generated. The $\overline{\text{START}}$ strobe clears the state counter to state 0 and zeros the IDLE signal which, in turn, unblocks the state clock. The first character is a printing character that requires a shift change; the shift change occurs immediately. The portion of the control PROM addressed will be one of the bottom four rows in the truth table (the actual row depends upon two bits in the bail code that are of no concern as all four rows are identical). During state zero, the first column in the truth table indicates that the control prom output is 7 during this 37 millisecond interval; no operation occurs with an output of 7, and thus the state will advance to 1 at the end of the 37 millisecond interval. Similarly, during states 1 and 2, no operation occurs. These three states provide a 111 millisecond delay

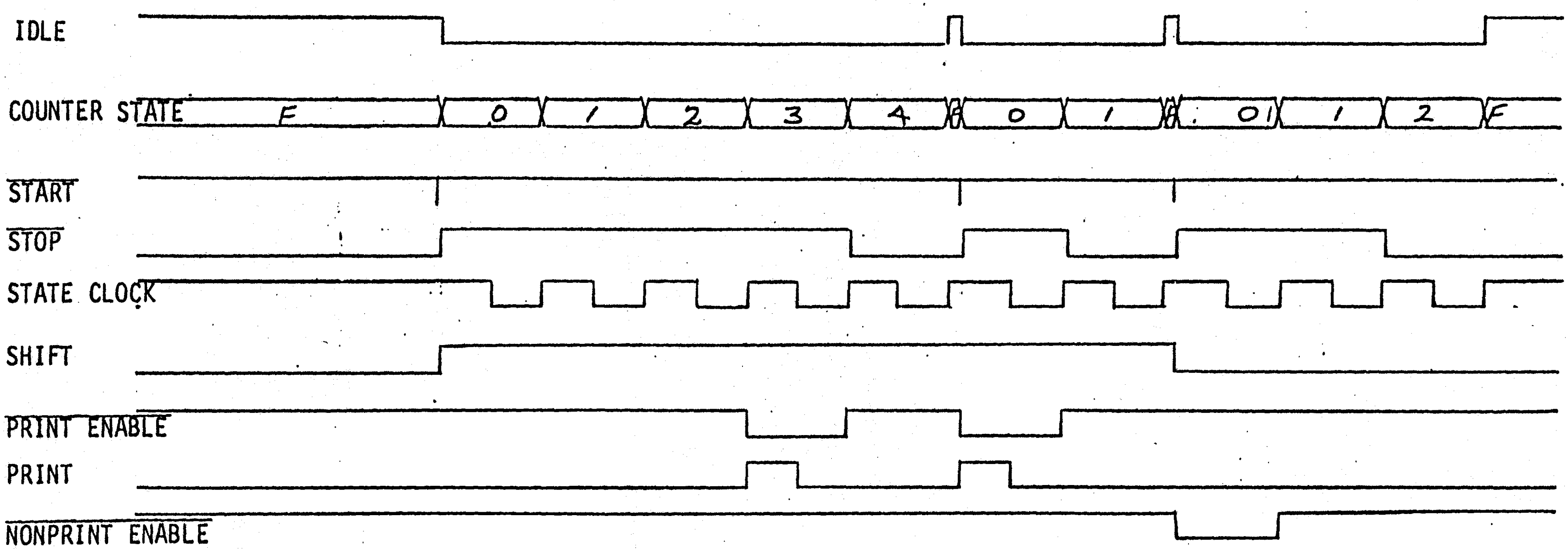


Figure 1. ESCON Timing Chart

For the situation where typewriter is initially idle with shift off and the CPU sends two upper case characters followed by a space.

for the shift operation to be completed. Upon advancing from state 2 to state 3, the control PROM output changes to 6; this output enables the selected tilt and rotate solenoids and also turns on the print cycle magnet during the first half of state 3 (while the state clock is high). At the end of the 37 milliseconds in state 3, the counter advances to state 4, for which the output is B_{16}. All magnets are turned off, but the $\overline{STOP}$ signal output from the PROM is now low, and because it is low, the next state will be the idle state, F_{16}.

As another character is waiting, the $\overline{START}$ strobe is generated immediately upon entering the IDLE state. The state clock is re-synchronized and started (within .14 milliseconds). For this second character, the shift state is unchanged, and thus the control prom output comes from the 5th, 6th, 7th, or 8th row—depending upon two bits in the bail code. (Again, these two bits are of no interest here as the four rows are identical). For this character, the 6 in the first column indicates that printing starts immediately—with state 0. The idle state follows state 1. Note that in typing a string of characters where no shift change occurs, the system will alternate between states 0 and 1—each 37 milliseconds long with a brief (<1 microsecond) idle state following each state 1.

As soon as the second character is complete, the third character—a space—is moved to the FIFO output, and the $\overline{START}$ strobe is generated.

The space is a lower-case non-printing operation for which the bail code PROM specified that no additional delay is required after the space operation. The eleventh row of the PROM is used. At state 0, the $\overline{\text{NONPRINT ENABLE}}$ signal is active (low) which allows the space solenoid to be turned on. At the same time, the shift solenoid is turned off; these are noninterfering operations. State 1 is a delay state where all solenoids are off. State 2 is required to allow adequate time for the completion of the shift operation; state 2 is followed by the idle state which persists as the FIFO buffer is now empty.

Had the second character been a lower case character, then the fourth row of the control prom would have been used thereby accomplishing the space in 2 states (74 msec) instead of 3 states. The bail code PROM translates the ASCII control character US (1F) into an upper case space.

Were the third character a carriage return instead of a shift, either the fifth or the 13th row of the truth table would have been used (depending upon whether the shift changed or not); the carriage return requires the maximum delay—15 states (556 msec). Even this will not be enough if the carriage is at the far right, and thus, the ASCII line-feed character is treated as a 15 state null operation. The usual sequence of sending the ASCII CR and then the ASCII LF characters thus is translated into a return on the Selectric, followed by a 1.111 second delay. The bail code prom translates the ASCII control character SO into a minimum-delay carriage return for use where appropriate.

For non-printing operations, bits 5 and 4 from the bail code prom determine the delay required to complete the operation. The total time is 2 (3 is ΔSHIFT = 1), 4, 8, or 15 states (of 37 msec each).

Provisions exist for the addition of future functions such as a tab and a block-space operation. The block-space operation will prevent carriage advance during the next print operation; thus, its status must be delayed by one character; this is the function of the second half of A27.

OPERATION OF THE INTERFACE BOARD (Con't)

Actuation of the Typewriter Magnets

The typewriter magnets are powered through transistors in the ESCON or other power supply. These transistors are controlled by 75453 positive-or driver circuits on the interface board. A magnet is actuated only if both inputs to the corresponding driver are low. The shift magnet is controlled by the SHIFT signal (from the bail code PROM) alone. The PRINT magnet is turned on for 18 msec once per printing character; this timing is a consequence of requiring that the $\overline{\text{PRINT ENABLE}}$ signal be low and the $\overline{\text{STATE CLOCK}}$ be low for its activation.

The remaining magnets have one input derived from the bail code PROM and the other is either the $\overline{\text{PRINT ENABLE}}$ or the $\overline{\text{NONPRINT ENABLE}}$ signal from the control PROM.

The expansion from 4 control operations to as many as 16 requires the insertion of a 74154 integrated circuit and the cutting of four traces at A4.

USING THE ESCON SYSTEM WITH A COMPUTER

The ESCON Model E-C interface board has been designed so that it may be added to virtually any 8080 or Z-80 system using the S100 bus. To this end, all detail of timing and character translation is performed on the board. The CPU needs only to test the READY signal to determine that the interface FIFO buffer is not full and then send a parallel output of the ASCII character to the selected output port. In many cases, the ESCON system may be adapted to existing software with no changes whatsoever in that software.

Computers perform their input and output functions through dedicated subroutines frequently named, "INPUT" and "OUTPUT". For output, the usual procedure is for the main program to place the desired output character in a CPU register and then call the output routine. The output routine must then perform all of the detail associated with the printing of the character. In the simplest situation, this means testing for a ready status for the selected device and delaying until the device is ready. As soon as the device is ready, the routine simply outputs the character and returns. In some cases, it may be necessary to save the CPU's accumulator prior to returning to the calling program.

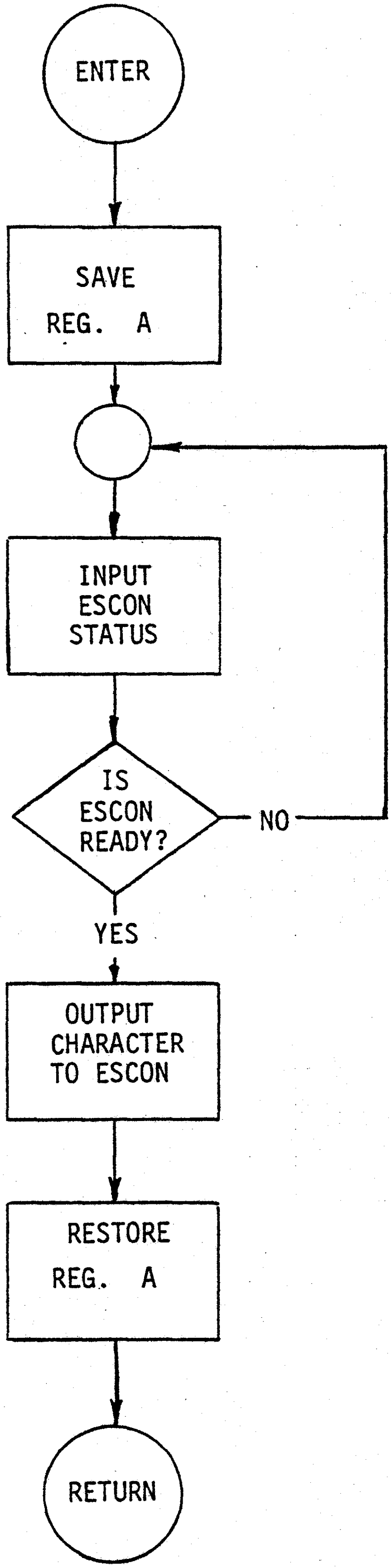
The ESCON E-C interface board requires only this most simple form of output subroutine. Figure 2 comprises a flow chart for such a routine that follows the steps outlined above.

8080 Computers

An example of an actual 8080 subroutine that corresponds to these steps is to the right of the flow chart. To use this subroutine without modification requires that the calling program has the desired ASCII character in CPU register B upon entry to the subroutine. Switches S1 on the interface board must all be set to the left except for the bottom switch which is set to the right. For this setting, the ESCON output port will be $7F_{16}$; the status bit will appear in the least-significant-bit position of the accumulator after an INPUT 7E instruction. A one for this bit indicates that the ESCON FIFO buffer is full and will not accept another character. The usual procedure in this case is for the output routine to jump back to the INPUT INSTRUCTION. The sequence of inputting the status and testing the status is repeated until the status bit is determined to be ready, i.e., zero for the configuration here described. The example shown at the right of the flow chart uses a RRC instruction to rotate the status bit into the carry bit of the CPU where it is tested by the JC instruction; the jump back to the input instruction occurs as long as the carry bit is a one. Control leaves this loop when the test finds the carry bit to be zero. At this point the MOV A,B instruction places the character which was transmitted in

FIGURE 2

GENERAL PURPOSE ESCON OUTPUT ROUTINE



<u>Example</u>

(ASCII character in REG. B)

```
STATUS EQU 7E
ESCON  EQU STATUS + 1
OUTPUT PUSH PSW

INPUT STATUS

RRC

JC  OUTPUT + 1

MOV A,B

OUT ESCON

POP PSW

RET
```

register B, into the accumulator. The OUT ESCON instruction sends the character to the interface board. At this point, the output operation is complete and a return follows. In this example we have added a PUSH PSW instruction upon entry into the output routine and a POP PSW instruction just prior to return. These instructions perform the function of saving and restoring the accumulator and also the CPU status bits in case that should be required.

If the program being used does not output the character in register B the MOV A,B instruction should be replaced by the corresponding instruction unless the register used is A, the accumulator. If A is used, the MOV instruction is eliminated and the OUT ESCON and POP PSW instructions are exchanged so OUT ESCON follows the POP instruction.

Process Technology SOL Computer

For a more specific example, we now show how the ESCON interface board would be implemented in the Processor Technology SOL computer. We will use the same subroutine and interface board switch settings as described for the 8080, that is all but the bottom siwtch set to the left. We need, therefore, only to locate an address for the subroutine and to actually insert it into the program. The internal memory of the SOL computer includes random-access memory (RAM) at $C800_{16}$ - $CBFF_{16}$. With the SOLOS operating system the block between C812 and C81B is unused and provides just enough room for the output routine outlined above, less the PUSH and POP instructions which are not needed. To enter the output routine from the console, the following operations should be performed.

First, we type on the console ENTER C812 followed by a carriage return.

We next type the following sequence:

DB 7E ØF DA 12 C8 78 D3 7F C9 /

This enters the instructions: INP STATUS, RRC, JC OUTPUT, MOV A,B, OUTPUT ESCON, RET. The program may be checked by calling for a dump: DUMP C812 C81B (followed by a carriage return). We must next tell the operating system where this routine is. This is accomplished by entering the following on the terminal:

SET CO C812 (followed by a carriage return; note that O is the letter O).

Finally, we direct that subsequent output should be sent to the typewriter by entering on the console:

SET O=3 (followed by a carriage return; again, O is the letter)

Unless means exist to save and restore this portion of RAM, the above sequence will have to be repeated each time the power is turned on. This can be avoided by saving and restoring the routine on a cassette or disk.

Next we show how the ESCON interface board may be added to an existing

Altair Computer

Next we show how the ESCON interface board may be added to an existing system without any program change. This example is for an Altair BASIC program. Here we make the interface board appear to the CPU as a

UART circuit. We will use the same input and output ports (7E for status and 7F for data-out). The Altair system calls for the output status to appear on bit 7. We, therefore, cut the traces between the pads for bit 0 and also for bit 7 on the back of the interface board at A25 (see Figure 3). We next put a jumper to the right to pad 6 of the ready bus as shown in Figure 3. If we are also going to use the optional input port for an external keyboard, we must connect the keyboard status which appears at pad 7 to bit 0 at the pad adjacent to pin 2 of A25 as shown in Figure 3.

Then to use the ESCON system, we need only enter the following line on the console:

CONSOLE 126,2 (note that $126_{10} = 7E_{16}$, the status port)

All but the bottom switch at S1 are set to the left as before.

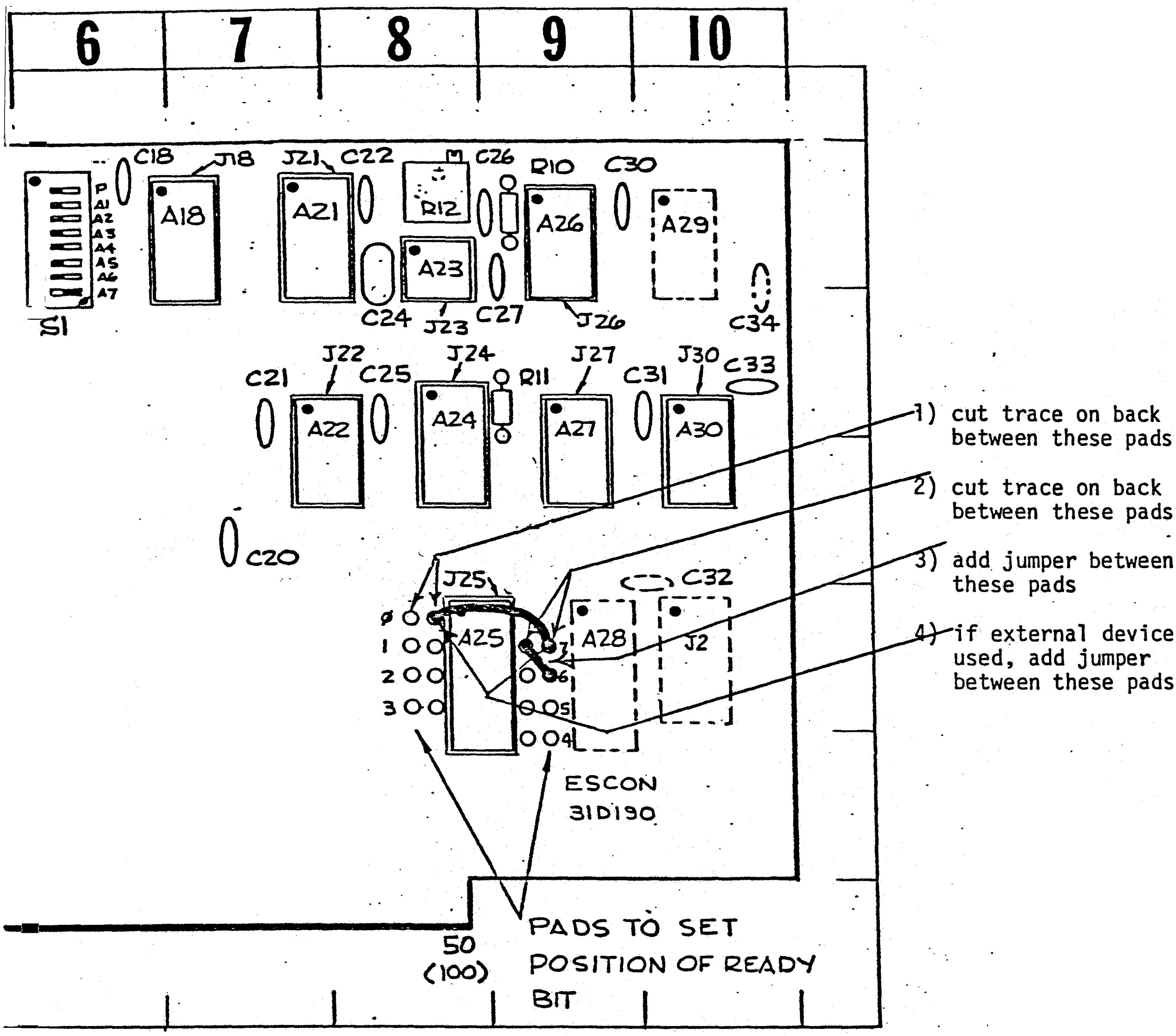


Figure 3. Changes Required to Adapt Interface Board to Correspond to the SIO port used in Altair Basic.

OPTIONAL EXTERNAL INPUT DEVICE

The ESCON E-C interface board provides for the simple addition of a parallel input port which will have the same address as the ESCON output port. This might be used, for example, to add an external keyboard. To use this port, a 16-pin socket J2 and a 20-pin socket A28 are soldered to the board. A mica decoupling capacitor C32 is inserted. A 74LS244 integrated circuit is placed in the 20 pin socket. The 16-pin socket J2 provides ground and regulated voltages of +5 volts and -12 volts for the external device. It also provides for the 8 data bits and for a status bit. The status bit would be used with a keyboard to indicate that a character has been entered. The pin position for these functions is shown on the circuit diagram.