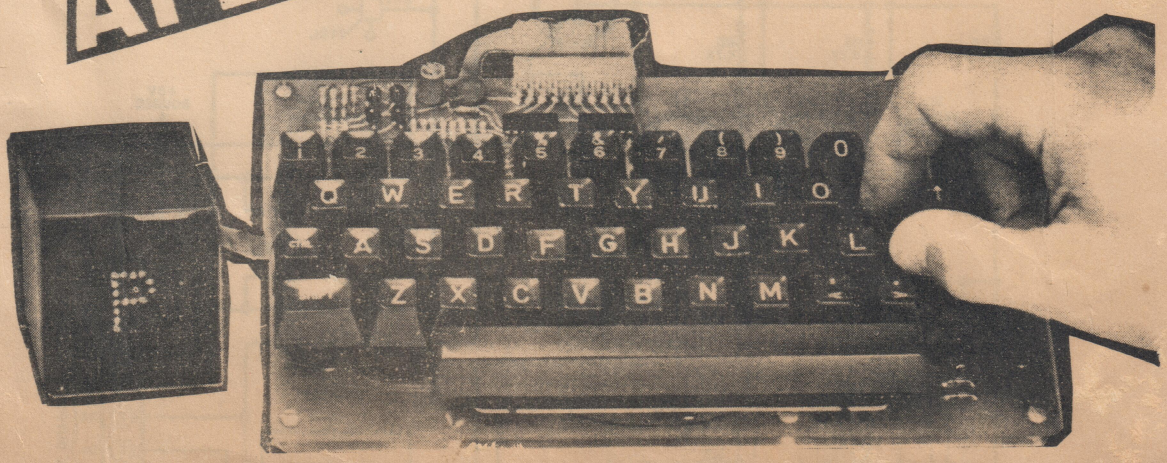
CONSTRUCTION

AT LAST!



A low-cost, fully professional ASCII KEYBOARD AND ENCODER you can build

PE TESTED

Using only two IC's, this simple-to-build alphanumeric system can be your springboard to many sophisticated applications

BY DON LANCASTER

MANY advanced electronic projects start with an alphanumeric keyboard. The difficulty is in finding one that is reasonable in cost, reliable in use, and equipped with the proper 7- or 8-bit parallel ASCII code. (See box.) This is particularly true if it is to be used with computer circuits, a calculator, ham RTTY equipment, video titling, etc. Commercial keyboards of this type are very expensive and hard to find. Surplus keyboards are limited in availability and usually have encoders and keytops that may

not be compatible with modern circuits.

Here is a brand-new, fully professional, alphanumeric typewriter-style keyboard that you can build yourself for less than $40 and uses only two IC's (readily available) for its integral ASCII encoder and debouncer. Thus, it's both simple to build and inexpensive. The output is directly compatible with TTL, DTL, RTL, CMOS, and PMOS integrated circuits.

The 49 keys provide all the upper-case alphabet, numbers, punctuation, spacing, and transparent or control commands. Two of the keys are uncommitted, which means they can be used for any purpose, either with or without the rest of the encoder circuit. Except for some punctuation which is seldom used, the design follows very closely the ANSI keyboard. It is easily made compatible with such popular industrial equipment as the ASR-33 Teletype®.

High-reliability modular keyswitches duplicate the full typewriter travel and tactile feedback. The two-shot molded keytops are identical to those found on quality office typewriters. The spacebar has an equalizer so that it travels smoothly, regardless of where it is depressed. Power needs are +5 volts at under 100 mA.

About the Circuit. The 48 single-contact, normally open keys are arranged in a matrix 8 keys high by 6 keys wide (Fig. 1). Some of the little-used keys are omitted from the matrix. When a key is depressed, it shorts the wires beneath it.

The "8" side of the matrix goes to a diode encoder (*D3-D11*) and an integrated circuit (½ of *IC1*) that generates the least significant three bits of the ASCII code (B1, B2, and B3).

The "6" side of the matrix goes to a diode encoder (*D12-D20*) and transistors (*Q1-Q4*) that sense which section of the matrix has been selected by a key. When any key is pressed, the signal is sensed by *Q4* and passed on to *IC2* as a key-pressed output, while *Q1* through *Q3* set up the upper, or most significant, four bits of the code, producing B4, B5, B6, and B7. Key actuation is logically combined with a shift key and a control key to handle the machine commands and the punctuation-numeral shifts.

The spacebar and carriage return key do two things at once. Space is a "shifted zero," while carriage return is a "control M." The spacebar is electrically the same as any other key. The eighth ASCII bit can be optionally picked up with an external IC parity generator (such as a 74180); but this feature is seldom used in experimental or small-scale circuits. Capacitor *C2* provides a delay of a few milliseconds so that the code is up and valid before the key-pressed common signal is sent.

Construction. The complete keyboard is assembled on a single, double-sided pc board. Since the two foil patterns are too large to be reproduced here, they are available *free* from the source given in the Parts List.

Adequate mechanical support for the board is essential. It should be backed with a similar-size blank board (or an insulating layer) mounted on a metal plate. The best operation angle is with a slight slope down from the top—about 10 or 15 degrees. If more response is needed on the spacebar, booster springs can be added to each equalizer post.

Testing. Ground terminal A of *SO1* and connect a 100-mA meter to the +5-volt line. Briefly connect the metered 5-volt line to terminal K of *SO1* and note that there is a current of about 30 mA.

Connect a dc voltmeter (5-volt range) to terminal J of *SO1* and note that there is a high level there. If it is low, recheck the key matrix for shorts.

Using the ASCII code as a guide, depress

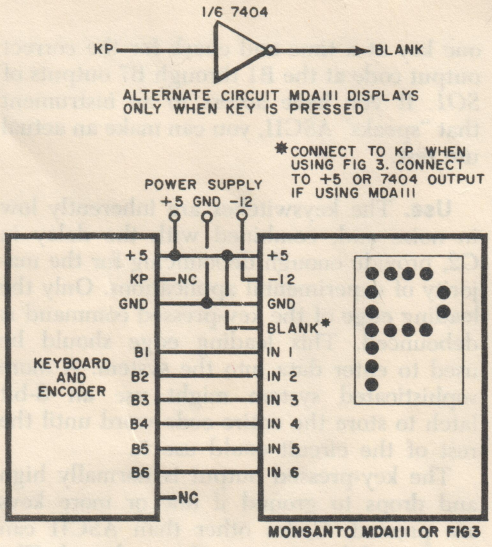


Fig. 2. One possible output display for the keyboard uses a Monsanto MDA111 readout

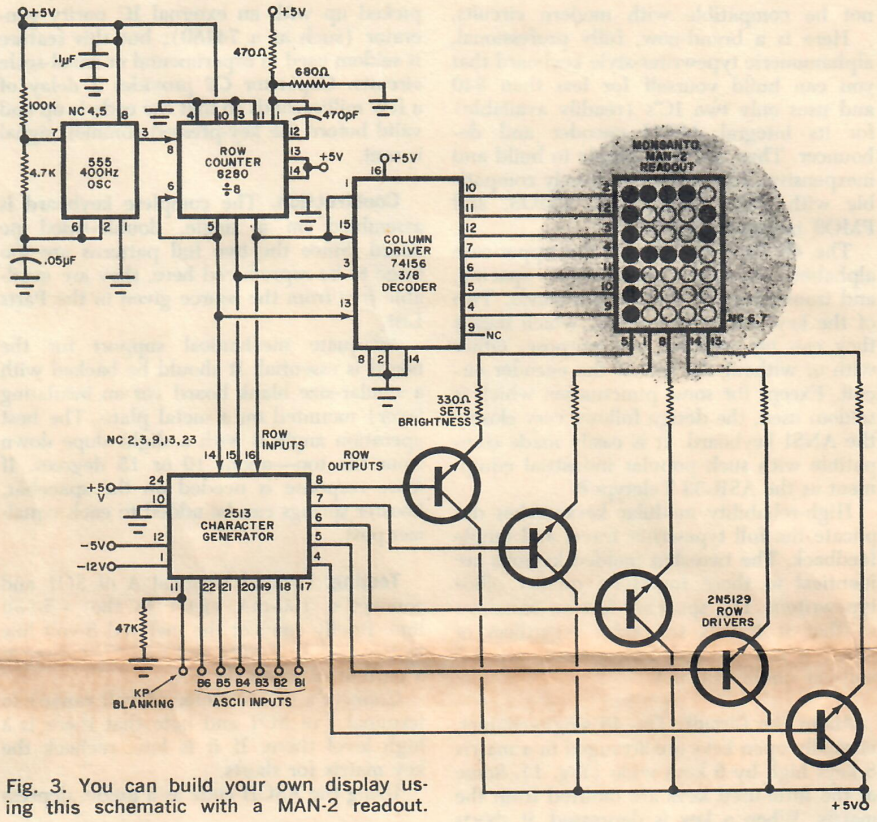


Fig. 3. You can build your own display using this schematic with a MAN-2 readout.

one key at a time and check for the correct output code at the B1 through B7 outputs of *SO1*. If you have access to an instrument that "speaks" ASCII, you can make an actual use test.

Use. The keyswitches are inherently low in noise and, combined with the delay in *C2*, provide enough debouncing for the majority of experimental applications. Only the leading edge of the key-pressed command is debounced. This leading edge should be used to enter data into the system. A more sophisticated system might use an 8-bit latch to store the entire code word until the rest of the circuit could use it.

The key-pressed output is normally high and drops to ground if one or more keys are pressed. Codes other than ASCII can be created by rewiring the pc board. The parallel code output can be converted to serial form by using a shift register such as a 74165 or 2536 UART.

The two uncommitted keys (*S48* and *S49*) can be tied to the encoder for extra commands or used separately for local or remote controlling.

Obviously, the keyboard has to be connected to something else to make it useful. For example, a Monsanto MDA111 alphanumeric display can be connected to the keyboard as shown in Fig. 2. To make your own single-character display (at lower cost), build the circuit shown in Fig. 3.

Some immediate and obvious applications of this one-character computer terminal are as a touch-typing teaching aide; as a means of communication for a deaf or handicapped person; as a pre-school lettering and spelling machine; for keyboard monitoring; for film annotation; as a secure communications loop (with bits of the ASCII code scrambled and

BIT NUMBERS								0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b_7 ↓	b_6 ↓	b_5 ↓	b_4 ↓	b_3 ↓	b_2 ↓	b_1 ↓	COLUMN → / ROW ↓	0	1	2	3	4	5	6	7
			0	0	0	0	0	NUL	DLE	SP	0	@	P	\	p
			0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
			0	0	1	0	2	STX	DC2	"	2	B	R	b	r
			0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
			0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
			0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
			0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
			0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
			1	0	0	0	8	BS	CAN	(	8	H	X	h	x
			1	0	0	1	9	HT	EM	)	9	I	Y	i	y
			1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
			1	0	1	1	11	VT	ESC	+	;	K	[	k	{
			1	1	0	0	12	FF	FS	,	<	L	\	l	|
			1	1	0	1	13	CR	GS	–	=	M	]	m	}
			1	1	1	0	14	SO	RS	.	>	N	^	n	~
			1	1	1	1	15	SI	US	/	?	O	–	o	DEL

WHAT IS ASCII?

ASCII is a standard 8-bit information interchange code, which is used with virtually every computer and data base system. It is essential as an input to such integrated-circuit character-generation systems as the Signetics 2513. ASCII is a machine language. It should not be confused with such programming languages as "Basic," "Fortran," "PLI," "APL," etc. All of the alphanumeric communications between machines using any of these programming languages are really nothing but a group of ASCII coded commands.

The eighth bit of the code is often a 1 all the time, though some systems use the eighth bit for parity or error testing. The remaining seven bits provide 128 possible different codes or characters. Of these, 32 are allocated for the upper-case alphabet and some are often used for punctuation. Another 32 are used for numbers, spacing, and other punctuation. Assigned but very rarely used is a third group of 32 for lower-case alphabet and little-used punctuation. Finally, the remaining 32 possible codes are "transparent" or machine commands, called control or CTRL commands. They never appear in print, but they handle the sequencing of machinery at both ends. A carriage return (CR) is a typical machine command. If only upper case alphanumerics are needed, only six of the eight bits of the code are used. This is called the ASCII-6 code.

The complete code is shown above. The first four bits are read from the left—the remaining three from the top. For instance "H" is 100-1000. A carriage return command is 000-1101, and a 7 is 011-0111. Note that the bottom four number bits are identical to the four-bit binary (BCD) code. By the same token, if the serial form of the ASCII is used with a start bit and two stop bits added, the result is the 11-bit Teletype code such as that used on an ASR-33.

ASCII can be used in parallel form (all bits at once) or serial form (one bit at a time, least, or B1 significant bit first.)

inverted on either end); or as an annunciator or electronic catalog.

On a more ambitious scale, the keyboard can be used as a computer timesharing terminal, either in commercial service or for home or school. The keyboard, with a simple parallel-to-series converter, forms half of an ASR-33 Teletype at a very reasonable cost.

Other applications include programmable calculators, ham RTTY transmission, videotape and TV titling and annotation, electronic editing and page composition, and data search and retrieval systems. ◈

ASSEMBLING YOUR KEYBOARD AND ASC-II ENCODER

All of the encoder parts and keyswitches mount on the top side of the board. See the enclosed component location sheet. The top side of your board is the side with the SwTPc trademark. Mount the diodes, resistors, capacitors and integrated circuits down against the board. The numerical markings on the diodes will vary. The important thing is to put them in so that the end with the band, or bands faces the bar portion of the diode symbol. The banded end is always the cathode on diodes or rectifiers. Solder the parts in place on the bottom side after bending the leads over and trimming them. Mount the transistors approximately 1/16 to 1/8 inch above the top of the board - bend, trim and solder the leads. Mount the output connector on the edge of the board and solder in place.

The keyswitch contacts may have to be adjusted slightly in or out to make them fit the holes exactly. Due to tolerances inherent in moulding plastic there will be some variation in the lead spacing. Push the wire lead gently in the direction needed until the switch will mount down against the board without rocking. Check each switch as it is installed for operation. This can save a lot of troubleshooting time later. Solder the switches in place after checking.

The spacebar and equalizer assembly goes together as follows. Mount a keyswitch on the board in the center of the spacebar area. Mount the two "L" shaped brackets with a notch in the top on each side of the keyswitch in the holes provided. The side of the bracket with the notch should be next to the circuit board edge. These should be fixed in place by melting and flattening slightly the plastic pins on the back side of the board. This can be done with your soldering iron tip. Press one of the equalizer wire retainers into place on the end of the spacebar itself. The hole for the wire should be on the more slanted side of the spacebar that has the four casting bumps. Slip the equalizer wire into the hole in the retainer you have mounted and into the hole on the other you have not yet pressed into place. Press the second retainer into place. Turn the spacebar upside down in front of the board and press the equalizer wire into the notches in the top of the mounting clips. Turn the spacebar over and position it over the keyswitch in the center of the board. Press it down into place.

CAUTION - Be very sure that you have the parts in your board properly before you solder them in place. It is quite easy to damage a double sided board of this type if you attempt to remove a component that has been soldered in place. If you must remove a part, we suggest that you use a solder removal tool, or wick to get the solder off of the connection before you try to remove the part. Attempting to melt the solder and pull the part of the board can easily result in destroying the upper pad and through hole plating.

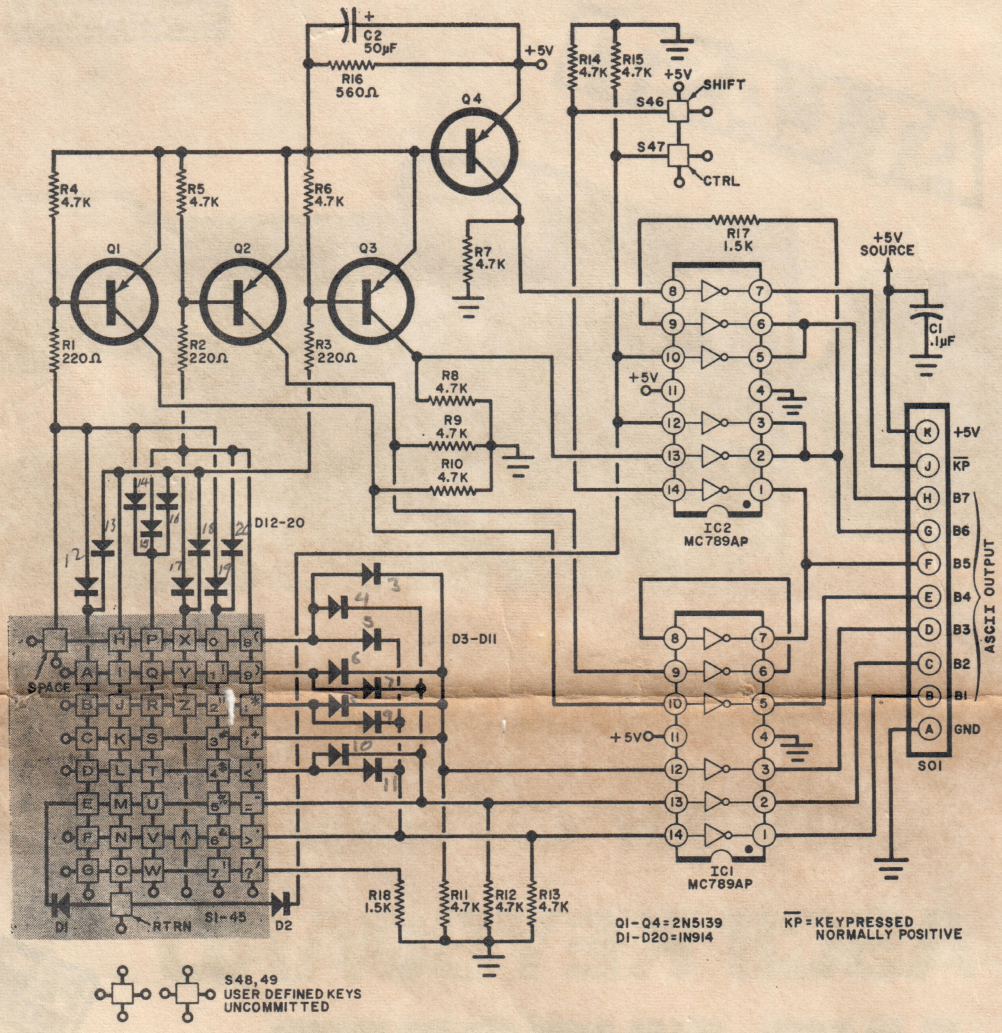
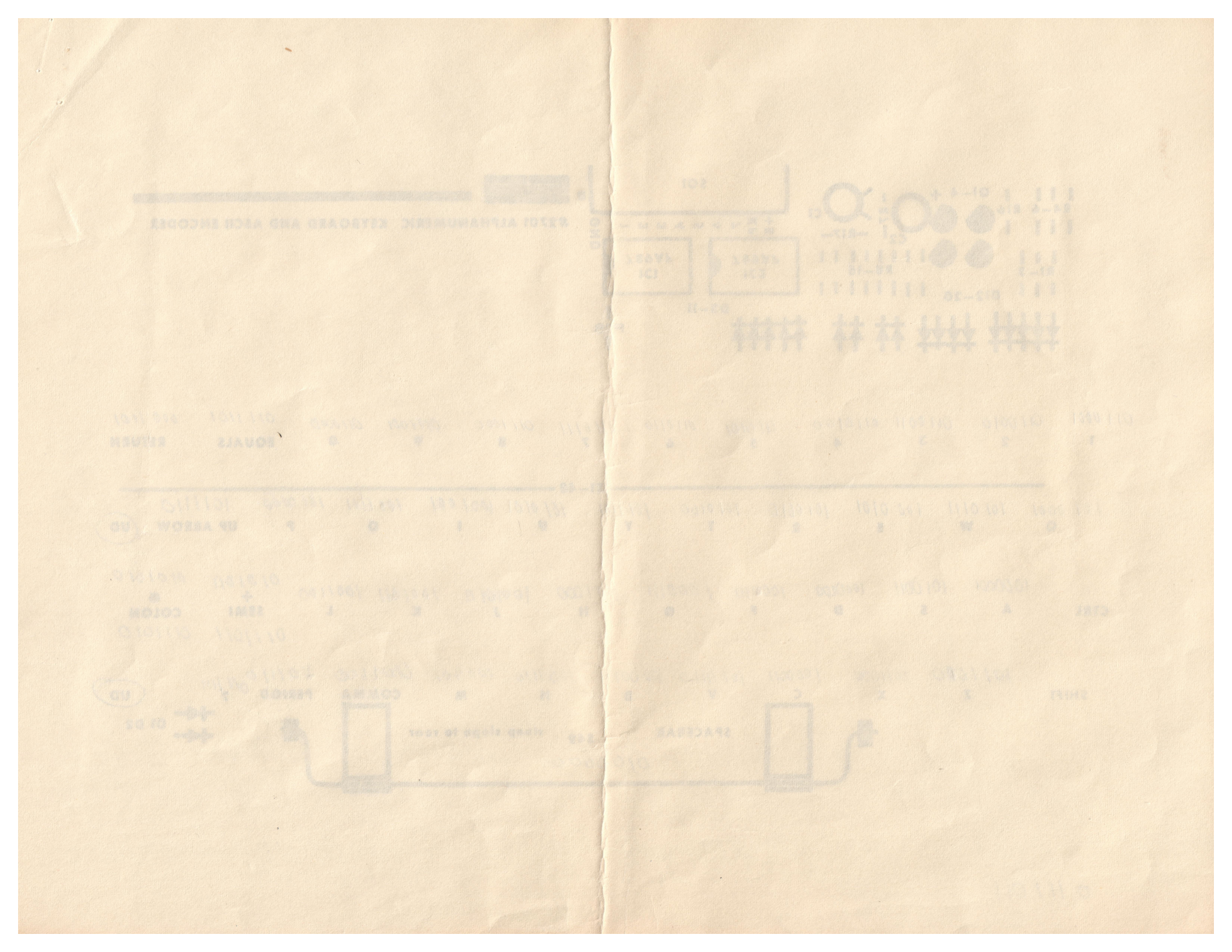
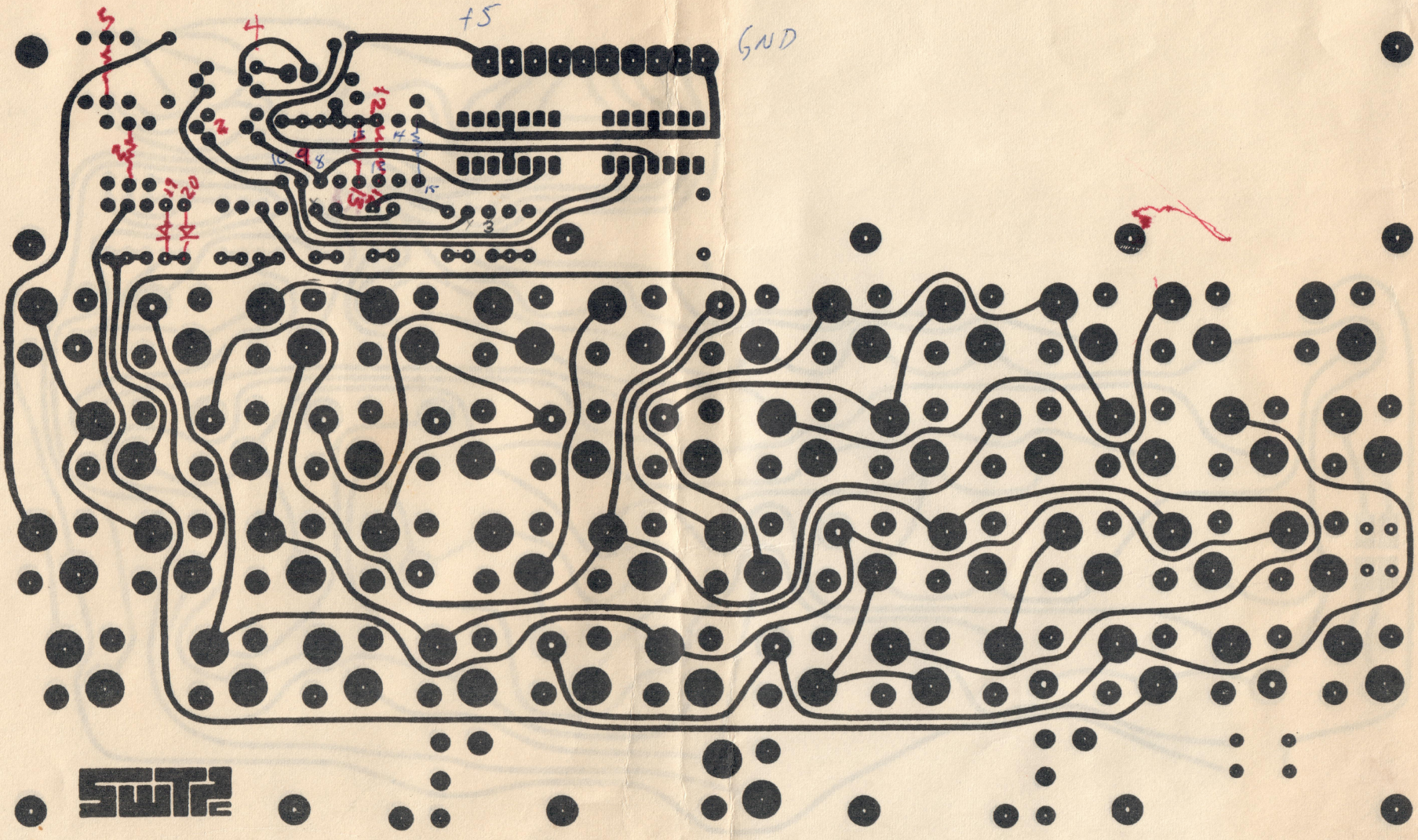


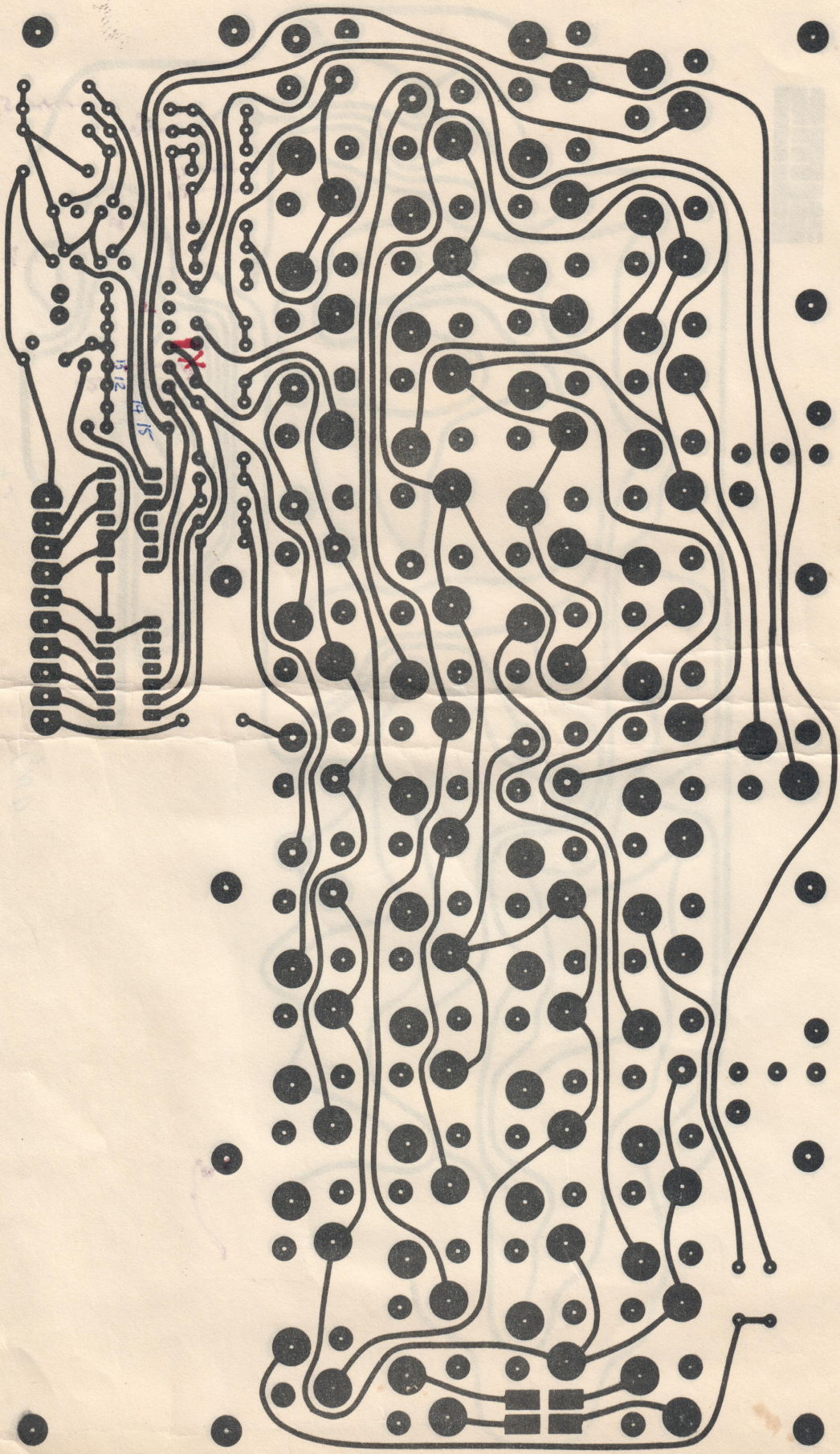
Fig. 1. The 48 keys are arranged in a 6-by-8 matrix as shown in block at lower left. The encoder, Q1 through Q4 and IC1 and IC2, provides the proper output.

PARTS LIST

C1—0.1-μF, 10-volt disc ceramic capacitor
C2—50-μF, 10-volt electrolytic capacitor
D1-D20—1N914 diode
IC1,IC2—MC789AP hex inverter (no substitute)
Q1-Q4—2N5139 transistor
R1-R3—220-ohm, ¼-watt resistor
R4-R15—4700-ohm, ¼-watt resistor
R16—560-ohm, ¼-watt resistor
R17,R18—1500-ohm, ¼-watt resistor
S1-S49—Keyswitches (Mechanical Enterprises LFW-CT)
SO1—Socket (Molex 09-52-3103)
Misc.—Keytops (two-shot molded) (shift and return are 1½ width); spacebar with equalizer and #2-56 mounting hardware; pc board (see text); #6 mounting hardware; solder; etc.
Note—The following are available from Southwest Technical Products, 219 W. Rhapsody, San Antonio, TX 78216: actual-size pc foil patterns and component installation diagram free on request; pc board, etched and drilled #Kb at $17.50; complete kit of all parts #KBC at $39.50 plus postage for 3 lb.




+5
GND



Warranty

Southwest Technical Products will replace at no charge any part in a kit, except semiconductors, that fails under normal use due to materials or workmanship for a period of ninety days from date of purchase. Parts to be submitted for replacement must be removed from the circuit and returned to the factory along with a copy of the order for the kit. Southwest Technical Products Corporation assumes no other liabilities or obligations expressed, or implied. No parts damaged in handling, or assembly will be replaced under warranty. If, in our opinion, inspection indicates that the part was faulty, it will be replaced by return mail. The above warranty applies only to the faulty part. No parts damaged by other failures can be replaced.

Semiconductors are tested by the manufacturer and assumed to be good, unless found to be defective during testing before they are used. Due to the many ways that such devices can be damaged, or destroyed by incorrect assembly, or operating conditions; no semiconductors can be replaced after they have been installed.

In Case of Problems

Southwest Technical Products Corporation offers consultation and repair service on all kits This service is available only on kits built from our parts, wired as directed in our instructions and not modified in any way Southwest Technical Products will not attempt repairs unless the above conditions are met. Consultation can only be given on problems associated with our kits. We cannot provide you with information on modifications for other uses, or additions needed to perform other functions.

If you have a problem with your kit that you cannot solve, either write giving all details possible, along with the type and model of the kit, or request details and permission to return the kit for repair. Do not return the kit until we request it.

Exchanges and Refunds—If you are not satisfied with your kit for any reason, we will exchange it, or issue a refund for the price of the kit if you return it to us in original condition within 10 days. We will exchange, or make refund on kits after this time for a 10% restocking fee. We will not exchange or make refund on kits that are discontinued, or no longer in production. You must return all original papers—no refunds, repairs, or adjustments will be made without them.