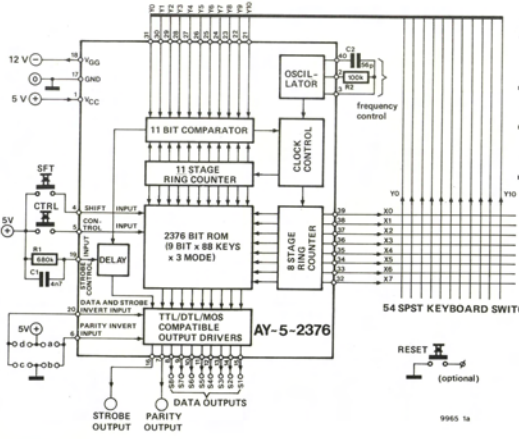
The most common method of communicating with a microcomputer is via an alphanumeric keyboard. The keyboard assembly described here is principally intended for use with the 'Elekterminal', which will be described next month, however the standard design ensures that it can also be employed with other data terminals.

As its name suggests, an alphanumeric keyboard is one which contains both alphabetic characters and (decimal) numerals as well as the usual punctuation marks. Obviously, for the computer and data terminal to be able to 'understand' one another, they have to speak the same language, and to this end, several standard formats have been devised, which allocate a particular binary code to each alphanumeric character. The most popular and widely-used format is the American Standard Code for Information Interchange, usually referred to by its acronym, ASCII. This is an 8-bit code, in which the most significant bit (MSB) is used as a parity bit for error detection. Since 7 binary digits can be arranged in 128 different combinations, it is clear that a considerable number of the 7-bit codes are left over once all the decimal digits, alphabetic characters and punctuation symbols have been catered for. In the ASCII format the remaining codes are assigned control functions. A complete listing of the ASCII character set, with an explanation of the control characters, is shown in table 1.

Keyboard circuit

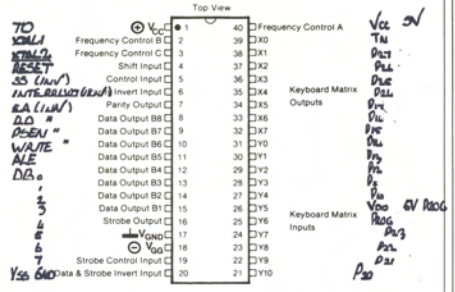
Although, in principle, it would be

1a



1b

AY-5-2376

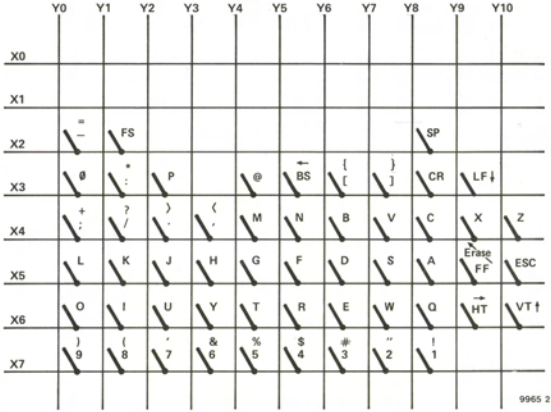


9965 - 1b

Figure 1. Pin configuration and block diagram of the AY-5-2376 amount to a circuit diagram of the keyboard.

Figure 2. This figure illustrates which elements of the matrix are occupied by keys.

2



9965 2

parts list to figures 1, 3 and 4

Resistors:
R1 = 100 k
R2 = 680 k

Capacitors:
C1 = 4n7
C2 = 56 p

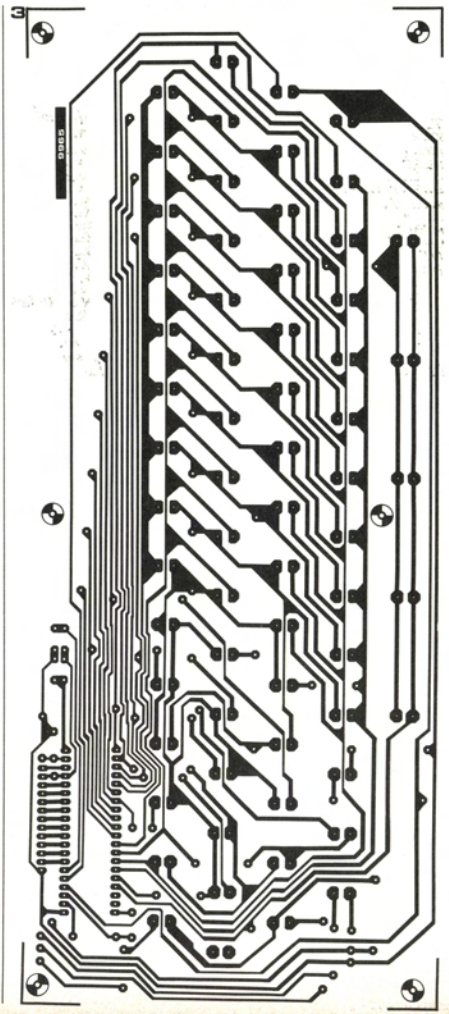
Semiconductors:
IC1 = AY-5-2376 (General Instruments)

Miscellaneous:
62 keyboard switches: TKC type MM9 — 2

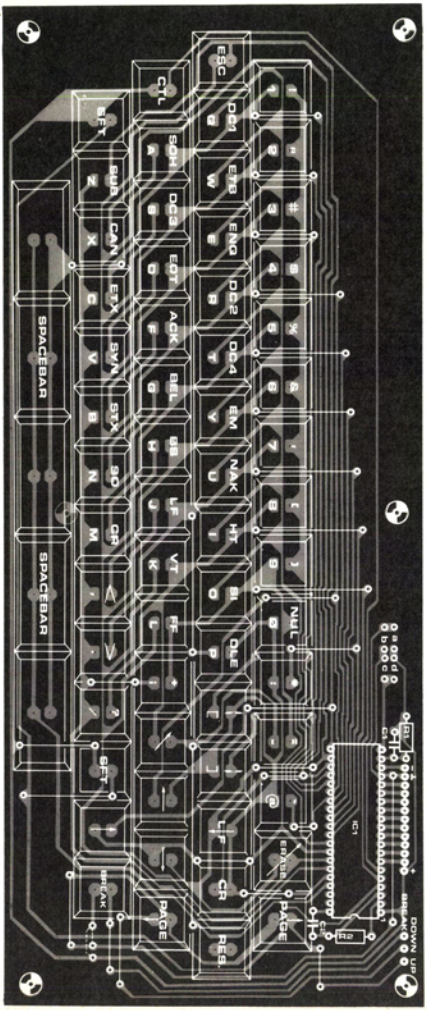
We have been informed that the TKC switches are to be supplied in the UK by the following companies (see advertisement section for further details):
Astec Europe Ltd., Windsor
De Boer Electronics, Eindhoven
Marshall's Ltd., London

Figure 3. Track pattern of the keyboard p.c.b. (EPS 9965).

Figure 4. Component overlay of the keyboard p.c.b.
Note that the copper layout and component overlay are reproduced here at 90% of actual size.



4



possible to design a keyboard which had a separate key for each of the 128 characters, it would obviously be not only extremely expensive, but rather unwieldy. Thus, as is the case with typewriters, each key is normally assigned a double (or triple) function, with a shift key to determine which of the codes which correspond to a particular key is in fact generated.

The key closures are converted into ASCII code by means of an encoder IC; this is basically little more than a ROM in which the complete ASCII code is stored, and which is addressed by the keyboard. There are several IC encoders currently available, the one used here is the AY-5-2376 from General Instruments. Pin-out details and internal block diagram of the IC – which constitutes virtually the entire circuit diagram of the keyboard – are shown in figure 1.

In order to keep the wiring of the keyboard as simple as possible, the keys are arranged in a matrix as shown in figure 2. For reasons which will become clear, not every point in the matrix requires a key. In addition to those keys in the matrix, several additional keys are shown in figure 1, namely a break key, two page keys, a reset key, a shift key and a control key. The break- and page keys are intended for the Elekterminal (to be described next month), whilst the reset key is optional. The shift- and control keys are used to select the different functions of each key in the keyboard matrix. This is illustrated in table 2, which lists the characters obtained when the 'N' (normal), 'S' (shift) and 'C' (control) keys are depressed. As can be seen, a large number of characters occur more than once in the table, which is the reason why not all the points in the matrix need be occupied by keys.

A number of ASCII characters are assigned non-standard functions in the Elekterminal. These are listed in table 3, along with an explanation of their new function. If the keyboard is used with other data terminals, then the characters can, of course, retain their original significance.

All mechanical switches are prone to a certain amount of contact bounce. In order to eliminate the effects of this the IC contains a delay network which can be controlled externally. The length of delay is determined by the time constant R1/C1. Via wire links a, b, c and d, pins 6 and 20 of the IC can be connected either to a '0' or '1' voltage level. In the latter case, the data outputs, strobe-output and parity output are inverted. In normal use these pins are grounded, i.e. only links c and b are made.

Construction

In order to facilitate construction of the keyboard a printed circuit board was designed, which is intended to accomo-

Table 1.

Character	Binary Bit 7 to Bit 0	Hexadecimal	Character	Binary Bit 7 to Bit 0	Hexadecimal
NUL	00000000	00	@	01000000	40
SOH	00000001	01	A	01000001	41
STX	00000010	02	B	01000010	42
ETX	00000011	03	C	01000011	43
EOT	00000100	04	D	01000100	44
ENQ	00000101	05	E	01000101	45
ACK	00000110	06	F	01000110	46
BEL	00000111	07	G	01000111	47
BS	00001000	08	H	01001000	48
HT	00001001	09	I	01001001	49
LF	00001010	0A	J	01001010	4A
VT	00001011	0B	K	01001011	4B
FF	00001100	0C	L	01001100	4C
CR	00001101	0D	M	01001101	4D
SO	00001110	0E	N	01001110	4E
SI	00001111	0F	O	01001111	4F
DLE	00010000	10	P	01010000	50
DC1	00010001	11	Q	01010001	51
DC2	00010010	12	R	01010010	52
DC3	00010011	13	S	01010011	53
DC4	00010100	14	T	01010100	54
NAK	00010101	15	U	01010101	55
SYN	00010110	16	V	01010110	56
ETB	00010111	17	W	01010111	57
CAN	00011000	18	X	01011000	58
EM	00011001	19	Y	01011001	59
SUB	00011010	1A	Z	01011010	5A
ESC	00011011	1B	[	01011011	5B
FS	00011100	1C	\	01011100	5C
GS	00011101	1D	]	01011101	5D
RS	00011110	1E	^	01011110	5E
US	00011111	1F	_	01011111	5F
SP	00100000	20	`	01100000	60
!	00100001	21	a	01100001	61
"	00100010	22	b	01100010	62
#	00100011	23	c	01100011	63
$	00100100	24	d	01100100	64
%	00100101	25	e	01100101	65
&	00100110	26	f	01100110	66
'	00100111	27	g	01100111	67
(	00101000	28	h	01101000	68
)	00101001	29	i	01101001	69
*	00101010	2A	j	01101010	6A
+	00101011	2B	k	01101011	6B
,	00101100	2C	l	01101100	6C
—	00101101	2D	m	01101101	6D
.	00101110	2E	n	01101110	6E
/	00101111	2F	o	01101111	6F
0	00110000	30	p	01110000	70
1	00110001	31	q	01110001	71
2	00110010	32	r	01110010	72
3	00110011	33	s	01110011	73
4	00110100	34	t	01110100	74
5	00110101	35	u	01110101	75
6	00110110	36	v	01110110	76
7	00110111	37	w	01110111	77
8	00111000	38	x	01111000	78
9	00111001	39	y	01111001	79
:	00111010	3A	z	01111010	7A
;	00111011	3B	{	01111011	7B
<	00111100	3C	|	01111100	7C
=	00111101	3D	}	01111101	7D
>	00111110	3E	~	01111110	7E
?	00111111	3F	DEL	01111111	7F

NUL — null, or all zeros
SOH — start of heading
STX — start of text
ETX — end of text
EOT — end of transmission
ENQ — enquiry
ACK — acknowledge
BEL — bell
BS — backspace
HT — horizontal tabulation
LF — line feed
VT — vertical tabulation
FF — form feed
CR — carriage return
SO — shift out
SI — shift in
DLE — data link escape
DC1 — device control 1
DC2 — device control 2
DC3 — device control 3
DC4 — device control 4
NAK — negative acknowledge
SYN — synchronous idle
ETB — end of transmission block
CAN — cancel
EM — end of medium
SUB — substitute
ESC — escape
FS — file separator
GS — group separator
RS — record separator
US — unit separator
SP — space
DEL — delete

Table 1. This table lists the complete ASCII character set, along with the corresponding binary and hexadecimal values for each character.

Table 2. This table illustrates the relationship between the keyboard matrix and the corresponding set of characters. It is apparent that, since several characters appear more than once, a key is not required for every element of the matrix.

Table 3. A number of ASCII characters are assigned non-standard functions in the Elekterminal. This table indicates which characters are involved and also their new significance.

Figure 5. Keyboard layout.

Table 2.

C: control
S: shift
N: normal

		y 0	y 1	y 2	y 3	y 4	y 5	y 6	y 7	y 8	y 9	y 10
	C	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	DC1	DLE	SI
x 0	S	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	DC1	@	←
	N	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	DC1	P	O
	C	DLE	VT	FF	SO	CR	NAK	SYN	ETB	CAN	EM	SUB
x 1	S	DLE	[	\	↑	]	NAK	SYN	ETB	CAN	EM	SUB
	N	DLE	K	L	N	M	NAK	SYN	ETB	CAN	EM	SUB
	C		FS	GS	RS	US				SP		US
x 2	S	=	FS	GS	RS	US	<	>	,	SP	•	←
	N	—	FS	GS	RS	US	<	>	,	SP	•	←
	C		DLE	US		BS	ESC	GS	CR	LF		
x 3	S		*	P	DEL	`	BS	{	}	CR	LF	RUB
	N	Ø	:	p	←	@	BS	[	]	CR	LF	OUT
	C					CR	SO	STX	SYN	ETX	CAN	SUB
x 4	S	+	?	>	<	M	N	B	V	C	X	Z
	N	;	/	•	,	m	n	b	v	c	x	z
	C	FF	VT	LF	BS	BEL	ACK	EOT	DC3	SOH	FF	ESC
x 5	S	L	K	J	H	G	F	D	S	A	FF	ESC
	N	l	k	j	h	g	f	d	s	a	FF	ESC
	C	SI	HT	NAK	EM	DC4	DC2	ENQ	ETB	DC1	HT	VT
x 6	S	O	I	U	Y	T	R	E	W	Q	HT	VT
	N	o	i	u	y	t	r	e	w	q	HT	VT
	C										RS	FS
x 7	S	)	(	'	&	%	$	=	"	!	ESC	|
	N	9	8	7	6	5	4	3	2	1	↑	\

Table 3.

CTL	+	L	=	FF	(FORM FEED)	= home cursor + page clear
CTL	+	J	=	LF	(LINE FEED)	= LF + cursor ↓
CTL	+	I	=	HT	(HORIZONTAL TAB)	= cursor →
CTL	+	K	=	VT	(VERTICAL TAB)	= cursor ↑
CTL	+	M	=	CR	(CARRIAGE RETURN)	= CR = erasure to end of line
CTL	+	H	=	BS	(BACK SPACE)	= cursor ←
CTL	+	\	=	FS	(FILE SEPARATOR)	= home cursor
SFT	+	↑	=	ESC	(ESCAPE)	= scroll up
CTL	+	Z				= erasure of current line

date all the necessary hardware (i.e. including the keys). Figures 3 and 4 show the copper track pattern and component overlay respectively. The board layout is designed to take TKC type MM9 keyboard switches. The keyboard layout is illustrated in figure 5. A certain amount of care should be used when mounting the keys. Since they are only held in place by their terminal pins one must be careful to ensure that the keys are correctly positioned, otherwise there is the danger that the key tops may touch one another and a key will remain depressed after being hit. The best solution is to mount the keys row by row, using a jig or template to hold the keys in place.

The connections between the keyboard and receiver section of the terminal are best made using ribbon cable, via which the keyboard can simultaneously be provided with the necessary supply voltages of +5 and −12 V. The current consumption of both supplies is a maximum of 10 mA. ⏹

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