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presents

The Best of The Transactor Volume 1

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Preface

The Best of The Transactor, Volume 1, is a collection of the finer articles published in the first 11 issues of The Transactor. These articles are printed in their entirety and follow the original format. The Best of The Transactor was not intended to introduce new material, but rather to unite material in co-existence.

I hope you will find this book a useful teaching tool and an interesting reference manual. The Transactor is put together, at least in part, with your input and I would like to say a special "thank you" to all who have contributed. If you have an interesting discovery, article or program listing that you would like to share, or if there is a subject you would like covered, I would be pleased to hear from you.

I have enjoyed my work with The Transactor over the past year and hope, with your continued support, that The Transactor Volume 2 will be even better.

Karl J. Hildon,
Editor.

BITS AND PIECES

ARE YOU READY?

There have been reported mysterious occurences of the out of data error when editing and fiddling about in general.

This is not a bug, but is due to pressing RETURN whilst the cursor is over the READY prompt. The machine interprets this as READ Y and as there is usually no corresponding data statement around we get the error.

REDO

It must be remembered that when RETURN is pressed, the machine consumes everything on the same line as the cursor, so even if you have correct information at the beginning of a given line, a single character of an incorrect type far over on the right hand side of the screen on the same line is likely to cause problems. A rather problematical example of this situation occurs if you try and put up a graphic form or set of boxes on the screen and then under programme control ask for data with an input statement, e.g.

NUMBER ?

When the number is typed and RETURN is pressed, the graphics character making up the right-hand side of the box will be entered as part of the inputting data. In the case of input to a numeric variable, the graphics character is of course non-numeric and not allowed and will give the error ? Redo from start, so you must always leave such boxes open ended.

INVERSE TRIGNOMETRIC FUNCTIONS

Here are a couple of handy methods of obtaining arc sine and arc cosine (remember, the result will be in radians).

```
ASNX = ATN (X/SQR(1-X↑2)
ACSX = ATN (SQR(1-X↑2)/X)
```

For those of you who are used to working in degrees, here are some handy user defined functions:

```
DEFFNS(V) = SIN(V/(180/π))
DEFFNC(V) = COS(V/(180/π))
DEFFNT(V) = TAN(V/(180/π))
```

These are three user defined functions which when called with arguments and degrees will give the appropriate results. In these examples V can be any variable but if all three are defined in the same programme, you must use three different dummy variables.

EXAMPLE: PRINT FNS(30)

Result of this will be .5. Notice that the argument for FNS, or FN anything for that matter, can be either a variable or numeric constant. Also, after a programme containing these definitions has been run, these functions may be called using FN in the direct mode, that is, from the keyboard directly without being in a programme.

INTERRUPT STRUCTURE

Interrupts (including Break or Software Interrupts) are handled by software polling.

When the processor recognizes an interrupt it vectors through FFFE, FFFF in ROM to a routine that first inspects the processor hardware (IRQ line low).

If it was caused by a Break instruction, a Jump Indirect is executed through locations 021B, C. If by a hardware interrupt then a Jump Indirect is taken through locations 0219, A.

These locations being in RAM may be user-modified to point to extra user code ahead of normal interrupt processing.

Note, however that the IRQ pointer is used by the cassette routines and should be restored to standard values before the cassette Save or Load functions are called.

Various sections of the I/O chips can be set up to cause interrupts through the IRQ line.

Example: POKE 59470,2 enables a negative edge on the user port CAL line to cause an interrupt.

However, have your code set up to handle it when it happens!

Also note that each pass through the regular interrupt code increments the time register.

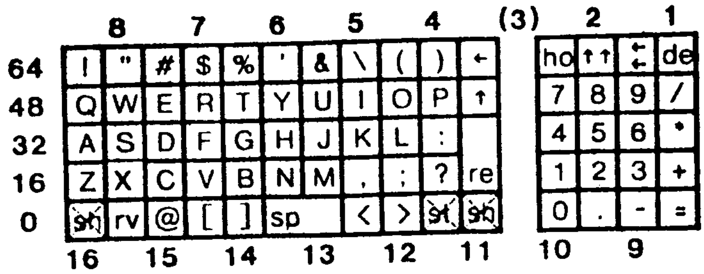
EDITING

There is an interesting property of the screen edit routine which gives rise to the following effects:-

If you insert using the INS key, more spaces than you type in characters, the DEL key must be pressed twice the number of times there are spare spaces. E.g. If you insert six spaces in a middle of a line and only type in four new characters, the first two presses of the DEL key will produce inverse characters which will disappear on the next two presses. Remember, the INS key will move all characters including the one under the cursor to the right, whilst the DEL key will delete the character on its immediate left.

PET Matrix-Decoded Keyboard

See 515 & 516 in table below



Interesting Locations Accessible from BASIC

Location (decimal)	Contents
225, 224 226	Byte address of screen line with Cursor Character position of Cursor (0 to 79)
515	Matrix-coordinate (row+column) of last key down 255 if no key down
516	1 if shift down, 0 if shift up
525 526-534	No. of characters in Keyboard Buffer Keyboard Buffer
578 to 587 588 to 597 598 to 607 610	Logical numbers of open files Device numbers of open files Read/write modes of open files How many open files
512, 513, 514 518, 517 59465, 59464	Clock that increments 60 times a second Clock that increments 30 times a second? Clock that decrements every microsecond
59456	WAIT 59456,32,32 waits for vertical retrace of display
64824	SYS(64824) simulates power-on reset
59469	Interrupt Flag Register; e.g., to input user port CA1: I=PEEK(59469) AND 2: POKE 59469,I: IF I=0 THEN *CA1 low*
59411	IEEE PIA B Control, e.g., to run cassette#1 motor N jiffies: 100 POKE 59411,53: T=TI 200 IF TI-T<N GOTO 200 300 POKE 59411,61 ADVICE: *Run motor at least 3 jiffies per 191 output chars*

TIMING TABLES

BASIC STATEMENTS AND I/O

CONSTRUCT	APPROX. TIME (MILLISEC)
FRE	1 to 10
PEEK, POKE	1
TI$	3 to 4
TI	1
GET	1 to infinity
POS	1
PRINT X or PRINT	15 to 19
PRINT X$;	14 + LEN (X$)/2
READ X and DATA 3	9
REM	0.2 to 2
RESTORE	0.3
TAB	2
SPC(N)	1 + 0.6*N
FOR 1 = ... NEXT 1	4.0 + (1.6 each)
STEP	1.3
IF	0.4
GOTO or GOSUB	1.1
ON A GOTO or GOSUB L_1 ...... L_M	0.5 + (0.3*A) + (0.2*M)
RETURN	0.9

Using colon,:, saves 0.6 over new line.
SAVE or LOAD
15 sec + (2 sec per 100 char)
i.e. 500 baud.

STRING FUNCTIONS

FUNCTION	APPROX. TIME (MILLISEC)
+	0.5 + (0.2 per char)
ASC	1
CHR$	1.2
LEFT$, RIGHT$	3 + (0.025 per char)
LEN	0 to 8
MID$	4 + (0.025 per char)
STR$	7 to 10

STRING FUNCTIONS (Cont'd)

FUNCTION	APPROX. TIME (MILLISEC)
VAL	1.3
=, <>, <, <=, >, >=	3 to 4

ARITHMETIC FUNCTIONS

FUNCTION	APPROX. TIME (MILLISEC)
ABS	0.6
ATN	42
COS	27
EXP	27
INT	1.2
LOG	23
RND RND (-1)	1.0
RND (0)	0.9
RND (1)	4.1
SGN	1.1
SIN	25
TAN	50
user FN	2.4

ARITHMETIC OPERATORS

SYMBOL	APPROX. TIME (MILLISEC)
↑ 0↑B, 1↑B	0.3
2↑B	32
else	50 to 100
/ 0/B, A/1	0.5
else	2 to 5
* 0*B, A*0	0.4
else	1.5 to 3
+	0.3 to 1
-	0.3 to 1
=, <>, <, <=, >, >=	0.7
AND, OR	1.7
NOT	1.4

VARIABLES AND CONSTANTS

ITEM	APPROX. TIME (MILLISEC)
A,A$,A =,A$ =	0.7 to (0.7 + nv*0.1) nv = no. of variables in program
AA,AA$,AA =,AA$ =	0.2 more than above
A%	0.3 more than A
A%=	0.6 more than A =
999	1 per digit
.999	0.7 + (4.2 per digit)
E16	0.2 + (0.4* exponent)
E-16	0.2 + (3.0* exponent)
"ABCDE"	(0.6 to 0.7) + (0.02 per char)
M (I,J....)	(1 to 1.5)* (no. of subscripts)

TIMING PROGRAM

```
100    N = 300
200    T1 = T1
300    FOR 1 = 1 TO N
400    REM PUT TEST CONSTRUCT HERE
500    NEXT 1
600    T2 = T1
700    FOR 1 = 1 TO N
800    NEXT 1
900    T3 = T1
1000   PRINT 1000* (2*T2-T1-T3)/(60*N)
1100   END
```

MEMORY USAGE (IN BYTES)

BASIC 1028 (1/0 buffers, tables etc)

each statement
- 4 for line number and following space, regardless for the line number
- 1 for each BASIC keyword
- 1 for each other character, including RETURN

each variable with a value assigned, regard less of spelling or value takes 7 bytes; for string variables, add the length of the string

each array (N.B., size includes 0th element) take f* (size + 1) + (2 per dimension) where f=5 for floating point arrays, f=2 for integer arrays, and f=3 for string arrays.

The system slows down noticeably when memory is neary full.

Character	ASC/CHR	PEEK/POKE	Character	ASC/CHR	PEEK/POKE	Character	ASC/CHR	PEEK/POKE	Character	ASC/CHR	PEEK/POKE
	0		@	64	0		128			192	64
	1		A	65	1		129		,a	193	65
	2		B	66	2		130		,b	194	66
	3		C	67	3		131		,c	195	67
	4		D	68	4		132		,d	196	68
	5		E	69	5		133		,e	197	69
	6		F	70	6		134		,f	198	70
	7		G	71	7		135		,g	199	71
	8		H	72	8		136		,h	200	72
	9		I	73	9		137		,i	201	73
	10		J	74	10		138		,j	202	74
	11		K	75	11		139		,k	203	75
	12		L	76	12		140		,l	204	76
RETURN	13		M	77	13		141		,m	205	77
	14		N	78	14		142		,n	206	78
	15		O	79	15		143		,o	207	79
	16		P	80	16		144		,p	208	80
⇓	17		Q	81	17	⇑	145		,q	209	81
RVS	18		R	82	18	RVSoff	146		,r	210	82
HOME	19		S	83	19	CLEAR	147		,s	211	83
DEL	20		T	84	20	INST	148		,t	212	84
	21		U	85	21		149		,u	213	85
	22		V	86	22		150		,v	214	86
	23		W	87	23		151		,w	215	87
	24		X	88	24		152		,x	216	88
	25		Y	89	25		153		,y	217	89
	26		Z	90	26		154		,z	218	90
	27		[	91	27		155			219	91
	28		\	92	28		156			220	92
⇒	29		]	93	29	⇐	157			221	93
	30		↑	94	30		158			222	94
	31		←	95	31		159			223	95
space	32	32	space	96	32		160			224	96
!	33	33	!	97	33		161	97		225	97
"	34	34	"	98	34		162	98		226	98
#	35	35	#	99	35		163	99		227	99
$	36	36	$	100	36		164	100		228	100
%	37	37	%	101	37		165	101		229	101
&	38	38	&	102	38		166	102		230	102
'	39	39	'	103	39		167	103		231	103
(	40	40	(	104	40		168	104		232	104
)	41	41	)	105	41		169	105		233	105
*	42	42	*	106	42		170	106		234	106
+	43	43	+	107	43		171	107		235	107
,	44	44	,	108	44		172	108		236	108
-	45	45	-	109	45		173	109		237	109
.	46	46	.	110	46		174	110		238	110
/	47	47	/	111	47		175	111		239	111
0	48	48	0	112	48		176	112		240	112
1	49	49	1	113	49		177	113		241	113
2	50	50	2	114	50		178	114		242	114
3	51	51	3	115	51		179	115		243	115
4	52	52	4	116	52		180	116		244	116
5	53	53	5	117	53		181	117		245	117
6	54	54	6	118	54		182	118		246	118
7	55	55	7	119	55		183	119		247	119
8	56	56	8	120	56		184	120		248	120
9	57	57	9	121	57		185	121		249	121
:	58	58	:	122	58		186	122		250	122
;	59	59	;	123	59		187	123		251	123
<	60	60	<	124	60		188	124		252	124
=	61	61	=	125	61		189	125		253	125
>	62	62	>	126	62		190	126		254	126
?	63	63	?	127	63		191	127		255	127

Hardware available:

Convenience Living Systems, 648 Sheraton Drive, Sunnyvale, CA 94087 EXPANDAPET for $435 assembled with 16K RAM, sockets for 4K EPROM, 2 parallel 1/0 ports with handshake, slots for 3 option cards, and all cables and brackets.

Forethough Products, Box 8066, Coburg, OR 97401. The PETSI PET to S-100 interface/motherboard. $105 kit or $160 assembled. Includes 4 slots, dynamic memory controller, and sockets for 8K 2716 EPROM.

The Net Works, 5014 Narragansett #6, San Diego, CA 92107 has an IEEE to RS-232 board (with dual ports) for $160 assembled and tested including on board power supplies. They also announced their TNW-488 Low Speed Modem Module to interface IEEE-488 (PET connector version) to the telephone network using the BELL 103A standard. Doug Gage, one of TNW's proprietors sent preliminary announcement specs and some documentation. He also said they had a prototype running for some time, and are now producing the first units at $225 assembled.

The 8 **bit** user port is actually part of an MOS Technology MCS 6522 Versatile Interface Adapter (VIA). You can get a copy of the VIA data sheet from Commodore Business Machines, 3370 Pharmacy Avenue, Agincourt, Ont. (416)499-4292.Most of the VIA's features apparently are used for the PET itself, leaving only an 8 bit port and two handshake lines, which are really quite simple to use.

The new PET user manual briefly describes the 8 bit port edge connector, pins A and N are grounded, pin B is CA1, the input handshake line, pin M is CB2, the output handshake line, and pins C through L are the 8 data lines, with C being the high order (leftmost) and L the low order bit. When the PET is turned on, the 8 data bits are programmed to act as inputs and CA1 is programmed to recognize a negative transition (from 1 to 0).

To generate an audio signal from the PET a programmable square wave generator is included in the MCS6522 which interfaces the PET Parallel User Port. When the tape drive is not in operation, the generator can be used to produce one of 514 different frequencies between 243HZ and 125KHZ on CB2 (User Port pin M). The 6522 makes this possible by recirculating shift register intended for serial data input and output. With a square wave pattern loaded into the shift register and the control set for free running output under timer controlled rate, a continuous square wave is produced on CB2.

The BASIC statements needed to control the output are as follows:

POKE 59467,16	Sets shift register to free running output mode.
POKE 59464,C	Sets shift rate. C is an integer of 0 to 255.
POKE 59466,D	Loads shift register. D should be 15, 51, or 85 for a square wave output.

The frequency of the square wave can be determined from the following equation:

$$\text{FREQUENCY} = \frac{500000\ \text{HZ}}{(C+2)(D1)}$$

Where: D1 = 8 for D= 15
D1 = 4 for D= 51
D1 = 2 for D= 85

Reading or writing the shift register must be done last as this initiates the shifting operation. The control register at 59467 must be reloaded with 0 for the tape drive to write correctly.

Do not connect a speaker or earphones directly to the CB2 output of the PET. An amplifier is necessary to isolate the 6522 from inductive loads.

The TAPE #2 READ signal on User Port pin 8 (TAPE #2 READ and TAPE WRITE are reversed in the introductory manual) appears to be the CB1 line from the 6522 and carries the shift clock signal. With both CB1 and CB2 available, it may be possible to use the I/O port expansion scheme described in the MCS6522 Data Sheet.

PET CODES:

There are two ways to write to the screen of your PET: either POKEing screen memory (32768-33767) or by PRINTing. Besides this, there are two ways in which memory is interpreted by the character generator: standard mode (location 59468 = binary XXXX110X) or lower case mode (location ≠XXXX110X). Some of this confusion may be simplified with a character code chart. In the chart the OFF and RVS columns refer to values POKEed in screen memory whereas CHR$ refers to the PRINT statement. Thus, either POKE 32768, 129 or PRINT CHR$(18) CHR$(65) will show a reverse A.

This simple program: 10 INPUT M,N:PRINT M;N,"AA"CHR$(M) CHR$(N)"BB":GOTO 10 allows you to explore the full CHR$ set including cursor and reverse. The chart gives CHR$ codes from (0-95) and (128-223). The missing values in the chart have the equivalents:(96-127) = (32-63), (224-254) = (160-190), and 255 = 222.

By referring to an ASC11 code chart we see that ASC11 (0-95) = PET(0-95) but that ASC11(96-127) = PET(192-223), ie. displaced by 96.

The printing mode (standard or lower case) is set by POKEing an address. So as not to disturb any of the other bits in the peripheral control register a safe way to set the lower case mode would be: POKE 59468,PEEK(59468) OR 14 and reset it to standard mode with POKE 59468, PEEK(59468) AND 253 OR 12.

Standard Mode: Location 59468 = XXXX110X

Key	OFF	RVS	CHR$
@	64	192	192
	0	128	64
A	65	193	193
	1	129	65
B	66	194	194
	2	130	66
C	67	195	195
	3	131	67
D	68	196	196
	4	132	68
E	69	197	197
	5	133	69
F	70	198	198
	6	134	70
G	71	199	199
	7	135	71
H	72	200	200
	8	136	72
I	73	201	201
	9	137	73
J	74	202	202
	10	138	74
K	75	203	203
	11	139	75
L	76	204	204
	12	140	76
M	77	205	205
	13	141	77
N	78	206	206
	14	142	78
O	79	207	207
	15	143	79
RETURN			141
			13

Key	OFF	RVS	CHR$
P	80	208	208
	16	144	80
Q	81	209	209
	17	145	81
R	82	210	210
	18	146	82
S	83	211	211
	19	147	83
T	84	212	212
	20	148	84
U	85	213	213
	21	149	85
V	86	214	214
	22	150	86
W	87	215	215
	23	151	87
X	88	216	216
	24	152	88
Y	89	217	217
	25	153	89
Z	90	218	218
	26	154	90
[	91	219	219
	27	155	91
\	92	220	220
	28	156	92
]	93	221	221
	29	157	93
↑	94	222	222
	30	158	94
←	95	223	223
	31	159	95
CLR SCREEN HOME			147
			19
OFF RVS ON			146
			18

Key	OFF	RVS	CHR$
SP	96	224	160
	32	160	32
!	97	225	161
	33	161	33
"	98	226	162
	34	162	34
#	99	227	163
	35	163	35
$	100	228	164
	36	164	36
%	101	229	165
	37	165	37
&	102	230	166
	38	166	38
'	103	231	167
	39	167	39
(	104	232	168
	40	168	40
)	105	233	169
	41	169	41
*	106	234	170
	42	170	42
+	107	235	171
	43	171	43
,	108	236	172
	44	172	44
-	109	237	173
	45	173	45
.	110	238	174
	46	174	46
/	111	239	175
	47	175	47
CURSOR (up/down)			145
			17
CURSOR (left/right)			157
			29

Key	OFF	RVS	CHR$
Ø	112	240	176
	48	176	48
1	113	241	177
	49	177	49
2	114	242	178
	50	178	50
3	115	243	179
	51	179	51
4	116	244	180
	52	180	52
5	117	245	181
	53	181	53
6	118	246	182
	54	182	54
7	119	247	183
	55	183	55
8	120	248	184
	56	184	56
9	121	249	185
	57	185	57
:	122	250	186
	58	186	58
;	123	251	187
	59	187	59
<	124	252	188
	60	188	60
=	125	253	189
	61	189	61
>	126	254	190
	62	190	62
?	127	255	191
	63	191	63
INST DEL			148
			20
RUN STOP			131
			3

Lower Case Mode: Location 59468 ≠ XXXX110X, Same Except 193 to 218 Prints as Lower Case a to z Plus Different Graphics:

105	233	169
122	250	186
94	222	222
95	223	223

Number to Keyboard Conversion

0: End of line
1-31: unused
32: space
33: !
34: "
35: #
36: $
37: %
38: &
39: '
40: (
41:)
42: *
43: +
44: ,
45: -
46: .
47: /
48: 0
49: 1
50: 2
51: 3
52: 4
53: 5
54: 6
55: 7
56: 8
57: 9
58: :
59: ;
60: <
61: =
62: >
63: ?
64: @
65: A
66: B
67: C
68: D
69: E
70: F
71: G
72: H
73: I
74: J
75: K
76: L
77: M
78: N
79: O
80: P
81: Q
82: R
83: S
84: T
85: U
86: V
87: W
88: X
89: Y
90: Z
91: [
92: \
93:]
94: ↑
95: ←
96: space
97: !
98: "
99: #
100: $
101: %
102: &
103: '
104: (
105:)
106: *
107: +
108: ,
109: -
110: .
111: /
112: 0
113: 1
114: 2
115: 3
116: 4
117: 5
118: 6
119: 7
120: 8
121: 9
122: :
123: ;
124: <
125: =
126: >
127: ?
128: END
129: FOR
130: NEXT
131: DATA
132: INPUT#
133: INPUT
134: DIM
135: READ
136: LET
137: GOTO
138: RUN
139: IF
140: RESTORE
141: GOSUB
142: RETURN
143: REM
144: STOP
145: ON
146: WAIT
147: LOAD
148: SAVE
149: VERIFY
150: DEF
151: POKE
152: PRINT#
153: PRINT
154: CONT
155: LIST
156: CLR
157: CMD
158: SYS
159: OPEN
160: CLOSE
161: GET
162: NEW
163: TAB(
164: TO
165: FN
166: SPC(
167: THEN
168: NOT
169: STEP
170: +
171: -
172: *
173: /
174: ↑
175: AND
176: OR
177: >
178: =
179: <
180: SGN
181: INT
182: ABS
183: USR
184: FRE
185: POS
186: SQR
187: RND
188: LOG
189: EXP
190: COS
191: SIN
192: TAN
193: ATN
194: PEEK
195: LEN
196: STR$
197: VAL
198: ASC
199: CHR$
200: LEFT$
201: RIGHT$
202: MID$
203-254: unused
255: π

USING THE PET COMPUTER

Note:- Words in a rectangle indicate a key to be pressed on the PET keyboard, capitals are individual letters to be typed.

To enter and run a program

1. Type NEW then [RETURN] . This will clear out any old programs in the useable memory.
2. Now type the program letter by letter on the keyboard, it will go into memory and also appear on the screen. At the end of each line you must press [RETURN] .
3. After you have typed the entire program correctly you are ready to run it. Type RUN then press [RETURN] and the program will start to operate.

To correct errors

1. The flashing cursor tells you where the next letter will go.
   (a) to move the cursor to the right press [CURSOR ⇆] once for each space.
   (b) to move the cursor to the left hold [SHIFT] down and press [CURSOR ⇆] once for each space.
   (c) to move the cursor down press [CURSOR ⇅] once for each line.
   (d) to move the cursor up hold [SHIFT] down and press [CURSOR ⇅] once for each line.
2. To change an instruction or part of one, move the cursor to the last correct part of the instruction and then type the correct part on top of the incorrect characters, to the end of that line, Be sure to put spaces on top of any letters left after the correction is made, press [RETURN] at the end.
3. To delete characters. Move the cursor to right of last character you wish to delete then press [INST DEL] . This removes the character it is over and moves everything after it left one space.
4. To insert characters. Move the cursor until it is located where the insertion is needed, then hold [SHIFT] down, press [INST DEL] followed by the character you wish to insert. You need to hold [SHIFT] down and press [INST DEL] for each letter you insert.

To load a program from tape

1. Place the casette in the recorder but do not press any buttons on the tape recorder.
2. Type LOAD followed by the name of the program, if no name is typed it will load the next program on tape.
3. When the computer is ready it will ask you to press the play button on the tape recorder.
4. If the tape loads correctly the computerwill then start to run the program. If there is just a ready indication you may have to type RUN. If there is an error in loading from tape, rewind the tape and start the loading instructions over.

Information on the screen

1. You may clear the screen and send the cursor to the upper left corner by holding down [SHIFT] and pressing [CLR HOME].
2. If you wish to get a listing of the program in memory at any time type LIST then [RETURN].
3. When the screen is full the first lines get lost at the top and new lines continue to be added at the bottom. If this happens during the listing of a program and you wish to examine some steps before they go off the top pressing [RUN/STOP] will stop the listing. Actually pressing [RUN/STOP] at any time stops the computer and if during the operation of your program it will tell you at what step you stoped it.

TEST FOR A PRIME NUMBER (BASIC)

```
10   PRINT "TYPE A WHOLE NUMBER"
20   INPUT A
30   IF A = 0 GO TO 999
40   IF A = 1 GO TO 200
50   IF A = 2 GO TO 220
60   B = 2
70   C = A/2
80   D = A/B
90   E = INT(D)
95   F = B*E
100  IF F = A GO TO 240
110  IF B > C GO TO 260
120  B = B + 1
130  GO TO 80
200  PRINT " 1 IS SPECIAL"
210  GO TO 10
220  PRINT " 2 IS A PRIME"
230  GO TO 10
240  PRINT A " IS NOT A PRIME"
250  GO TO 10
260  PRINT A " IS A PRIME"
270  GO TO 10
999  END
```

TO SORT UP TO 20 NUMBERS INTO ASCENDING ORDER

```
10   DIM A(20)
20   PRINT "HOW MANY NUMBERS TO SORT"
30   INPUT N
40   IF N = 0 GO TO 230
50   PRINT " GIVE ME" N "  NUMBERS"
60   FOR K = 1 TO N
70   INPUT A(K)
80   NEXT K
90   J = N - 1
```

TO SORT UP TO 20 NUMBERS INTO ASCENDING ORDER ...continue

```
100 FOR M = 1 TO J
110 FOR I = 1 TO J
120 IF A(I)<A(I+1) GO TO 160
130 B  = A(I+1)
140 A(I+1) = A(I)
150 A(I) = B
160 NEXT I
170 NEXT M
180 PRINT "THE NUMBERS IN ASCENDING ORDER"
190 FOR K = 1 TO N
200 PRINT A(K)
210 NEXT K
220 GO TO 20
230 PRINT "FINIS"
240 END
```

TABLE OF SQUARES, CUBES, ROOTS

```
10   PRINT " TYPE A STARTING NUMBER"
20   INPUT A
30   PRINT " TYPE THE ENDING NUMBER"
40   INPUT B
50   PRINT " [SHIFT] [CLR HOME] "
60   PRINT "N      SQUARE     CUBE       ROOT"
70   FOR N = A TO B
80   C = N↑2
90   C = INT(C)
100  D = N↑3
110  D = INT(D)
120  E = SQR(N)
130  PRINT N;
140  PRINT TAB(6);C;
150  PRINT TAB(16);D;
160  PRINT TAB(26);E
170  NEXT N
999  END
```

DIFFERENCES BETWEEN PET BASIC AND FORTRAN

BASIC	FORTRAN
In General	
BASIC is an interpreter, interpreting and executing each statement as it comes to it.	FORTRAN is a compiler and makes two compiling passes before it attempts to execute.
Statements	
All statements must be numbered in BASIC as it executes them in numerical order.	Only statements to which you transfer may be numbered and must be numbered, numerical order means nothing.
Constants and Variables	
All constants and variables are real until you use the Integer function A = INT(B) truncates the value of B and puts it in A. Can get garbage in 9th digit	Has both integer and real arithmetic and variable names. Must be careful of mixed mode. Has double precision for extra accuracy.
Arithmetic	
BASIC uses A↑2 for A^2	FORTRAN uses A * 2 for A^2
Decisions	
BASIC IF is a logical if e.g. IF A = B IF A < B IF A > = B etc	FORTRAN is a logical if e.g. IF(A-B) 2,3,4
Looping	
BASIC FOR N= 1 TO 20 ... ... NEXT N	FORTRAN DO 10 N= 1, 20 ... ... CONTINUE
Input	
INPUT A,B stops calculating and waits for two numbers to be typed on keyboard and return button to be pushed READ A,B takes information from a DATA statement in sequence	READ(8,2)A,B 2 FORMAT (2F8.2) for card read Some versions of FORTRAN have simpler unformated reads.

Output

PRINT A,B,C prints values at 10,20,30,40

PRINT A;B;C prints 3 spaces apart

PRINT "HELLO" prints characters in quotes

BASIC also has TAB and signals at the end of the statement for more detailed spacing

WRITE(3,5)A,B,C
5 FORMAT(1X,3F15.2) format is more complicated but allows for great flexibility

Some FORTRANS have an output much like BASIC.

Subscripts

Dimension is DIM A(n)

Can have up to 4 subscripts in PET BASIC and 256 limit to their size.

Most FORTRANS only allow triple subscripts, Dimension statement is DIMENSION

Subroutines

GOSUB L in BASIC
Must know the statement number of the routine, and be sure you use the same names of variables to communicate with a subroutine and subroutine may destroy your variables if you use the same names

CALL NAME(a,b,c...) in FORTRAN
Linkage is through the calling sequence and the subroutine is compiled at a different time, hence the actual variable name is not significant. Better for large programs.

Comments

REM followed by printing is not executed by the program, only used to help the reader and programmer tell what is taking place in the program

C. COMMENT followed by printing is not executed by the program, only to give notes to those who read the program.

```
1 OPEN5,4:CMD5
2 PRINTCHR$(26):PRINTCHR$(7):PRINTCHR$(7)
10 DIMA$(75),B$(75)
20 FORI=0TO74
30 READA$(I),B$(I)
40 NEXT
50 PRINT"THIS PROGRAM WILL TEST YOUR KNOWLEDGE OFWORLD CAPITAL CITIES."
60 PRINT:PRINT:PRINT"AFTER EACH STATE (SELECTED AT RANDOM)"
65 PRINT"PLEASE TYPE IN THE APPROPRIATE CAPITAL  FOLLOWED BY A 'RETURN'."
80 PRINT:PRINT
90 N=0:C=0:W=0
100 N=N+1:IFN>10THEN400
105 I=74*RND( 6)
106 I=INT(I)
108 Q=0
110 PRINT:PRINT:PRINT"WHAT IS THE CAPITAL OF "          ;A$(I);
115 PRINT:INPUTZ$
120 IFZ$=B$(I)THEN200
130 PRINT"NOT CORRECT!...TRY AGAIN":W=W+1
140 Q=Q+1:IFQ>=2THEN800
150 GOTO110
200 R=4*RND( 1)   :C=C+1
201 R=INT(R)
210 IFR=1THEN300
220 IFR=2THEN301
230 IFR=3THEN302
240 IFR=4THEN303
250 PRINT"CORRECT..YOU'RE A GENIUS!":GOTO100
300 PRINT"RIGHT ON, BABY!":GOTO100
301 PRINT"ALL RIGHT!!":GOTO100
302 PRINT"YES SIR!!":GOTO100
303 PRINT"YOU'RE TOO MUCH!":GOTO100
400 PRINT"YOUR SCORE IS";C;"CORRECT,";W;"WRONG"
401 PRINT:PRINT"RATING";C/(C+W)*100;"%"
402 PRINT:PRINT:PRINT"DO YOU WISH TO CONTINUE THE LESSON      (TYPE YES OR NO)?
"
403 INPUTC$
404 IFC$="YES"THEN90
405 IFC$="NO"THEN830
406 GOTO402
600 DATAAFGHANISTAN,KABUL,ANGOLA,LUANDA,ALGERIA,ALGIERS,ARGENTINA,BUENOS AIRES
610 DATAAUSTRALIA,CANBERRA,AUSTRIA,VIENNA,BELGIUM,BRUSSELS,BOLIVIA,SUCRE
620 DATABRAZIL,BRASILIA,BULGARIA,SOFIA,BURMA,RANGOON,CAMBODIA,PHNOM PENH
630 DATACANADA,OTTAWA,CHILE,SANTIAGO,COLUMBIA,BOGOTA,COSTA RICA,SAN JOSE
640 DATACUBA,HAVANA,CYPRUS,NICOSIA,CZECHOSLOVAKIA,PRAGUE,DENMARK,COPENHAGEN
650 DATADOMINICAN REPUBLIC,SANTO DOMINGO,ECUADOR,QUITO,EGYPT,CAIRO
660 DATAEL SALVADOR,SAN SALVADOR,ETHIOPIA,ADDIS ABABA,FINLAND,HELSINKI
670 DATAFRANCE,PARIS,W.GERMANY,BONN,E.GERMANY,BERLIN,GREECE,ATHENS
680 DATAGUATEMALA,GUATEMALA CITY,GUYANA,GEORGEROWN,HAITI,PORT-AU-PRINCE
690 DATAHONDURAS,TEGUCIGALPA,HUNGARY,BUDAPEST,ICELAND,REYKJAVIK
700 DATAINDIA,NEW DELHI,IRAN,TEHRAN,IRAQ,BAGHDAD,IRELAND,DUBLIN
710 DATAISRAEL,JERUSALEM,ITALY,ROME,JAMAICA,KINGSTON,JAPAN,TOKYO,JORDAN,AMMAN
720 DATAKENYA,NAIROBI,LEBANON,BEIRUT,LIECHTENSTEIN,VADUZ,LUXEMBOURG,LUXEMBOURG
730 DATAMALTA,VALLETTA,MEXICO,MEXICO CITY,MOROCCO,RABAT,NETHERLAND,AMSTERDAM
740 DATANEW ZEALAND,WELLINGTON,NICARAGUA,MANAGUA,NIGERIA,LAGOS,NORWAY,OSLO
750 DATAPARAGUAY,ASUNCION,PERU,LIMA,POLAND,WARSAW,PORTUGAL,LISBON,SPAIN,MADRID
760 DATASUDAN,KHARTOUM,SWEDEN,STOCKHOLM,SWITZERLAND,BERN,SYRIA,DAMASCUS
770 DATATHAILAND,BANGKOK,TURKEY,ANKARA,UGANDA,KAMPALA,USSR,MOSCOW,USA,WASHINGTO
N
780 DATAU.K.,LONDON,URUGUAY,MONTEVIDEO,VENEZUELA,CARACAS,YUGOSLAVIA,BELGRADE
800 PRINT"WELL,I GUESS YOU REALLY DON'T KNOW IT!! (SHAME)"
810 PRINT:PRINT:PRINT"THE CORRECT ANSWER IS '";B$(I);"'
815 PRINT:PRINT"NOW I WILL ASK YOU AGAIN!"
820 GOTO108
830 END
READY.
```

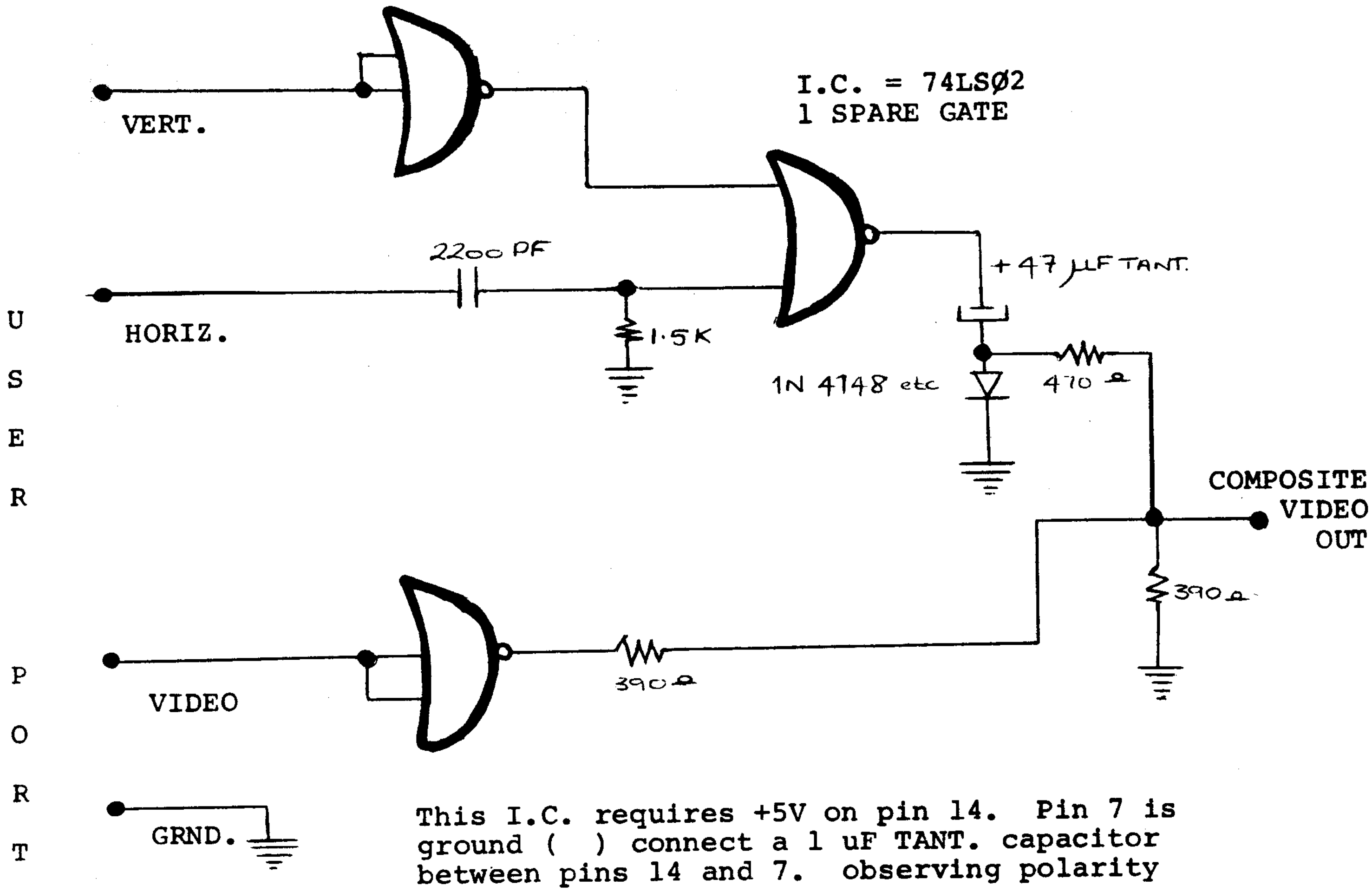
```
*****************************************************
  1)   ROM112.MIC;1
  799       C589  8DFD01    M=A      STA  01FD
  800       C58C  68        (        PLA
  801       C58D  8DFE01    M>A      STA  01FE
  802       C590  A2FC      "<       LDX  #FC
  803       C592  9A        Z        TXS
  804       C593  A900      )@       LDA  #00
  805       C595  858D      EM       STA  8D
  806       C597  8561      E!       STA  61
  807       C599  60                 RTS
  808       C59A  18        X        CLC
****************
  2)   ROM192.MIC;1
  799       C589  A8        (        TAY
  800       C58A  68        (        PLA
  801       C58B  A2FE      ">       LDX  #FE
  802       C58D  9A        Z        TXS
  803       C58E  48        h        PHA
  804       C58F  98        X        TYA
  805       C590  48        h        PHA
  806       C591  A900      )@       LDA  #00
  807       C593  858D      EM       STA  8D
  808       C595  8561      E!       STA  61
  809       C597  60                 RTS
  810       C598  5160      Q        EOR  (60),Y
  811       C59A  18        X        CLC
*****************************************************
```

DIFFERENCES FOUND BETWEEN ROM 011 AND ROM 019
TO CORRECT LOSS OF CURSOR.

```
1 REM*****SQUIGGLE VERSION 2.0*****
2 REM IDEA BY PAUL HITTLE
3 REM PROGRAMMING BY B.SEILER, G.YOB
4 REM CLEAR SCREEN TO START
5 PRINT"♥";
9 REM SQUIGGLE GRAPHICS CHARACTERS
10 DATA"|","—","┘","└","┌","┐"
18 REM CHARACTERS FOR EACH DIRECTION
19 REM 20-UP,30-DOWN,40-RIGHT,50-LEFT
20 DATA1,0,5,6
30 DATA0,1,4,3
40 DATA3,6,2,0
50 DATA4,5,0,2
55 REM A$ HOLDS CHARS, B HOLDS PTRS
56 REM FOR EACH DIRECTION
60 DIMA$(5),B(5,5)
65 REM SET UP A$ AND B()
70 FORI=0TO5
80 READA$(I)
90 NEXT I
100 FORI=1TO4
110 FORJ=1TO4
120 READB(J,I)
130 NEXT J
140 NEXT I
150 REM INITIAL VALUES
160 REM T1,T2 = DIRECTION OF TRAVEL
161 REM T1 IS CURRENT DIRECTION
162 REM T2 IS PREVIOUS DIRECTION
163 REM 1=UP, 2=DOWN, 3=RIGHT, 4=LEFT
170 REM
180 REM X,Y ARE POSITION OF WRIGGLER
181 REM ON SCREEN. 0,0 IS UPPER LEFT
182 REM CORNER (CURSOR HOME)
183 REM 20,12 IS CENTER OF SCREEN
190 T1=1
200 T2=1
210 X=20
220 Y=12
```

```
250 REM GET RANDOM FACTOR
260 PRINT"WIGGLE FACTOR(0-9)";
265 PRINT"▒▮";:FOR J=1TO130:NEXTJ
266 PRINT" ▮";:FOR J=1TO100:NEXTJ
270 GET W$:IFW$=""THEN265
275 IF W$<"0" OR W$ >"9" THEN 260
280 W=VAL(W$)/10+.1
290 PRINT"▮";
300 REM***MAIN LOOP***
301 REM ** TURN OR NOT??
305 IF RND(1)>W*W THEN 325
306 REM YES, DO TURN
310 T1=4*RND(1)+1
320 IFB(T1,T2)=0THEN310
324 REM DRAW MOVE ON SCREEN
325 GOSUB2000
330 T2=T1
339 REM UPDATE POSITION
340 ONT1GOTO400,410,420,430
400 Y=Y-1:GOTO500
410 Y=Y+1:GOTO500
420 X=X+1:GOTO550
430 X=X-1:GOTO550
490 REM ADJUST FOR WRAP-AROUND
500 IFY<1THENY=23:GOTO300
510 IFY>23THENY=1:GOTO300
550 IFX<1THENX=39:GOTO300
560 IFX>39THENX=1:GOTO300
570 GOTO300
1990 REM ***DRAWING SUBROUTINE***
1991 REM POSITION CURSOR AT X,Y
2000 PRINT"▮";
2010 FORI=1TOY
2020 PRINT"▮";
2030 NEXT I
2040 FORI=1TOX
2050 PRINT"▮";
2055 NEXT I
2060 REM PRINT THE CHARACTER
2080 PRINTA$(B(T1,T2)-1);
2090 RETURN
READY.
```

ATTACHING A VIDEO MONITOR TO PET



This I.C. requires +5V on pin 14. Pin 7 is ground ( ) connect a 1 uF TANT. capacitor between pins 14 and 7. observing polarity

Above is a simple circuit which takes the horizontal drive, vertical drive and video waveforms from the PET User Port and converts them to composite video suitable for driving an RF modulator or a straightforward monitor. The circuit requires a 5 volt power supply and this may be obtained from a 2nd cassette socket which has a few milliamps available at 5 volts. There are no particular points to watch out for when constructing this circuit. Lay-out is not critical. In the unlikely event of the horizontal hold of your display device misbehaving, adjust the value of the 1.5K resistor. This will alter the horizontal sync. pulse width.

6502 ASSEMBLER FOR PET 2001

The 6502 Assembler in BASIC is designed to run on an 8K Commodore PET. It accepts all standard 6502 instruction mnemonics, pseudoops and addressing modes, and evaluates binary, octal, hex, decimal, and character constants, symbols and expressions. Source statements can be read from cassette or from DATA lists and machine code can be assembled anywhere in memory or directed to an external device through a user-supplied subroutine.

The package includes a text editor in BASIC, and an execution monitor with a disassembler. Price with documentation is $24.95 by cheque or Visa/MC from Personal Software, P.O. Box 136-17, Cambridge, MA 02138, (617)783-0694.

```
 50 CLR:PRINT"♥";:POKE 245,6:PRINT
 100 PRINT"THIS  PROGRAM  TESTS  YOUR  REFLEXES  BY"
 200 PRINT"MEASURING YOUR REACTION  TIME.  WHENEVER"
 300 PRINT"THE SCREEN IS CLEARED HIT ANY CHARACTER—"
 400 PRINT"YOUR  REACTION TIME  IN  SECONDS WILL BE"
 500 PRINT"DISPLAYED--WHEN  THIS  DISSAPPEARS  HIT"
 600 PRINT"ANOTHER KEY (ANY KEY WILL DO) AND SO ON—"
 650 FOR I=1 TO 7500:NEXT:PRINT TAB(15)"▣GET READY"
 700 FOR I=1 TO  2500:NEXT:PRINT"♥":POKE 245,11
 800 PRINT:PRINT TAB(11)"(▣HIT ANY KEY NOW■)":GETA$,A$,A$,A$,A$,A$,A$:GOTO 1100
 1000 FOR I=1 TO RND(1)*2000+750:GET C$:NEXT:PRINT"♥";
 1100 T=TI:FOR I=1 TO 500:GET C$:IF C$<>"" THEN 1500
 1200 NEXT:PRINT"♥":POKE 245,10:PRINT
 1300 PRINT"▣ YOU SHOULD HAVE TYPED A CHARECTER WHEN ";
 1350 PRINT"▣                                        ";
 1400 PRINT"▣          THE SCREEN WAS CLEARED        ";
 1420 FOR I=1 TO 1000:NEXT
 1425 FOR I=1 TO 40:PRINT"▣ ";:NEXT
 1430 PRINT"▣     (STAND BY FOR MORE INSTRUCTIONS)    "
 1440 FOR I=1 TO 1000:GETC$:IF C$<>"" THEN 1500
 1470 NEXT:GOTO 50
 1475 GOTO 50
 1500 T1=TI-T:PRINT"♥";:POKE 245,11
 1530 FOR I=1 TO 2500:GETC$:IF C$<>"" THEN 1500
 1550 PRINT:POKE 226,17
 1600 PRINT INT((T1/60*1000)+.5)/1000:GOTO1000
READY.
```

DELAYS

Quite a few people have asked how to put delays into programs. Here are two common methods:

```
10  FOR A = 1 to 1000 : NEXT
```
this will cause a delay of approximately 1 second

```
10  FOR A = 1 to 2000 : NEXT
```
this will cause a delay of approximately 2 seconds etc.

```
10 T=TI
20 IF TI - T < 60 THEN 20
```

Lines 10 and 20 cause a delay of approximately one second and work as follows:

Line 10 sets the variable T equal to the real time jiffy clock TI (a jiffy is 1/60 of a second)

Line 20 tests to see whether 60/60 of a second have elapsed, if not the program returns to the beginning of line 20 and checks again.

Here is a small program you might like to try which uses delays involving the real time clock in an interesting manner.

```
READY.

 5 PRINT"KEY IN A NUMBER>";
 10 T=0:A$=""
 20 GETK$:IFK$=""THEN20
 30 T=TI:GOTO60
 40 GETK$
 50 IFTI-T>60THEN70
 60 IFK$<>""THENPRINTK$;:A$=A$+K$:T=TI:GOTO40
 65 GOTO40
 70 IFA=0THENPRINT"+";:A=VAL(A$):GOTO10
 80 PRINT"="A+VAL(A$)
READY.
```

PLOTTING

It is possible, with very little effort, to address locations on the screen using simple XY co-ordinates. Below we have a program that uses a simple formula that enables one to do this.

```
READY.

 5 DATA12,15,22,5,12,25,33
 10 PRINT""
 20 PI=3.14159265
 30 FORA=0TO4*PI STEP(4*PI)/39
 40 Y=INT(SIN(A)*12+12):X=X+1
 50 GOSUB80
 60 NEXT
 70 FORA=33568TO33574:READZ:POKEA,Z:NEXT
 75 GOTO75
 80 POKE((24-Y)*40+32768)+X,46:RETURN
READY.
```

The line that does the actual XY co-ordinate conversion is line 8Ø. For the sake of clarity line 8Ø has been made a sub-routine but the formula is so compact that in some cases, including this one, it is not necessary. Line 5 and 7Ø should be included when you test this program out but may be omitted subsequently. X has a range of Ø-39 and Y has a range of Ø-24.

DATA FILE ERRORS

A problem with opening files to write on either built-in cassette #1, or external cassette #2, has been discovered. When a file is opened, garbage will be written out instead of a proper data tape file header. Without this header, it is impossible to open the tape file for reading.

You may not have encountered this problem previously, because it is disguised by having loaded a program on the cassette prior to writing a data file. In this mode, the start address of the buffer with the header information is initialized properly but cassette data file operation still could be random.

Fortunately, there is a software patch you can implement in your BASIC program to force the open for write on tape to work every time.

Before opening to write on #1 cassette:

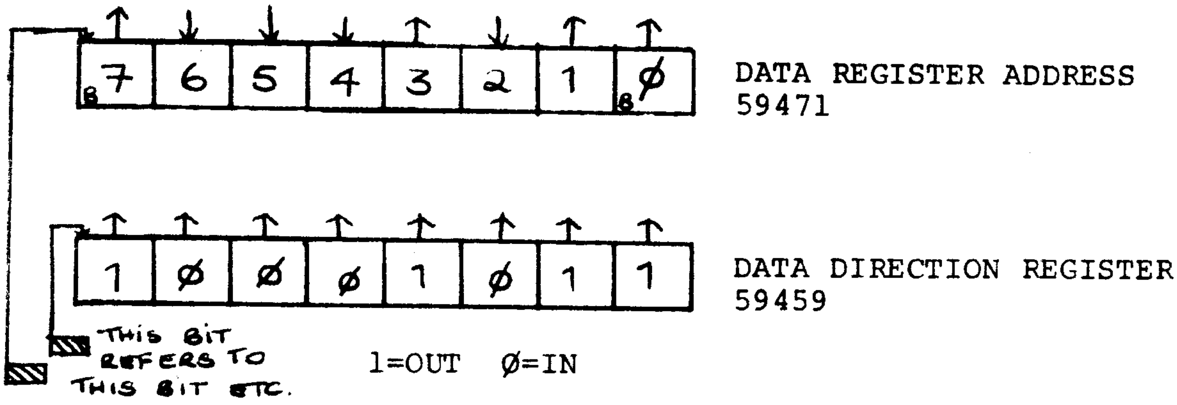
```
POKE 243,122
POKE 244,2
```

and on #2 cassette:

```
POKE 243,58
POKE 244,3
```

Locations 243 and 244 contain the lo and hi order bytes respectively of the address of the currently active cassette buffer. The start address of buffer #2 is $33A which is 3,58 ($3=3,$3A=58) in double byte decimal. Similarly cassette #1 is $27A ($2=2,$7A=122).

More User Port Info



The major portion of the user port consists of 8 connections at the rear of the PET. Whether these connections are used for INPUT or OUTPUT is up to the programmer. These 8 wires may be used as either input or output. Before using this 8 bit port you must first configure these wires as inputs or outputs. This is done by writing a byte to the data direction register at address 59459. In the example above bits Ø, 1, 3 and 7 are configured as outputs. Bits 2,4,5 and 6 are configured as inputs. The bit that you see in the data direction register is generated by poke 59459, 139. In order to test a particular bit being used as an input in the data register (59471) one must peek 59471 and apply a "mask" in order to mask out unwanted bits. For instance to examine bit 2 we would use the expression PRINT PEEK (59471) AND 4. If the result of this expression is Ø then bit 2 of the data register (59471) has been held at Ø volts by the outside world.

MACHINE CODE ENVIRONMENT

If you wish to write machine code programs in your PET and do not wish to have BASIC trampling all over them here is a suggestion:

When the PET is first powered up a test pattern is written into and read back from the RAM in ascending address order. When this routine discovers a location which does not read back properly it presumes that it has run out of RAM and displays XXXX bytes free. At this point it makes a note of where it thinks the 'top of memory' is.. A quick glance at the memory map will show that BASIC program text is stored from location 1Ø25 upwards and strings are stored from the top of the memory downwards which means that in any normal circumstances there is nowhere in the PET main memory where you can hide your machine code routines.
If however, the first thing you do after powering up the PET is to alter the top of memory pointer to say 6ØØØ everything from 6ØØ1 upwards, as far as PET is concerned, does not exist. e.g. strings will be stored from 6ØØØ downwards etc. and machine code programs can be safely put in location 6ØØ1 upwards. This pointer is held in locations 134 and 135 constituting a 16 bit pointer with 134 being its lower 8 bits. This is a binary pointer which means that we must convert your 6ØØØ or whatever to binary before POKING locations 134 and 135 with the information. In the standard 8K PET 134 will be Ø and 135

will be 32 (32 x 256 = 8192) Remember that 1Ø25 bytes are used for house keeping by the PET (8192 - 1Ø25 = 7167) However to give the PET a ceiling of 6ØØØ we convert 6ØØØ into binary which gives us POKE 134, 112 and POKE 135, 23.

LIFE FOR YOUR PET

Here is a good example of what can be done in machine code in the PET. It is the game of "LIFE" by John H. Conway of Cambridge. If one attempts to write a Commodore PET screen size (1ØØØ cell) version of LIFE in BASIC it can take up to two or three minutes per generation. This program performs two generations per second. In order to use it type in a listing in the form of data statements and load in the machine code with a small BASIC routine being careful to fill in the gaps between 1928 (HEX) and 193Ø and also 1954 and 197Ø with no-ops. Below is a listing of the documentation provided by the author.

LIFE FOR YOUR PET

Since this is the first time I have attempted to set down a machine language program for the public eye, I will attempt to be as complete as practical without overdoing it.

The programs I will document here are concerned with the game of "LIFE", and are written in 6502 machine language specifically for the PET 2001 (8K version). The principles apply to any 6502 system with graphic display capability, and can be debugged (as I did) on non-graphic systems such as the KIM-1.

The first I heard of LIFE was in Martin Gardner's "Recreational Mathematics" section in Scientific American, Oct-Nov 1970; Feb. 1971. As I understand it, the game was invented by John H. Conway, an English mathematician. In brief, LIFE is a "cellular automation" scheme, where the arena is a rectangular grid (ideally of infinite size). Each square in the grid is either occupied or unoccupied with "seeds", the fate of which are governed by relatively simple rules, i.e. the "facts of LIFE". The rules are: 1. A seed survives to the next generation if and only if it has two or three neighbors (right, left, up, down, and the four diagonally adjacent cells) otherwise it dies of loneliness or overcrowding, as the case may be. 2. A seed is born in a vacant cell on the next generation if it has exactly 3 neighbors.

With these simple rules, a surprisingly rich game results. The original Scientific American article, and several subsequent articles reveal many curious and surprising initial patterns and results. I understand that there even has been formed a LIFE group, complete with newsletter, although I have not personally seen it.

The game can of course be played manually on a piece of graph paper, but it is slow and prone to mistakes, which have usually disasterous effects on the final results. It would seem to be the ideal thing to put to a microprocessor with bare-bones graphics, since the rules are so simple and there are essentially no arithmetic operations involved, except for keeping track of addresses and locating neighbors.

As you know, the PET-2001 has an excellent BASIC interpreter, but as yet very little documentation on machine language operation. My first stab was to write a BASIC program, using the entire PET display as the arena (more about boundaries later), and the filled circle graphic display character as the seed. This worked just fine, except for one thing - it took about 2-1/2 minutes for the interpreter to go through one generation! I suppose I shouldn't have been surprised since the program has to check eight neighboring cells to determine the fate of a particular cell, and do this 1000 times to complete the entire generation (40x25 characters for the PET display).

The program following is a 6502 version of LIFE written for the PET. It needs to be POKE'd into the PET memory, since I have yet to see or discover a machine language monitor for the PET. I did it with a simple BASIC program and many DATA statements (taking up much more of the program memory space than the actual machine language program!). A routine for assembling, and saving on tape machine language programs on the PET is sorely needed.

The program is accessed by the SYS command, and takes advantage of the display monitor (cursor control) for inserting seeds, and clearing the arena. Without a serious attempt at maximizing for speed, the program takes about 1/2 second to go through an entire generation, about 300 times faster than the BASIC equivalent! Enough said about the efficiency of machine language programming versus BASIC interpreters?

BASIC is great for number crunching, where you can quickly compose your program and have plenty of time to await the results.

The program may be broken down into manageable chunks by subroutining. There follows a brief description of the salient features of each section:

MAIN (hex 1900)

In a fit of overcaution (since this was the first time I attempted to write a PET machine language program) you will notice the series of pushes at the beginning and pulls at the end. I decided to save all the internal registers on the stack in page 1, and also included the CLD (clear decimal mode) just in case. Then follows a series of subroutine calls to do the LIFE generation and display transfers. The zero page location, TIMES, is a counter to permit several loops through LIFE before returning. As set up, TIMES is initialized to zero (hex location 1953) so that it will loop 256 times before jumping back. This of course can be changed either initially or while in BASIC via the POKE command. The return via the JMP BASIC (4C 8B C3) may not be strictly orthodox, but it seems to work all right.

INIT (hex 1930) and DATA (hex 193B)

This shorty reads in the constants needed, and stores them in page zero. SCR refers to the PET screen, TEMP is a temporary working area to hold the new generation as it is evolved, and RCS is essentially a copy of the PET screen data, which I found to be necessary to avoid "snow" on the screen during read/write operations directly on the screen locations. Up, down, etc. are the offsets to be added or subtracted from an address to get all the neighbor addresses. The observant reader will note the gap in the addresses between some of the routines.

TMPSCR (hex 1970)

This subroutine quickly transfers the contents of Temp and dumps it to the screen, using a dot (81 dec) symbol for a live cell (a 1 in TEMP) and a space (32 dec) for the absence of a live cell (a 0 in TEMP).

SCRTMP (hex 198A)

This is the inverse of TMPSCR, quickly transferring (and encoding) data from the screen into TEMP.

RSTORE (hex 19A6)

This subroutine fetches the initial addresses (high and low) for the SCR, TEMP, and RCS memory spaces.

NXTADR (hex 19BD)

Since we are dealing with 1000 bytes of data, we need a routine to increment to the next location, check for page crossing (adding 1 to the high address when it occurs), and checking for the end. The end is signaled by returning a 01 in the accumulator, otherwise a 00 is returned via the accumulator.

TMPRCS (hex 19E6)

The RCS address space is a copy of the screen, used as mentioned before to avoid constant "snow" on the screen if the screen were being continually accessed. This subroutine dumps data from TEMP, where the new generation has been computed, to RCS.

GENER (hex 1A00)

We finally arrive at a subroutine where LIFE is actually generated. After finding out the number of neighbors of the current RCS data byte from NBRS, GENER checks for births (CMPIM $03 at hex addr. 1A0E) if the cell was previously unoccupied. If a birth does not occur, there is an immediate branch to GENADR (the data byte remains 00). If the cell was occupied (CMPIM 81 dec at hex 1A08), OCC checks for survival (CMPIM $03 at hex 1A1A and CMPIM $02 at hex 1A1E), branching to GENADR when these two conditions are met, otherwise the cell dies (LDAIM $00 at hex 1A22). The results are stored in TEMP for the 1000 cells.

NBRS (hex 1A2F)

NBRS is the subroutine that really does most of the work and where most of the speed could be gained by more efficient programming. Its job, to find the total number of occupied neighbors of a given RCS data location, is complicated by page crossing and edge boundaries. In the present version, page crossing is taken care of, but edge boundaries (left, right, top, and bottom of the screen) are somewhat "strange". Above the top line and below the bottom line are considered as sort of forbidden regions where there should practically always be no "life" (data in those regions are not defined by the program, but I have found that there has never been a case where 81's have been present (all other data is considered as "unoccupied" characters). The right and left edges are different, however, and lead to a special type of "geometry". A cell at either edge is not considered as special by NBRS, and so to the right of a right-edge location is the next sequential address. On the screen this is really the left edge location, and one line lower. The inverse is true, of course for left addresses of left-edge locations. Topologically, this is equivalent to a "helix". No special effects of this are seen during a simple LIFE evolution since it just gives the impression of disappearing off one edge while appearing on the other edge. For an object like the "spaceship" (see Scientific American articles), then, the path eventually would cover the whole LIFE arena. The fun comes in when a configuration spreads out so much that it spills over both edges, and interacts with itself. This, of course cannot happen in an infinite universe, so that some of the more complex patterns will not have the same fate in the present version of LIFE. Most of the "blinkers", including the "glider gun" come out OK.

This 40x25 version of LIFE can undoubtedly be made more efficient, and other edge algorithms could be found, but I chose to leave it in its original form as a benchmark for my first successfully executed program in writing machine language on the PET. One confession, however - I used the KIM-1 to debug most of the subroutines. Almost all of them did not run on the first shot! Without a good understanding of PET memory allocation particularly in page zero, I was bound to crash many times over, with no recovery other than pulling the plug. The actual BASIC program consisted of a POKING loop with many DATA statements (always save on tape before running!).

A Brief Introduction to the Game of Life

One of the interesting properties of the game of LIFE is that such simple rules can lead to such complex activity. The simplicity comes from the fact that the rules apply to each individual cell. The complexity comes from the interactions between the individual cells. Each individual cell is affected by its eight adjacent neighbors, and nothing else.

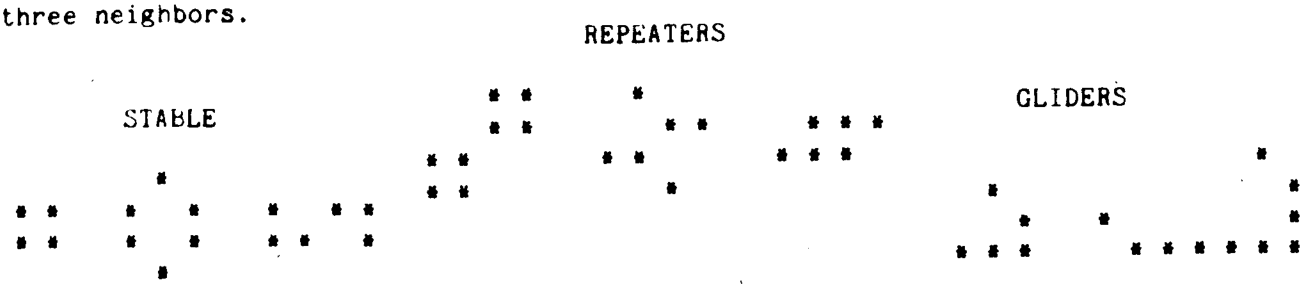
The rules are:

1. A cell survives if it has two or three neighbors.

2. A cell dies from overcrowding if it has four or more neighbors. It dies from isolation if it has one or zero neighbors.

3. A cell is born when an empty space has exactly three neighbors.

With these few rules, many different types of activity can occur. Some patterns are STABLE, that is they do not change at all. Some are REPEATERS, patterns which undergo one or more changes and return to the original pattern. A REPEATER may repeat as fast as every other generation, or may have a longer period. A GLIDER is a pattern which moves as it repeats.



```
1900             LIFE   ORG   $1900

1900             BASIC   *    $C38B  RETURN TO BASIC ADDRESS
1900             OFFSET  *    $002A  PAGE ZERO DATA AREA POINTER
1900             DOT     *    $0051  DOT SYMBOL = 81 DECIMAL
1900             BLANK   *    $0020  BLANK SYMBOL = 32 DECIMAL

1900             SCRL    *    $0020  PAGE ZERO LOCATIONS
1900             SCRH    *    $0021
1900             CHL     *    $0022
1900             CHH     *    $0023
1900             SCRLO   *    $0024
1900             SCRHO   *    $0025
1900             TEMPL   *    $0026
1900             TEMPH   *    $0027
1900             TEMPLO  *    $0028
1900             TEMPHO  *    $0029
1900             UP      *    $002A
1900             DOWN    *    $002B
1900             RIGHT   *    $002C
1900             LEFT    *    $002D
1900             UR      *    $002E
1900             UL      *    $002F
1900             LR      *    $0030
1900             LL      *    $0031
1900             N       *    $0032
1900             SCRLL   *    $0033
1900             SCRLH   *    $0034
1900             RCSLO   *    $0035
1900             RCSHO   *    $0036
1900             TMP     *    $0037
1900             TIMES   *    $0038
1900             RCSL    *    $0039
1900             RCSH    *    $003A

1900 08          MAIN   PHP          SAVE EVERYTHING
1901 48                 PHA          ON STACK
1902 8A                 TXA
1903 48                 PHA
1904 98                 TYA
1905 48                 PHA
1906 BA                 TSX
1907 8A                 TXA
1908 48                 PHA
1909 D8                 CLD          CLEAR DECIMAL MODE
190A 20 30 19           JSR   INIT
190D 20 8A 19           JSR   SCRTMP
1910 20 E6 19    GEN    JSR   TMPRCS
1913 20 00 1A           JSR   GENER
1916 20 70 19           JSR   TMPSCR
1919 E6 38              INCZ  TIMES  REPEAT 255 TIMES
191B D0 F3              BNE   GEN    BEFORE QUITTING
191D 68                 PLA          RESTORE EVERYTHING
191E AA                 TAX
191F 9A                 TXS
1920 68                 PLA
```

```
1921 A8             TAY
1922 68             PLA
1923 AA             TAX
1924 68             PLA
1925 28             PLP
1926 4C 8B C3       JMP   BASIC  RETURN TO BASIC

1930                ORG   $1930

          MOVE VALUES INTO PAGE ZERO

1930 A2 19    INIT   LDXIM $19    MOVE 25. VALUES
1932 BD 3A 19 LOAD   LDAX  DATA   -01
1935 95 1F           STAZX $1F    STORE IN PAGE ZERO
1937 CA              DEX
1938 D0 F8           BNE   LOAD
193A 60              RTS

193B 00       DATA   =     $00    SCRL
193C 80              =     $80    SCRH
193D 00              =     $00    CHL
193E 15              =     $15    CHH
193F 00              =     $00    SCRLO
1940 80              =     $80    SCRHO
1941 00              =     $00    TEMPL
1942 1B              =     $1B    TEMPH
1943 00              =     $00    TEMPLO
1944 1B              =     $1B    TEMPHO
1945 D7              =     $D7    UP
1946 28              =     $28    DOWN
1947 01              =     $01    RIGHT
1948 FE              =     $FE    LEFT
1949 D8              =     $D8    UR
194A D6              =     $D6    UL
194B 29              =     $29    LR
194C 27              =     $27    LL
194D 00              =     $00    N
194E E8              =     $E8    SCRLL
194F 83              =     $83    SCRLH
1950 00              =     $00    RCSLO
1951 15              =     $15    RCSHO
1952 00              =     $00    TMP
1953 00              =     $00    TIMES

1970                 ORG   $1970

1970 20 A6 19 TMPSCR JSR   RSTORE GET INIT ADDRESSES
1973 B1 26    TSLOAD LDAIY TEMPL  FETCH BYTE FROM TEMP
1975 D0 06           BNE   TSONE  BRANCH IF NOT ZERO
1977 A9 20           LDAIM BLANK  BLANK SYMBOL
1979 91 20           STAIY SCRL   DUMP IT TO SCREEN
197B D0 04           BNE   TSNEXT
197D A9 51    TSONE  LDAIM DOT    DOT SYMBOL
197F 91 20           STAIY SCRL   DUMP IT TO SCREEN
1981 20 BD 19 TSNEXT JSR   NXTADR FETCH NEXT ADDRESS
1984 F0 ED           BEQ   TSLOAD
```

```
1986 20 A6 19          JSR    RSTORE RESTORE INIT ADDRESSES
1989 60                RTS

198A 20 A6 19   SCRTMP JSR    RSTORE GET INIT ADDRESSES
198D B1 20      STLOAD LDAIY SCRL    READ DATA FROM SCREEN
198F C9 51             CMPIM DOT     TEST FOR DOT
1991 F0 06             BEQ    STONE  BRANCH IF DOT
1993 A9 00             LDAIM $00     OTHERWISE ITS A BLANK
1995 91 26             STAIY TEMPL   STORE IT
1997 F0 04             BEQ    STNEXT UNCOND. BRANCH
1999 A9 01      STONE  LDAIM $01     A DOT WAS FOUND
199B 91 26             STAIY TEMPL   STORE IT
199D 20 BD 19   STNEXT JSR    NXTADR FETCH NEXT ADDRESS
19A0 F0 EB             BEQ    STLOAD
19A2 20 A6 19          JSR    RSTORE RESTORE INIT ADDRESSES
19A5 60                RTS

19A6 A9 00      RSTORE LDAIM $00     ZERO A, X, Y
19A8 AA                TAX
19A9 A8                TAY
19AA 85 20             STAZ   SCRL   INIT VALUES
19AC 85 26             STAZ   TEMPL
19AE 85 39             STAZ   RCSL
19B0 A5 25             LDAZ   SCRHO
19B2 85 21             STAZ   SCRH
19B4 A5 29             LDAZ   TEMPHO
19B6 85 27             STAZ   TEMPH
19B8 A5 36             LDAZ   RCSHO
19BA 85 3A             STAZ   RCSH
19BC 60                RTS

19BD E6 26      NXTADR INCZ   TEMPL  GET NEXT LOW ORDER
19BF E6 20             INCZ   SCRL   BYTE ADDRESS
19C1 E6 39             INCZ   RCSL
19C3 E8                INX
19C4 E4 33             CPXZ   SCRLL  IS IT THE LAST?
19C6 F0 0C             BEQ    PAGECH IS IT THE LAST PAGE?
19C8 E0 00             CPXIM $00     IS IT A PAGE BOUNDARY?
19CA D0 0E             BNE    NALOAD IF NOT, THEN NOT DONE
19CC E6 27             INCZ   TEMPH  OTHERWISE ADVANCE TO
19CE E6 21             INCZ   SCRH   NEXT PAGE
19D0 E6 3A             INCZ   RCSH
19D2 D0 06             BNE    NALOAD UNCONDITIONAL BRANCH
19D4 A5 34      PAGECH LDAZ   SCRLH  CHECK FOR LAST PAGE
19D6 C5 21             CMPZ   SCRH
19D8 F0 03             BEQ    NADONE IF YES, THEN DONE
19DA A9 00      NALOAD LDAIM $00     RETURN WITH A=0
19DC 60                RTS
19DD A9 01      NADONE LDAIM $01     RETURN WITH A=1
19DF 60                RTS

19E6                   ORG    $19E6

19E6 20 A6 19   TMPRCS JSR    RSTORE INIT ADDRESSES
19E9 B1 26      TRLOAD LDAIY TEMPL   FETCH DATA FROM TEMP
19EB D0 06             BNE    TRONE  IF NOT ZERO THEN ITS ALIVE
```

```
19ED A9 20            LDAIM BLANK   BLANK SYMBOL
19EF 91 39            STAIY RCSL    STORE IT IN SCREEN COPY
19F1 D0 04            BNE   NEWADR  THEN ON TO A NEW ADDRESS
19F3 A9 51     TRONE  LDAIM DOT     THE DOT SYMBOL
19F5 91 39            STAIY RCSL    STORE IT IN SCREEN COPY
19F7 20 BD 19  NEWADR JSR   NXTADR  FETCH NEXT ADDRESS
19FA F0 ED            BEQ   TRLOAD  IF A=0, THEN NOT DONE
19FC 20 A6 19         JSR   RSTORE  ELSE DONE. RESTORE
19FF 60               RTS

1A00 20 A6 19  GENER  JSR   RSTORE  INIT ADDRESSES
1A03 20 2F 1A  AGAIN  JSR   NBRS    FETCH NUMBER OF NEIGHBORS
1A06 B1 39            LDAIY RCSL    FETCH CURRENT DATA
1A08 C9 51            CMPIM DOT     IS IT A DOT?
1A0A F0 0C            BEQ   OCC     IF YES, THEN BRANCH
1A0C A5 32            LDAZ  N       OTHERWISE ITS BLANK
1A0E C9 03            CMPIM $03     SO WE CHECK FOR
1A10 D0 14            BNE   GENADR  A BIRTH
1A12 A9 01     BIRTH  LDAIM $01     IT GIVES BIRTH
1A14 91 26            STAIY TEMPL   STORE IT IN TEMP
1A16 D0 0E            BNE   GENADR  INCONDITIONAL BRANCH
1A18 A5 32     OCC    LDAZ  N       FETCH NUMBER OF NEIGHBORS
1A1A C9 03            CMPIM $03     IF IT HAS 3 OR 2
1A1C F0 08            BEQ   GENADR  NEIGHBORS IT SURVIVES
1A1E C9 02            CMPIM $02
1A20 F0 04            BEQ   GENADR
1A22 A9 00     DEATH  LDAIM $00     IT DIED!
1A24 91 26            STAIY TEMPL   STORE IT IN TEMP
1A26 20 BD 19  GENADR JSR   NXTADR  FETCH NEXT ADDRESS
1A29 F0 D8            BEQ   AGAIN   IF 0, THEN NOT DONE
1A2B 20 A6 19         JSR   RSTORE  RESTORE INIT ADDRESSES
1A2E 60               RTS

1A2F 98        NBRS   TYA           SAVE Y AND X ON STACK
1A30 48               PHA
1A31 8A               TXA
1A32 48               PHA
1A33 A0 00            LDYIM $00     SET Y AND N = 0
1A35 84 32            STYZ  N
1A37 A2 08            LDXIM $08     CHECK 8 NEIGHBORS
1A39 B5 29     OFFS   LDAZX OFFSET -01
1A3B 10 15            BPL   ADD     ADD IF OFFSET IS POSITIVE
1A3D 49 FF            EORIM $FF     OTHERWISE GET SET TO
1A3F 85 37            STAZ  TMP     SUBTRACT
1A41 38               SEC           SET CARRY BIT FOR SUBTRACT
1A42 A5 39            LDAZ  RCSL
1A44 E5 37            SBCZ  TMP     SUBTRACT TO GET THE
1A46 85 22            STAZ  CHL     CORRECT NEIGHBOR ADDRESS
1A48 A5 3A            LDAZ  RCSH
1A4A 85 23            STAZ  CHH
1A4C B0 11            BCS   EXAM    OK, FIND OUT WHAT'S THERE
1A4E C6 23            DECZ  CHH     PAGE CROSS
1A50 D0 0D            BNE   EXAM    UNCOND. BRANCH
1A52 18        ADD    CLC           GET SET TO ADD
1A53 65 39            ADCZ  RCSL    ADD
1A55 85 22            STAZ  CHL     STORE THE LOW PART
```

```
1A57 A5 3A          LDAZ  RCSH   FETCH THE HIGH PART
1A59 85 23          STAZ  CHH
1A5B 90 02          BCC   EXAM   OK, WHAT'S THERE
1A5D E6 23          INCZ  CHH    PAGE CROSSING
1A5F B1 22    EXAM  LDAIY CHL    FETCH THE NEIGHBOR
1A61 C9 51          CMPIM DOT    DATA BYTE AND SEE IF ITS
1A63 D0 02          BNE   NEXT   OCCUPIED
1A65 E6 32          INCZ  N      ACCUMULATE NUMBER OF NEIGHBORS
1A67 CA       NEXT  DEX
1A68 D0 CF          BNE   OFFS   NOT DONE
1A6A 68             PLA          RESTORE X, Y FROM STACK
1A6B AA             TAX
1A6C 68             PLA
1A6D A8             TAY
1A6E 60             RTS
```

This program was prepared by:

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USA.

```
100 READL
110 READ A$:C=LEN(A$):IFA$="*"THENEND
120 IFC<1ORC>2THEN200
130 A=ASC(A$)-48:B=ASC(RIGHT$(A$,1))-48
140 N=B+7*(B>9)-(C=2)*(16*(A+7*(A>9)))
150 IFN<ØORN>255THEN2ØØ
160 POKEL,N:L=L+1:GOTO11Ø
2ØØ PRINT"BYTE"L"=["A$"] ???":END
3ØØ DATA64ØØ
31Ø DATA Ø8,48,8A,48,98,48,BA,8A,48,D8,2Ø,3Ø,19,2Ø,8A,19,2Ø,E6,19,2Ø,ØØ,1A
32Ø DATA2Ø,7Ø,19,A9,FF,CD,12,E8,FØ,FØ,4C,8B,C3,AA,68,28,4C,8B,C3
33Ø DATA EA,EA,EA,EA,EA,EA,EA,A2,19,BD,3A,19,95,1F,CA,DØ,F8,6Ø,ØØ,8Ø,ØØ,15,ØØ
34Ø DATA8Ø,ØØ,1B,ØØ,1B,D7,28,Ø1,FE,D8,D6,29,27,ØØ,E8,83,ØØ,15,ØØ,ØØ
35Ø DATAEA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA
36Ø DATAEA,EA,EA,EA,EA,2Ø,A6,19,B1,26,DØ,Ø6,A9,2Ø,91,2Ø,DØ,Ø4,A9,51,91,2Ø,2Ø
37Ø DATA BD,19,FØ,ED,2Ø,A6,19,6Ø,2Ø,A6,19,B1,2Ø,C9,51,FØ,Ø6,A9,ØØ,91,26,FØ
38Ø DATAØ4,A9,Ø1,91,26,2Ø,BD,19,FØ,EB,2Ø,A6,19,6Ø,A9,ØØ,AA,A8,85,2Ø,85,26,85
39Ø DATA39,A5,25,85,21,A5,29,85,27,A5,36,85,3A,6Ø,E6,26,E6,2Ø,E6,39,E8,E4
4ØØ DATA33,FØ,ØC,EØ,ØØ,DØ,ØE,E6,27,E6,21,E6,3A,DØ,Ø6,A5,34,C5,21,FØ,Ø3,A9,ØØ
41Ø DATA 6Ø,A9,Ø1,6Ø,EA,EA,EA,EA,EA,EA,2Ø,A6,19,B1,26,DØ,Ø6,A9,2Ø,91,39,DØ
42Ø DATAØ4,A9,51,91,39,2Ø,BD,19,FØ,ED,2Ø,A6,19,6Ø,2Ø,A6,19,2Ø,2F,1A,B1,39,C9
43Ø DATA51,FØ,ØC,A5,32,C9,Ø3,DØ,14,A9,Ø1,91,26,DØ,ØE,A5,32,C9,Ø3,FØ,Ø8,C9,Ø2
44Ø DATAFØ,Ø4,A9,ØØ,91,26,2Ø,BD,19,FØ,D8,2Ø,A6,19,6Ø,98,48,8A,48,AØ,ØØ,84,32
45Ø DATAA2,Ø8,B5,29,1Ø,15,49,FF,85,37,38,A5,39,E5,37,85,22,A5,3A,85,23,BØ,11
46Ø DATAC6,23,DØ,ØD,18,65,39,85,22,A5,3A,85,23,9Ø,Ø2,E6,23,B1,22,C9,51,DØ,Ø2
47Ø DATAE6,32,CA,DØ,CF,68,AA,68,A8,6Ø,*
READY.
```

Mr. J. Smith of 38 Claremont Crescent, Croxley Green, Rickmansworth, Herts. WD3 3QR

wrote in: The error in the definition of arc cos X should, I feel, be corrected. A possible version is:- (*)

ACS X = ATN(SQR (1-X↑2)/X) + (1-SGN(X))*π/2

this correctly gives (unless X=Ø) arc cos (-Ø.5) as

Cont/...

2π/3 (12ø°) ; your formula gives

arc cos (-ø.5) as -6ø° this would be incorrect in e.g. a "cosine rule" problem.

As you expect PET to be used in educational establishments for solving trig. problems, I think it important to put this right.

(*) Note that if X is negative

1-SGN(X) = 2

& if X is positive

1-SGN(X) = ø

this ensures that a correct multiple of π is added to the arctangent. Also, would it not be better to suggest..

P = 18ø/π (before FNS is used)

DEFFNS(V) = SIN (V/P) etc.

for the user defined functions?

HERE ARE SOME COMMENTS FROM MR. M.J. SMYTH who is the Senior Lecturer, Department of Astronomy, Royal Observatory, Edinburgh EH9 3HJ.

Using BASIC and the IEEE 488 bus, PET can input 4ø numbers per second from a 3½ digit voltmeter (Hewlett Packard 3437A). Also using BASIC, the user port can generate an output trigger (e.g. to a measuring device) within about 1Ø ms of an input trigger. We have not yet tried using assembler. But the BASIC speeds make possible very interesting applications in equipment control and real-time data processing.

To input data in BASIC without returning to BASIC command mode on receipt of a null string then an input statement can be simulated by a GET loop which contains additional statements to cope with DEL codes. This has the additional advantage that if there is a displayed frame on screen the frame characters will not be accepted as part of the input.

The attached listing shows the above routine. This starts at line 9000 and to use it, instead of INPUT A$ you put GOSUB 9000:A$=IN$.

```
8000 REM SUBROUTINE TO SIMULATE NON-PET      STANDARD INPUT STATEMENT
8010 REM STANDARD INPUT DOES NOT BREAK      ON RECEIPT OF A NULL STRING
8020 REM "TINPUT" COULD BE ALSO BE          SIMULATED EASILY
8030 REM ZA$ IS DEFINED IN LINE 10
9000 IN$="":PRINT" ? ";
9010 GOSUB9070:PRINTZA$(ZB);:IFZ$=""THEN9010
9020 IFZ$=CHR$(13)THENPRINT" ":RETURN
9030 IFZ$=CHR$(20)THENONSGN(LEN(IN$))+1GOTO9010,9060
9040 PRINTZ$;:IN$=IN$+Z$:GOTO9010
9060 PRINTZ$;:IN$=MID$(IN$,1,LEN(IN$)-1):GOTO9010
9070 ZB=1+(ZB=1):FORZA=1TO60:GETZ$:IFZ$<>""THENRETURN
9080 NEXT:RETURN
```

Snowless Version of Life:

The "Life" program listed in Transactor #5 can be further refined to eliminate the snowy effect on the screen. Mark Taylor, in the U.K., has written to us with a snowless version of Life. He also included another interesting program illustrated in example 2:

1. If you are plagued by snow on the screen during POKE operations to the screen RAM or with machine code programmes, then if in BASIC location 59409 is POKEd with 52 then that will inhibit the character generator. Any transfer operations can then be carried out with the screen totally blank. To restore normal operation the above location should be POKEd with 60. For machine code programmes then LDA 52 & STA ABSOLUTE the above location will be somewhat faster.

The attached listing is a snowless version of "Life".

```
100 READL
110 READA$:C=LEN(A$):IFA$="*"THENEND
120 IFC<1ORC>2THEN200
130 A=ASC(A$)-48:B=ASC(RIGHT$(A$,1))-48
140 N=B+7*(B>9)-(C=2)*(16*(A+7*(A>9)))
150 IFN<0ORN>255THEN200
160 POKEL,N:L=L+1:GOTO110
200 PRINT"BYTE"L"=["A$"] ???":END
300 DATA6400
310 DATA20,30,19,20,8A,19,20,E6,19,20,00,1A,A9,34,3D,11,E8
320 DATA20,70,19,A9,3C,8D,11,E8,A9,FF,CD,12,E8,F0,E6,4C,8B,C3,AA,68,28,4C,8B,C3
330 DATA EA,EA,EA,EA,EA,EA,EA,A2,19,BD,3A,19,95,1F,CA,D0,F8,60,00,80,00,15,00
340 DATA80,00,1B,00,1B,D7,28,01,FE,D8,D6,29,27,00,E8,83,00,15,00,00
350 DATAEA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA
360 DATAEA,EA,EA,EA,EA,20,A6,19,B1,26,D0,06,A9,20,91,20,D0,04,A9,51,91,20,20
370 DATA BD,19,F0,ED,20,A6,19,60,20,A6,19,B1,20,C9,51,F0,06,A9,00,91,26,F0
380 DATA04,A9,01,91,26,20,BD,19,F0,EB,20,A6,19,60,A9,00,AA,A8,85,20,85,26,85
390 DATA39,A5,25,85,21,A5,29,85,27,A5,36,85,3A,60,E6,26,E6,20,E6,39,E8,E4
400 DATA33,F0,0C,E0,08,D0,0E,E6,27,E6,21,E6,3A,D0,06,A5,34,C5,21,F0,03,A9,00
410 DATA 60,A9,01,60,EA,EA,EA,EA,EA,EA,20,A6,19,B1,26,D0,06,A9,20,91,39,D0
420 DATA04,A9,51,91,39,20,BD,19,F0,ED,20,A6,19,60,20,A6,19,20,2F,1A,B1,39,C9
430 DATA51,F0,0C,A5,32,C9,03,D0,14,A9,01,91,26,D0,0E,A5,32,C9,03,F0,08,C9,02
440 DATAF0,04,A9,00,91,26,20,BD,19,F0,D8,20,A6,19,60,98,48,8A,48,A0,00,84,32
450 DATAA2,08,B5,29,18,15,49,FF,85,37,38,A5,39,E5,37,85,22,A5,3A,85,23,B0,11
460 DATAC6,23,D0,0D,18,65,39,85,22,A5,3A,85,23,90,02,E6,23,B1,22,C9,51,D0,02
470 DATAE6,32,CA,D0,CF,68,AA,68,A8,60,*
```

Programme Overlays on a PET - Supplied by Mike Stone

1. The 8K core of a PET is not usually a limitation in the home computer and hobbyist world, nor even in an educational environment where students are just creating small exercise programs. With the devices now available for attachement - the second cassette,(the printer, and floppy discs shortly) - the PET becomes a valid and genuine data processing machine, and complex string handling programs with files may well run out of space.

2. Programmers with experience on other computers know that one answer to this kind of problem is to break the program down into segments, so that only part of it is occupying memory at any time, and all or part is "overlaid" by other segments as required. When the program segments are on a disc, direct access features normally permit great flexibility, in that any required segment can be loaded; for tape only systems, the segments have to be arranged in order of need - e.g. job initialisation, main coding, and termination segments.

3. Since PET's BASIC includes a LOAD instruction to acquire dynamically a new program from tape, and (provided the new program is no longer than the one issuing the LOAD) all data areas remain available to the loaded program, the basis exists for an overlay system. However, for true overlaying, it is essential that some of the original program (e.g. control of the program flow, common subroutines, etc.) be retained throughout, whatever new segments are loaded. PET does not do this automatically; this paper tells you how to do it.

4. PET stores BASIC programs in location 1024 upwards. Note that the pointers, and line numbets, are pairs of bytes giving low/high. The high must be multiplied by 256 and added to the low to give the actual quantity.

5. Whenever a line of code is entered from the keyboard, PET moves every statement around as necessary and re-adjusts all the chaining, so that statements are always stored in strict sequence of line number.

6. When your program contains a LOAD statement, this does NOT imply either CLR or NEW. The new program is simply loaded in at (and then executed from) location 1024, for as much space as it needs. The new program does NOT (as with some BASIC's) just replace those statements with identical line numbers; it is strictly a new program in its own right. However, any program statements at the end of the LOAD<u>ING</u> program whose space is not required by the LOAD<u>ED</u> program do remain unscathed by the LOAD. The problem is that the new program has no (forward-) chain into them, so PET knows nothing about them.

7. It follows from the above that if we code the instructions-to-be-preserved with high line numbers; and if the space needed by the newly-loaded segment does not over-write them; and if we can force the new segment to chain into the old instructions; then we have a real overlay system. So, if during the original program you can find in memory the last statement <u>not</u> to be preserved, you know it forward chains into the next highest line number, i.e. the first of the statements you <u>do</u> want preserved. Then when the overlay arrives, you need only find <u>its</u> very last statement and replace its forward-chain by the one you previously found, and both new and old code form a contiguous program.

8. A very simple illustration follows

Enter this program (do <u>NOT</u> put any spaces, except after line numbers):

```
10    A=A+1
20    GOSUB50
30    LOAD"NEWPROG"
50    PRINTA*2
55    RETURN
```

This is stored as follows ("PEEK" values):

1024)	0	
5)	11	forward chain; 4 x 256 = 1024 + 11 = 1035
6)	4	
7)	10	line number 10
8)	0	
9)	65	A
1030)	178	=
1)	65	A
2)	170	+
3)	49	1

4)	0	
→ 5)	19	forward chain; 4 x 256 = 1024 + 19 = 1043
6)	4	
7)	20	line number 20
8)	0	
9)	141	GOSUB
1040)	53	5
1)	48	0
2)	0	
→ 3)	34	forward chain; 4 x 256 = 1024 + 34 = 1058
4)	4	
5)	30	line number 30
6)	0	
7)	147	LOAD
8)	34	"
9)	78	N
1050)	69	E
1)	87	W
2)	80	P
3)	82	R
4)	79	O
5)	71	G
6)	34	"
7)	0	
→ 8)	43	forward chain; 4 x 256 = 1024 + 43 = 1067
9)	4	
1060)	50	line number 50
1)	0	
2)	153	PRINT
3)	65	A
4)	172	*
5)	50	2
6)	0	
7)	49	forward chain; 4 x 256 = 1024 + 49 = 1073
8)	4	
9)	55	line number 55
1070)	0	
1)	142	RETURN
2)	0	
→ 3)	0	

If we want lines 50 and 55 to be available to an overlay, the important information is the forward chain in line 30, i.e. locations 1043 and 1044.

9. To see how it works, SAVE"PROG" and leave the cassette Record and Play keys down.

Enter NEW; then the following (again, <u>no</u> spaces):

```
 5    A=A*2
10    GOSUB50
15    STOP
```

LIST if you like, to confirm that there are no lines 50 and 55.
SAVE"NEWPROG".

Now rewind your tape, and press RUN.
PROG will be loaded, will print "2", and continue up the tape. When NEWPROG has been loaded, you will get

```
?UNDEF'D STATEMENT ERROR IN 10
```

That is because the overlay looks like this:

1024)	0	
5)	11	} forward chain to 1035
6)	4	
7)	5	} line number 5
8)	0	
9)	65	A
1030)	178	=
1)	65	A
2)	172	*
3)	50	2
4)	0	
→ 5)	19	} forward chain to 1043
6)	4	
7)	10	} line number 10
8)	0	
9)	141	GOSUB
1040)	53	5

```
  1)   48          0
  2)    0
→ 3)   25   } forward chain to 1049
  4)    4   }
  5)   15       } line number 15
  6)    0       }
  7)  144          STOP
  8)    0
→ 9)    0
```

10. The last line, 15, does not chain into the old line 50. But that line 50 is still there, in location 1058 et seq. So, do this:

    POKE 1043,34
    POKE 1044, 4

    LIST - and behold, NEWPROG now includes lines 50 and 55!
    You can RUN if you like, to prove it.

    What we have done is to use what we discovered about the first program (last sentence of paragraph 9) to modify the second program.

11. How do you program all this to happen automatically? It is not at all difficult. Let us assume that the statements-to-be-preserved are at lines 5000 and upwards. So, just before that, code this (NO SPACES):

```
4997    N1=PEEK(201)    Get (low) address of line 4998
4998    N2=PEEK(202)    Get (high) address of line 4999
4999    RETURN
5000    ....   ....
```

(Locations 201, 202 always contain, during instruction execution, the address of the next instruction - strictly, the "Ø" between instructions.)

12. Now, just before your program wants to load in the overlay program, code this (spaces if you like!):

```
850   GOSUB 4997
860   N1 = N1 + 14              Low address of 4999 (the length
                                of 4998 is 14 bytes)
870   N2 = N2 * 256             Actual high address of 4999
880   If N1 < 256 THEN 900      Adjust low for page boundary
890   N1 = N1 - 256
900   BC = N1 + N2 + 1          BC is now actual machine address
                                    of line 4999
910   Z1 = PEEK(BC):Z2=PEEK(BC+1)   Hold the forward-chain
                                    locations out of 4999
920   LOAD "NEWPROG"
```

13. As the first instructions of NEWPROG, the chain-adjusting must be done. The necessary code is very similar:

At the <u>end</u> of NEWPROG, as the very last statements, code (<u>NO</u> spaces):

```
3997     N1=PEEK(201)
3998     N2=PEEK(202)
3999     RETURN
```

And at the beginning code:

```
10       GOSUB3997
20       N1=N1+14
30       N2=N2*256
40       IF N1<256 THEN 60
50       N1=N1-256
60       BC=N1+N2+1       BC is now actual machine
                          address of 3999
70       POKE BC,Z1:POKE BC+1,Z2
```

14. It is worth just reiterating that the <u>total size</u> of the incoming overlay (irrespective of line numbers; just its size in bytes occupied) must be less than the total size of the instructions being overlaid.

Mike Stone

ABBREVIATING BASIC WORDS

As explained in the instruction manual, any BASIC word takes up 1 byte of memory storage space. It has been stated that the work "PRINT" can be abbreviated to "?" which saves time on entering programs. When listed, the word is expanded to its full form. Both forms take 1 byte per word.

We now have information on how to abbreviate the complete list of BASIC words. The algorithm to remember is as follows:

1. For any BASIC word, type in the first letter of the word (e.g. V for VERIFY).

2. Hold down the 'Shift' key and type in the second letter. If you are in graphics mode, this will appear as a graphic character (e.g.  for E). It is a good idea to go into lower case mode as the two letters are then easy to read. (Poke 59468, 14 → 12 for PET to graphics).

In some cases, this two-letter method gives a possibility of more than one BASIC word (e.g. READ and RESTORE). For one of the words (usually the longer) it will be necessary to type the first two letters and the shifted third. All these abbreviations are converted to full words upon the command LIST.

Below is a complete list of the words and abbreviations:

BASIC	ABBREV	BASIC	ABBREV	BASIC	ABBREV
LET	Le	DEF	De	RUN	Ru
READ	Re	RETURN	REt	CLR	Cl
PRINT	?	STOP	St	LIST	Li
PRINT#	Pr	STEP	STe	CONT	Co
DATA	Da	INPUT#	In	FRE	Fr
THEN	Th	SGN	Sg	TAB(	Ta
FOR	Fo	ABS	Ab	SPC(	Sp
NEXT	Ne	SQR	Sq	PEEK	Pe
DIM	Di	RND	Rn	POKE	Po
END	En	SIN	Si	USR	Us
GOTO	Go	ATN	At	SYS	Sy
RESTORE	REs	EXP	Ex	WAIT	Wa
GET	Ge	AND	An	LEFT$	LEf
GOSUB	GOs	NOT	No	RIGHT$	Ri
OPEN	Op	VAL	Va	MID$	Mi
CLOSE	CLo	ASC	As	CHR$	Ch
SAVE	Sa	CMD	Cm	STR$	STr
LOAD	Lo	VERIFY	Ve		

SIMULATING A CALCULATOR ON YOUR PET

Many users have asked whether the PET can do live calculations. Although a simple sum such as 2 + 3 can be performed thus:

```
PRINT 2 + 3 'RETURN'
```

it would be more convenient if the operation of a calculator could be simulated directly. The following program should give you an idea of how this can be achieved:

```
5 REM    GRAPHICS
10 PRINT"┌────────────────────┐"
20 PRINT"│                    │"
25 PRINT"│                    │"
30 PRINT"└────────────────────┘"
40 FORI=1TO19
50 PRINT"     [illegible]              "
60 NEXT
1000 REM  CONTROLLER / INPUT
1010 GETA$:IFA$=""GOTO1010
1020 A=ASC(A$)
1030 IFA>57THEN4000
1040 IFA<48ANDA<>46THEN2000
1050 IF  T=1 THENX$="":T=0
1055 IFLEN(X$)=9THEND$="ERROR       ":GOSUB5115:T=1:GOTO1000
1060 X$=X$+A$:X=VAL(X$):GOSUB5020
1070 GOTO1000
2000 REM OPERATORS
2010 IFA<40ORA=44THEND$="ERROR           ":GOSUB5115:CLR:GOTO1000
2020 IFA=40THENN=N+1:B(N)=X:X=0:Y=0:O$(N)=O$:O$="":T=1:GOSUB5000 :GOTO1000
2030 IFO$="*"THENX=X*Y
2040 IFO$="/"THENX=Y/X
2050 IFO$="+"THENX=X+Y
2060 IFO$="-"THENX=Y-X
2065 Y=X:O$=A$:T=1
2070 IFA=41THENY=B(N):O$=O$(N):N=N-1:T=0
2080 GOSUB5000:GOTO1000
4000 IFA$="S"THENX=SIN(X)
4010 IFA$="C"THENX=COS(X)
4020 IFA$="T"THENX=TAN(X)
4030 IFA$="L"THENX=LOG(X)
4040 IFA$="E"THENX=EXP(X)
4042 IFA$="="GOTO2030
4043 IFA$="←"THENCLR:T=1
4045 GOSUB5000
4050 GOTO1000
5000 REM DISPLAY
5010 X$=STR$(X)
5020 D$=RIGHT$("                "+X$,11)+"      "
5030 IFX<=999999999ANDX>.01GOTO5115
5040 IFX=0GOTO5115
5050 IFABS(X)>1E38ORABS(X)<1E-38THEND$="ERROR           ":GOTO5115
5100 R$=RIGHT$("               "+X$,15)
5110 D$=LEFT$(R$,11)+"  "+RIGHT$(R$,3)
5115 PRINT"[illegible]"D$
5120 RETURN
READY.
```

{"home" 2x "cursor down" 12x "cursor right"

Although the program is by no means perfected, the framework exists for a versatile program. Lines 4000 onwards determine the functions so that when 'S' is pressed the sine of the number on display is calculated and to clear all registers '←' is pressed. The normal operation for +, −, x and ÷ is the same as a straightforward calculator, and there are multiple sets of brackets.

This idea could be used to simulate actual models - including programmable calculators, thus giving access to a wide range of ready-written low key software. We would like to hear from any user who succeeds in doing this.

BITS AND PIECES

Some more hints and tips to help you write efficient programs:

When writing REMark statements, graphics and lower case can be included if they are put inside inverted comma's. This enables separating lines such as:

```
10    REM "——————————————————"
```

* * * * * * * * * * * *

When using subscripted variables such as A(4) the operating system automatically reserves 10 elements without having to declare a dimension with DIM. If, however, you are using a very long program and are using less than 10 elements per variable - say 4 - it will save space to declare the dimension's length. For example:

```
10    DIM A(4), C$(3)
```

* * * * * * * * * * * *

To display a number (N) to D decimal places, use the following routine:

```
1Ø    M = INT(N*1Ø↑D+Ø.5)/1Ø↑D

2Ø    PRINT M
```

*   *   *   *   *   *   *   *   *   *   *   *

For an intriguing display of graphics, try running this one line program entitled "BURROW"

```
1 A$="⇑⇓⇒⇐":PRINTMID$(A$,RND(.5)*4+1,1)"*⇐";:FORT=1TO3Ø:
NEXT:PRINT"Ⓡb̸⇐";:GOTO1
```

*   *   *   *   *   *   *   *   *   *   *   *

STANDARD SYMBOLS

I have assembled a small table of symbols that are not hard to obtain from a typewriter (if you are using one) and are quite distinguishable if you write out your programs in capital block letters. It would be appreciated if you use these when submitting software for publication; especially programs containing cursor control.

SYMBOLS

h - cursor home	¢ - carriage return
c - clear screen	b̸ - space (blank)
cr- cursor right	! - RVS on
cl- cursor left	/ - RVS off
cu- cursor up	@ - Shift on
cd- cursor down	
d - delete	
i - insert	

To represent any graphic characters clearly, the character below should be followed by the '@'. For example:

⧅ = M@   (M w/Shift on)

Following this standard should make programs fairly easy to read however any suggestions are quite welcome.

INTERFACERS....

This month I received a letter from Andrew Hwang of Concordia Designs in Toronto. Andrew has successfully interfaced a PET to an X-Y Plotter. Excellent! A copy of his response follows. Thank you Andrew.

If anyone else has gizmos or gadgets interfaced to their PETs, be it practical or unusual, write in and tell us about it! A brief note is sufficient (such as Andrew's), and businessess... the "TRANSACTOR" is sent to over 500 subscribers. Get the hint?

CONCORDIA DESIGNS

INNOVATIVE
CUSTOM DESIG
SPECIALISTS

INTERFACING DIVISION

P.O.Box 219, Station D, Scarborough, Ontario, Canada. M1R 5B7

CPU Club Members

c/o Commodore Business Machines Ltd.
3370 Pharmacy Ave., Agincourt,
ONTARIO. M1W 2K4

13 Dec.1978

RE: Full Graphical Plotting Capability with the PET and a Digital Plotter

Dear Fellow CPU Members:

We have succeeded in interfacing the PET with a Digital Plotter made by Houston Instruments. Full hard-copy graphs of data or functions can now be easily plotted with pen accuracy of up to 0.005 inches. Softwares are also available to issue plotting commands in simple basic steps. Anyone wishing more information may write to: Concordia Designs, Interfacing Div., P.O.Box 219, Station D, Scarborough, Ontario, Canada. M1R 5B7.

Faithfully,

Mr. Andrew Hwang, M.Sc.
PET User Club Member #65

Jim Butterfield, well known PET enthusiast, has sent to Commodore a couple of interesting items which have also been passed on to PET User Notes. Thanks Jim...and thanks for recognizing Brad as a source--maybe he'll send in something else as well.

Summary of Cassette data file "patches"

The following information has been passed around users, and is now "official" with the issuance of a Commodore bulletin. It seems worth while to summarize briefly:

1. Opening a file for writing: an omission in current ROM programs makes it highly desirable to precede all OPEN statements with a couple of POKEs:
   before OPEN x,1... for writing: POKE 243,122 : POKE 244,2
   before OPEN x,2,.. for writing: POKE 243,58 : POKE 244,3

2. When writing tapes, it is useful to increase the spacing between tape blocks; otherwise you might miss a block during subsequent reading. There are several approaches to this; my technique is to call the following subroutine immediately after each PRINT#:

Cassette #1	Cassette #2
950 IF Z9<=PEEK(625)GOTO 990	950 IF Z9<=PEEK(626)GOTO 990
960 POKE 59411,53	960 POKE 59456,207
970 FOR Z9=1 TO 60:NEXT Z9	970 FOR Z9=1 TO 60: NEXT Z9
980 POKE 59411,61	980 POKE 59456,223
990 Z9=PEEK(625):RETURN	990 Z9=PEEK(626):RETURN

3. Even with the above coding, it seems wise to guard against a potential "dropped block". Think in terms of writing a "number of items" total on tape so that when reading, you can check that nothing has been lost.

4. Don't PRINT# a line of over 80 characters unless you're prepared to do some careful work with GET# statements when you read it back in. In general, avoid "print punctuation" when writing (PRINT#1, A;B ... PRINT#2, X$,Y$); each data element can be written as a separate "line". Watch for long strings.

5. Either: check the value of ST after every read, or use your own checking routines on your data. ST can be useful, but doesn't guarantee your data is 100% good. IF ST=0 .. no errors are seen; IF ST>63 .. you have come to the end of file; if anything else, an error has been detected.

6. Always CLOSE your cassette files after you're finished with them. When writing, your data is accumulated into a buffer .. if you don't CLOSE, it may not go onto tape.

   Most Basic errors abort the cassette file without CLOSEing it; if this happens while you have a cassette tape open for writing, better start over .. your tape will likely have data missing.

UNLIST Revisited

Jim Butterfield, Toronto

Larry Tessler's UNLIST appeared in User Notes without much fanfare. If you can read between the lines, however (and cope with the typos) it's quite a blockbuster of a program.

In general, it allows a program to be handled as data ... using the UNLIST key, you can re-process programs as if they were data files, and create such things as program-writing programs, language translators, and many other startling things.

Perhaps the most immediate use of UNLIST for the casual computerist is to merge two programs together. One program could contain subroutines; and these could be merged with other programs to save a lot of typing. It's especially useful to be able to merge a single set of DATA statements into several programs, each of which is set up to process the DATA in different ways.

Brad Templeton (Toronto) has passed me an even more concise way of doing the same thing. I'll go through the whole operation, step by step.

First, prepare the program you will want to merge in the following manner. Load the program. Put a blank tape into the cassette and rewind. Enter OPEN 1,1,1 : CMD 1 : LIST. Be sure to put this on a single line, using colons as indicated. Press RECORD and PLAY as instructed. The tape will move. When it stops, type ?"POKE611,0": PRINT#1:CLOSE1. Your tape is now ready, and PET should be back to normal operation. You may file this tape and use it at any future time.

Now for the merge. When you have your second program loaded into the PET, mount the tape you have previously written. Type OPEN1, press PLAY as requested, and wait for the tape to stop.

Here comes the tricky bit. Clear the screen, give 4 cursor down's, and type the following line, but DO NOT HIT RETURN:

POKE611,1:POKE525,1:POKE527,13:?"h" (h is Cursor Home, displaying reverse S)

Don't hit return. Instead, press cursor home and 6 cursor downs ... then type the identical line. This time, hit RETURN at the end of the line and listen to the tape move.

Eventually, things will stop with a ?SYNTAX ERROR or ?OUT OF DATA printed between the two lines, and the tape should stop. (If it doesn't, stop it with the RUN-STOP key). The merge is now complete. Type CLOSE 1 to close the file.

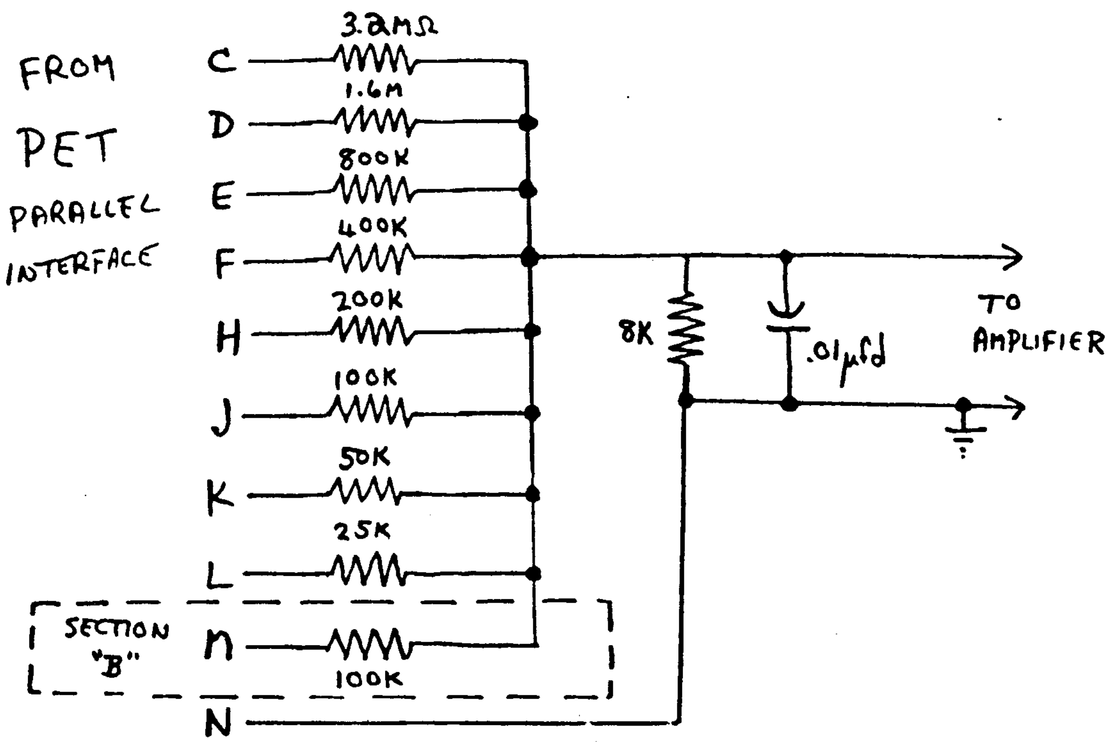
(The ?"POKE611,0" in paragraph 5 may be unnecessary .. I put it there to guard against a processor crash situation I encountered during early testing ...)

Jim has also submitted a schematic of a circuit he demons demonstrated at the first meeting of the Toronto PET Users Group. The schematic has been published in the club newsletter and Lyman Duggan suggested I pass it on to Transactor subscribers. Thanx again Jim. -Karl J.

Poor Man's D/A Converter

Cheap; good for generating Chamberlin/style music. Precision resistors are preferred, but most anything will generate a recognizable sound.

Section B of the diagram supports the CB2 sound effects - so that one interface board covers most sound requirements.



The capacitor provides some reduction of the sampling frequency (when generating music) .. tone controls on the amplifier will also help, if available.

The HUH "Petunia" gives a high quality equivalent of this converter. Toronto price - about $40.

Reference: see BYTE, September 1977, lengthy article by Hal Chamberlin on computer-generated music. 6502 programs are given.

The "ON...GOTO" Statement

e.g. 100 ON I GOTO 10, 20, 146, 2040

The above statement, when encountered, will cause program execution to branch to the line indicated by the I'th number after the GOTO. That is:

```
If I=1    GOTO 10
If I=2    GOTO 20
If I=3    GOTO 146
If I=4.4  GOTO 2040
```

I is truncated to an integer value. If I is equal to zero, or attempts to select a non-existent line (greater than or equal to 5), in this case the statement after the ON...GOTO is executed. As many line numbers as will fit on a line can follow an ON...GOTO. Thus the main purpose is to eliminate successive IF...GOTO statements and save on memory consumption.

e.g. 200 ON SGN(X)+2 GOTO 40, 50, 310

In this case, execution will branch to line 40 if the SGN(X) expression is less than zero, line 50 if equal to zero and line 310 if equal to one.

When using expressions in the ON...GOTO statement, do not allow the final result to be negative. Implement an ABS function into the expression, else an ILLEGAL QUANTITY ERROR will result.

The "ON...GOSUB" Statement

Identical to the ON...GOTO statement except that a subroutine call is executed instead of an absolute GOTO. On return from the subroutine, execution continues at the line following the ON...GOSUB.

A Short Note On Subroutines

Jumping out of a subroutine can be HAZARDOUS! That is, subroutines containing IF...GOTO's or ON...GOTO's can cause an OUT OF MEMORY ERROR for this reason: When a program encounters a GOSUB, the machine loads the return address into a stack area. The subroutine is then executed and let's say 'jumps out' on a GOTO statement within the subroutine. Thus the RETURN statement is never executed and the return address is not unloaded from the stack. The stack will fill to the limit and the error message results.

To avoid this problem the ON...GOTO statement can be used instead of RETURN. Thus all GOSUB statements directed at that particular subroutine must also be replaced with absolute GOTO's. By implementing a control variable just prior to the GOTO, the return addresses can be placed after the ON...GOTO in the subroutine and the hazard is eliminated. For example:

```
100  C=1:GOTO 5000              Subroutine address
110  REM RETURN FROM SUB.

500  C=2:GOTO 5000              Same subroutine
510  REM RETURN FROM SUB.



5000 REM SUBROUTINE
5010 )
  .  |
  .  {    'SUBROUTINE'
  .  |
5080 )
5090 ON C GOTO 110, 510         Instead of RETURN
```

NEWSLETTER ADDRESSES

1. The "Tranasctor" (subs. $10.00 Cdn.)
   3370 Pharmacy Avenue
   Agincourt, Ont.
   M1W 2K4

2. PET User Notes (subs. $6.00 U.S.)
   P.O. Box 371
   Montgomeryville, PA 18936

3. THE PET PAPER (subs. $15.00 U.S.)
   P.O. Box 43
   Audubon, PA 19407

4. Cursor (subs. $24.00 U.S.)
   P.O. Box 550
   Goleta, Calif. 93017

5. The PET Gazette (Free w/lg. S.A.S.E. U.S. postage)
   c/o Len Lindsay
   1929 Northport Drive
   Room 6
   Madison, Wisconsin 53704

FAILSAFING

Recently I have received a number of inquiries on how to avoid entering the command mode by hitting "RETURN" after an input statement without data entry. I know of three such methods:

1. The "GET" loop instead

e.g.

```
20 GET A$: IF A$=" " THEN 20
30 PRINT A$
```

The above routine will loop continuously in line 20 until a key is depressed. Once entry is made, the routine will print the entry be it alphabetic, numeric or graphic character. Use of the numeric variable is confusing because even if no key has been struck, the value returned is zero. That is:

```
20 GET A: IF STR$(A)=" " THEN 20
30 PRINT A
```

will return 0 immediately.

2. Forced Input

If after an INPUT statement you arrange an invalid input to the right of the '?', hitting "RETURN" will result in a ? REDO FROM START and go back to the INPUT statement. For example:

```
10 INPUT "A VALUE b̸b̸b̸b̸ ■ clclclcl";A
20 PRINT A
```

The cursor is left 2 character spaces beyond the '?'. Therefore you must arrange your 'invalid input' such that it will be erased by the entry else it will be included (be it to the right or left of the entry), and a ?REDO FROM START will be returned.

The above routine does not work with string variables because ' ▚ ' will be accepted as an alphabetic input if "RETURN" is hit. Therefore a test statement must be added:

```
10 INPUT "A CHAR. b̸b̸b̸b̸ ▚  clclclcl";A$
15 IF A$ = " ▚ " THEN 10
20 PRINT A$
```

3. Opening the Keyboard as a File

By assigning the keyboard a file number using the OPEN statement and opening that file for reading, all input statements will accept data only as an entry. The following program will demonstrate this.

```
1 OPEN 1,0,0 (last 0 optional)
.
.
.
.
500 PRINT "A VALUE?";
510 INPUT #1,A$
520 PRINT: PRINT A$
530 END
```

The open statement may be placed at the very beginning of the program and may even be line 0. Other programming can be inserted (between 1 and 500). The preceding words and '?' must be displayed using a PRINT statement (line 500). The double PRINT's in line 520 are required to get A$ to print on the next screen line. Otherwise A$ will be displayed just to the right of the entry.

If anyone should find bugs with this due to not closing the file or otherwise, please let me know so that I may pass it on.

HARDWARE FIX

Most PET Users involved with data files are aware of the problem concerning file reads. That is after a block READ the tape motor does not stop instantaneiously and tends to roll the tape past the beginning of the next block resulting in 'LOST DATA'. Realizing this, Richard Leon and Larry Phillips of the Vancouver PET Users Group devised a hardware fix. It consists of a resistor, a capacitor, a diode and the unused half of the DPDT switch connected to the record button of the cassette deck (Figure 1).

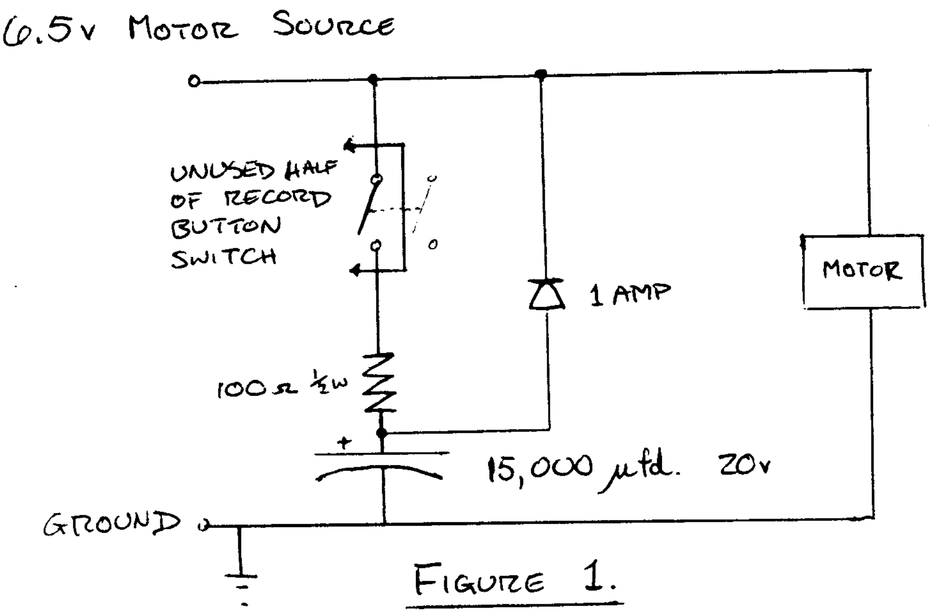


FIGURE 1.

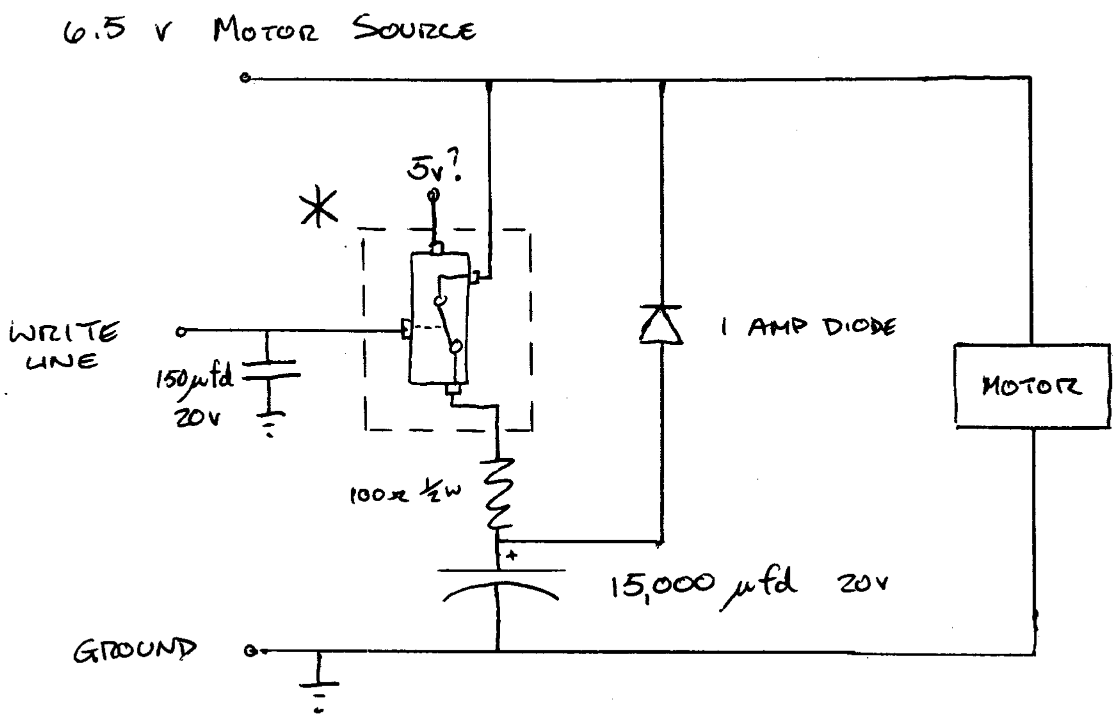
Operation is relatively simple. During Data writes the record switch is closed and the capacitor charges through the resistor. When the block is finished the motor voltage turns off and C1 discharges into the motor through the diode causing the armature to rotate that extra little bit. This allows a larger gap between blocks. During reads, the motor still does not stop instantaneously but it won't roll far enough for the tape head to encounter the next block. (During reads the record switch is up and the charging network is disabled).

The fix itself poses only one problem. Installation. Many of you may not be willing to dismantle your cassette decks to access the record button DPDT switch. Therefore I have a second idea. Using the same concept as Richard Leon, build an 'INTERFACE' for your tape deck and install it between the 6 pin molex plug and the printed circuit board edge connector. The same circuitry is used with one major difference. The enable/disable switch must be simulated such that identical operation is obtained without using a mechanical switch. Therefore the swtich needs control logic such that it enables the circuit during data writes and disables it during reads. Ideally, this could be done with logic gates, however most TTL logic chips require +15 and -15 volt supplies. There is "logic" available on the PCB cardedge. Here are the characteristics:

PIN	OPERATION		
on PCB Cardedge	NONE	READ	WRITE
READ	Low	Active	Active
WRITE	High	High	Active
SENSE	High	Low	Low
MOTOR	Open (floating)	6.5v	6.5v

Using these lines a control must be designed to either open the switch during reads or close it during writes. This is where I stand right now. The 'write' line seems to be the most likely candidate for the control input since 'write' is held high constantly and goes low only during writes. Therefore it could be used to hold open a N.C. (normally closed)switch. However, when data is passed to the tape, 'write' is active (high and low) which means the switch will be on, off or unstable anyways.

If this signal could be 'filtered' and seen by the switch input as low during writes the switch would stay closed and the design is complete. Here's what I have so far. Will it work?



* N.C. integrated switch. Part number anyone?

Richvale Telecommunications, 10610 Bayview Ave; Richmond Hill, Ontario L4C 3N8 884-4165 are pleased to announce "Hampet": A morse and RTTY interface.

The "Hampet" is a morse and RTTY(Baudot) interface. You simply plug the "Hampet" into the Pet, and your ready to display, transmit and receive morse and RTTY at rates upto 100WPM. The interface will also send random words and characters, displayed and with audio from a built in side tone oscillator and speaker. In addition the "Hampet" can re-transmit 400 characters from memory for "brag" transmissions. The "Hampet" is sold wired and tested, and comes in an attractive, blue and sand, sloping front, aluminum case, with on-off, volume control, frequency control, PLL control, tune LED, on LED, headphone muting jack and four RCA phone jacks. The "Hampet" is capable of perfect copy with an "S4" signal. The "Hampet" retails for 189 dollars with immediate delivery.

Dealer enquiries are invited.

ADDRESSING

Every memory location in your PET contains one byte of information. In order for PET to get at these bytes it must have a means of accessing them. Therefore each and every memory location has its own individual address; all 65536 of them. The microprocessor places these addresses on the address buss which immediately enables one memory location to the data buss. Bearing that in mind, one of two operations can happen now. PET can either place a byte into that location (i.e. POKE) or "look" at what's already there (i.e. PEEK). When performing the first operation the microprocessor places a byte on the data buss and transfers it along the buss and into the enabled memory location.

In the second operation, the information or byte in the enabled location is transferred onto the data buss and along the data buss back to the microprocessor. This location is not "emptied" but rather only a duplicate or copy of the information is transferred. Once either of these operations is complete the microprocessor then places a new address on the address buss and another location is enabled. This process repeats thousands of times every second, however these operations aren't possible on all memory locations, but I'll explain this later.

The microprocessor has control of 99.9% of the addresses being placed on the address buss. That extra 0.1% control was left for the user and can be obtained through use of the PEEK, POKE and SYS commands. When executing these commands the user must choose an address. This address will be one of the 65,536 memory locations (i.e. 0 to 65535). This is where the memory map enters the picture. The memory map may well be your most powerful tool for choosing addresses. If you look at the map you'll see that all of the addresses are listed in ascending order down the left hand side; first in hexadecimal and then in decimal. (See section on hexadecimal and binary for explanation of this conversion) the decimal address is the one you use when executing the above 3 BASIC commands. To the right are the descriptions of what you can expect to find at the corresponding addresses. If we then PEEK these addresses we are returned the actual bytes that are in those particular memory locations. For example, let's say during a program we hit the STOP key and got:

```
BREAK IN 600
READY.
█
```

PET gets '600' from a storage register at addresses 138 and 139. We could also PEEK these locations and find that 600 is indeed stored in 138, 139. However it is not stored as a six, a zero and a zero. Instead it is stored as the decimal conversion of the line numbers representation in hexadecimal. All information of this type is returned in this manner. Now that we know what the memory map will help us do let's cover some of the rules.

RAM and ROM

We all go through life with basically 3 types of memory:

1. MEMORY PRESENT: This memory we use to remember things like what street we're driving on or our present location.
2. MEMORY PERMANENT: Things like our names and fire is hot we never forget.
3. MEMORY PAST: Recent occurrences and not so recent such as things we did 10 or 12 years ago.

In the PET there are only two:

1. RAM Random Access Memory: This type of storage is used for our programs and things that change such as the clock and previous line number.
2. ROM Read Only Memory: This is PET's permanent memory. In ROM are the addition routines, clock updating routines and loading routines to name a few. These functions would have to programmed into PET on each power up if they weren't permanently 'burnt in'.

The third type, memory past, is instantly 'forgotten' on power down. The only way to recall it is to first save it on tape, disc, etc.

Recall earlier I mentioned that POKE and PEEK aren't possible on all memory locations for several reasons:

A. Not all PET memory locations actually exist. On the memory map, locations 1024 to 32767 is the 'available RAM including expansion'. If you have a PET with 8K, simple arithmetic shows that 3/4 of the available RAM space is non-existent. If you decide to expand your system, PET will 'fit' the added RAM into this area. However POKing or PEEKing this space (i.e. 8192 to 32767) will return invalid results on 8K PETs.

B. The same concept applies to locations 36864 to 49151. This is the available ROM expansion area.

C. Next on the memory map is the Microsoft BASIC area; locations 49152 to 57463. This is the memory that recognizes and performs your commands. Changing the contents of these locations is impossible because it is Read Only Memory and is actually 'burnt in' at the factory. Therefore, POKing these locations will simply do nothing. Also, Microsoft requested that these locations return zeros if PEEKed (for copyright reasons).

With these 3 rules and your memory map you are now equipped to explore capabilities of your PET that you probably never thought possible. Before we try some examples let's go into one more important occurrence that may have had you scratching your head ever since that first power up.

MISSING MEMORY?

When you turn on your 8K (where **K** = 1024) PET, the first thing it tells you is 7167 BYTES FREE; a reduction of almost 12%.

Q. Where did the missing 1024 bytes go?

A. It's still there...right below the available RAM space (notice it starts at location 1024). PET uses this memory to do some very useful operations for you which you can find and access by looking them up on the memory map.

Q. But why not do this in ROM space?

A. PET needs RAM type memory to store this data because it is always changing. The information in this "low" end of memory is actually produced by routines found in ROM.

Take for example the built-in clock. The clock or time is stored in locations 512, 513 and 514 of RAM. However the data comes from a routine found in ROM at location $F736_{hex}$. The time is of course always changing, therefore it must be stored in RAM. But because it is in RAM, you may also change it; either by setting TI or TI$ or you can POKE the above 3 locations. Try it.

Now let's try some examples.

1. Location 226 (00E2 in HEX) holds the position of the cursor on the line. Try these:

```
POKE 226,20:?"PRINTS AT NEXT SPACE
?"123456789";:?PEEK(226)
```

2. Location 245 (00F5 in HEX) stores the line the cursor is presently on (0 to 24). POKing this location will move the cursor to the specified line after a display execution. For example try:

```
?"A": POKE 245,10:?"B":?"C"

POKE 245,21-1:?"cu":POKE 226,20:?"PRINTS HERE"
```

The above will move the cursor to line 20 (21-1), print a 'cursor up' on line 21 and display your message starting at column 21, line 20.

While experimenting with out-of-range values I obtained some rather interesting results. Try POKing location 245 with a number greater than 24, say 40 or 60, and hit the cursor up/down key a number of times. Also, experiment with unusual numbers in location 226 such as:

```
POKE 226,100:?"123456789"
```

In the command mode (i.e. when you're operating PET directly all typed keys go first into the keyboard buffer and then into screen memory or VIDEO RAM. However you may also load the buffer under program control by POKing the ASCII representations of the characters into sequential locations of the buffer. You must also increment by 1 the contents of 525 each time another character is POKed in, but remember -- not past 9. Page 6 of "Transactor" #2 contains a table of all the values for characters and commands. "Transactor" #1, page 12 lists some extras such as cursor controls and the RETURN key (13). Try the following endless loop. 145 is a cursor up

```
POKE 525,4:POKE527,145:POKE528,145:POKE529,145:POKE530,13
```

Some other interesting items are:

```
POKE59409,52 - Blanks screen
POKE59409,61 - Screen back on
POKE59411,53 - Turns cassette motor on
POKE59411,61 - Turns motor off
POKE59468,14 - Lower case mode
POKE59468,12 - Graphics mode
POKE537,136 -  Disables STOP key and clock
```

If anyone knows of or discovers any peculiarities by "POKing" around, please send them in. When I receive enough of them a handy dandy 'PETRIX' card will be included in a future "Transactor" bulletin.

THE SYStem COMMAND

On the last three pages of the memory map are listings of the subroutines stored in PET ROM that perform your commands and programs. These subroutines are stored as machine language.

When a SYS command is executed PET jumps to the specified decimal address and continues from there in machine language. Take for example the Machine Language Monitor program. This is a machine language program and is initialized by a SYS command stored as a BASIC program line. LOAD and RUN your M.L.M. then type 'X' and hit 'RETURN' to exit to BASIC. Now list. What you'll see is:

```
10 SYS (1039)
```

Location 1039 is the address to which PET will jump and also the address at which the first maching language instruction is stored. (A listing of all of the M.L.M. instructions is in "Transactor" #5, pages 5A and 5B) . When this BASIC line is executed PET operates in machine code beginning with address 1039.

The SYS command does not require brackets around the specified address.

Since PET has its subroutines stored in machine language you can use the SYS command to access and execute them. However you may come up with some rather peculiar if not disastrous results. When jumping into ROM you may find yourself in the middle of a subroutine or at the beginning of a subroutine belonging to a major function routine. Often PET will 'hang-up' or crash and you will be forced to power down to resume normal operation. To demonstrate jumping into the middle of a routine, try the following examples:

1. SYS52764 (CE1C)
2. SYS62498 (F422)
3. POKE523,1:SYS62498 (F422)
4. SYS62463 (F3FF)
5. SYS64824 (FD48)

The numbers on the right are the addresses of the above subroutines in hexadecimal. Compare them to the memory map, especially for e.g. #1. Also take a look at 523.

The following are examples of valid locations which you can use with the SYS command to access useful routines, however these routines are already accessible through BASIC.

1. SYS62651 (F346)
2. SYS62278 (F4BB)
3. SYS63134 (F69E)

Example #3 will perform a 'SAVE' but will not produce a tape header.

Experiment with your memory map. Hex to decimal conversions can be obtained using the method following this article.

SUMMARY

This has been merely 'a scratch on the surface' of the extremely complex inner workings of PET. Do not be afraid to experiment with the POKE and SYS commands. There is absolutely nothing you can do to harm PET from the keyboard that turning power off and on won't fix. Also do some PEEKing around especially in low end memory. One good way is to write a small monitor program:

```
10?"c"PEEK(516):GOTO 10
```

The above will monitor the 'SHIFT' key. Try running it and depress 'SHIFT'. Compare the map.

When POKing or SYSing to random addresses, remember the address you choose. Often PET will do something which may erase the address from the screen (e.g. SYS64840).

The addresses that have been listed here are only a few of many that are already known and only a minute percentage of the ones not known. Probe around and send in any discoveries, useful, peculiar or otherwise. They will be collected together and published in a future "Transactor" bulletin.

BINARY to HEXADECIMAL to DECIMAL

We all know how to count in base 10 or decimal. We start at zero and count one...two...three and so on to nine. Once nine is reached we've run out of numbers, that is single digit numbers. So in order to continue we must now make use of two digits; we place a "1" in the 10's column and reset the 1's column back to zero. Continuing from here, sooner or later we would reach 99. Adding "1" would generate a carry into the 10's column and this in turn will generate a carry into the 100's columns to zeros.

This explanation of base 10 was given simply to demonstrate how we actually do our counting that we just do naturally. Binary is much simpler than decimal because there are only two numbers to worry about; zero (0) and one (1).

Base 2 number set	Base 10 number set
0, 1	0, 1, 2, 3, 4, 5, 6, 7, 8, 9

With a little practise you'll see that counting in Binary is just as easy as counting in decimal.

Binary is base 2 ('Bi') just as decimal is base 10 ('Deci') just as hexadecimal is base 16 ('Hexadeci') but I'll talk about the "HEX" numbering system later.

In base 10 we are 'allowed' to count up to 9 before carrying the "1" into the next column. Generally in any base we count to one less than the base # and generate a carry into the next column. In base 2 we count up to "1" and do our carry. Just as we cannot fit a "10" base ten into one column we cannot fit a "2" base two into one column. The base # is most important. Let's illustrate by comparison.

NUMBER	NUMBER REPRESENTATION IN:	
	BASE 2	BASE 10
0	0000	0000
1	0001	0001
2	0010	0002
3	0011	0003
4	0100	0004
5	0101	0005
6	0110	0006
7	0111	0007
8	1000	0008
9	1001	0009
10	1010	0010
11	1011	0011

Notice how in binary, on every multiple of 2 a carry is generated whereas in decimal the carry is generated upon multiples of 10.

Let's now define the columns of the two number bases. In base 10 we have the 1's column, 10's column, 100's column and so on. Each column is the previous column times ten; 1 = 0.1 x 10, 10 = 1 x 10, 100 = 10 x 10 and so on. We can also represent these using exponents; $1 = 10^0$, $10 = 10^1$, $100 = 10^2$ (10 'squared'), $1000 = 10^3$ (10 'cubed'), and so on. In base two each column is the previous column times two; we have the 1's column, 2's column, 4's column, 8's, 16's, 32's and on. Using exponent representation, $1 = 2^0$, $2 = 2^1$, $4 = 2^2$, $8 = 2^3$, $16 = 2^4$, $32 = 2^5$, and so on. Now let's represent some numbers of the two bases using their column breakdown:

$2_{base\,10} = 0002 = 0*1000 + 0*100 + 0*10 + 2*1$

$2_{base\,2} = 0010 = 0*8 + 0*4 + 1*2 + 0*1$

$7_{10} = 0007 = 0*1000 + 0*100 + 0*10 + 7*1$

$7_2 = 0111 = 0*8 + 1*4 + 1*2 + 1*1$

$12_{10} = 0012 = 0*1000 + 0*100 + 1*10 + 2*1$

$12_2 = 1100 = 1*8 + 1*4 + 0*2 + 0*1$

The same three examples using exponent representation will be:

$2 = 0002 = 0*10^3 + 0*10^2 + 0*10^1 + 2*10^0$

$2 = 0010 = 0*2^3 + 0*2^2 + 1*2^1 + 0*2^0$

$7 = 0007 = 0*10^3 + 0*10^2 + 0*10^1 + 7*10^0$

$7 = 0111 = 0*2^3 + 1*2^2 + 1*2^1 + 1*2^0$

$12 = 0012 = 0*10^3 + 0*10^2 + 1*10^1 + 2*10^0$

$12 = 1100 = 1*2^3 + 1*2^2 + 0*2^1 + 0*2^0$

$2^0 = 1$	$2^4 = 16$
$2^1 = 2$	$2^5 = 32$
$2^2 = 4$	$2^6 = 64$
$2^3 = 8$	$2^7 = 128$

Use this table as a reference for the following exercises.

Try the following example on representing decimal numbers in binary by placing a 1 or a 0 in the correct column position.

NUMBER		2^3	2^2	2^1	2^0
4	=	_	_	_	_
12	=	_	_	_	_
13	=	_	_	_	_
14	=	_	_	_	_
15	=	_	_	_	_

What must be done to represent the number 16 in binary. If you said " A fifth digit must be used at the leftmost position ", then you're absolutely right. Except for one thing: digit is a word we use in decimal. In binary we use the word BIT derived from Binary digIT. By implementing a fifth bit it is now possible to represent numbers greater than 16 but only up to 31. Once past 31, a sixth bit position must be used. Continue with the exercise. Notice the leftmost column values have changed.

NUMBER		2^5	2^4	2^3	2^2	2^1	2^0
16	=	_	_	_	_	_	_
21	=	_	_	_	_	_	_
28	=	_	_	_	_	_	_
32	=	_	_	_	_	_	_
51	=	_	_	_	_	_	_
62	=	_	_	_	_	_	_
63	=	_	_	_	_	_	_

What would be the highest posible number you could represent using only 6 bits?

	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
? =			1	1	1	1	1	1

7 bits?

? =		1	1	1	1	1	1	1

8bits?

? =	1	1	1	1	1	1	1	1

If your answers were 63, 127 and 255, you're correct. Notice how these values are 1 less than the value of the next bit position to the left. (2^8 =256)

The BYTE

Every memory location in PET is actually one byte. A byte consists of 8 bits. In computer electronics the binary number system is used. This way we can use a high voltage to represent a "1" and a low voltage to represent a "0". Can you imagine the circuitry that would be required to operate a computer in decimal or base 10? Ten unique voltages would have to be used to represent each of the ten digits. Then a separate computer would probably be required to distingusih between them all. By using binary PET must only distinguish between two voltages. Since a 5 volt supply is used for the logic circuitry, anything over 2.4 volts is considered high or a "1" and anything under is considered low or a "0". These voltages are typically 4.8 volts and 0.2 volts, respectively. Each bit of every byte in memory holds one of these voltages. With 8 bits in each byte, 256 combinations can be obtained (0-255) as you can see from the above exercise. If you look at the table on page 6, "Transactor #2, you'll see that all the keys can be encoded into one of these combinations. PET uses some combinations to represent the commands so that they only take up one byte in memory. PET also uses some of these combinations twice to represent graphics as you'll see by comparing the table to page 12 of "Transactor" #1. PET ROM routines distinguish between commands and graphics.

Try POKing a RAM location, say 6000, with a number greater than 255, say 256. A ?ILLEGAL QUANTITY ERROR will be returned because more than 8 bits are required to represent 256 in binary.

	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
256 =	1	0	0	0	0	0	0	0	0

Essentially, 256 won't 'fit' into a single byte.

Try PEEKing a non-existent memory location, say 10,000:

```
?PEEK(10000)
```

A 255 will be returned. A unconnected or open line is considered high by PET. Since the byte is not really there, the data buss lines will be open and read as high or all 1's by the microprocessor.

Hexadecimal or "HEX"

Hexadecimal means base 16. This means we can count up to 15 before generating a carry. However we can't use the numbers 10, 11, 12, 13, 14 and 15; these take up two columns. We need to represent these numbers using a single character. Therefore we use the first 6 letters of the alphabet.

Hexadecimal number set

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

$A_{16} = 10_{10}$ $D_{16} = 13_{10}$
$B_{16} = 11_{10}$ $E_{16} = 14_{10}$
$C_{16} = 12_{10}$ $F_{16} = 15_{10}$

When counting in HEX we generate our carry upon 16:

$$14_{10} = E_{16}$$
$$\downarrow \qquad \downarrow$$
$$15_{10} = F_{16}$$
$$\downarrow \qquad \downarrow$$
$$16_{10} = 10_{16}$$

Recall in binary, 4 bits will yield a maximum of 15

$$15_{10} = 1111_2 = F_{16}$$

Now since a byte has 8 bits, we can split it up into two fields of our and then represent it as two hexadecimal characters.

$$4_{10} = 0000\ 0100_2 = 04_{16}$$
$$12_{10} = 0000\ 1100_2 = 0C_{16}$$
$$255_{10} = 1111\ 1111_2 = FF_{16}$$

HEX Addresses

We won't discuss how a byte recognizes its own address; this is buried deep inside the integrated electronics of the IC chips. The address buss consists of 16 lines, 0 through 15. PET needs this many lines to address all 65,536 bytes. Because location 0 (zero) is included, the maximum address obtainable is 65,535 in decimal. When this location is addressed, all 16 lines of the address buss will have ahigh voltage. In other words logic 1.

	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}
65,535 =	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

$$= 2^{15} + 2^{14} + 2^{13} + 2^{12} + 2^{11} + 2^{10} + 2^{9} + 2^{8} + 2^{7} + 2^{6} + 2^{5} + 2^{4} + 2^{3} + 2^{2} + 2^{1} + 2^{0}$$

On PET = 2 ↑ 15 + 2 ↑ 14+... 2 ↑ 0   Try it.

If we now split the 16 columns into four fields of four we can also represent each field using a hexadecimal character thus converting decimal to hexadecimal as Jim has on the left of the memory map.

$65{,}535_{10} = 1111\ 1111\ 1111\ 1111_{(2)}$

$= FFFF_{16}$

Recall e.g. #1 of the SYS command (pg.8)

$52764_{10} = 1100\ 1110\ 0001\ 1100_{(2)}$

$= CE1C_{16}$

When operating PET, the decimal addresses are used for PEEK, POKE and SYS. Therefore you probably won't find yourself converting from decimal to HEX when using BASIC. However you will need to convert from HEX to decimal when you want to SYS to those ROM subroutines.

$CE1C_{16} = 1100\ 1110\ 0001\ 1100$

$= 2^{15} + 2^{14} + 2^{11} + 2^{10} + 2^{9} + 2^{4} + 2^{3} + 2^{2}$

ON PET = 2 ↑ 15 + 2 ↑ 14 + 2 ↑ 11 + 2 ↑ 10 + 2 ↑ 9 + 2 ↑ 4 + 2 ↑ 3 + 2 ↑ 2

$= 52764_{10}$

$F422_{16} = 1111\ 0100\ \ 0010\ 0010$

$= 2^{15} + 2^{14} + 2^{13} + 2^{12} + 2^{10} + 2^{5} + 2^{1}$

On PET = 2 ↑ 15 + 2 ↑ 14 + 2 ↑ 13 + 2 ↑ 12 + 2 ↑ 10 + 2 ↑ 5 + 2 ↑ 1

$= 62498_{10}$

Try verifying some of the other examples using the same conversion method. With a little practice HEX conversions will be as easy as counting to 'F'.

COMMERCIAL CONFUSION,
or,
"Where'd the penny go?"

Jim Butterfield
Toronto

PET is certainly the greatest business tool since electric pencil sharpeners, and printers and floppy disks will herald an explosion of commercial applications.

Basic seems like the ideal language for a small business system - but it has a hidden "gotcha" that will give you problems if you don't know how to handle it. I call it, "the missing pennies problem", and it's common to almost all Basic implementations.

Crank up your PET and try this: PRINT 2.23 - 2.18 -- it's a simple business calculation and the answer has gotta be a nickel, right? So how come PET says .0499999998?

Think of the mess this could cause if you're printing out neat columns of dollar-and-cent results. Think of the problems if you arrange to print the first two places behind the decimal point: you'll print .04 instead of .05! Think of what the auditor will say when he finds that the totals don't add up correctly!

In a moment we'll discuss how to get rid of this problem. First, though, let's see how it happens.

PET holds numbers in floating binary. That means certain fractions don't work out evenly. Just as, in decimal, one third works out to .333333..., an endless number, PET sees fractions like .10 or .68 as endless repeating fractions - in binary. To fit the fraction in memory, it must trim it. Thus, many fractions such as .37 are adjusted slightly before storage.

Try this program: it will tell you how numbers are stored inside PET:

```
100 INPUT"AMOUNT";A:B=INT(A):C=A-B:?A;"=";B;" ";
110 FORJ=1TO10:C=C*10:D=INT(C):C=C-D:?D;:IFC>0 THEN NEXTJ
120 ?:GOTO100
```

If you try entering numbers in our above example, 2.23 and 2.18, you'll see how PET stores them - and why the problems happen.

How to fix the problem. Easy. Change all numbers to pennies - which eliminates fractions - and your troubles disappear. For example:

```
340 INPUT"AMOUNT";A : A=INT (A*100 +.5)  converts A to pennies;
        ..............
760 PRINT A/100      outputs pennies in dollars-and-cents.
```

Micro Magazine

Published monthly, MICRO is the only mag. devoted entirely to 6502 based systems. It covers software and hardware on PET, KIM-1, APPLE, AIM, SYM and virtually anything to do with the MOS 6502. MICRO has run out of back issues but they are offering "The Best of MICRO Volume 1", which covers issues 1 through 6. Cost is $6.00 plus $1.00 postage and handling, payable in US Funds. Subscriptions are also available; $15.00 (US) for 12 issues. Send your name and address, etc., to:

MICRO Magazine
P.O.Box 3,
SO. CHELMSFORD, MA
01824.

Specify Best of MICRO and/or subscription and at which issue you wish your subscription to start. Highly recommended.

T I S Workbooks

Total Information Services now has 5 workbooks relating to the PET. All are excellent, particularly PET Cassette on data file writing.

Getting Started With Your PET	-	$5.00*
PET String and Array Handling	-	$5.00*
PET Graphics	-	$6.00*
PET Cassette	-	$6.00*
PET Miscellaneous	-	$5.00*

* payable in US Funds. Write To:

Total Information Services
P.O.Box 921,
LOS ALAMOS, NM
87544

```
600 DATA3042,426,18
610 DATA1521,167,17
620 DATA761,46,16
630 DATA-1E10,0,6
640 DATA-1
650 READX,Y,P:IFI<X*102GOTO650
660 T=Y*100:PRINT"ON FIRST $";X;"TAX IS        ";Y
670 J=I-X*100:I=FNP(J):PRINT"ON RMG $";J/100;"TAX AT";P;"% IS $";I/100
680 I=I+T:C=3:F=1:I$="TOTAL FED INCM TAX":GOSUB2150
690 S=I:P=25:I=FNS(FNP(D(0))):D(11)=I
695 IFI>0THENF=-1:I$="DIV TAX CREDIT":GOSUB2150
700 I=C(C):I$=" *BASIC FEDERAL TAX*":GOSUB2200:PRINT:D(6)=I
710 IFI<3E4GOTO740
720 IFI<=333E2THENI=3E4:GOTO740
730 P=9:I=FNP(I)
740 C=4:C(C)=0:F=1:I$="GENERAL TAX REDUCTION":GOSUB2150
750 I$="REDUCTION FOR CHILDREN":GOSUB2100
760 S=5E4:I=FNS(C(C)):C(C)=0:C=3:F=-1:I$="TOTAL REDUCIONS":GOSUB2150
770 GOSUB2300:I$=" **FEDERAL TAX**":GOSUB2200:D(7)=I:D(8)=I
780 C=4:I$="FOREIGN TAX PAID":GOSUB2100:IFI=0GOTO850
790 W=I:I$="FORGN INCOME":GOSUB2100:K=I:X=(D(3)-D(10))/100:Y=(D(7)+D(11))/100
800 S=INT(K/X*Y):PRINTK/100;"/";X;"*";Y;"=";S/100
810 I$="--DEDUCT:":I=FNS(W):GOSUB2200:D(8)=D(8)-I
820 PRINT"..ANOTHER COUNTRY...":GOTO780
850 I=D(8):I$="FEDERAL TAX PAYABLE":PRINT:GOSUB2200:PRINT
860 P=44:I=FNP(D(6)):I$="BASIC ONTARIO TAX":GOSUB2200:D(9)=I
1000 READX:IFX<>-1GOTO1000
1010 PRINT"==ONTARIO PROPERTY TAX=="
1020 I$="TOTAL RENT PAYMENTS":GOSUB2100:IFI=0GOTO1040
1030 P=20:I=FNP(I):I$="*20% OF RENT":GOSUB2200
1040 C=1:C(C)=I:F=1:I$="PROPERTY TAXES&COLLG RES":GOSUB2100
1050 I=C(C):P=10:X=FNP(I):I$="*OCCUPANCY COST*":GOSUB2200:PRINT
1060 S=18E3:I=FNS(I):I$=" ADD  ":GOSUB2200:C(C)=I:I=X:I$=" TO.  ":GOSUB2150
1070 I$="PROPERTY TAX CREDIT":I=C(C):GOSUB2200
1080 P=1:I=FNP(D(12)):I$="SALES TAX CREDIT":GOSUB2150
1090 I$="PENSIONER CREDIT":GOSUB2100:I=C(C):I$="TOTAL CREDITS":GOSUB2200
1100 P=2:I=FNP(D(5)):I$="LESS--":F=-1:GOSUB2150
1110 GOSUB2300:S=5E4:I=FNS(I):I$="ONTARIO P S & P CREDITS":GOSUB2200
1120 C(C)=I:I$="POLITICAL TAX CREDIT":GOSUB2100
1130 I=C(C):I$="*TOTAL ONT TAX CREDITS":D(13)=I:GOSUB2200
1140 P1=4:GOSUB2000:I=D(8):I$="FEDERAL TAX PAYABLE":GOSUB2200
1150 I$="POLIT/BUS/EMPLMT CREDIT":GOSUB2100:X=D(8)+D(9)-I
1160 I$="ONTARIO TAX PAYABLE":I=D(9):GOSUB2200
1170 I$="TOTAL PAYABLE":I=X:GOSUB2200:PRINT
1180 C=1:C(C)=0:F=1:I$="TAX DEDUCTED PER SLIPS":GOSUB2100
1190 I$="ONTARIO TAX CREDITS":I=D(13):GOSUB2150
1200 I$="OVERPAYMENTS/INSTALMENTS":GOSUB2100
1210 I=C(C):I$="**TOTAL CREDITS**":GOSUB2200:PRINT
1220 I$="BALANCE DUE":I=X-I:IFI<0THENI$="REFUND:":I=ABS(I)
```

```
1230 GOSUB2200:PRINT
1999 END
2000 PRINT:PRINT"===PAGE";:GOTO2020
2010 PRINT:PRINT"===SCHEDULE";
2020 PRINTP1;"OF RETURN===":RETURN
2100 I=0:GETZ$:PRINTI$;"? ";
2110 Y$="":PRINT"&";
2120 GETZ$:IFZ$=""GOTO2120
2130 Z=ASC(Z$):IFZ>47ANDZ<58GOTO2145
2133 IFZ$="-"ANDY$=""GOTO2145
2136 IFZ$="."GOTO2145
2139 IF(Z=157ORZ=20)ANDY$<>""THENY$=LEFT$(Y$,LEN(Y$)-1):PRINT" ";:GOTO2147
2140 IFZ$="+"THENPRINT"";:I=I+VAL(Y$):FORJ=1TOLEN(Y$):PRINT"";:NEXT:GOTO2110
2142 IFZ=13ANDI=0THENPRINT"";
2143 IFZ=13THENI=FNI(I+VAL(Y$)):PRINT:GOTO2150
2144 GOTO2120
2145 Y$=Y$+Z$
2147 PRINTZ$;:GOTO2120
2150 C(C)=C(C)+I*F
2200 PRINTI$;:M=1E8:FORJ=LEN(I$)TO25:PRINT" ";:NEXTJ:J=ABS(I):Z$=" ":Z=0
2210 D=INT(J/M):J=J-D*M:IFD=ZTHENPRINT" ";:GOTO2230
2220 Z$=",":Z=10:PRINTCHR$(D+48);
2230 M=M/10:IFM=1E4THENPRINTZ$;
2240 IFM=10THENPRINT".";:Z=M
2250 IFM>=1GOTO2210
2260 IFI<0THENPRINT"CR";
2270 PRINT:RETURN
2300 B=0:I=FNB(C(C)):C(C)=I:RETURN
READY.
```

TAX ONTÁRIO 1978

Last months listing of the Income Tax program requires a few revisions due to the fact that the Centronics 779 does not recognize PET graphics. The corrections are as follows:

```
111 INPUT"cdINSTRUCTI.....
112 PRINT"cdONTARIO IN.....
113 PRINT"cdFOLLOW YOUR.....
115 PRINT"cdFOR 'NIL' ITEMS.....
116 PRINT"cdFOR 'MULTIPLE' ITEMS.....
310 PRINT"!EXEMPTIONS.....
470 IF I 231E3 THEN PRINT"!NO TAX PAYABLE.....
2110 Y$="":PRINT"&@cl";
2139 IF (Z=157 OR Z=20) AND Y$  "" THEN Y$=LEFT$(Y$,
     LEN(Y$)-1):PRINT"cl⌀";:GOTO2147
2140 IF Z$="+" THEN PRINT"cd";:I=I+VAL(Y$):FORJ=1TO
     LEN(Y$):PRINT"cl";:NEX.....
2142 IF Z=13 AND I=Ø THEN PRINT"cu";
```

cd-Cursor Down, !-RVS On, &@-Shifted '&', cl-Cursor Left,
⌀-Blank or Space, cu-Cursor Up.

When operating in machine language, PET is at top efficiency. Machine code programs can execute at speeds 10 to 1000 times that of the equivalent BASIC implementation. Also, depending on the operation, they may consume as much as 10 times less memory. The reason BASIC is so "slow" is that BASIC must first be interpreted into machine code such that the Microprocessor can handle it. In fact, about 90% of the total execution time is spent interpreting while only about 10% of the time is spent on the actual operation. In machine code programs the BASIC interpreter is bypassed hence the greatly increased speed of processing. This speed is realized most in programs where a lot of tests or comparisons are made. MicroChess[c] is a prime example. At level 8 (playing at it's best) the machine can still spend as much as 10 minutes on a move in some situations. Imagine a chess program coded in BASIC!

A brief explanation of machine language would be highly impracticle because of the variations and possibilities of the concepts. Undoubtedly a lot of imprtant information would be overlooked. However I have here an exerpt from PET User Notes, Issue #5, written by Jim Butterfield:

"A Little Exercise in PET Machine Language
Jim Butterfield Toronto, Canada

Clear the PET completely (NEW:CLR) and enter the following three lines of BASIC...Do not insert extra spaces!

```
100 SYS(1050)
110 GOTO100
120 XXXXXXXXXXXXXXXXXXXXXXXXX
```

The last line should not be less than 15 X's, and preferably a few more, say 25. You may list this program but do not try to run yet.

Now you have some POKEing to do, and unfortunately you can't have a program help you. First, make sure that the above lines are OK by ?PEEK(1050); this should return an 88 (X character). Now starting with POKE1050 ,32...input the following values:

```
Starting at 1050:  32 228 255 208   1  96 162   0 157   0
Starting at 1060: 128 157   0 129 157   0 130 157   0 131
Starting at 1070: 202 208 241  96
```

Double-check the above values by listing them with:

```
FOR J=1050 TO 1070 STEP 10:FOR K=0 TO 9:?PEEK(J+K);:
NEXTK:?:NEXTJ
```

It is vital that these numbers be correct - one mistake and your system will crash. Behind the 96 you should see some leftover X's (88's).

Now type RUN. Try tapping a few keys and note how the screen changes. Stop the program with the STOP key.

What's it all about? We've written a program in machine language, the fundamental 6502 language of the PET. In working with the inner fabric of the machine we find we get: (i) compactness - we've fitted a whole program within one BASIC line: (ii) speed - no BASIC program could fill the screen that fast. We lose, however, in the need for preciseness; one mistake and the system crashes, and you have to switch off and on again. We also lose flexibility - adding an instruction isn't easy.

For those who would like to try tracking the machine language program above, a few brief notes. 32-228-255 calls the PET subroutine to get a character (something like BASIC GET). 208-1--96 exits if no character is seen (like IF X$=" " THEN RETURN). Now we're ready to zip through the screen with the character we found. We set up for repetition with 162-0 which loads an internal (X) register for 256 repeats; much later we invoke the repetition with 202-208-241, and after the 256th time we return (96). Within the repetition itself, we set the four quarters of the screen with four 157-0-xx instructions."

Those interested in getting seriously involved in machine language should consider first the MOS KIM-1 Microcomputer Module and:

<u>The First Book of KIM</u> By: Jim Butterfield, Stan Ockers and Eric Rehnke
Publisher: Hayden

The book is mostly machine language programs written for the KIM. Programming them into PET would be most difficult even with the Machine Language Monitor. KIM has numerous subroutines in ROM that aren't like PET's.

Other suggested reading:

<u>Programming a Microcomputer</u> By: Caxton C. Foster
Publisher: Addison-Wesley

<u>MOS 6500 Programming Manual</u> By: Commodore/MOS Technology

<u>6502 User Notes</u> By: Eric Rehnke
P.O. Box 33093
North Royalton, Ohio
44133

$12.00/Yr.?

All four publications are excellent, but for beginners I suggest the last three in order (if using PET with the M.L.M.).

Besides the program outlined in J. Butterfields article are four more that also operate in machine language. The first three read from the DATA statements data which has already been converted into decimal. This data represents the machine language instructions which (in these three particular programs) are POKEd into the second cassette buffer (826 to 1017). Since they are in decimal, a conversion program has been included so you may convert back to HEX and compare them to the table. However, not all of these will necessarily be instructions (as you will see when you find one that matches a "Future Expansion" code). Some may be addresses of direct data depending on the preceeding instruction. Addresses will appear as low order first, high order second. For example:

JSR 00 05

....will jump to the subroutine starting at location 0500.

The DATA statements in Life contain the actual hexadecimal representations of the instructions and addresses. They are read by the program (line 110), tested for validity (lines 120 and 150), converted to decimal (lines 130 and 140) and POKEd into memory (line 160) starting at decimal location 6400 (HEX 1900). SYS 6400 executes the program.

View By Jim Butterfield
from an idea by Brad Templeton

```
10 PRINT"SYS826 TURNS PAGEVIEW ON AND/OR OFF
20 PRINT:PRINT"SELECT PAGES WITH 'POKE849,X'
30 PRINT TAB(10)"TRY X=0,2,4,31,232
40 FOR J=826 TO 858:READ X:POKE J,X:NEXT: END
50 DATA 120,173,25,2,73,200,141,25,2
60 DATA 173,26,2,73,229,141,26,2,88,96
70 DATA 162,0,189,0,0,157,0,128,202
80 DATA 208,247,76,133,230
```

Non-Stop By Jim Butterfield

```
0 REM**MACHINE LANGUAGE STOP KEY DISABLE**
1 GOSUB 63520:END
63520 DATA 120,169,96,141,25,2,169,3
63521 DATA 141,26,2,88,96,0,0,0
63522 DATA 120,169,133,141,25,2,169,230
63523 DATA 141,26,2,88,96,0,0,0
63524 DATA 32,234,255,169,255,141,9,2
63525 DATA 76,136,230
63526 FOR L=832 TO 874:READ K:POKE L,K:NEXT
63527 RETURN
```

Auto-Repeat By The Software Shoppe
From 'The Paper' Volume 1, Issue #10

```
5 REM**MACHINE LANGUAGE AUTO-REPEAT**
10 DATA 120,56,169,233,237,26,2,141
20 DATA 26,2,88,96,173,35,2,201,255
30 DATA 208,12,169,0,141,119,3,169
40 DATA 90,141,120,3,208,25,238,119
50 DATA 3,173,120,3,205,119,3,176,14
60 DATA 169,6,141,120,3,162,255,142
70 DATA 3,2,232,142,119,3,76,133,230
80 FOR I=889 TO 947
90 READ J
100 POKE I,J
110 NEXT I
120 PRINT"SYS889 WILL ENABLE AND DISABLE
130 PRINT"THE AUTO REPEAT FUNCTION
140 END
200 REM**TRY THIS AUTO-REPEAT IN BASIC**
210 GET A$
220 PRINT A$;
230 POKE 515,255
240 GOTO 200
```

Life By Mark Taylor

```
100 READL
110 READA$:C=LEN(A$):IFA$="*"THENEND
120 IFC<1ORC>2THEN200
130 A=ASC(A$)-48:B=ASC(RIGHT$(A$,1))-48
140 N=B+7*(B>9)-(C=2)*(16*(A+7*(A>9)))
150 IFN<0ORN>255THEN200
160 POKEL,N:L=L+1:GOTO110
200 PRINT"BYTE"L"=["A$"] ???":END
300 DATA6400
310 DATA20,30,19,20,8A,19,20,E6,19,20,00,1A,A9,34,8D,11,E8
320 DATA20,70,19,A9,3C,8D,11,E8,A9,FF,CD,12,E8,F0,E6,4C,8B,C3,AA,68,28,4C,8B,C3
330 DATA EA,EA,EA,EA,EA,EA,EA,A2,19,BD,3A,19,95,1F,CA,D0,F8,60,00,80,00,15,00
340 DATA80,00,1B,00,1B,D7,28,01,FE,D8,D6,29,27,00,E8,83,00,15,00,00
350 DATAEA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA,EA
360 DATAEA,EA,EA,EA,EA,20,A6,19,B1,26,D0,06,A9,20,91,20,D0,04,A9,51,91,20,20
370 DATA BD,19,F0,ED,20,A6,19,60,20,A6,19,B1,20,C9,51,F0,06,A9,00,91,26,F0
380 DATA04,A9,01,91,26,20,BD,19,F0,EB,20,A6,19,60,A9,00,AA,A8,85,28,85,26,85
390 DATA39,A5,25,85,21,A5,29,85,27,A5,36,85,3A,60,E6,26,E6,20,E6,39,E8,E4
400 DATA33,F0,0C,E0,00,D0,0E,E6,27,E6,21,E6,3A,D0,06,A5,34,C5,21,F0,03,A9,00
410 DATA 60,A9,01,60,EA,EA,EA,EA,EA,EA,20,A6,19,B1,26,D0,06,A9,20,91,39,D0
420 DATA04,A9,51,91,39,20,BD,19,F0,ED,20,A6,19,60,20,A6,19,20,2F,1A,B1,39,C9
430 DATA51,F0,0C,A5,32,C9,03,D0,14,A9,01,91,26,D0,0E,A5,32,C9,03,F0,08,C9,02
440 DATAF0,04,A9,00,91,26,20,BD,19,F0,D8,20,A6,19,60,98,48,8A,48,A0,00,84,32
450 DATAA2,08,B5,29,18,15,49,FF,85,37,38,A5,39,E5,37,85,22,A5,3A,85,23,B0,11
460 DATAC6,23,D0,0D,18,65,39,85,22,A5,3A,85,23,90,02,E6,23,B1,22,C9,51,D0,02
470 DATAE6,32,CA,D0,CF,68,AA,68,A8,60,*
```

```
100 DIM A$(3)
110 FOR K=0 TO 39:PRINT ".";:NEXT:A=0:B=0:C=0:L=0:M=0:N=0:X=0
120 PRINT:INPUT"HEX$crcrcrcrcrcrcrcr ";HEX$:L=LEN(HEX$)
130 IF L<>4 AND L<>2 THEN PRINT" 2 OR 4 HEX DIGITS ONLY":GOTO 110
140 IF L=4 THEN C=2:A$(2)=LEFT$(HEX$,2)
150 A$(1)=RIGHT$(HEX$,2):C=2
160 X=X+1
170 A=ASC(A$(X))-48
180 IF A<0 OR A>22 THEN PRINT "!HEX DIGITS ONLY":GOTO 110
190 B=ASC(RIGHT$(A$(X),1))-48
200 IF B<0 OR B>22 THEN PRINT  "!HEX DIGITS ONLY":GOTO 110
210 N=B+7*(B>9)-(C=2)*(16*(A+7*(A>9)))
220 IF L=0 THEN M=M+N:PRINT"DEC ADDRESS = "M:GOTO 110
230 IF L=4 THEN L=0:M=N*256:GOTO 160
240 PRINT"IN DEC =crcrcrcrcr"N:GOTO 110
```

```
100 REM DECIMAL TO BINARY TO HEXADECIMAL CONVERTER FROM TRANSACTOR ISSUE NO. 10
110 REM WRITTEN BY KARL J. HILDON ABSOLUTELY NO COPYRIGHTS
120 DIM A$(16)
130 INPUT"DEC VALUE      ";D$
140 A=VAL(D$)
150 IF A-INT(A)<>0 THEN PRINT:PRINT"!INTEGERS ONLY  ":PRINT:GOTO130
160 IF 0>65535 THEN PRINT:PRINT"!65535 MAXIMUM  ":PRINT:GOTO130
170 PRINT:PRINT"BINARY:   ";
180 REM *********************
190 REM ***BINARY CONVERT***
200 REM *********************
210 FOR X=15 TO 0 STEP-1
220 Y=A-2↑X
230 IF Y<0  THEN A$(X)="0"
240 IF Y>=0 THEN A$(X)="1":A=A-2↑X
250 PRINT A$(X);
260 C=C+1:IF C=4 THEN PRINT" ";:C=0
270 NEXT
280 REM ******************
290 REM ***HEX CONVERT***
300 REM ******************
310 S$="    ":K=3
320 PRINT:PRINT:PRINT"HEX:      ";
330 FOR H=15 TO 0 STEP-1
340 G=VAL(A$(H))
350 IF G=1 THEN T=T+2↑K
360 K=K-1
370 IF K<0 THEN GOSUB 400:K=3:T=0
380 NEXT
390 PRINT:FOR L=0 TO 39:PRINT".";:NEXT:PRINT:GOTO130
400 ON T+1 GOTO 410,420,430,440,450,460,470,480,490,500,510,520,530,540,550,560
410 PRINT "0"+S$;:RETURN
420 PRINT "1"+S$;:RETURN
430 PRINT "2"+S$;:RETURN
440 PRINT "3"+S$;:RETURN
450 PRINT "4"+S$;:RETURN
460 PRINT "5"+S$;:RETURN
470 PRINT "6"+S$;:RETURN
480 PRINT "7"+S$;:RETURN
490 PRINT "8"+S$;:RETURN
500 PRINT "9"+S$;:RETURN
510 PRINT "A"+S$;:RETURN
520 PRINT "B"+S$;:RETURN
530 PRINT "C"+S$;:RETURN
540 PRINT "D"+S$;:RETURN
550 PRINT "E"+S$;:RETURN
560 PRINT "F"+S$;:RETURN
```

SHIFTED CAPITALS

When writing programs with a great deal of text, it is sometimes best to use the lower case character set. This makes for easier reading. The game Hammurabi is a good example.

To obtain the lower case mode on PET, location 59468 must be POKEd with 14 (12 returns it to graphics). Now lower case letters, plus some other graphics are available on the PET by typing the desired letter while depressing the 'shift' key. However when a lot of text is involved, constantly holding down the shift key can become rather awkward. A 'keyboard inverter' would certainly be desirable.

P.T. Spencer, a high school teacher in Agincourt, enquired about this possibility and then answered his own question with the following program which he has submitted for the Transactor.

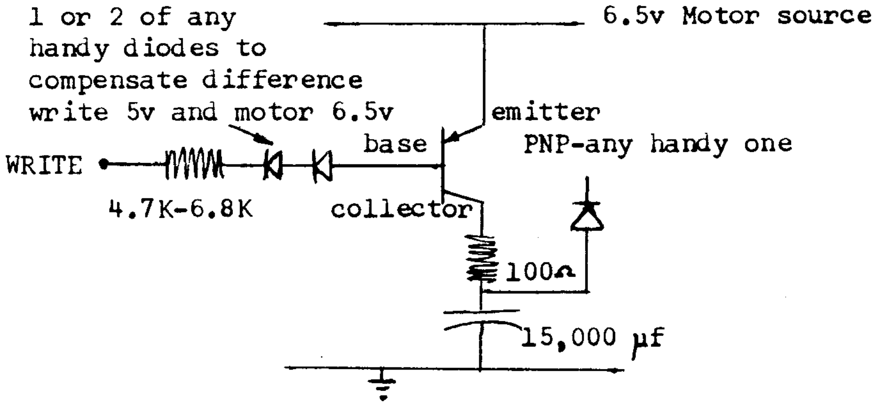
```
10000 REM**KEYBOARD INVERTER SUBROUTINE**
10010 POKE 59468,14
10020 Z$=""
10040 GET Y$:IF Y$="" THEN 10040
10050 Y=ASC(Y$):IF Y=13 THEN 10120
10060 IF Y>64 AND Y<91 THEN Y=Y+128:GOTO 10090
10070 IF Y>192 AND Y<219 THEN Y=Y-128:GOTO 10090
10080 GOTO 10100
10090 Y$=CHR$(Y)
10100 PRINT Y$;:Z$=Z$+Y$:GOTO 10040
10120 PRINT:RETURN
```

The program only affects the alphabetic characters and prints everything else out normally. Also, since the characters are being displayed under program control the lines won't be entered into memory, only displayed! To do this program execution would have to be halted and then line numbers followed by ?" inserted at the beginning of every second line of text. (Be careful not to type more than 75 characters per 2 lines or inserting is impossible. Also do not stop program execution less than 5 lines from the bottom or the "BREAK - READY" signal will cause text on the very top line to be scrolled off the screen.) Once this insertion is finished, hitting 'RETURN' enters the characters as program text. Only one pitfall is that these PRINT statements will return the text without the visual continuity (i.e. 'PRINT' starts at extreme left) unless the closing quotation marks are inserted and followed by semi-colons. Therefore it would be more desirable to enter the text into DATA statements and concatenate using the READ command. Instead you would insert the line numbers followed by DATA" or you could have the program do it for you using the following modifications:

```
10000 REM ***(DATA KEYBOARD INVERTOR**)
10010 POKE 59468,14
10020 Z$=""
10030 L=0:I=I+10:PRINT:PRINTI;"cl";"DATA";:PRINT CHR$(34);
10040 GET Y$:IF Y$="" THEN 10040
10050 Y=ASC(Y$):IF Y=13 THEN 10120
10060 IF Y>64 AND Y<91 THEN Y=Y+128:GOTO 10090
10070 IF Y>192 AND Y<219 THEN Y=Y-128:GOTO 10090
10080 GOTO 10100
10090 Y$=CHR$(Y)
10100 PRINT Y$;:Z$=Z$+Y$:L=L+1:IF L=70 THEN 10020
10110 GOTO 10040
10120 PRINT:STOP
```

Hardware Fix

In Transactor #8, a hardware fix was illustrated to overcome the data file write problem. However, to install it required dismantling the cassette deck so the interface idea was presented. This still had one problem area: the switch. Fortunately, I've received two responses regarding the 'INTERFACE'. The first was from Jim Yost in Somerville,MA. He writes..... "In reference to Bulletin #8: The capacitor charging switch you want is a simple transistor. The basic operational rule is that whatever current flows in the base allows β times that to flow into the collector. β's typically are 100 or more nowadays. The circuit is thus:



The write pulses (lows) charge the 15,000µF cap in pulses so that it is charged at the end of a write sequence when the motor source drops. Don't use the 15µF - it would short the write pulses".

Secondly, Andrew Chiu of Toronto has designed, among other things, an interface type fix for file writing to the cassette deck. This and other devices are for sale through Rapid Electronics. Andrew has submitted a complete description of the cassette deck interface and its operation which follows.

Thank you, Andrew and Jim, and once again..... thanks to Richard Leon for launching the concept.

Andrew Chiu
39 Farmview Cr.,
WILLOWDALE, Ontario
M2J 1G5

HARDWARE FIX ADAPTER

The object of this design is to adapt Richard Lean's Hardware Fix (ref: TRANSACTOR BULLETIN #8) without dismantling your cassette and using Karl's "Interface" idea we can install a circuit between a 6 pin Molex Plug and the printed circuit board edge connector (see Fig.6).

A quick look at the table provided by Karl J. in the Transactor Bulletin #8 (table 1) indicates that when the cassette is doing a write operation the write-line is 'active' and for other operations it is 'high', therefore based on this unique active state a simple switching circuit can be controlled.

TABLE 1

PIN on PCB Cardedge	OPERATION		
	NONE	READ	WRITE
READ	LOW	ACTIVE	ACTIVE
WRITE	HIGH	HIGH	ACTIVE
SENSE	HIGH	LOW	LOW
MOTOR	OPEN	6.5V	6.5V

HOW IT WORKS. Most PET lovers are the software type, in order to understand the theory behind this circuit, let us review some characteristics of the key element, a diode.

The ideal-diode approximation strips away all but the bones of diode operation. What does a diode do? It conducts well in the forward direction and poorly in the reverse direction. Boil this down to its essence, and this is what you get: ideally, a rectifier diode acts like a perfect conductor (zero voltage) when forward-biased and like a perfect insulator (zero current) when reverse-biased as shown in Fig.3.

In circuit terms, an ideal diode acts like an automatic switch. When conventional current tries to flow in the direction of the diode arrow, the switch is closed (see Fig.3b). If conventional current tries flowing the other way, the switch is open (Fig. 3c). We cannot simplify the idea of the diode beyond this point.

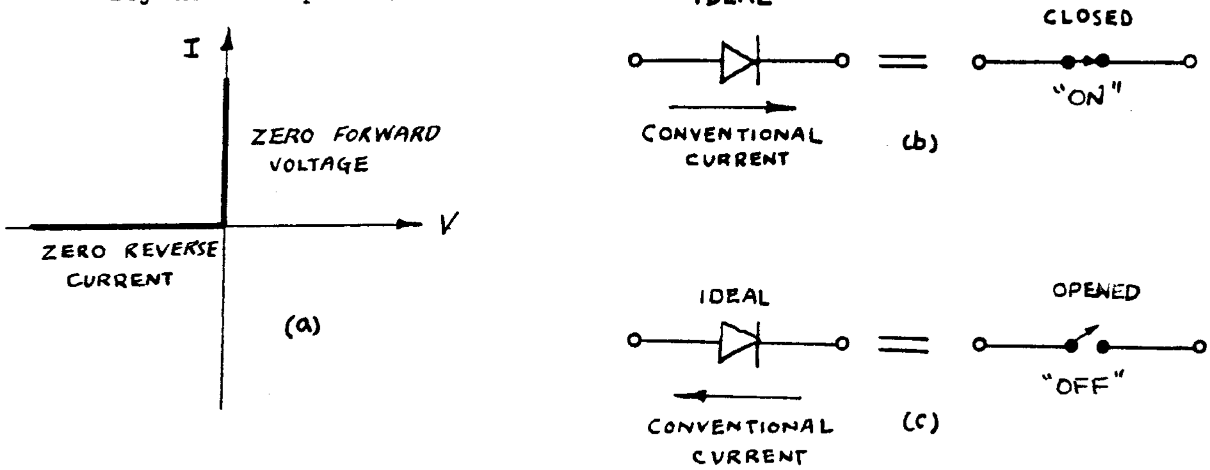


Fig 3. (a) Ideal-diode Curve. (b) Cloded-switch analogy.
(c) Open-switch analogy.

Once the operation of the diode is understood, then we can look at Fig.1. It is a complete diagram of the Hardware Fix Adapter. IC.1 is connected as a negative-recovery monostable circuit. As long as the write-line is active, the circuit stays triggered and the output remains High. (approximately equal supply voltage at no load). The current flows out from pin 3 and the capacitor C3 charges through the resistor R2 and diode D2. The capacitor is acting like a temporary quick charge battery. When the block is finished, the power to the motor is turned OFF and the write-line go High. The capacitor C3 will discharge through D3 to the cassette motor. The discharged energy provided power to the motor for a small period of time. This allows a larger gap between blocks.

Fig. 4 is a simplified circuit, only the diode and C3 is shown. The imaginary switches are the approximation of IC.1 and the transistor switch which is controlled by the internal operation of your PET. Fig. 4 a & b when the motor power switch is turned ON and write-line is active, D1 and D2 are both ON, but D3 is OFF. Therefore the current has to flow into the capacitor and the motor. Fig 4 c & d when motor power switch is OFF and write-line is High, D1 and D2 is Off, but D3 is ON. Therefore the current can discharge through D3 to the motor. The ideal diode model is a helpful tool to explain the operation of the circuit.

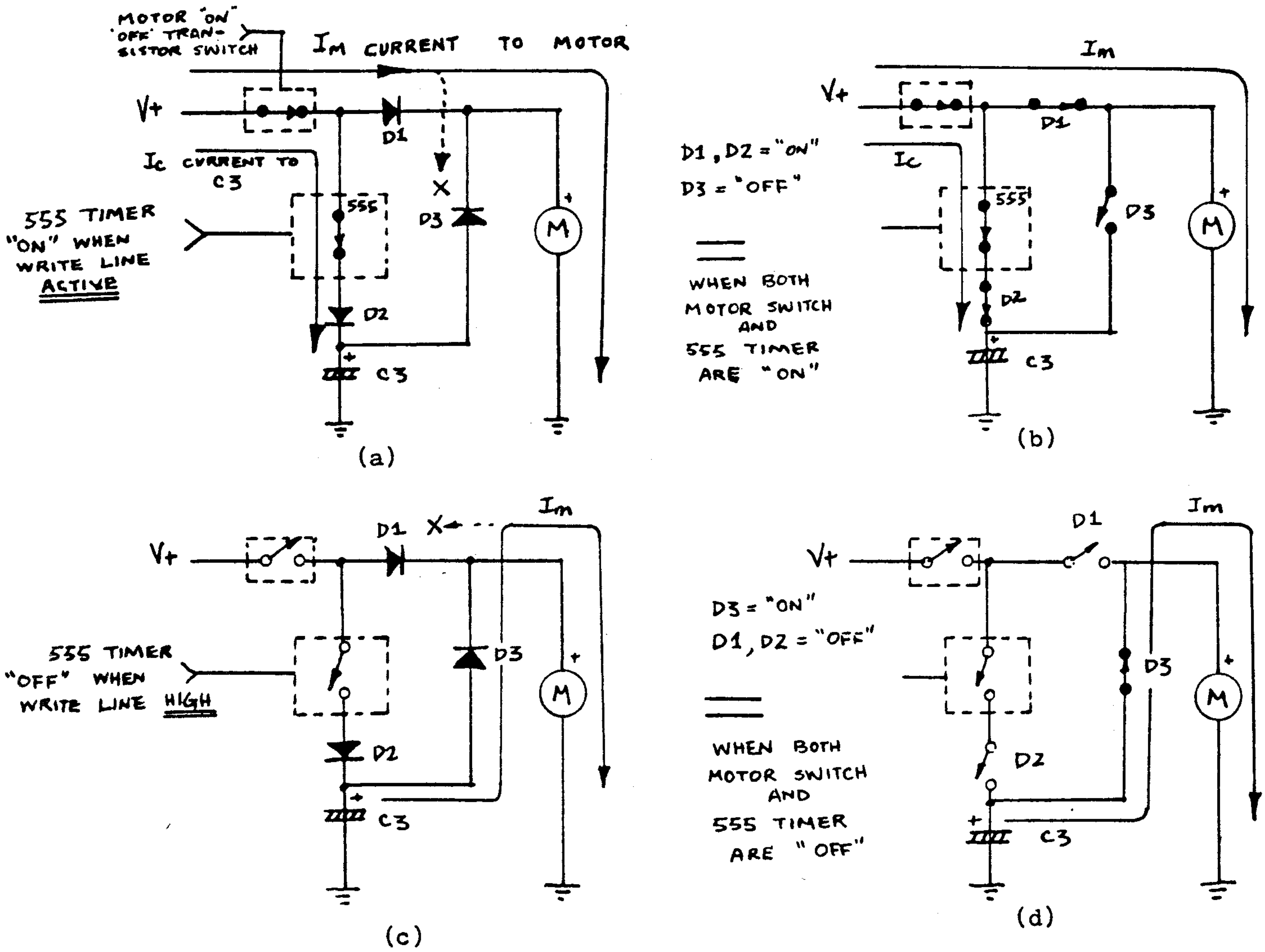


Fig. 4 Simplified circuit diagram of the Hardware Fix Adapter.

CONSTRUCTION. Wire-Wrap, point-to-point or printed-circuit techniques can be employed in the construction of the Adapter. However a printed-circut board definitely makes things easier once it has been made or obtained. I built my unit with all the components mounted on the board except the 20,000 uF capacitor. Watch the polarity of all the diodes and C3. The cathode (-Ve) end of the diode is marked with a Band or Bands. The polarity of the capacitor is marked on the label, some are colour coded. (red for positive). Transistor Q1 may be supplied in different shapes. To identify the transistor leads, please check the manufacturers data book. A component lay out diagram is shown in Fig. 2. Watch the spacing (0.156") of the card-edge connector. and the slot. The physical dimension must fit the 6 pin Molex Plug which the cassette uses.

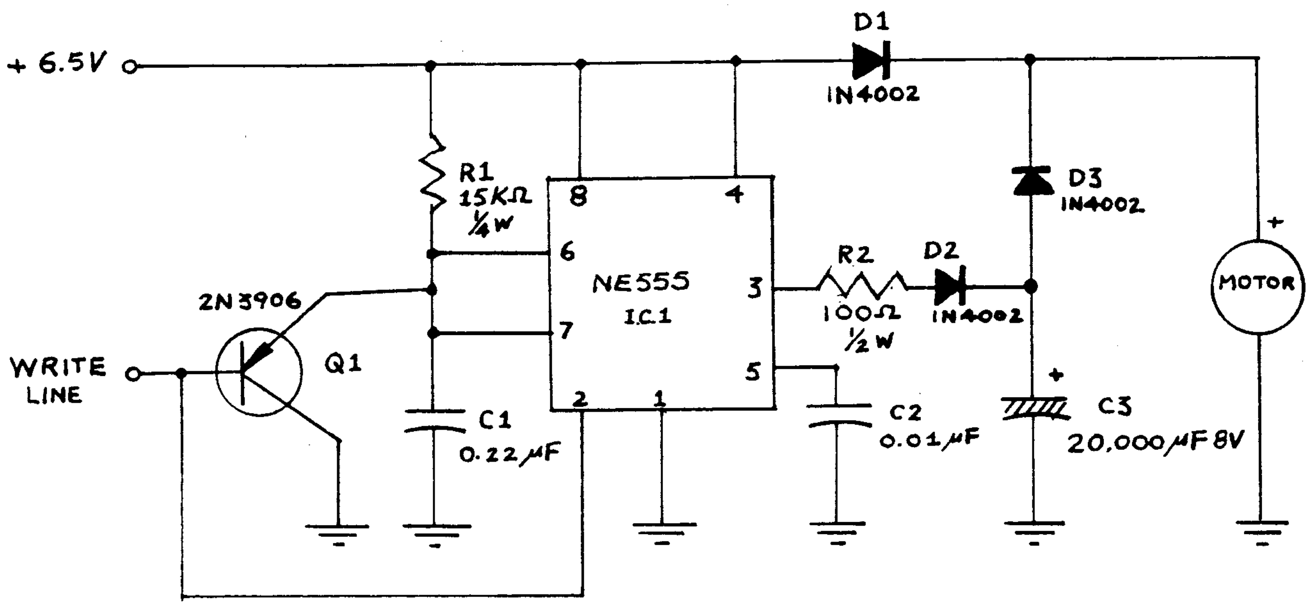


Fig 1. Circuit diagram of the Hardware Fix Adapter.

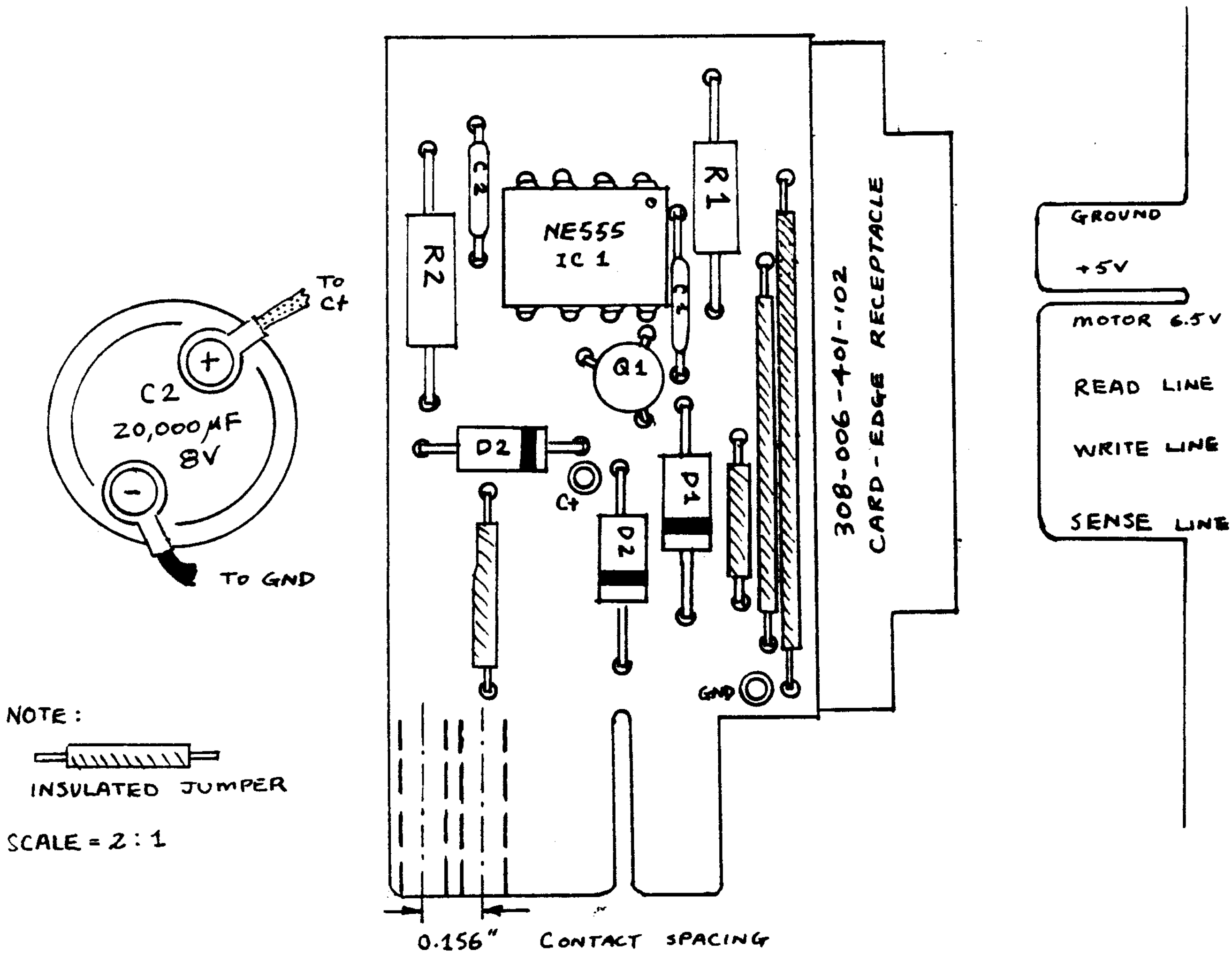


Fig 2. Parts placement, component-side view.

OPEN THE PET COMPUTER. (This is the procedure outlined in the service manual)

1. Press the rocker switch to the OFF position.
2. Remove the power cord from the wall socket to avoid possible electrical shock.
3. Remove the two screws located on each side of the unit under the lip of the cover.
4. Lift the cover slowly - a few inches. When you locate the cable leading to the cassette, remove the connector at the main board. Then left the cover all the way up and engage the supporting rod located on the left side of the cover.

INSTALLATION PROCEDURE OF THE ADAPTER. (see Fig. 5,6 & 7)

1. Plug the 6 pin Molex Plug to the Adapter's card-edge connector.
2. Plug the Adapter to the main board's card-edge connector.
3. The big 20,000 uF capacitor can be mount in front of the main board by locking cable ties and adhesive backed mounts.

FINAL TESTING. Murphy's law states that "If anything can go wrong, IT WILL". So please check the polarity of all the components again before you touch the power switch. One thing will damage your PET for sure is a short circuit between ground and +5V line or +6.5V motor control line. When you think everything is OK. Turn On your PET, and use a voltmeter to measure the voltage across C3, it should give you a very small reading (amost zero). If the voltage is right, type in the testing program. After you finished, SAVE the program, while your PET is saving the program, monitor the voltage across C3 again, it should rise slowly to approximately to 4.5V and stop there. When finished saving, the voltage will drop to zero again (0.6V). Next, put a new tape in the cassette and RUN the test program. The test program will check and print the number of drop out errors found - you should have none.

PARTS AVAILABILITY. Essential parts, including 6 pin card-edge receptacle (# K60013PCSCGD6), Universal PC Board and 20,000 uF are available from ARKON ELECTRONICS LTD., 91 Queen Street E., TORONTO, Ontario, M5C 1S1.
A assembled and tested unit for $26.00 is available from RAPID ELECTRONIC, P.O. Box 1031, Station 'B', WILLOWDALE, Ontario, M2K 2T6.

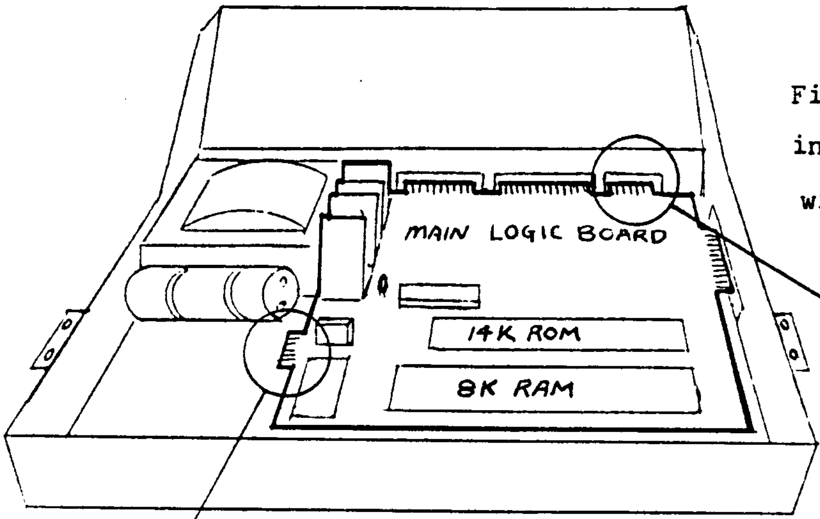


Fig 5. Simplified inside view of the PET with the cover removed.

Card-edge connector for cassette No.2 6 pin Molex Plug.

Card-edge connector for cassette No.1 6 pin Molex Plug.

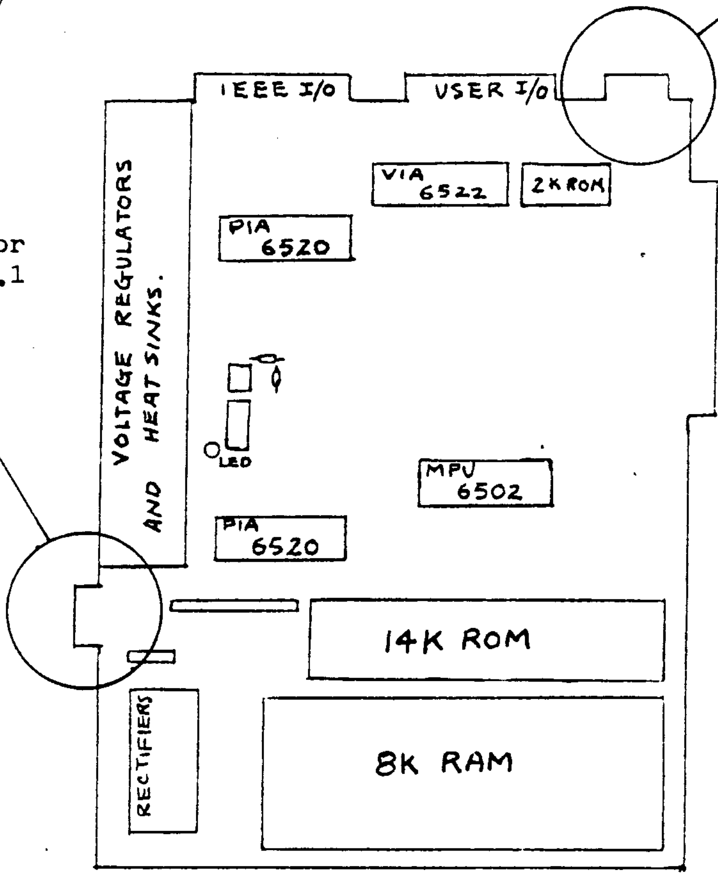
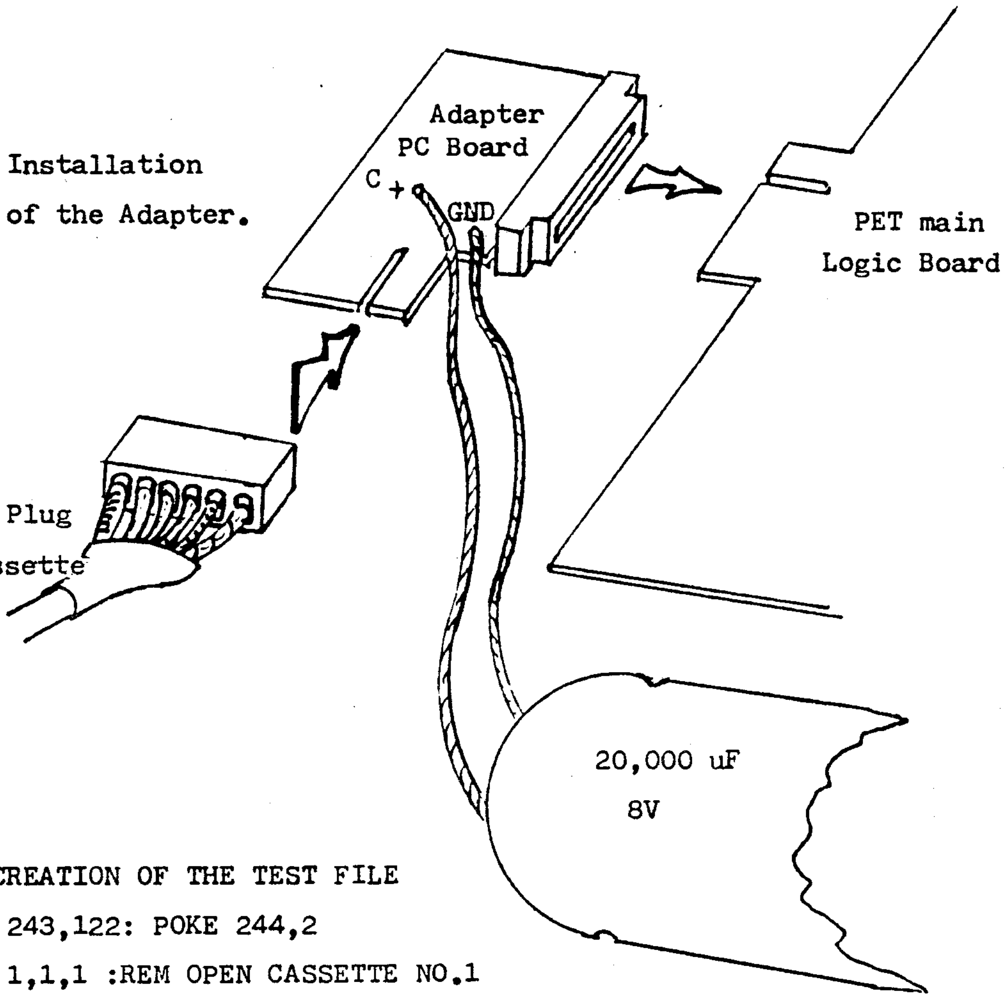


Fig 7. Simplified view of the main logic board.

Fig. 6 Installation of the Adapter.




```
1   REM CREATION OF THE TEST FILE
10  POKE 243,122: POKE 244,2
20  OPEN 1,1,1 :REM OPEN CASSETTE NO.1
30  FOR I=1 TO 300
40  PRINT I
50  PRINT#1, I
60  NEXT I
70  PRINT#1: CLOSE1
80  STOP
```

NOTE: For Cassette NO.2 the following lines have to be changed to :-

```
10 POKE 243,58:POKE 244,3
20 OPEN 1,2,1
105 OPEN 1,2
```

```
100 REM RECOVER AND TEST THE TEST FILE
105 OPEN 1
110 FOR I=1 TO 300
120 INPUT#1,A
130 IF (ST) AND 64 THEN GOTO 170
140 PRINT A;
150 IF A  B+1 THEN PRINT "ERROR": J=J+1
160 B=A: NEXT I
170 CLOSE 1: PRINT J;"ERRORS FOUND"
```

INTERUPTS ON THE COMMODORE PET

(c) 1979 Brad Templeton

One of the most important features of the COMMODORE PET operating system is the use of interrupts. They are used to reset the PET, and they handle most of the tape and all of the keyboard i/o. This article will provide an introduction to interrupts on the 6502 (The PET's cpu) and a description of how the PET handles them. For your information, pseudo source listing is provided for the interrupt software of the PET, as produced by my disassembler.

Under normal conditions, a processor executes machine code in a linear fashion. It moves through memory, obtaining instructions (which can be one, two or three bytes long) and executing them. Sometimes, certain programmed instructions cause jumps to other places, just like GOTO and GOSUB of basic. To make a machine more flexible, however, interrupts are provided to do jobs that would be very expensive to do in software.

Essentially, an interrupt is controlled by a line right into the processor. When the processor detects the correct voltage on this line, an interrupt may be generated. First, in order to simplify matters, the processor finishes the instruction it is presently carrying out. Then, if the interrupt is ok (interrupts can be masked), The processor saves the program location it was at, and the contents of its flags onto the stack. It then goes to a special reserved area of memory (in ROM on the PET) and pulls out two bytes indicating what location it should start executing from. It then goes there and executes machine code until the instruction RTI (Return from Interupt $40) is encountered. It then goes back to the stack and restores its flags, and loads the location it saved to the instruction counter. It then goes and executes the code after where it stopped as though nothing had occured. (If the interrupt program was correctly written)

On the 6502, three types of hardware interrupts can occur, as well as a fourth special type. The locations they branch to are kept in byte pairs called vectors at the end of memory. One of these interrupts, NMI or Non Maskable Interrupt, can not be used on the PET. Its vector, $FFFA-B, points to $CA60, which is the middle of a subroutine. The line for this is also fixed off by a resistor on the pc board. Later PETs may plan to include this.

The interupt called for power up is named RES. It branches to a routine which sets up basic and the operating system. It also, through what I consider to be one of the PET's worst design flaws, branches to the routine to destructively test how much memory is in the machine. At the very start, it also tests the condition of the diagnostic sense (MSB of $E810), and goes to the diagnostic routine if this is set. RES is fired by power up, or by grounding pin 27 on the bottom of your memory expansion bus. If you set it by touching that pin, it does not clear memory below $400, so programs there (the tape buffers) are safe. This is, unfortunately, a very small area. It vectors through $FFFC-D.

The general use hardware inte unt is the IRQ. IRQ vectors through $FFFE-F, as does BRK. This points to location $E66B in the PET. It is generated every 60th of a second by the tv hardware, and can also be generated from the memory expansion bus, on pin 28. It is also connected to the 6522 versatile interface adaptor. I will discuss the 60 per second interrupts here in detail. For information of generation by the 6522 (there is another whole article's worth of material in there) you can write MOS[1] for the manual on it. Interrupts can be generated from it at exactly timed intervals, and by certain i/o conditions on the user port and IEEE bus. The exactly timed intervals are used to send precise frequency signals to the tape. (In fact, the 6522 is the PET's tape interface!)

The 60 per second interupts do the following:

Scan the keyboard, checking for new keys and decoding them.

Increment the real time clock, and check for midnight

Flash the cursor if it is on. ($0224 = 0)

Test tape recorder status for stop-start

Copy a byte for the break key test.

Whatever else you want them to do.

When the IRQ occurs, the code at $E66B (see source) saves the processor register A, X and Y on the stack. It then checks, by loading back from the stack, the flags, to see if the BRK flag was set. The BRK, a software IRQ, vectors through the same place, but sets the BRK flag. This is handy to test what type of interrupt occured. It then does a jump indirect to one of two places in RAM ($219 or $21B) depending on the type of interrupt.

Normally, the RAM IRQ vector is set to $E685, which is the standard IRQ code. BRK has no default setting. The small piece of code you see after the JMP indirects is the return code, which restores the registers and does the RTI. The first thing INT_CODE does is the JSR INCR_CLOCK which increments the clock and copies the PIA register the break key test uses. When Steve Punter of Mississauga saw this with the disassembler, he devised an ingenious way to disable the BREAK key of the PET. By telling the PET to branch to $E688 instead of $E685 by means of a POKE 537, 136 statement, the PET bypasses the INCR_CLOCK subroutine, and does not test the break key. (Note INCR_CLOCK passes through a JMP vector table in high ROM at $FFEA) This has the side effect of turning off the real time clock. When this statement is not used the clock proceeds normally. After it is updated, it is compared with a three byte table that contains the value for midnight. If it is midnight on the clock, it is zeroed. The PET also keeps a secondary clock just after the main one. This is used for calibrating the real time clock. About every 6 seconds, this clock reaches a special limit, and when it does, it is zeroed, and the main clock is not incremented on this cycle. This is becuase the interrupt generator runs slightly faster than exactly 60 times per second. Even with this compensation, you may have noticed the clock is a few seconds off after several hours of PET operation. If they had used the 60 hz ac power line for the interupt, it would have been more accurate, but that would have caused problems for PETs sold abroad.

After doing the clock, it proceeds to flash the cursor, once every third of a second, if the location FLASHING ($224) is set to zero. (POKE 548,0 in a program turns the cursor on, but with some bugs - try it and see.) It does it with a very silly method that has no apparent purpose, instead of the standard method, a EOR $80. It then sets up two keyboard test locations.

In using your PET, you may have noticed that if the tape drive is stopped by the machine itself, that you can push stop and play and the motor will run again. This is handled by the section of code at $E6CD. After this comes the keyboard interpretation routines. The method of decoding the keyboard PIA has already been published in your

PET manual, and in PET user notes, so I will not dwell on it here. Once it has the matrix coordinate of the key, it waits for it to stabilize, to avoid bounce and repeating letters. (The TRS-80 does this poorly). It then converts the matrix number to an ascii character through the table at $E75C. (You can use this table in your programs, if you want to account for how long a key is held down - a great real time feature!) It then puts the key in the correct place in the keyboard buffer starting at $20F. Finally it goes back.

WHAT YOU CAN DO

Because the PET IRQ goes through RAM, it is one of the main links you have that can give you operating system control. You can insert your own programs before and after the interupt code to have your PET do two jobs at once, like handle i/o while running basic. I have used interupts to write programs to:

Interpret the PET keyboard and the full sized keyboard I attached to the PET like a regular keyboard.

Provide functions like repeat after a certain period of time and shift lock.

Turn the ! key to a statement number key, so that it would provide a line number 10 higher with every push.

Have upper case letter keys print out as full basic keywords.

Display whole pages of PET memory constantly on the screen.

Provide a non-destructive reset that works in special cases.

Much more is possible.

To use your own programs, you merely set them up in some convenient location (machine code only), preferably starting at location that ends in $85, such as $385 in the second tape buffer. Something located there can then be started with a POKE538,3 and stopped with POKE 538,230, rather than having to write a special machine language program that disables the interrupt with SEI, changes the locations, and enables the interrupt with CLI. You do not need to disable if you are only changing one byte of the location. Put some code there and follow it with a JMP $E685. This way it does your code and proceeds on to do its own. If you put in the following series:

EE 50 80 4C 85 E6

starting at $385 (901 base 10), and initiate it with POKE 538,3 you will see a byte on the screen constantly increasing in "value", once every 60th of a second. The PET will also be doing everything else as usual. The following code:

A2 00 BD 00 00 9D 50 80 E8 D0 F7 4C 85 E6

will dump a page of memory on the screen constantly. You can poke 905 with the page you wish to examine. Try 0,1,2,4,31,232. It starts with page 0. When scanning page 0, move the cursor and see what happens.

While doing this, you may have noticed that there is no flicker whatsoever on the screen despite the massive amount of writing to it being done. (Far faster than BASIC printing). This is because the interrupt is fired by the screen scan signal, and the screen is doing nothing shortly after the interrupt goes. This is also why the flashing cursor will never "snow" the screen. You can store almost half a screen without "snow" this way.

Sometimes it is important to put code in after the interrupt code of the PET. This can be done by manipulation of the stack, and is necessary for programs like the statement numberer or keyword printer I included in my list above. I have included some code you can put in to allow you to do this. >PROG means the high order byte of where your post interupt code starts and PROG is the low order byte. PCLO and PCHI are two locations for storing the correct pc you can use. The program works by altering the stack, so that the PET goes to your program when it RTIs. The second part of the program, which finishes your routine off (GOBACK) resets the stack and restores the proper program counter and machine registers. You should be able to have a lot of fun with it.

It should be noted that probably the only reason the IRQ vector is in RAM is that the PET does change it for tape i/o routines. There is a table of possible vectors starting at $FD28 in the rom, and the table ends with the standard vector $E685. If you ever change the high order byte of the IRQ RAM vector, you must reset it before tape i/o is done. If you don't, the PET will reset it anyway, but the tape i/o may not be done, and you may crash your PET.

Incidentally, the disassembler was written in the system language B (a very nice, much improved BCPL) here at the University of Waterloo where I go to school and work for the Mathematics Faculty Computing Facility. This article was also prepared and formatted on the same Honeywell 66/60. Many of the labels used in the disassembly were provided through the massive effort of examining the PETs ROMs done by Jim Butterfield of Toronto. My next article for the Transactor will be on programming interactive games for the PET.

① The 6522 Data Sheets (24 pgs.) and other MOS publications are available through dealers.

Here is the code for the interrupts on the PET

```
E66B  48          INTERUPT    PHA
E66C  8A                      TXA
E66D  48                      PHA
E66E  98                      TYA
E66F  48                      PHA
E670  BA                      TSX
E671  BD 04 01                LDA  $104,X
E674  29 10                   AND  #$10
E676  F0 03                   BEQ  $E67B
E678  6C 1B 02                JMP  [BRK_LOW]
E67B  6C 19 02                JMP  [IRQ_LOW]
E67E  68          RETURN_INT  PLA
E67F  A8                      TAY
E680  68                      PLA
E681  AA                      TAX
E682  68                      PLA
E683  40                      RTI


E684  60                      RTS


E685  20 EA FF    INT_CODE    JSR  INCR_CLOCK
E688  AD 24 02                LDA  FLASHING
E68B  D0 23                   BNE  $E6B0
E68D  CE 25 02                DEC  C_TIMER
E690  D0 1E                   BNE  $E6B0
E692  A9 14                   LDA  #$14
E694  8D 25 02                STA  C_TIMER
E697  A4 E2                   LDY  C_COLUMN
E699  4E 27 02                LSR  C_STATE
E69C  B1 E0                   LDA  (C_ROWADR),Y
E69E  B0 06                   BCS  $E6A6
E6A0  EE 27 02                INC  C_STATE
E6A3  8D 26 02                STA  CHAR_UND_C
E6A6  0A                      ASL
E6A7  B0 03                   BCS  $E6AC
E6A9  38                      SEC
E6AA  B0 01                   BCS  $E6AD
E6AC  18                      CLC
E6AD  6A                      ROR
E6AE  91 E0                   STA  (C_ROWADR),Y
E6B0  A2 FF                   LDX  #$FF
E6B2  8E 23 02                STX  KEY_IMAGE
E6B5  E8                      INX
E6B6  8E 04 02                STX  SHIFT_FL
E6B9  A2 50                   LDX  #$50
E6BB  AD 10 E8                LDA  PIA1
E6BE  29 F0                   AND  #$F0
```

```
E6C0  8D 10 E8     STA  PIA1
E6C3  A0 00        LDY  #$0
E6C5  AD 10 E8     LDA  PIA1
E6C8  0A           ASL
E6C9  0A           ASL
E6CA  0A           ASL
E6CB  10 07        BPL  $E6D4
E6CD  8C 07 02     STY  C1_STAT
E6D0  A9 3D        LDA  #$3D
E6D2  D0 07        BNE  $E6DB
E6D4  AD 07 02     LDA  C1_STAT
E6D7  D0 05        BNE  $E6DE
E6D9  A9 35        LDA  #$35
E6DB  8D 13 E8     STA  PIA1_B4
E6DE  90 0A        BCC  $E6EA
E6E0  8C 08 02     STY  C2_STAT
E6E3  AD 40 E8     LDA  PORT_B
E6E6  09 10        ORA  #$10
E6E8  D0 0A        BNE  $E6F4
E6EA  AD 08 02     LDA  C2_STAT
E6ED  D0 08        BNE  $E6F7
E6EF  AD 40 E8     LDA  PORT_B
E6F2  29 EF        AND  #$EF
E6F4  8D 40 E8     STA  PORT_B
E6F7  A0 08        LDY  #$8
E6F9  AD 12 E8     LDA  KB_ROWIN
E6FC  CD 12 E8     CMP  KB_ROWIN
E6FF  D0 F6        BNE  $E6F7
E701  4A           LSR
E702  B0 05        BCS  $E709
E704  48           PHA
E705  20 3F E7     JSR  DECODE_KBD
E708  68           PLA
E709  CA           DEX
E70A  F0 08        BEQ  $E714
E70C  88           DEY
E70D  D0 F2        BNE  $E701
E70F  EE 10 E8     INC  PIA1
E712  D0 E3        BNE  $E6F7
E714  AD 23 02     LDA  KEY_IMAGE
E717  CD 03 02     CMP  KEY_DOWN
E71A  F0 20        BEQ  $E73C
E71C  8D 03 02     STA  KEY_DOWN
E71F  AA           TAX
E720  30 1A        BMI  $E73C
E722  BD 5B E7     LDA  $E75B,X
E725  4E 04 02     LSR  SHIFT_FL
E728  90 02        BCC  $E72C
E72A  09 80        ORA  #$80
E72C  AE 0D 02     LDX  KEYCOUNT
E72F  9D 0F 02     STA  KEY_BUFF,X
E732  E8           INX
E733  E0 0A        CPX  #$A
E735  D0 02        BNE  $E739
```

```
E737  A2 00                  LDX  #$0
E739  8E 0D 02               STX  KEYCOUNT
E73C  4C 7E E6               JMP  RETURN_INT
E73F  BD 5B E7   DECODE_KBD  LDA  $E75B,X
E742  D0 07                  BNE  $E74B
E744  A9 01                  LDA  #$1
E746  8D 04 02               STA  SHIFT_FL
E749  D0 10                  BNE  $E75B
E74B  C9 FF                  CMP  #$FF
E74D  F0 0C                  BEQ  $E75B
E74F  C9 3C                  CMP  #$3C
E751  D0 05                  BNE  $E758
E753  2C 11 E8               BIT  PIA1 + 1
E756  30 03                  BMI  $E75B
E758  8E 23 02               STX  KEY_IMAGE
E75B  60                     RTS


F736  AD 05 02   UPDATE_CLK  LDA  CLOCK_2
F739  69 01                  ADC  #$1
F73B  8D 05 02               STA  CLOCK_2
F73E  90 03                  BCC  $F743
F740  EE 06 02               INC  CLOCK_2 + 1
F743  C9 6F                  CMP  #$6F
F745  D0 07                  BNE  $F74E
F747  AD 06 02               LDA  CLOCK_2 + 1
F74A  C9 02                  CMP  #$2
F74C  F0 26                  BEQ  $F774
F74E  EE 02 02               INC  M_CLOCK + 2
F751  D0 08                  BNE  $F75B
F753  EE 01 02               INC  M_CLOCK + 1
F756  D0 03                  BNE  $F75B
F758  EE 00 02               INC  M_CLOCK
F75B  A2 00                  LDX  #$0
F75D  BD 00 02               LDA  M_CLOCK,X
F760  DD 88 F7               CMP  $F788,X
F763  90 17                  BCC  $F77C
F765  E8                     INX
F766  E0 03                  CPX  #$3
F768  D0 F3                  BNE  $F75D
F76A  A9 00                  LDA  #$0
F76C  9D FF 01               STA  $1FF,X
F76F  CA                     DEX
F770  D0 FA                  BNE  $F76C
F772  F0 08                  BEQ  $F77C
F774  A9 00                  LDA  #$0
F776  8D 05 02               STA  CLOCK_2
F779  8D 06 02               STA  CLOCK_2 + 1
F77C  AD 12 E8               LDA  KB_ROWIN
F77F  CD 12 E8               CMP  KB_ROWIN
F782  D0 F8                  BNE  $F77C
F784  8D 09 02               STA  PIA_COPY
F787  60                     RTS
```

Here is the source for the post interrupt code program

```
START     LDA   $105,X          GET
          STA   PCLO            PROGRAM
          LDA   $106,X          COUNTER AND
          STA   PCHI            STORE IT
          LDA   PROG            PUT IN YOUR
          STA   $105,X          OWN CODE
          LDA   >PROG           LOCATION
          STA   $106,X
          JMP   $E685           DO NORMAL INTERUPT
          REM   THIS CODE GOES AFTER YOUR CODE, TO RETURN
GOBACK    LDA   PCHI            RESTORE
          PHA   OLD
          LDA   PCLO            LOCATION
          PHA
          TSX
          DEX                   RESET
          DEX                   STACK
          DEX
          DEX
          TXS
          JMP   $E65F           DO RTI
```

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Convert Upper to Lower Case

The following is a program that will convert all upper case text to lower case. However, keep in mind that any graphics above the alphabetic keys will now be unusable if they are to appear simultaneously with lower case letters.

```
59030 FOR T=1024 TO 8006-FRE(0):A=PEEK(T)
59031 ON Z GOTO 59034,59037
59032 IF A=153 OR A=178 THEN Z=1
59033 NEXT
59034 IF A=34 THEN Z=2:NEXT
59035 IF A=58 OR A=0 THEN Z=0
59036 NEXT
59037 IF A 64 AND A 91 THEN POKE T,A+128
59038 B=PEEK(T+1):IF B=34 OR B=0 THEN Z=0
59039 NEXT:END
```

When writing the program use no spaces. The program will convert strings and PRINT statements but will not affect DATA statements. Also, it may terminate with a '?NEXT WITHOUT FOR ERROR IN 59036' but that's OK.

Of course you need not use the same line numbers. They were chosen due to their unusualness. The program was then recorded using the UNLIST routine in Transactor #7. It can then be merged with other programs with a good chance of not interfering with other program lines.

....

To receive Transactor Volume 2 bulletins, please return this form with your cheque for $15.00 annually renewable, to CBM 3370 Pharmacy Avenue, Agincourt, Ontario, M1W 2K4. Volume 1 back issues will be available at 10 dollars for a limited time only (while supplies last).

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IDEAS & COMMENTS..

....

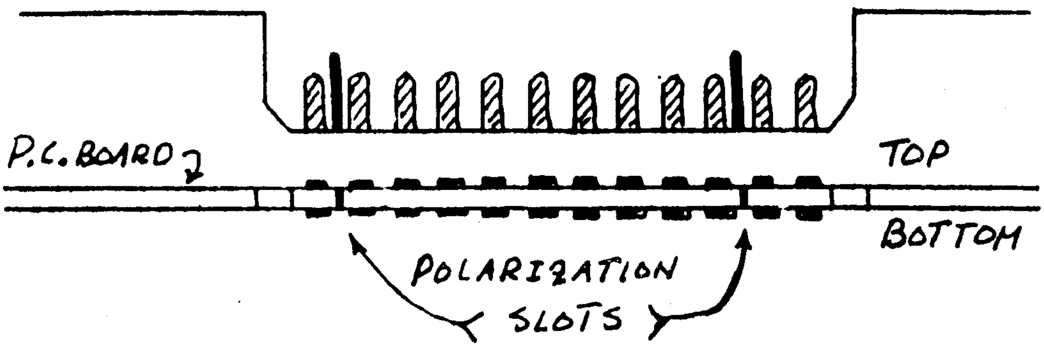
NOTES

This bulleting describes how to use your PET's user port and how to interface it to real devices.

The pin-out of the user port is shown below:

(Viewed from the top)

NAME	GND	CA1	PAØ	PA1	PA2	PA3	PA4	PA5	PA6	PA7	CB2	GND
PIN	A	B	C	D	E	F	H	J	K	L	M	N



The user port pins are on the bottom of the PET circuit board.

Page 22 of "An Introduction to Your New PET Personal Electronic Transactor" describes the manufacturer part # for several edge connectors which will fit the user port. If you cannot find a 12 position 24 contact connector, saw off a larger one to fit.

Note: Be sure that the upper and lower contacts in the connector are not electrically connected! Other signals reside on the top side which are not compatible with the user port.

The pin names correspond to the lines which connect to a MOS 6522 VIA, Versatile Interfree Adaptor.

The data sheet for this LSI chip is available from Commodore, 360 Euston Road, London NW1 3BL. (It is 24 pages long.) This bulletin is concerned with using the user port, and will not describe the 6522 in any more detail than is required.

Cont'd...

Pins CA1 and CB2 act as "handshake" lines. Pins PA0 through PA7 act as data lines Electronically, these lines can drive one TTL load. If your cable is more than 24" long, you may have to buffer the lines.

A series of memory locations in the PET act as control and data registers for the 6522. These are accessed via PEEK and POKE in BASIC, and by the 6502 machine language instructions which read and write to memory.

The memory locations of use to us are:

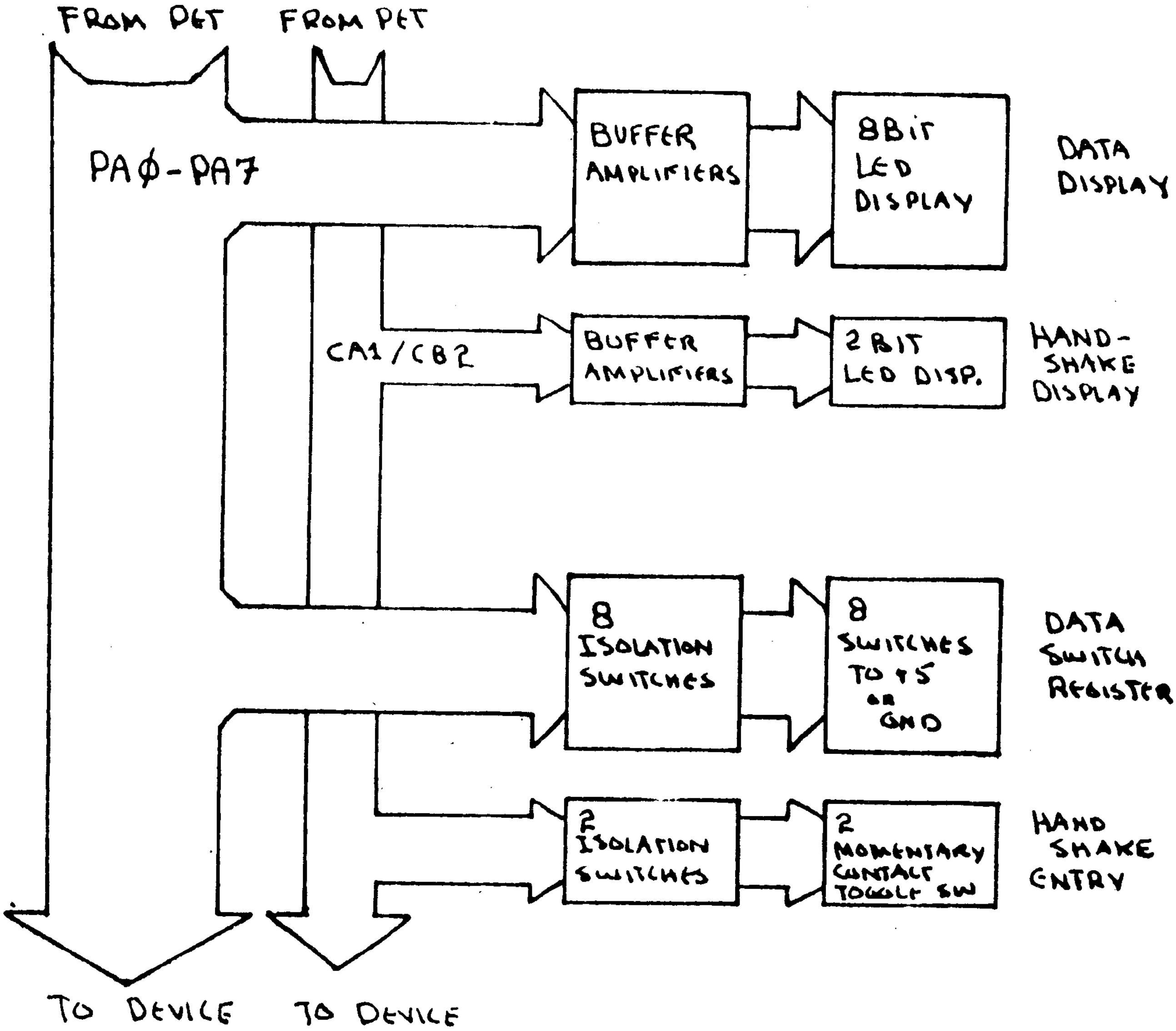
Name	Hexadecimal	Decimal
Data Direction Register	E843	59459
Data Register	E84F	59471
Data With Handshake	E841	59457
Peripheral Control Register	E84C	59468
Auxillary Control Register	E84B	59467
Interrupt Flag Register	E84D	[illegible]469

See the 6522 sepc. sheet for the exact definitions of these registers. The examples in this bulletin will cover most of your usual uses of the user port.

Cont'd...

THE "BLINKIN LIGHT" MACHINE

One way to get started with the user port is to build a device cabpable of showing the status of each line and to permit manual control of the lines Here is a block diagram of a display/switch panel:

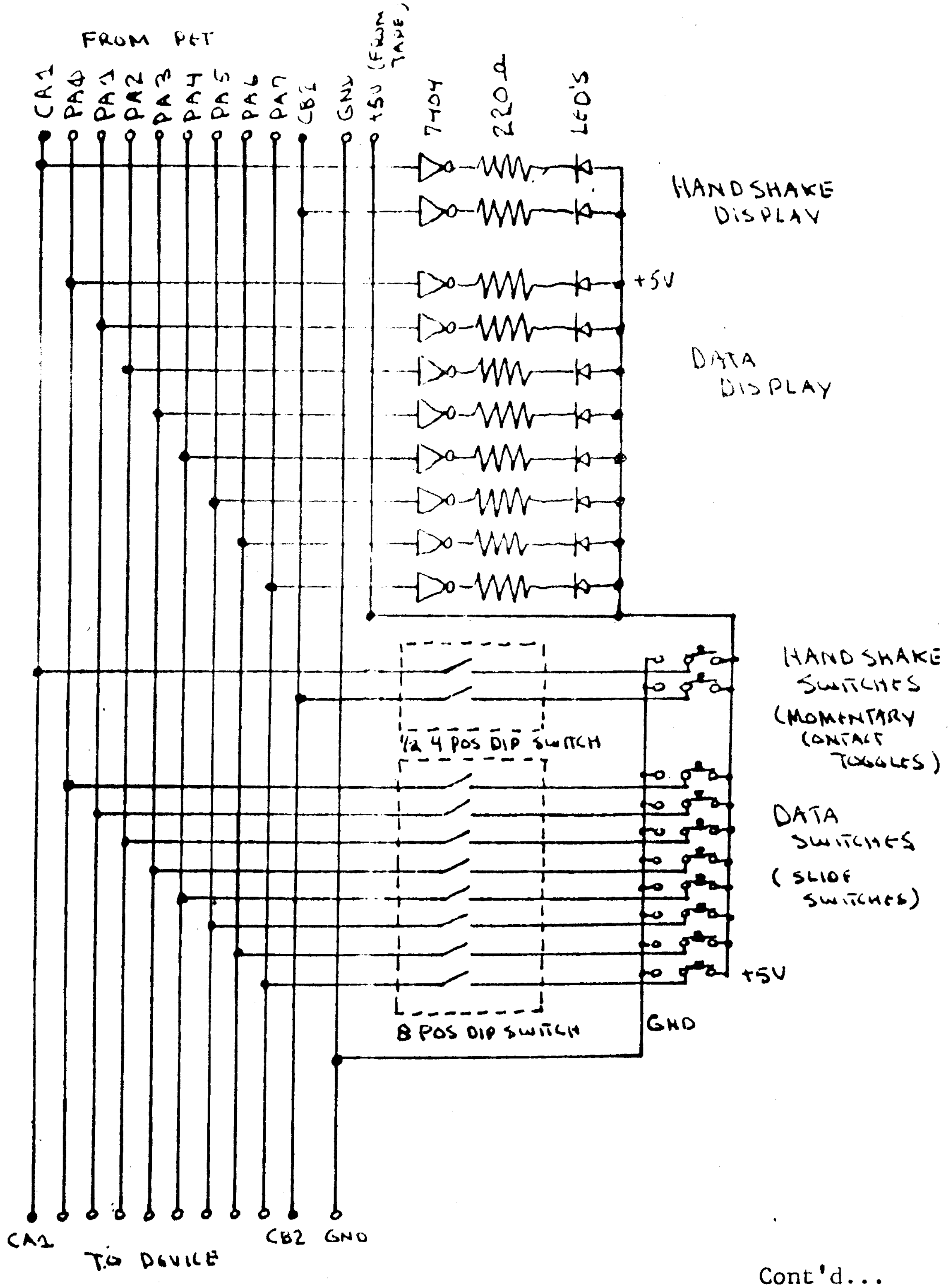


Some breadboard and about $20.00 of parts (at very retail prices) resulted in the following circuit. 7404 inverters serve as the buffer amplifiers, the +5 is taken from the cassette #2 supply, dip switches are used for isolation, slide switches for the register, and some toggle switches for the handshakes.

Note: This circuit draws ≈ 200MA which is close to the maximum available from the PET.

Cont'd...

Parallel User Port Indicator and Switch Register



Cont'd...

The following examples assume you have an equivalent device to attach to your user port. Be sure that (i) the device works correctly, and (ii) the connector is correctly pluged in. Sometimes the PET PCB has its pins offset slightly, making it possible to insert the connector so that one pin on the connector touches two on the PET, etc. The best solution is to use the polarizer slots.

1. Simple Output

Enter and run: (Be sure your isolation switches are all open)

```
10      REM SINPLE OUTPUT
20      REM DATA DIRECTION = ALL OUTPUT
30      POKE 59459,255
40      FOR J= 0 to 255
50      POKE 59471, J
60      POKE - 1 to 100 : NEXT K
70      NEXT J
80      GO TO 40
```

You should see your data LEDs count in binary from 00 to FF (0-255) with PAO, the LSB, blinking at about 3HZ.

Line 30 sets the data direction register to all '1', which sets all data lines for output. Each bit in the D.D.R. corresponds to a given PAO-7 line. The PA line is:

Input if bit is zero
Output if bit is one

To see the effect of this, change line 30 to:

```
30 POKE 59459,15
```

Now, only the 4LSB (PAO-PA3) will blink. Lines PA4-PA7 will be lit with no change. (Note: The TTL input of the 7404 will force the input lines high. Therefore the 4 MSB will indicate A '1' state If your display circuit is different the state of the MSB might be zero. In any case, they won't change.)

Try other masks to see other patterns.

Cont'd...

Line 50 POKES the data register with J (0-255) inside the For-Next loop in lines 40-70.

Line 60 is a delay. Try removing it and you will notice that the PAO line will blink too fast for you to see. (Vut PAl will flicker).

Line 80 starts the counting loop over again.

You can write other programs to make moving patterns, etc.

II. Simple Input

Enter and run:

```
10      REM SIMPLE INPUT                    [V] Clear/home
20      REM D.D.R. = INPUT                  [S] Home
30      POKE 59459, 0                       [l] Cursor left
40      PRINT "[V]";
50      PRINT "[S]" PEEK (59471) "[l]";
60      GO TO 50
```

Connect your data switch register by closing the 8 data isolation switches When these switches are closed, the switch register forces PAO-PA7 to the value selected by the switches.

A number will appear in the upper left corner of your PET's screen. Set your switches to all zero, and then set bit 0 to 1. A '1' will now appear on the PET, and on your date display.

Try one switch at a time to get: 1-2-4-8-16-32-64-128 and then try other combinations.

Notice that if you open an isolation switch for a given bit, it will become a '1' due to the 7404's.

Line 30 sets the D.D.R. to all zeros, naming PAO-PA7 inputs.
Line 40 clears the screen.
Line 50 homes the cursor
prints the data register's value
prints the CURSOR LEFT and 3 blanks.
Line 60 loops back to line 50.

<u>Note</u>: The CURSOR LEFT is required because numbers are printed on the PET in the form:

```
           123.45
      |_| |______| |_|
       ↑            ↑
     BLANK  DIGITS  CURSOR
     OR "-"         RIGHT
```

Cont'd...

This 'trick' removes left over digits from the previous number - suppose you had set bits 7 and 3 (giving 136) and then you reset bit 7 (leaving 8). If you don't remove the characters, you will see 836!!

III. The Handshake Lines

The 6522 provides several options for the CA1 and CB2 lines. See the 6522 specification for full details.

Note: Several of the addresses mentioned below control other aspects of the 6522. If you can bits other than those mentioned, you may have an inoperable PET, as your PET uses the 6522 for internal uses as well. (The 6522 has CA2, CB1, PB0-7 lines which the PET uses for other I/O functions than the user port.) You are warned! (I wasn't able to SAVE a program until I had reset two of the registers which had been POKEd erroneously!!)

For our purposes, these registers control the CA1 and CB2 lines:

Data Register	DATA
Data with Handshake	HDATA
Peripheral Control Register	PCREG
Auxillary Control Register	AUXKEY
Interrupt Flag Register	IFREG

The acronymns in the right column above will be used from here.

CA1 CA1 is an input only line which can detect a "Data Ready" transition. When it does so, bit 1 of the interrupt flag register is set. *(Our convention is MSB is bit 7, LSB is bit 0)*

When the HDATA Register is read or written, the bit in the IFREG will be reset. Accessing the data register has no effect on the IFREG.

Detecting the flag bit is done by:

```
IF PEEK (59469) AND 2 THEN (Line #)   or:
WAIT 59469, 2
```

Cont'd...

Bit 0 in the PCREG controls whether CA1 sets the flag in the IFREG. If this bit is zero, a negative transition sets the flag bit. It it is one, a positive transition will be detected

Negative Transition

POKE 59468, PEEK (59468) AND 254

Positive Transition

POKE 59468, PEEK (59468) OR 1

Use the expressions above to choose the transition you want.

The flag bit will remain set until the HDATA register is read or written. Bit 0 of the AUXKEY controls whether the data is latched when the flag bit is set.

AUXKEY	Bit 0	0 = No latching The value of the DATA and HDATA registers follow the PA0-PA7 lines (those set for Input) regardless of th: the CA1 flag bit in the IFREG.
	Bit 0	1 = Latching. When the CA1 flag bit is set, DATA and HDATA will be latched. Their value remains the same, even though PA 0-PA7 may change.

CB2 Using CB2 is more complex than CA1. The 6522 specification should be consulted for the more exotic ways of using CB2.

CB2 can be used as:

A. Handshake output
B. Handshake input
C. Shift register I/O.

Bits 2, 3, and 4 of the AUXREG control whether handshake or shift register mode is to be used. If the bits are all zero, CB2 is in handshake mode. If any bit is not zero, CB2 is in a shift register mode.

Cont'd...

HANDSHAKE MODES

Output Mode

First you must set the AUXREG to disable the shift register. This is done with POKE 59467, PEEK (59467) AND 227.

Then you can force CB2 low with POKE 59468, PEEK ((59468) AND 31) OR 192 and you can force CB2 high with:

POKE 59468, PEEK (59468) OR 224.

Here is an example program which blinks CB2 at about 1 HZ:

```
10 REM     CB2 BLINKER
20 POKE    59467, PEEK (59467) AND 227
30 POKE    59468, PEEK (59468) AND 31 OR 192
40 FOR J= 1 TO 300:  NEXTJ
70 GO TO 30
```

Input Mode

Note: This section has not worked in practice. Toggling CB2 does not set the flag bit.

CB2 will set bit 3 in the IFREG if a transition occurs and the PCREG is set correctly.

First, set the AUXREG bits 2, 3 and 4 to zero,

POKE 59467, PEEK (59467) AND 227

If detection of a negative transition is wanted,

POKE 59468, PEEK (59468) AND 31

If a positive transition is wanted,

POKE 59468, PEEK (59468) AND 31 OR 64

Then, to detect a transition, check bit 3 of IFREG:

IF PEEK (59469) AND 16 THEN (line #)

or, WAIT 59469, 16

Cont'd...

To reset the flag bit, the B port register must be read.

X = PEEK (59456)

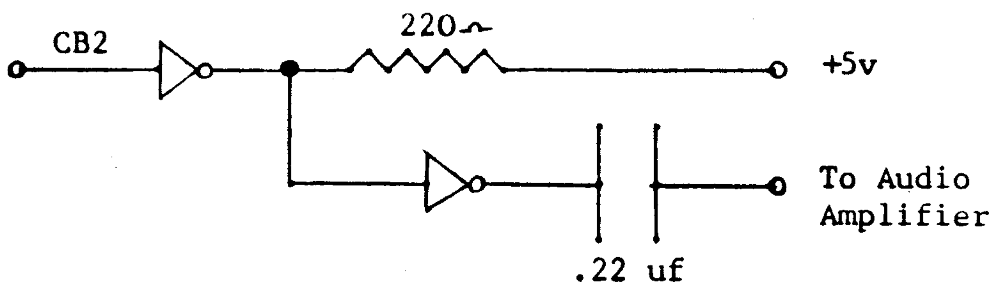
((Don't POKE this address!!))

SHIFT REGISTER MODES

If bits 2, 3 and 4 in the AUXREG are not zero, CB2 acts as a shift register. Set the 6522 specification for details.

Only one of these MODES can be conveniently handled in BASIC. The others require machine code to operate correctly.

The "Blinken Lites" can be given an audio capability with the following change:



Just add an extra inverter (two remain for use) and a capacitator to the CB2 Led driver's output.

Note: It is advisable to add an electrolytic capacitator, say 100 mfd to the Blinken Lite so that a sudden drain of power won't reset the PET.

Check the audio extension by toggling the CB2 line in output handshake mode:

```
10      POKE 59467, PEEK (59467) AND 227
20      A = 59468:X = PEEK (A) AND 131 OR 192
30      Y = PEEK (A) OR 224
50      POKE A, X: POKE A, Y: GO TO 50
```

LINE 10 sets up AUXREG to disable shift registers, LINE 50 turns CB2 on and off.

Cont'd...

The reason for making the variables A, X and Y is because BASIC references variables much faster than converting constants. This maximizes BASIC's speed.

The PET keyboard can change the tones by using these changes:

```
40 Z=515
50 POKE A, X: FOR J=1 TO PEEK (Z): NEXT: POKE A,Y:GOTO 50
```

Pressing different keys will give different rates of clicking. You now have a low fidelity sound-maker.

FREE RUNNING MODE

When AUXREG bits 4-2 are "100", the shift register cyclically outputs its contents on CB2 at a rate determined by the Timer 2. The addresses are:

SHIFT REGISTER:	59466
TIME 2	59464

Time 2 decrements to zero and then shifs the shift register once. Timer 2 is reloaded and this goes on. The output bit of the shift register is put in bit 7, causing the register to "rotate right".

Here is a simple "Music Maker" program:

```
 10    REM MUSIC MAKER
 20    POKE 59467, PEEK (59467) AND 227 OR 16
 30    PRINT "TONE COLOR";
 40    INPUT TC
 50    IF TC < 1 OR TC > 254 THEN 30
 60    POKE 59466, TC
 70    PRINT "PRESS KEYS FOR TONES"
 80    GET A $:  IF A $ = " " THEN 80
 90    POKE 59464, ASC (A $)
100    GO TO 80
```

It is straightforward to use the letters to make a true "keyboard" - choose notes for each key and make a table which is indexed by the ASCII value of the key. This is left as an exercise. (With only 256 possible frequencies, the options are somewhat limited.)

Cont'd...

IV. Some Interfacing examples

The following program lets you monitor the user part and modify any registers you wish as required. Be sure to save it on tape BEFORE running it. (Also, be sure you have not run any other programs first, i.e. turn the power on/off to initialise properly!!)

Once you have it saved, RUN it. Its operation is quite simple. The registers are named according to the 6522 specification with one exception, "DATA" is ORA without handshake. Use the "Blinken Lights" and this program to see how all parts except the shift register works.

```
10     REM PET 6522 VIEWING PROGRAM
20     REM BY:  GREGORY YOB, COMMODORE
30     REM
40     REM SET UP R $ = REGISTER NAMES,
50     REM A () = REGISTER ADDRESSES,
60     REM F () = SHOW REGISTER IF   0
70     DATA "ORB", "ORA", "DDRB", "DDRA"
80     DATA "TILC-L", "TIC-H", "T1L-L", "T1L-11"
90     DATA "T2LC-L", "T2C-11", "SR", "ACR"
100    DATA "PCR", "IFR", "IER", "DATA"
110    REM 'DATA' IS ORA WITHOUT HANDSHAKE
120    DIM R $ (16), F (16), A (16)

200    A=59456:  FOR J =1 TO 16
210    READ A $:  R $ (J) = LEFT $ (A $ + "eight blanks",
       E) + ":"
220    A(J) = A:  A=A+1
230    NEXT J
240    F(4) = 1:  F (12) = 1: F (13) = 1: F(14) = 1:
       F(16) = 1

300    REM SET UP DISPLAY
310    PRINT "[V]   7   6   5   4   3   2   1   0"
320    PRINT "[Q] [Q] [Q] [Q] [Q] [Q] [Q] [Q] [Q] [Q] [Q] [Q] [Q]";
330    PRINT "D = DATA P = POKE S = SHOW"
340    PRINT "II = HELP Q = QUIT"
```

[V] = Clear/Home
[Q] = Cursor Down
[S] = Home
[]] = Cursor Left

Cont'd...

```
400     REM DISPLAY Y LOOP
410     PRINT ' S Q Q ';
420     FOR J = 1 TO 16
430     IF F(J) = Ø THEN 450
440     Z = PEEK (A(J)):  PRINT R $ (J);:  COSUR 1000
450     NEXT J
460     REM IF NO INPUT DO LOOP AGAIN   [●] = Cursor up
470     GET A $ : IF A $ =  " " THEN 410

500     REM DO COMMANDS
510     IF A $ = "D" THEN GOSUB 2000
520     IF A $ = "P" THEN GOSUB 2500
530     IF A $ = "S" THEN GOSUB 3500
540     IF A    "H" THEN GOSUB 3000
550     IF A $ - "Q" THEN END

700     CO TO 310

1000    REM BINARY DISPLAY
1010    Z1 = 128
1020    FOR Z2 = 1 TO 8
1030    PRINT SGN (Z AND E1);
1040    IF Z2 = 4 THEN PRINT " ";
1050    Z1 = Z1/2:  NEXT Z2:  PRINT:  RETURN

2000    REM DISPLAY HANDSHAKE REGISTER
2010    Z = PEEK (59457): PRINT '[Q]' R $ (2);: GOSUB 1000
2020    PRINT "[Q]";:  GOSUB 4990:  RETURN

2500    PRINT "[v]  POKE REGISTER [S][Q][Q]"
2510    GOSUB 4000
2520    GOSUB 4500
2530    POKE A (Z), B
2540    RETURN

3000    PRINT "[v]    6522 REGISTER DISPLAY AND CHANGE [Q][Q]
3010    PRINT "THIS SHOWS THE VALUES FOR THE PET'S
3020    PRINT "VIA REGISTERS.   YOU CAN LOOK AT ALL OF
3030    PRINT "THEM.   THOSE USED FOR THE USER
3040    PRINT "PORT ARE SHOWN WHEN THE PROGRAM
3050    PRINT "STARTS. [Q][ ][;][ ] THE DISPLAY IS REFRESHED
        ABOUT ONCE
3060    PRINT "PER SECOND.   PRESS A KEY TO DO A COMMAND
3070    PRINT "[Q]  D = DATA  READS ORA WITH HANDSHAKE
```

Cont'd...

```
3080    PRINT "    P = POKE   LETS YOU POKE A REGISTER
3090    PRINT "    S = SHOW   SELECTS REGISTERS TO DISPLAY
3100    PRINT "    Q = QUIT   STOP PROGRAM
3300    PRINT "[ ][Q]";: GOSUB 4990:  RETURN
3500    REM CHANGE DISPLAYED REGISTERS
3510    PRINT "[v]" SHOW REGISTERS [Q][Q][Q]
3520    GOSUB 4000
3530    PRINT "S = SHOW, E = ERASE, X = FINSISH";:
        GOSUB 5000
3540    IF A $ = "S" THEN F (Z) = 1
3550    IF A $ = "E" THEN F (Z) = 0
3560    IF A $ = "X" THEN RETURN
3570    PRINT "[S][Q][Q][Q][Q]";
3580    GO TO 3520

4000    REM GET REGISTER NAME, RETURN Z = INDEX
4010    PRINT "QQ REGISTER NAME:[ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]";: INPUT AS
4020    RESTORE:  FOR Z = 1 TO 16: READ B S
4030    IF B$ = A$ THEN RETURN
4040    NEXT Z:  PRINT "[Q][Q][Q]THE REGISTERS ARE CALLED:
4050    FOR J = 1 TO 16:  PRINT LEFT $ (R$ (J), 6)"   ";:
        NEXT J
4060    PRINT " [● ● ● ● ● ● ● ● ● ● ● ]";:  GO TO 4010
4500    REM GET BINARY NUMBER
4510    PRINT "BINARY VALUE: " ;: INPUT A$: Z1 = 128:
        B = Ø
4520    IF LEN (A$) < 8 THEN PRINT " ● "; GO TO 4510
4530    FOR J = 1 TO 8
4540    IF MID $ (A$, J, 1) = "1" THEN B = B OR Z1
4550    Z1 = Z1/2:  NEXT J
4560    RETURN

5000    GET A$:  PRINT "[&][ ][ ]";:  FOR K = 1 TO 20: NEXT K
5010    PRINT "[ ][ ]"; FOR K = 1 TO 20:  NEXT K
5020    IF A $ = " " THEN 5000
5030    RETURN
```

<u>EXAMPLE 1</u> An Encoded ASCII Keyboard.

A surplus encoded ASCII keyboard was found with the following pinout:

		<u>Keyboard</u>	<u>Wired to PET'S</u>
Pin	1	INT KEY 1	
	2	RPT KEY	
	3	—— (NO CORRECTION)	CB2
	4	——	

Cont'd...

Keyboard		Wired to PET'S
5	GND	GND
6	+5v	(SEPARATE +5 SUPPLY)
7	STROBE	CA1
8	PARITY	PA7
9	B4	PA3
10	B3	PA2
11	B1	PAØ
12	B7	PAG
13	B2	PA1
14	B6	PA5
15	B5	PA9

First, the keyboard was connected to the "Blinken Lights" to check what it did, The "Blinken Lights" power was provided by the supply for the keyboard.

Watching the LEDS for PAØ-7 and CA1 it was found that: (1) the correct ASCII code with parity appeared, and (2) the CA1 went high when a key was depressed.

The CA1 LED flickered when roll-over was tried (press one key, press 2nd key, release first key), showing that the keyboard had this feature.

Next, the keyboard was attached to the PET and the following program entered:

```
10        PRINT "[S]" PEEK (59471) and 127 "[][]    ";
20        GO TO 10
```

The ASCII values now appear in decimal on the PET's screen.

Now to us the CA1 input, and write characters on the screen, we have to:

1. Enable latching
2. Set CA1 to positive transition
3. Wait for CA1 FLAC bit
4. Get the data and print it as a character
5. Go to 3.

In Basic:

```
10        REM PRINT ON SCREEN FROM USER PORT
20        PRINT "[v]";
30        POKE 59468, PEEK (59468) OR 1:  REM PCR +
```

Cont'd...

```
40      POKE 59467, PEEK (59467) OR 1:  REM ACR LATCH
50      IF PEEK (59469) AND 2 THEN 70
60      GO TO 50
70      PRINTS CHR$ (PEEK (59457) AND 127);
80      GO TO 50
```

Of course (!!) you must enter your characters in UPPER case - so press SHIFT if you have a FULL ASCII keyboard.

Note: When I was doing this, I would plug the unit in and nothing would happen!! Using the Blinken Lights, I saw the keyboard worked just fine. The actual problem? Be sure your socket is CORRECTLY inserted and is LINED UP with the pins!

DIGRESSION

How to represent the PET character set using ASCII. A study of PET & ASCII reveals that the PET recognizes 138 symbols and functions while ASCII recognizes 128 combinations.

Here is a solution to this problem.

1. ASCII Characters 0 - 31 are ignored except for these: (all values are in decimal)

1	A → RVS ON		17 → Q	DELETE
2	B → RVS OFF		18 → R	INST
3	C → HOME		13 →	RETURN
4	D → HOME/CLR			
5	E → CRSR DOWN			
6	F → CRSR UP			
7	G → CRSR RIGHT			
8	H → CRSR LEFT			

27 (ESCAPE) Puts the conversion into "Graphics Mode"
10 (LINE FEED) Puts the conversion into "Normal Mode"

2. Normal Mode

Characters Ø - 31 Are the same
Characters 32 - 93 Are Unchanged
Characters 96 - 127 Are changed to 64 - 95 (Convert to Upper Case)

3. Graphics Mode

Characters Ø - 31 Are the Same
Characters 32 - 95 Are Changed to 160 - 223
Characters 96 127 Are Changed to 192 - 223

Cont'd...

This subroutine fetches an ASCII character and converts it to a PET character by the above rules. It is assumed that the initialization is performed and the mode flag, MF, is not changed.

```
1000    REM - INITIALIZE ROUTINE
1010    DATA Ø, 10, 146, 19, 147, 17, 145, 29, 157,
        Ø, Ø, Ø, Ø, 13, Ø, Ø, Ø, 20, 148
1020    DIM TT (31): FOR J = Ø TO 18: READ TT (J):
        NEXT J
1030    MF = Ø
1040    POKE 59468, PEEK (59468) OR 1
1050    POKE 59467, PEEK (59467) OR 1: RETURN

2000    REM - CONVERSION ROUTINE, RETURNS A$
2010    IF (PEEK (59469) AND 2) = Ø THEN 2010
2020    CH = PEEK (59457) AND 127
2030    IF CH > 31 THEN 2100
2040    REM CTRL CHAR
2050    IF CH = 10 THEN MF = Ø
2060    IF CH = 27 THEN MF = 1
2070    IF TT (CH) = O THEN 2010
2080    A $ = CHR$ (TT(CH)): RETURN
2090    REM CASE CONVERT
2100    IF CH > 95 THEN CH = CH-32
2110    REM MODE CONVERT
2120    CH = CH + MF * 128
2130    A $ = CHR$ (CH): RETURN
```

Try it out and see!! Look at your PET keyboard if you are confused.

Note: Don't forget the parenthesis in line 2020

EXAMPLE 2 The Writehander

The Writehander TM is a one-handed keyboard described in INTERFACE AGE, January 1978, and is manufactured by the NEWO Company, 246 Walter Hays Drive, Palo Alto, California 94303. We interfaced it to the PET to try it out...

Cont'd...

The Writehander has a 16 line rainbow ribbon cable with this pinout:

WRITEHANDER Line	Color	What	PET
1	Brown	Bit 1	PAØ
2	Red	+7-+23v Power	
3	Orange	Bit 2	PA1
4	Yellow	GMD	GND
5	Green	Bit 3	PA2
6	Blue	+5v	+5 (Separate)
7	Violet	Bit 4	PA3
8	Gray		
9	White	Bit 5	PA4
10	Black		
11	Brown	Bit 6	PA5
12	Red		
13	Orange	Bit 7	PA6
14	Yellow	Strobe	CA1
15	Green	Bit 8	PA7
16	Blue	ACK	CB2

These were wired to the PET as indicated, with the ground and +5V connected to a separate power supply.

The Writehander was wired with these options:

1 Strobe goes active low + to -

2 Acknowledge is a tive low + to -

3 Parity fixed at low (Ø)

This means the following sequence is required:

1 POKE DDR TO ALL INPUT
2 CA1 TO HI-LD TRANSITION
3 DISABLE SHIFT REGISTER CB2 MODE
4 ENABLE CA1 LATCHING
5 TURN CB2 ON
6 WAIT FOR INERRUPT FLAG
7 READ DATA WITH HANDSHAKE, MASK OFF, PARITY BIT
8 TURN CB2 OFF
9 DISPLAY VALUE ON SCREEN
10 GO TO 5

Cont'd...

This was turned into a basic program:

```
 5    PRINT "[V]";
10    POKE 59459, Ø
20    POKE 59468, PEEK (59468) AND 254
30    POKE 59467, PEEK (59467) AND 227
40    POKE 59467, PEEK (59467) OR 1
50    POKE 59468, PEEK (59468) OR 224
60    IF (PEEK (59469) AND 2) = Q THEN 60
70    X = PEEK (59457)
80    POKE 59468, (PEEK (59468) AND 31), OR 192
90    PRINT X AND 127;
100   GO TO 50
```

This program shows the ASCII codes input by the Writehander. To show the characters, change line 90 to:

```
90    PRINT CHR$ (X AND 127);
```

Three items are worth noting!!

1. The Writehander would work well with the Blinken Lightes and refuse to work with the PET! Eventually it was learned that:

CB2 (ACK) must be high when the Writehander brings CA1 (strobe) low. The Writehander won't strobe unless (ACR) is high.

2. OR is evaluated before AND by the PET! Line 80 was first written as:

```
POKE 59468, PEEK (59468) AND 31 OR 192
```

And it was discovered that the data went into the PET when CB2 was toggled manually! A PEEK of 59468 revealed bit Ø was set, i.e. positive CA1 transition. When parenthesis were inserted it worked!!

So - interfacing has its hazards!!

3. The CHR$ function in PET does not correspond to the ASCII code. To get the corresponding graphic character for an ASCII LOWER case,

```
90    X = X AND 127:  IF X > 95 THEN X = X + 96
100   PRINT CHR$ (X);:  GO TO 5Ø
```

NOTES

MCS6501-MCS6505 MICROPROCESSOR INSTRUCTION SET – ALPHABETIC SEQUENCE

ADC	Add Memory to Accumulator with Carry
AND	"AND" Memory with Accumulator
ASL	Shift Left One Bit (Memory or Accumulator)
BCC	Branch on Carry Clear
BCS	Branch on Carry Set
BEQ	Branch on Result Zero
BIT	Test Bits in Memory with Accumulator
BMI	Branch on Result Minus
BNE	Branch on Result not Zero
BPL	Branch on Result Plus
BRK	Force Break
BVC	Branch on Overflow Clear
BVS	Branch on Overflow Set
CLC	Clear Carry Flag
CLD	Clear Decimal Mode
CLI	Clear Interrupt Disable Bit
CLV	Clear Overflow Flag
CMP	Compare Memory and Accumulator
CPX	Compare Memory and Index X
CPY	Compare Memory and Index Y
DEC	Decrement Memory by One
DEX	Decrement Index X by One
DEY	Decrement Index Y by One
EOR	"Exclusive-Or" Memory with Accumulator
INC	Increment Memory by One
INX	Increment Index X by One
INY	Increment Index Y by One
JMP	Jump to New Location
JSR	Jump to New Location Saving Return Address
LDA	Load Accumulator with Memory
LDX	Load Index X with Memory
LDY	Load Index Y with Memory
LSR	Shift Right One Bit (Memory or Accumulator)
NOP	No Operation
ORA	"OR" Memory with Accumulator
PHA	Push Accumulator on Stack
PHP	Push Processor Status on Stack
PLA	Pull Accumulator from Stack
PLP	Pull Processor Status from Stack
ROL	Rotate One Bit Left (Memory or Accumulator)
ROR	Rotate One Bit Right (Memory or Accumulator)
RTI	Return from Interrupt
RTS	Return from Subroutine
SBC	Subtract Memory from Accumulator with Borrow
SEC	Set Carry Flag
SED	Set Decimal Mode
SEI	Set Interrupt Disable Status
STA	Store Accumulator in Memory
STX	Store Index X in Memory
STY	Store Index Y in Memory
TAX	Transfer Accumulator to Index X
TAY	Transfer Accumulator to Index Y
TSX	Transfer Stack Pointer to Index X
TXA	Transfer Index X to Accumulator
TXS	Transfer Index X to Stack Pointer
TYA	Transfer Index Y to Accumulator

ØØ - BRK
Ø1 - ORA - (Indirect,X)
Ø2 - Future Expansion
Ø3 - Future Expansion
Ø4 - Future Expansion
Ø5 - ORA - Zero Page
Ø6 - ASL - Zero Page
Ø7 - Future Expansion
Ø8 - PHP
Ø9 - ORA - Immediate
ØA - ASL - Accumulator
ØB - Future Expansion
ØC - Future Expansion
ØD - ORA - Absolute
ØE - ASL - Absolute
ØF - Future Expansion
1Ø - BPL
11 - ORA - (Indirect),Y
12 - Future Expansion
13 - Future Expansion
14 - Future Expansion
15 - ORA - Zero Page,X
16 - ASL - Zero Page,X
17 - Future Expansion
18 - CLC
19 - ORA - Absolute,Y
1A - Future Expansion
1B - Future Expansion
1C - Future Expansion
1D - ORA - Absolute,X
1E - ASL - Absolute,X
1F - Future Expansion

2Ø - JSR
21 - AND - (Indirect,X)
22 - Future Expansion
23 - Future Expansion
24 - BIT - Zero Page
25 - AND - Zero Page
26 - ROL - Zero Page
27 - Future Expansion
28 - PLP
29 - AND - Immediate
2A - ROL - Accumulator
2B - Future Expansion
2C - BIT - Absolute
2D - AND - Absolute
2E - ROL - Absolute
2F - Future Expansion
3Ø - BMI
31 - AND - (Indirect),Y
32 - Future Expansion
33 - Future Expansion
34 - Future Expansion
35 - AND - Zero Page,X
36 - ROL - Zero Page,X
37 - Future Expansion
38 - SEC
39 - AND - Absolute,Y
3A - Future Expansion
3B - Future Expansion
3C - Future Expansion
3D - AND - Absolute,X
3E - ROL - Absolute,X
3F - Future Expansion

40 - RTI
41 - EOR - (Indirect,X)
42 - Future Expansion
43 - Future Expansion
44 - Future Expansion
45 - EOR - Zero Page
46 - LSR - Zero Page
47 - Future Expansion
48 - PHA
49 - EOR - Immediate
4A - LSR - Accumulator
4B - Future Expansion
4C - JMP - Absolute
4D - EOR - Absolute
4E - LSR - Absolute
4F - Future Expansion
50 - BVC
51 - EOR - (Indirect),Y
52 - Future Expansion
53 - Future Expansion
54 - Future Expansion
55 - EOR - Zero Page,X
56 - LSR - Zero Page,X
57 - Future Expansion
58 - CLI
59 - EOR - Absolute,Y
5A - Future Expansion
5B - Future Expansion
5C - Future Expansion
5D - EOR - Absolute,X
5E - LSR - Absolute,X
5F - Future Expansion

60 - RTS
61 - ADC - (Indirect,X)
62 - Future Expansion
63 - Future Expansion
64 - Future Expansion
65 - ADC - Zero Page
66 - ROR - Zero Page
67 - Future Expansion
68 - PLA
69 - ADC - Immediate
6A - ROR - Accumulator
6B - Future Expansion
6C - JMP - Indirect
6D - ADC - Absolute
6E - ROR - Absolute
6F - Future Expansion
70 - BVS
71 - ADC - (Indirect),Y
72 - Future Expansion
73 - Future Expansion
74 - Future Expansion
75 - ADC - Zero Page,X
76 - ROR - Zero Page,X
77 - Future Expansion
78 - SEI
79 - ADC - Absolute,Y
7A - Future Expansion
7B - Future Expansion
7C - Future Expansion
7D - ADC - Absolute,X
7E - ROR - Absolute,X
7F - Future Expansion

80 - Future Expansion
81 - STA - (Indirect,X)
82 - Future Expansion
83 - Future Expansion
84 - STY - Zero Page
85 - STA - Zero Page
86 - STX - Zero Page
87 - Future Expansion
88 - DEY
89 - Future Expansion
8A - TXA
8B - Future Expansion
8C - STY - Absolute
8D - STA - Absolute
8E - STX - Absolute
8F - Future Expansion
90 - BCC
91 - STA - (Indirect),Y
92 - Future Expansion
93 - Future Expansion
94 - STY - Zero Page,X
95 - STA - Zero Page,X
96 - STX - Zero Page,Y
97 - Future Expansion
98 - TYA
99 - STA - Absolute,Y
9A - TXS
9B - Future Expansion
9C - Future Expansion
9D - STA - Absolute,X
9E - Future Expansion
9F - Future Expansion

A0 - LDY - Immediate
A1 - LDA - (Indirect,X)
A2 - LDX - Immediate
A3 - Future Expansion
A4 - LDY - Zero Page
A5 - LDA - Zero Page
A6 - LDX - Zero Page
A7 - Future Expansion
A8 - TAY
A9 - LDA - Immediate
AA - TAX
AB - Future Expansion
AC - LDY - Absolute
AD - LDA - Absolute
AE - LDX - Absolute
AF - Future Expansion
B0 - BCS
B1 - LDA - (Indirect),Y
B2 - Future Expansion
B3 - Future Expansion
B4 - LDY - Zero Page,X
B5 - LDA - Zero Page,X
B6 - LDX - Zero Page,Y
B7 - Future Expansion
B8 - CLV
B9 - LDA - Absolute,Y
BA - TSX
BB - Future Expansion
BC - LDY - Absolute,X
BD - LDA - Absolute,X
BE - LDX - Absolute,Y
BF - Future Expansion

CØ - CPY - Immediate

C1 - CMP - (Indirect,X)

C2 - Future Expansion

C3 - Future Expansion

C4 - CPY - Zero Page

C5 - CMP - Zero Page

C6 - DEC - Zero Page

C7 - Future Expansion

C8 - INY

C9 - CMP - Immediate

CA - DEX

CB - Future Expansion

CC - CPY - Absolute

CD - CMP - Absolute

CE - DEC - Absolute

CF - Future Expansion

DØ - BNE

D1 - CMP - (Indirect),Y

D2 - Future Expansion

D3 - Future Expansion

D4 - Future Expansion

D5 - CMP - Zero Page,X

D6 - DEC - Zero Page,X

D7 - Future Expansion

D8 - CLD

D9 - CMP - Absolute,Y

DA - Future Expansion

DB - Future Expansion

DC - Future Expansion

DD - CMP - Absolute,X

DE - DEC - Absolute,X

DF - Future Expansion

EØ - CPX - Immediate

E1 - SBC - (Indirect,X)

E2 - Future Expansion

E3 - Future Expansion

E4 - CPX - Zero Page

E5 - SBC - Zero Page

E6 - INC - Zero Page

E7 - Future Expansion

E8 - INX

E9 - SBC - Immediate

EA - NOP

EB - Future Expansion

EC - CPX - Absolute

ED - SBC - Absolute

EE - INC - Absolute

EF - Future Expansion

FØ - BEQ

F1 - SBC - (Indirect),Y

F2 - Future Expansion

F3 - Future Expansion

F4 - Future Expansion

F5 - SBC - Zero Page,X

F6 - INC - Zero Page,X

F7 - Future Expansion

F8 - SED

F9 - SBC - Absolute,Y

FA - Future Expansion

FB - Future Expansion

FC - Future Expansion

FD - SBC - Absolute,X

FE - INC - Absolute,X

FF - Future Expansion

0000-0002	0-2	USR Jump instruction
0003	3	Current I/O Device for prompt-suppress
0005	5	Cursor position for Input & Print
0008-0009	8-9	Integer address from Basic (for SYS, GOTO, etc.)
000A-0059	10-89	Basic input buffer; # of array subscripts
005A	90	Search character (usually ':' or end-of-line)
005B	91	Scan-between-quotes flag
005C	92	Basic input buffer pointer; number of subscripts
005D	93	First-character of array-name; default DIM flag
005E	94	Type: FF=string; 00=numeric
005F	95	Type: 80=integer; 00=floating point
0060	96	'DATA' scan flag; LIST quote flag; memory flag
0061	97	Subscript flag; FNx flag
0062	98	0=input, 64=get, 152=read (flag)
0063	99	flag for trigonometric signs/comparison evaluation flag
0064	100	input flag (suppress output if negative)
0065	101	variable pseudo-stack pointer
0066	102	fixed-point pseudo-stack pointer
0067	103	dummy value (0)
0068-0070	104-112	variable x pseudo-stack
0071-0072	113-114	pointer for number transfer
0073-0074	115-116	number pointer
0075-0078	117-120	product staging area for multiplication
007A-007B	122-123	start of basic pointer
007C-007D	124-125	end of basic/start of varibles pointer
007E-007F	126-127	end of variables/startof arrays
0080-0081	128-129	start of available space pointer
0082-0083	130-131	bottom of strings (moving down) pointer
0084-0085	132-133	top of strings (moving down) pointer
0086-0087	134-135	limit of Basic memory pointer
0088-0089	136-137	current program line number
008A-008B	138-139	previous line number
008C-008D	140-141	previous line address (for CONT)
008E-008F	142-143	line number of DATA line
0090-0091	144-145	memory address of DATA line
0092-0093	146-147	input vector (DATA etc.)
0094-0095	148-149	current variable name
0096-0097	150-151	current variable address
0098-0099	152-153	variable pointer for current FOR/NEXT
009A	154	Y save register; new operator save
009C	156	comparison symbol accumulator: < 1 = 2 > 4
009D-00A1	157-161	number work area for SQR, etc.
00A2	162	pseudo-stack yardstick (3 or 7)
00A3-00A5	163-165	jump vector for functions
00A6-00AA	166-170	numeric store area
00AB-00AF	171-175	numeric store area
00B0-00B5	176-181	primary accumulator E,M,M,M,M,S
00B6	182	Taylor series constant counter
00B7	183	accumulator high-order propogation word
00B8-00BD	184-189	secondary accumulator
00BE	190	sign comparison, primary/secondary
00BF	191	low-order rounding byte for primary acc

00C0-00C1	192-193	Cassette buffer length/Taylor constant pointer
00C2-00D9	194-217	Subrtn: Get Basic Char; C9.CA=pointer
00DA-00DE	218-222	RND storage and work area
00E0-00E1	224-225	Pointer to screen cursor line
00E2	226	Poisition of cursor on line
00E3-00E4	227-228	Utility pointer; tape buffer,scrolling
00E5-00E6	229-230	End of current program/tape end address
00E7-00E8	231-232	Tape timing constants
00E9	233	Tape buffer character
00EA	234	Direct/programmed cursor; 00=direct
00EB	235	Tape read/verify flag
00EC	236	Tape write flag
00ED	237	
00EE	238	Number of characters in file name
00EF	239	Logical file number
00F0	240	File command (from OPEN)
00F1	241	Device number
00F2	242	Maximum line length (40 or 80)
00F3-00F4	243-244	Tape buffr address (start of buffer)
00F5	245	Line where cursor lives
00F6	246	Last key pushed (ASCII); buffer checksum
00F7-00F8	247-248	Tape start address/tape pointer
00F9-00FA	249-250	File name pointer
00FB	251	Number of "insert" keys pushed
00FC	252	Serial bit shift word
00FD	253	# blocks remaining to write
00FE	254	Serial word buffer
0100-010A	256-266	Binary to ASCII conversion area
010B-01FF	267-511	Stack area
0200-0202	512-514	TI and TI$ clock - jiffies
0203	515	Which key depressed: 255 = no key
0204	516	Shift key: 1 if depressed
0205-0206	517-518	Clock (unused?)
0207	519	Cassette 1 status switch
0208	520	Cassette 2 status switch
0209	521	Keyswitch PIA: STOP & RVS flags, etc.
020A	522	
020B	523	Load=0, Verify=1
020C	524	Status
020D	525	# characters in keyboard buffer
020E	526	Reverse flag
020F-0218	527-536	Keyboard buffer
0219-021A	537-538	Hardware interrupt vector
021B-021C	539-540	Break interrupt vector
021D	541	
021E	542	End-of-line-for -input pointer
0220-0221	544-545	Cursor log (row, column)
0222	546	PBD image for tape I/O
0223	547	Key image
0224	548	0=flashing cursor; else no cursor shows
0225	549	Cursor timing countdown
0226	550	Character under cursor
0227	551	Cursor blink flag
0228	552	Tape write
0229-0241	553-577	Line address high & screen line wrap table

0242-024B	578-587	Logical numbers of open files
024C-0255	588-597	Device numbers of open files
0256-025F	598-607	Command/Secondary address of open files
0260	608	Input from screen/input from keyboard
0261	609	X-save flag
0262	610	How many open files
0263	611	Input device, normally 0
0264	612	Output CMD device, normally 3
0265	613	Tape parity
0266	614	
0268	616	Pointer in filename transfer
026A	618	
026C	620	Serial bit count
026F	623	
0270	624	Tape write countdown
0271	625	Tape buffer #1 count
0272	626	Tape buffer #2 count
0273	627	Leader counter
0274	628	Flag for tape error
0275	629	0 if 1st ½-byte cntr not written
0276	630	2nd ½-byte cntr/tape error count
0277	631	
0278	632	Cassette read flag
0279	633	Checksum working word
027A-0339	634-825	Tape #1 buffer
033A-03F9	826-1017	Tape #2 buffer
0400-7FFF	1024-32767	Available RAM including expansion
8000-8FFF	32768-36863	Video RAM
9000-BFFF	36864-49151	Available ROM expansion area
C000-E077	49152-57463	Microsoft Basic
E078-E7F8	57464-59384	Keyboard/Screen/Interrupt monitor
E810	59408	PIA1 - Keyboard A register; (Direction with CRA2=1)
E811	59409	PIA1 - Keyboard A control
E812	59410	PIA1 - Keyboard B register; (Direction with CRB2=1)
E813	59411	PIA1 - Keyboard B control
E820	59424	PIA2 - IEEE A register; (Direction with CRA2=1)
E821	59425	PIA2 - IEEE A control
E822	59426	PIA2 - IEEE B register; (Direction with CRB2=1)
E823	59427	PIA2 - IEEE B control
E840	59456	VIA I/O register B
E841	59457	VIA I/O register A with handshake
E842-E843	59458-59459	VIA Data Direction regs, A and B
E844-E845	59460-59461	VIA Timer 1
E846-E847	59462-59463	VIA Timer 1 latch
E848-E849	59464-59465	VIA Timer 2
E84A	59466	VIA shift register
E84B	59467	ACS: T1.T1.T2.SR.SR.SR.PB.PA
E84C	59468	PCR: B2.B2.B2.B1.A2.A2.A2.A1
E84D-E84E	59469-59470	IFR, IER: T1.T2.CB1.BC2.SR.CA1.CA2
E84F	59471	I/O Register A without handshake
F000-FFFF	61440-65535	Reset/tape/diagnostic monitor

E810	DIAGNOS. SENSE	IEEE EOI in	CASSETTE SENSE #2	#1	KEYBOARD ROW SELECT PA				59408
E811	TAPE#1 INPUT FLAG	...	SCREEN BLANK OUTPUT CA2			DDRA ACCESS	CASSETTE #1 READ CONTROL CA1		59409
E812	KEYBOARD ROW INPUT								59410
E813	RETRACE I FLAG	...	CASSETTE #1 MOTOR OUTPUT CB2			DDRB ACCESS	RETRACE INTERR. CONTROL CB1		59411

E820	IEEE-INPUT								59424
E821	$\overline{ATN}$ I FLAG	...	IEEE $\overline{NDAC}$ out CB2			DDRA ACCESS	IEEE $\overline{ATN}$ in CONTROL CA1		59425
E822	IEEE-OUTPUT								59426
E823	$\overline{SRQ}$ I FLAG	...	IEEE $\overline{DAV}$ out CB2			DDRB ACCESS	IEEE $\overline{SRQ}$ in CONTROL CB1		59427

E840	$\overline{DAV}$ in	$\overline{NRFD}$ in	RETRACE IN	CASS #2 MOTOR	CASSETTE OUTPUT	$\overline{ATN}$ out	NFRD out	$\overline{NDAC}$ in PB	59456
E841									59457
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E845	H								59461
E846	TIMER 1 L								59462
E847	LATCH H								59463
E848	TIMER 2 L								59464
E849	H								59465
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E84B	T1 CONTROL PB7 OUT	ONE-SHOT FREE-RUN	T2 CONTR. PB6 SENSE	SHIFT REG. CONTROL			PB, PA LATCH CONTROL		59467
E84C	CB2 (P.U.P. PIN M) CONTROL IN/OUT			CB1 in CASSETTE#2 POLARITY	CA2 (Graphics, Lower Case) Control IN/OUT			CA1 in POLARITY	59468
E84D	IRQ STATUS	T1 INT	T2 INT	CB1 CASS#2 INT	CB2 INT	SR INT	CA1 (P.U.P.B) INT	CA2 INT	59469
E84E	ENABLE CLEAR/SET	T1 INT ENAB	T2 INT ENAB	CB1 INT ENAB	CB2 INT ENAB	SR INT ENAB	CA1 INT ENAB	CA2 INT ENAB	59470
E84F	PARALLEL USER PORT I/O (PA) PA								59471

CDC1-CDE7 checks for special characters (+,-,",.) at start of expression
CDE8-CDF6 performs NOT function
CDF7-CE04 checks for various functions
CE05 evaluates expression within parentheses ()
CE0B checks for right parenthesis)
CE0E checks for left parenthesis (
CE11-CE1B checks for comma
CE1C-CE20 prints SYNTAX ERROR and exits
CE21-CE27 sets up function for future evaluation
CE28-CE39 set up a variable name search
CE3B-CE96 checks for special variables TI, TI$, and ST
CE97-CED5 identifies and sets up function references
CED6-CF05 perform the OR and AND functions
CF06-CF6D performs comparisons
CF6E-CF7A sets up DIM execution
CF7B-D00E searches for a Basic variable
D00F-D078 creates a new Basic variable
D079-D087 logs Basic variable location
D088-D098 is array pointer subroutine
D099-D09C is 32768 in floating binary
D09D-D0B8 is floating point-to-fixed conversion for signed values
D0B9-D263 locates and/or creates arrays
D264-D277 performs FRE function
D278-D284 converts fixed point-to-floating
D285-D28A performs POS function
D28B-D294 checks direct/indirect command, gives 'ILLEGAL DIRECT'
D295-D348 executes DEF statements and evaluation FNx
D349-D36A performs STR$ function
D36B-D3D1 scans and sets up string elements
D3D2-D403 builds string vectors
D404-D5C3 does 'garbage collection' - discards unwanted strings
D5C4-D5D7 performs CHR$ function
D5D8-D653 performs LEFT$, RIGHT$, MID$ functions
D654-D662 performs LEN, gets string length
D663-D672 performs ASC function
D673-D684 gets a single-byte value from Basic
D685-D6C3 evaluates VAL function
D6C4-D6CF gets two arguments (16-bit and 8-bit) from Basic
D6D0-D6E5 checks argument is in range 0-65535
D6E6-D701 performs PEEK and POKE
D702-D71D executes WAIT statement
D71E-D890 performs addition and subtraction
D891-D8BE contains floating-point constants
D8BF-D8FC performs LOG function
D8FD-D95D performs multiplication
D95E-D988 loads secondary accumulator from memory ($B8 to $BD)
D989-D9B3 test and adjust primary/secondary accumulators
D9B4-D9E0 routines to multiply or divide by 10
D9E1-DA73 performs division
DA74-DA98 loads primary accumulator from memory ($b0-$B5)
DA99-DACD transfers primary accumulator to memory
DACE-DADD transfers secondary accumulator to primary
DADE-DAEC transfers primary accumulator to secondary
DAED-DAFC rounds the primary accumulator
DAFD-DB29 extracts primary sign; performs SGN function
DB2A-DB2C performs ABS
DB2D-DB6C compares primary accumulator to memory

DB6D-DB9D	Convert Floating point to fixed, unsigned
DB9E-DBC4	perform INT function
DBC5-DC4F	convert ASCII string to floating point
DC50-DC84	get new ASCII digit
DC94-DCAE	print Basic Line number
DCAF-DDE2	convert floating point to ASCII string (at 0100 up)
DDE3-DE23	conversion constants - decimal or clock
DE24-DE2D	evaluation SQR function
DE2E-DE66	evaluation of power function
DE67-DE71	negate (monadic -)
DEA0-DEF2	perform EXP function
DEF3-DF3C	perform function series evaluation
DF45-DF9D	perform RND calculation
DF9E	evaluate COS function
DFA5-DFED	evaluate SIN function
DFEE-E019	evaluate TAN function
E048-E077	evaluate ATN function
E0B5-E0CC	Basic scan program, transferred to 00C2-00D9
E0D2-E173	completion of power-on-reset; memory test, etc.
E19B-E1BB	partial test for TI and TI$
E1BC-E1E0	input/read/get director
E1E1-E27C	initialize I/O registers. clear screen, reset subroutine
E27D-E3C3	receive input from keyboard/screen
E3C4-E3E9	set up new screen line
E3EA-E52F	output character to screen
E530-E5DA	check for and perform screen scrolling
E5DB-E66A	start new screen line
E66B-E67D	interrupt entry
E67E-E683	interrupt return
E685-E73E	hardware interrupt routine: cursor flash, tape motor, keyboard
E73F-E7AB	convert keyboard matrix to ASCII
E7AC-E7B9	write-on-screen subroutine
E7DE-E7EB	print canned monitor message
F0B6-F1CB	IEEE-488 channel open, test, close
F1CC-F22F	get input character from keybaord, screen cassette, IEEE
F230-F27C	output character to screen, cassette, IEEE
F27D-F2A3	restore normal I/O, clear IEEE channels
F2A4-F2AA	abort (not close!) all files
F2AB-F2B7	locate logical file table entry
F2B8-F2C7	transfer file table entries to Device, Command
F2C8-F329	perform file CLOSE
F32A-F33E	test stop key
F33F-F345	test if direct/indirect command for suppressing file advice
F346-F3FE	perform file LOAD
F3FF-F421	print "SEARCHING .. "
F422-F432	print "LOADING .. " or "VERIFYING"
F433-F461	get parameters for LOAD and SAVE
F462-F494	perform IEEE sequences for LOAD, SAVE, and OPEN
F495-F4BA	search for specific tape header
F4BB-F4D3	perform VERIFY
F4D4-F529	get parameters for OPEN and CLOSE
F52A-F5AD	perform OPEN
F5AE-F5E2	search for any tape header
F5E3-F5EC	clear tape buffer
F5ED-F64C	write tape header
F64D-F666	get start & end addresses from tape header

F667-F67C Set buffer start address
F67D-F694 set tape buffer start and end pointers
F695-F69D perform SYS command
F69E-F71B perform SAVE
F71C-F735 find unused secondary address
F736-F78A update clock
F78B-F7DB set input device
F7DC-F82C set output device
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FBEC-FBFF subroutine to count 8 serial bits per byte
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FD48-FD7B diagnostic routine
FD7C-FD8F checksum routine
FD90-FD9A pointer advance subroutine
FD9B-FFB1 diagnostic routines

JUMP TABLE:

FFC0	OPEN
FFC3	CLOSE
FFC6	set input device
FFC9	set output device
FFCC	restore normal I/O devices
FFCF	input character (from screen)
FFD2	output character
FFD5	LOAD
FFD8	SAVE
FFDB	VERIFY
FFDE	SYS
FFE1	test stop key
FFE4	get character from keyboard buffer
FFE7	abort all I/O channels
FFEA	update clock

FFED-FFFA turn off cassette motors
FFFA-FFFB NMI vector (mangled)
FFFC-FFFD reset vector
FFFE-FFFF interrupt vector

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