HOW TO UPGRADE A BASIC ELF MICROCOMPUTER

TTY COMMUNICATION · TAPE CASSETTE READ/WRITE · MUSICAL PROGRAMS · FREQUENCY/TIME INTERVALS · MEMORY PRENUMBERING

IF YOU OWN a basic (256 bytes of RAM) Elf computer, for less than $5 in hardware costs you can:

- Read and write data using a conventional cassette tape machine.
- Create musical programs.
- Communicate with a TTY.
- Measure frequency/time intervals.
- Memory prenumbering.

Here's how to upgrade an Elf to accomplish the foregoing. These applications require a 2-MHz crystal, or the timing programs modified.

Cassette Storage. The "Kansas City" tape cassette standard uses 8 cycles of 2400-Hz tone for a logic "1", and 4 cycles of a 1200-Hz tone for a logic "0". Eleven bits are required for each byte. First, there is a 0 to indicate the beginning of transmission, followed by eight 1's and 0's to form the actual data byte, and finally two 1's to finish. The byte rate is about 27 per second.

The hardware required for a simple cassette interface is shown in Fig. 1. Note that a resistor network is required to reduce the Q-signal output down to the level required by the cassette recorder MIC or AUX input. The values of these resistors have to be determined by experimenting with your own recorder. (Try 47k as the value for the series resistor. You may or may not need the resistor to ground.) The transistor circuit accepts the tone data from the cassette recorder, using a 2N2222 to provide clean data for the EF2 input of the Elf.

The program shown in Table I writes the 152 bytes in locations 68 through FF

BY EDWARD M. McCORMICK

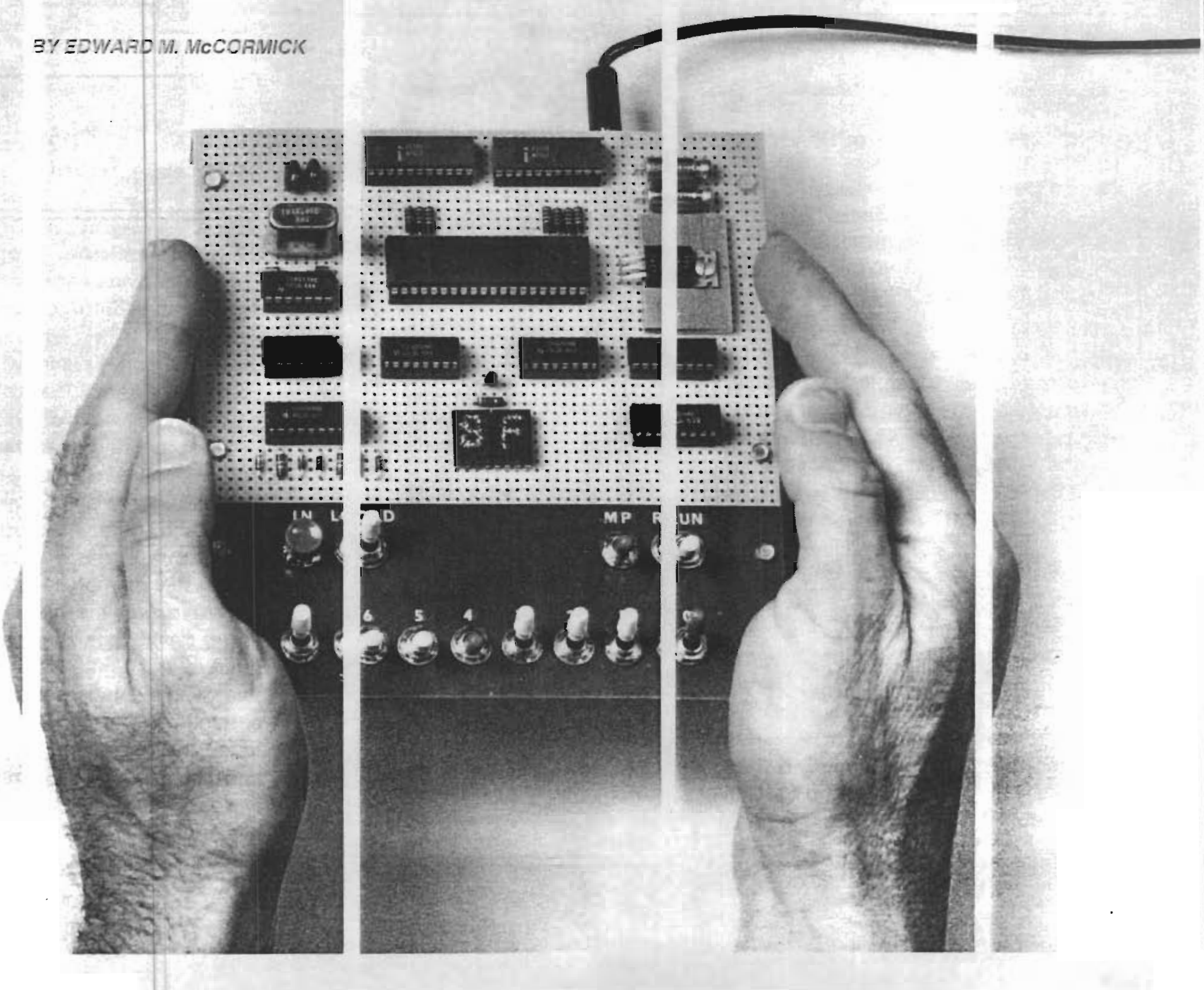

TABLE I. PROGRAM TO READ FROM MEMORY TO CASSETTE.

Loc	Instr	Remark	Loc	Instr	Remark
00	E1	X=1	33	F8 01	* continue mark
01	7A	Turn Q off	35	A6	*
02	F8 68	Set first core	36	F0	Start by getting
04	A1	* address	37	A4	* byte,
05	F8 00	Clear	38	F8 09	* setting shift
07	A6	* reg 6	3A	A5	* count in reg 5,
08	A7	* reg 7, eob sw	3B	30 4B	* going to space
09	F8 10	Generate a mark,	3D	87	Branch if end
0B	A2	* 8 cycles at	3E	3A 5A	* of byte
0C	F8 01	* 2400 hertz	40	85	If not, reduce
0E	A3	*	41	FF 01	* shift count and
0F	30 11	*	43	A5	* branch if end
11	31 16	If Q on, turn	44	32 53	* of byte
13	7B	* it off, if	46	84	Go to mark or
14	30 19	* off, turn it	47	76	* space according
16	7A	* on	48	A4	* to bit of byte
17	30 19	*	49	33 09	*
19	83	Variable delay	4B	F8 08	Generate a space,
1A	FF 01	* to balance	4D	A2	* 4 cycles at
1C	3A 1A	* half cycles	4E	F8 0E	* 1200 hertz
1E	82	Repeat if cycle	50	A3	*
1F	FF 01	* count not	51	30 11	*
21	A2	* zero	53	F8 01	At end of byte,
22	32 2E	*	55	A7	* set eob switch
24	F8 07	Fixed delay	56	F8 20	* and start double
26	FF 01	*	58	30 08	* mark
28	3A 26	*	5A	F8 00	When end of byte,
2A	30 2C	*	5C	A7	* display byte and
2C	30 11	*	5D	64	* if end of core,
2E	86	End of mark	5E	81	* go to mark, if not,
2F	3A 3D	* test	5F	32 01	* get next byte
31	3F 09	If IN up,	61	30 36	* and return

TABLE II. PROGRAM TO READ FROM CASSETTE INTO ELF MEMORY.

Loc	Instr	Remark	Loc	Instr	Remark
00	30 02	Optional branch	32	FC ED	Branch if mark
02	E1	X=1	34	3B 3F	*
03	F8 68	First "load-to"	36	7A	If space, turn
05	A1	* address	37	F0	* Q off,
06	F8 80	Put a one in	38	F6	* shift output
08	A7	* reg 7	39	51	* byte and set
09	F8 08	Put shift count	3A	F8 59	* delay for
0B	A5	* in reg 5	3C	A2	* 2.5 ms
0C	7B	Turn on Q	3D	30 49	*
0D	F8 00	Clear byte to	3F	7B	If mark, turn
0F	51	* be loaded	40	F0	* Q on, add one
10	35 10	Loop on marks	41	F6	* to byte, shift
12	3D 12	* in header of	42	51	* it, restore
14	F8 00	* tape or	43	87	* it and
16	FC 01	* between	44	F4	* set delay
18	35 16	* bytes	45	51	* for 2.9 ms
1A	FC ED	*	46	F8 68	*
1C	3B 10	*	48	A2	*
1E	F8 B3	If space, start	49	85	Continue if not
20	A2	* 5 ms delay	4A	FF 01	* all 8 bits in
21	7A	*	4C	A5	* byte
22	82	Do delay using	4D	3A 22	Continue if not
23	FF 01	* duration in	4F	64	* all core loaded,
25	C4	* reg 2	50	81	* display byte,
26	3A 23	*	51	3A 09	* and return
28	35 28	Determine if	53	7A	If core loaded,
2A	3D 2A	* mark or	54	3F 54	* turn off Q and
2C	F8 00	* space at	56	37 56	* execute program
2E	FC 01	* sampling	58	30 68	* when IN down
30	35 2E	* time			

onto the tape in about six seconds. When the program runs, it first generates a 2400-Hz tone for the leader. After recording the leader for about 10 seconds, depress the IN pushbutton to initiate the data recording. At the conclusion of the data, a trailer tone should also be recorded.

Table II's program will read the bytes from the tape into locations 68 through FF. The RUN switch should be turned on only when the cassette is playing back the 2400-Hz leader. When the data is encountered, it will be displayed. The tape recorder should be stopped while on the trailer.

Depressing the IN pushbutton causes the program starting at 68 to be executed. When the RUN switch is turned off, the Elf is ready to read another program from the cassette. To re-execute the program presently residing at 68, temporarily change the byte at memory location 01 from 02 to 68.

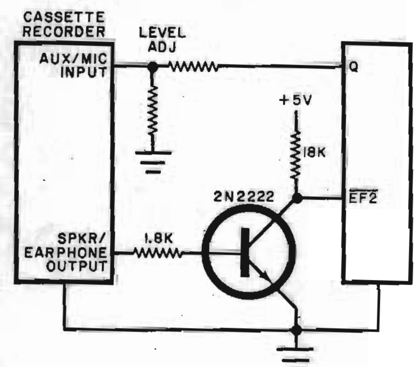

Fig. 1. Simple interface between Elf and cassette recorder.

20-mA Interface. The circuit shown in Fig. 2 provides an interface between the Elf and a 20-mA current-loop device (such as a TTY). The signal from Q drives the current loop, while the signal from the external current-loop device drives the EF3 input of the Elf.

A program to read and write to this interface is shown in Table III. When first executed, the program from 00 through 3E causes characters read from the keyboard or tape reader to be written into successive memory locations starting at 7A. Whenever the memory is filled, or the IN pushbutton is operated, the program reverts to the section between 3F and 6F that reads from memory to the current-loop device. This program illustrates the basic input/output technique and can be adapted for specific needs.

Note that the system will read all eight bits from a byte of memory and will punch all eight bits. Similarly, all eight bits on the tape will be read to memory. However, striking a key on the TTY enters only seven information bits since it is an ASCII device. The printer will ignore the eighth (most significant bit). Thus, Elf programs must be initially entered via the switches or from a hex keypad.

TABLE III. PROGRAM TO READ FROM TELETYPE TO ELF AND VICE VERSA

Loc	Instr	Remark	Loc	Instr	Remark
00	F8 28	Delay subr exit	37	F8 76	Else set delay
02	A6	* in reg 6	39	30 1E	* for 9 ms
03	7B	Turn on Q	3B	64	Display byte
04	E1	X=1	3C	81	*
05	F8 70	First read-to	3D	3A 0B	Read next byte
07	A1	* address	3F	F8 70	First read-from
08	F8 80	Put a one in	41	A1	* address
0A	A7	* reg 7	42	7A	Start space
0B	F8 00	Clear mx	43	F0	Store output
0D	51	*	44	A4	* byte
0E	F8 08	Shift count to	45	F8 09	Shift count to
10	A5	* reg 5	47	A5	* reg 5
11	3E 19	Start if EF3=0	48	F8 4F	Set subr exit
13	3F 11	Loop if IN up	4A	56	*
15	37 15	Loop if IN down	4B	F8 76	Set delay for
17	30 3F	Branch otherwise	4D	30 1E	* 9 ms
19	F8 29	Set subr exit	4F	84	Modify output
1B	56	*	50	76	* according to
1C	F8 B2	Set 13.5 ms delay	51	A4	* bit in byte
1E	C4	Delay loop subr	52	33 57	*
1F	C4	*	54	7A	*
20	C4	*	55	30 58	*
21	C4	*	57	7B	*
22	C4	*	58	85	Return if not
23	FF 01	*	59	FF 01	* all 8 bits
25	3A 1E	*	5B	A5	*
27	30 00	Subr exit	5C	3A 4B	*
29	F0	Form byte	5E	7B	Start mark
2A	F6	* according	5F	F8 66	Set subr exit
2B	51	* to EF3 at	61	56	*
2C	3E 31	* sampling	62	F8 ED	Set delay for
2E	87	* time	64	30 1E	* 18 ms
2F	F4	*	66	64	Display byte
30	51	*	67	81	* just put out
31	85	Branch if all	68	32 05	All core go to read
32	FF 01	* 8 bits read	6A	3F 42	Else start next byte
34	A5	*	6C	37 6C	Loop if IN down
35	32 3B	*	6E	30 05	Return to read

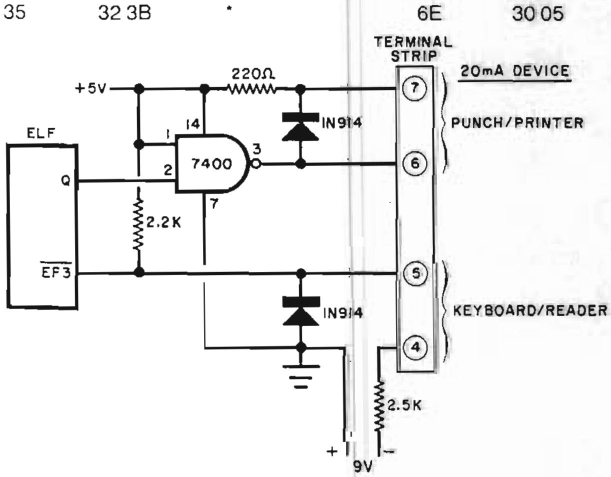

Fig. 2. Interface between Elf and a 20-mA current-loop device such as a TTY.

Memory Prenumbering. As a practical matter, it is often advantageous to "prenumber" all memory before entering data into the Elf. When the program shown in Table IV is entered and run, each memory location's contents is the address of that location. As a result, you can watch the hex display when manually entering programs to see if the next unused location is where it should be, or whether you have entered too many or too few bytes. This approach can be very useful in debugging programs.

TABLE IV. PROGRAM TO PRENUMBER MEMORY.

Loc	Instr
00	E2
01	F8 09
03	A2
04	82
05	52
06	64
07	30 04

Music. It is possible to program the Elf to reproduce the notes of the musical scale by connecting a speaker system to the Q output line and using the program shown in Table V.

The music program requires two data bytes for each note played. The first byte determines the duration of the note, while the second byte determines the pitch. Table VI shows the hexadecimal values for whole-note duration and the pitch of various notes. These byte pairs must immediately follow the music program shown in Table V—that is, it must start at hex AC. To illustrate, data for the first eight bars of Neil Simon's "Feeling Groovy" is listed in Table VII.

The music tempo depends on the hex value stored in memory 77 of Table V. The larger the hex value, the slower the tempo. The usual range is from hex 10 to hex 20.

Incidentally, the music program starts at hex 68; thus it can be recorded on a cassette. However, this leaves space for only 43 notes in a basic Elf. If the program starts at 00, then 91 notes can be stored.

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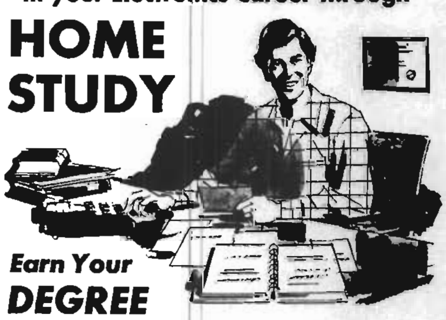

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MUSIC PROGRAMMING

TABLE V. PROGRAM TO PLAY MUSIC.

Loc	Instr	Remark	Loc	Instr	Remark
68	E5	X=5	89	3A 87	* indicates
69	F8 AC	Put first data	8B	89	Repeat as often
6B	A5	* in reg 5	8C	FF 01	* as tempo
6C	F0	Stop if data	8E	A9	* indicates
6D	3A 70	* is 00	8F	3A 99	*
6F	00	*	91	88	Repeat as often
70	A8	Store duration	92	FF 01	* as duration
71	15	* in reg 8	94	A8	* indicates
72	64	Display pitch,	95	3A 76	*
73	25	* store it in	97	30 A1	*
74	F0	* reg 7	99	C4	Delay to make
75	A7	*	9A	C4	* alternate
76	F8 10	Store tempo	9B	30 9D	* paths take
78	A9	* in reg 9	9D	30 9F	* same time
79	87	Stop alternating	9F	30 79	*
7A	FC B4	* Q if a rest	A1	7A	When note done,
7C	33 86	*	A2	15	* turn off Q,
7E	31 83	If Q on, turn	A3	F8 0E	* and insert
80	7B	* it off; if	A5	B3	* short quiet
81	30 86	* off, turn it	A6	23	* interval
83	7A	* on	A7	93	* between
84	30 86	*	A8	3A A6	* notes
86	87	Repeat as often	AA	30 6C	Get next note
87	FF 01	* as pitch			

TABLE VI. HEX VALUES FOR WHOLE NOTE DURATION AND PITCH OF MUSICAL NOTES.

Note	Dur	Pitch
D	93	12
C#	8B	14
C	83	15
B	7B	17
A#	75	19
A	6E	1B
G#	68	1D
G	62	1F
F#	5D	22
F	57	24
E	52	27
D#	4E	2A
D	49	2D
C#	45	30
*C	41	33
B	3E	37
A#	3A	3B
A	37	3F
G#	34	43
G	31	47
Rest	2D	4C

*Middle C

TABLE VII. PORTION OF SIMON'S "FEELING GROOVY".

Loc	Data	Loc	Data
AC	31 1F	D6	31 1F
AE	2C 24	D8	29 2A
B0	83 24	DA	83 24
B2	25 2D	DC	25 2D
B4	52 2A	DE	29 2A
B6	2C 24	E0	57 24
B8	25 2D	E2	25 2D
BA	94 2D	E4	94 2D
BC	17 4C	E6	17 4C
BE	1D 3B	E8	31 1F
C0	31 1F	EA	31 1F
C2	29 2A	EC	29 2A
C4	57 24	EE	57 24
C6	25 2D	F0	25 2D
C8	2C 24	F2	2C 24
CA	2C 24	F4	2C 24
CC	57 24	F6	57 24
CE	3A 19	F8	49 12
D0	75 19	FA	49 12
D2	57 24	FC	AF 19
D4	2D 4C	FE	00

TABLE VIII. FREQUENCY COUNT PROGRAM.

Loc	Instr	Remark	Loc	Instr	Remark
00	3F 00	Wait for IN to	25	C4	*
02	37 02	* be operated	26	30 15	*
04	F8 2C	Store values	28	F8 01	Zero side,
06	A2	* for one	2A	A3	* no count
07	F8 32	* second	2B	30 2D	*
09	B2	*	2D	30 15	*
0A	F8 00	Clear freq	2F	14	One side,
0C	A4	* count	30	F8 00	* add to freq
0D	B4	*	32	A3	* count
0E	A3	*	33	30 15	*
0F	3E 13	Wait for 0-1	35	E1	Display high
11	36 11	* transition	36	F8 46	* order
13	3E 13	*	38	A1	* byte of
15	22	Exit if end	39	94	* freq
16	92	* of second	3A	51	* count
17	32 35	*	3B	64	*
19	83	Monitor if on	3C	21	*
1A	32 22	* zero or	3D	3F 3D	Wait for IN to
1C	36 2F	* one side	3F	37 3F	* be operated
1E	C4	One side,	41	84	Display low
1F	C4	* after count	42	51	* order byte
20	30 15	*	43	64	* freq cnt
22	3E 28	One side,	44	30 00	Start over
24	C4	* no count			

Frequency Counter. The input circuit used to read from a cassette (Fig. 1), can also be employed to make the Elf act as a limited range frequency counter when the program shown in Table VIII is entered and run.

When the IN pushbutton is operated, the program counts the number of cycles occuring in a one-second interval and displays the most significant byte of that count. Operating the IN pushbutton switch again displays the least significant byte to be displayed. Operating the IN switch again results in a second frequency count, etc.

The input signal should overdrive the 2N2222 to ensure clean 0's and 1's. The maximum frequency is about 5800 Hz.

TABLE IX. PROGRAM TO MEASURE TIME INTERVALS.

Loc	Instr	Remark	Loc	Instr	Remark
00	3F 00	Wait till IN	16	F8 26	Display high
02	37 02	* sw depressed	18	A1	* hex position
04	F8 00	Clear registers	19	92	* of interval
06	A2	*	1A	51	* count
07	B2	*	1B	64	*
08	A3	*	1C	21	*
09	3E 0D	Wait for first	1D	3F 1D	Wait for IN
0B	36 0B	* 0 to 1	1F	37 1F	* sw depressed
0D	3E 0D	* crossing	21	82	Display low
0F	12	Add when	22	51	* hex position
10	36 0F	* EF3=1	23	64	* of interval
12	12	Add when	24	30 00	Repeat
13	3E 12	* EF3=0	26		Storage
15	E1	Exit at end			

Interval Timer. Using a similar input technique, the program shown in Table IX allows the Elf to be used as a simple interval timer.

When the IN pushbutton is depressed, the Elf waits for the next 0-to-1 crossing, and then measures the time to the next 0-to-1 crossing. The count displayed in the hex readouts is in 16-microsecond units. Accordingly, the maximum count with this program is about one second. The program can be modified for decimal display and longer time intervals. ◇

A future issue will show other alternatives for upgrading an Elf Computer.

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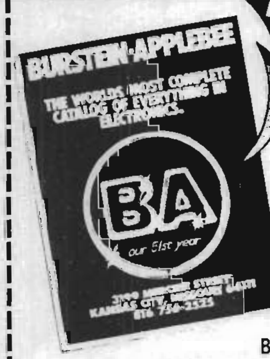

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Letters

AUDIO COMPANDER ENHANCES RECORDING

I have always prided myself on making the fullest possible use of my home tape recorder. But with the addition of the "Audio Compander" (November 1977) to my taping system, I discovered that I had fallen short of my goal. I found that the Audio Compander's ability to accommodate a wide range of levels obviates the need to "pot up and down." One of the simplest and most dramatic rewards is realized when using the compander with a simple cassette deck and a stereo system. But recording from discs or off-the-air FM programs is not enough of a challenge.

One way to demonstrate the dynamic range and noise-reduction properties of the compander is to make a recording of at least a couple of people placed around a room, with one person very far from and another very close to the microphone. If you can then arrange to A-B compare the recording with and without the Audio Compander, you will immediately hear the superiority of the recording with the compander. *—David J. Malinaric, Pittsburgh, PA.*

PATENT INFRINGEMENT POSSIBILITY

With reference to "Experiments With Programmable Logic Arrays" (June 1978), I would like to inform your readers of possible patent infringement if the circuit described in the article is used commercially. A very similar circuit forms the basis of the waveform control circuitry used in our new digital polyphonic synthesizer that can generate a virtually unlimited spectrum of waveshapes, with variable resolution (16 to 4096 points), up to 2 MHz. Our American patent has been pending since April 1977.

It may also be of interest to readers who build this project that inexpensive 8223 programmable read-only memory chips can be used as an alternative to the PLA and *IC4* through *IC6*. Of course, the 8223 PROM's must be connected to a +5-volt source through *R1*. *—Charles D. Kellner, Director, R&D, Syntauri, Inc., Salem, OR.*

TWO-SIDED COIN

I wish to thank POPULAR ELECTRONICS for the Operation Assist column. I have received several replies to my request for a schematic diagram.*—John H. Taylor, Glen Mills, PA.*

As a long-time reader of POPULAR ELECTRONICS, I am always on the lookout for someone in the Operation Assist column to whom I might be of some help. Having offered to help several individuals who were listed in the column and receiving not even one "thank you," I've become disillusioned. *—C.A. Harvey, Sturbridge, MA.*

We're sure that anyone aided in this manner appreciates it, but it would be a nice gesture to send a "thank you" note.—Ed.

PART AVAILABILITY

POPULAR ELECTRONICS readers interested in building the project in "Listen to a New World of Sounds With Ultrasonic Detector" (July 1978) may have trouble finding a source for the TBA231 dual operational amplifier specified for *IC1*. If so, (in Canada and U.S.) they can obtain it from us for $3.50 postpaid. *—D. Rost, Northern Bear Electronics, Box 7260, Saskatoon, Saskatchewan, S7K4J2, Canada.*

CB SIDEBANDERS' REBUTTALS

I greatly enjoyed your coverage of a sideband CB club meeting in the July 1978 issue (CB Scene). However, so as not to give the general public the wrong impression, I feel I must present some of my own observations. First, the failure to use official FCC call signs must be a local phenomenon because practically all sidebanders I hear give call signs to begin and end a transmission. Secondly, the use of linears is not nearly as widespread as you would have your readers believe. Except when the DX is really bad, the average sidebander needs no more than 10 to 12 watts PEP to communicate 25 to 50 miles with an inexpensive omnidirectional antenna.

Your statement about the five-minute talk limit also deserves comment. Due to the general cooperation with slow keying, most people feel that as long as no one asks for a QSK, the frequency is clear and they are not inconveniencing anyone. I have never found a situation where someone did not give way to a QSK in a minute or so. *—Jerry Brown, Δ505, KAIT-5860, Louisville, KY.*

Convenience or pragmatism still isn't a valid reason for breaking the law. We're pleased to hear that some illegal practices cited are not spread throughout the country.—Ed.

After reading the July 1978 CB Scene, I felt I had to write in to tell you that I have been a member of the Whiskey group for almost three years. I use my W number, first name, and license information number at the end of all transmissions. There are almost 7000 members in the Chicago-area W group. I know that a lot of CB'ers on AM and a few even on SSB operate in an illegal manner, but not me. I am no fool. *—Richard W. Bailey, W-3862, Chicago Area W Group, Chicago, IL.*

MIXED FEELINGS

Overall, the February 1978 issue of POPULAR ELECTRONICS was good. The hi-fi articles were excellent, especially the Stereo Scene on digital electronics in hi-fi. However, on the articles on computers, it appears that a reader must already know all there is to know about computers to understand them. There are a lot of us who do not understand computer jargon. *—Donald D. Capodanno, Vinton, VA.*

There are many low-cost computer "buzz word" books available so that one may enter the field more smoothly.—Ed.

IMPROVING THE IMPROVEMENT

"How to Upgrade a Basic ELF Microcomputer" was a delight (Feb 78). However, the usefulness of the TAPE OUT and TAPE IN programs (Tables I and II) would be greatly improved if they contained a provision for specifying the end of the read routine. The following "fix" adds this feature to the TAPE OUT programs; a similar modification applies to the TAPE IN program.

Original

Loc.	Instr.	Remarks
0000	E1	
01	7A	
02	F8 68 A1	Start addr
05	F8 00	
07	A6 A7	
09	F8 10 A2	
0C	F8 01 A3	
•		
•		
5D	64	Display byte
5E	81	Get next byte
5F	32 01	If end, goto mark
61	30 36	Else return

Modification

Loc.	Instr.	Remarks
0000		
02	F8 B1	Start PAGE addr
05	F8 A1	First byte addr
08	F8 B8	MSB } of total bytes + 1
0B	F8 A8	LBS } of total bytes + 1
0E	F8 00 A6 A7	
12	F8 A2	} See note
15	F8 A3	} See note
•		
•		
68	64	Display byte
69	88 FF 01 A8	R(8).0 - 1 into R(8).0
6D	32 72	If end LSB, goto MSB
6F	81	Get next byte
70	30 41	and return
72	98 FF 01 B8	R(8).1 - 1 into R(8).1
76	32 01	If end MSB, goto mark
78	30 6F	else get next byte

This fix will now permit one to dump any contiguous section of memory (up to 65K), provided the starting address and total number of bytes plus one in hex are specified. The

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MSB of the total number of bytes should have a nominal value of 01 to prevent the program from going into an infinite loop. Bear in mind that the additional instructions will affect program timing. It will be necessary, therefore, to adjust the values of R(2).0 and R(3).0, based on the system clock, to reflect the added timing. *—Henry H. Tolbert, Tallahassee, FL.*

TAPE HEADS DO WEAR

...I recently read with interest Craig Stark's article "Selecting the Best Cassette Tape for Your Recording Needs" (November 1977). It was very informative and helpful. However, I was quite surprised when I read "A better known CrO_2 disadvantage—rapid head wear—is actually a myth at cassette speeds and pressures. Believe it only when you find someone who has actually worn out a cassette head using any kind of tape."

I have a deck that is one year and nine months old with a worn playback/record head (high density, Permaflux) that makes listening to tape intolerable. I would estimate the total playing time of the deck to be 2500 hours. The heads have been cleaned and demagnetized regularly and it is not operating in a dusty atmosphere. I have also seen many cheaper tape decks with severely worn tape heads. So, tape head wear does occur and can be a serious problem to the recordist who uses his machine as often as I do. *—M. F. Amirault, New Glasgow, Nova Scotia, Canada.*

TYPICAL PE READER

From your March 1978 Editorial, I've concluded that I'm a typical POPULAR ELECTRONICS reader. I'm close to the norm in age, education, and income, and most of your other survey demographics. So, I've decided to join your vocal minority as well. I would like to see the Amateur Radio column become a monthly feature.

POPULAR ELECTRONICS has been a pioneer in educating us in microcomputers and all kinds of other fine things. And I hope this leadership continues. However, I don't see any reason to scrap the Amateur Radio column in deference to the CB service.*—Mary M. Cappuccili, WB8RRG, Toledo, OH.*

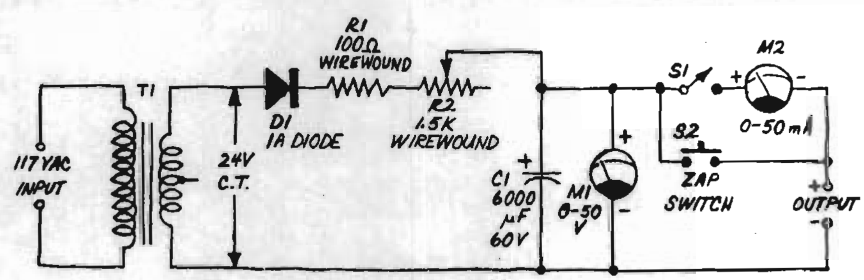
An Amateur Radio column is planned to be run on at least a bimonthly basis.—Ed.

AUDIO AUTO ALARM NEEDS COMPARATOR FOR METER CIRCUITS

In regard to my article "Audio Alarm Backs Up Car Warning Lights or Meters" (August, p 64), it should be pointed out that the circuit won't work directly with most car *metering* systems. In such cases, a simple comparator would have to be added so that its limit point could be set to indicate a fault condition. The comparator output could go high or low at the limit point, assuming it were connected to the correct point in the circuits as printed. Included should be a low-pass filter (20-V, 5-μF electrolytic capacitor to ground and series 220,000-ohm resistor) between the meter output and the comparator input to provide a 1-second time constant. Also the trace between pins 13 and 14 on the Autotel (see Parts List) board will have to be opened for input C to function properly. *—Gene Nelson.*

MODIFIED NI-CD CELL ZAPPER

"'Zap' New Life Into Dead Ni-Cd Batteries" (July 1977) was of great interest to me. After building the project, I decided to modify it as shown in the schematic diagram to add what I feel is an extremely desirable feature. My battery "zapper" both zaps and charges Ni-Cd cells. The 1500-ohm wirewound potentiometer (*R2*) is in the circuit to accommodate the charging current required and to allow the charge rate to be varied for different size cells. The milliammeter is required to provide a means for monitoring the charge current. *—Clifford D. Dorman, La Habra, CA.*



Out of Tune

In "Build an Electronic Voltage Regulator for Your Car" (July 1978), on page 57, the quantity n is stated to be 3; it should be 5. This would make the actual value of *R5* 2700 ohms, for an output of 14 volts, instead of 2000 ohms, which would yield a 13.5-volt output.

In "Build a Fail-Safe Timer" (May 1978), it was stated that a 556 dual-timer IC could be substituted for the two 555 timers. This is *not* the case. Both halves of the 556 share a common internal ground, which renders it useless for this application.