order and produces reports in either of two formats—tables (rows and columns); or index card format. Quick File III can calculate totals and subtotals of numeric information, it can also allow for the choice of which rows and columns are to be printed and in what order. This program requires an Apple III system with at least 128K bytes of RAM. $100. Scheduled to be available in August 1982.

Apple LOGO. Requiring an Apple II with a 16K RAM extension, this MIT LOGO package includes the LOGO language system, a unique instant LOGO tutorial program, an introduction to LOGO, a very fascinating teaching program called Alice in Logoland, and a LOGO back-up disk. It also works in color. Materials describing the Young Peoples LOGO Association are also available. $179.95. **Address:** Krell Software, 21 Millbrook Drive, Stony Brook, NY 11790 (Tel: 516-751-5139).

Genealogy Program. Your Family Tree, is a genealogical program that sets up a data base to hold pertinent information about each ancestor including name, date, place of birth, marriage, and death information, plus a comment line. Access is virtually unlimited, with full search capability on any key field using full or partial information. For TRS-80 Model I and III. Cassette or diskette. $29.95. **Address:** Acorn Software Products Inc., 634 North Carolina Ave., S.E. Washington, DC 20003 (Tel: 202-544-4259).

6809 FORTRAN. Running under FLEX and UniFLEX, this compiler complies with ANSI FORTRAN-77 (ANSI X3.9-1978) subset of FORTRAN, with the following exceptions; INTRINSIC and SAVE statements are ignored, EQUIVALENCE is not currently implemented, BACKSPACE is allowed on direct access files, ENDFILE performs no useful function, statement functions are not supported, variable names may be of any length with 7 characters significant, all keywords are reserved names, and direct access files are not available under FLEX. It includes modules for 16.8 digit floating point arithmetic, standard scientific functions, complete file manipulations, runtime traceback features, and a post-mortem dump. Available on 5- or 8-inch diskette. UniFLEX version is $450, FLEX is $375. **Address:** Technical Systems Consultants, Inc., Box 2570, West Lafayette, IN 47906 (Tel: 317-463-2502).

Apple Utility. The Manager contains programs to set up a turnkey memory management system for the Apple making use of either one or two 16K boards. HIDOS loads the DOS onto one 16K card, thus freeing the normally occupied 10.5K space. It will also alter a copy of the System Master so that its utilities make full use of the extra memory. HIDOS then looks for a second 16K card and if found, loads an alternate language. SOLIDOS makes a 16K card into a small (45 sector) disk emulator. $34.95. **Address:** Omega MicroWare, 222 S. Riverside Plaza, Chicago, IL 60606 (Tel: 312-648-4844).

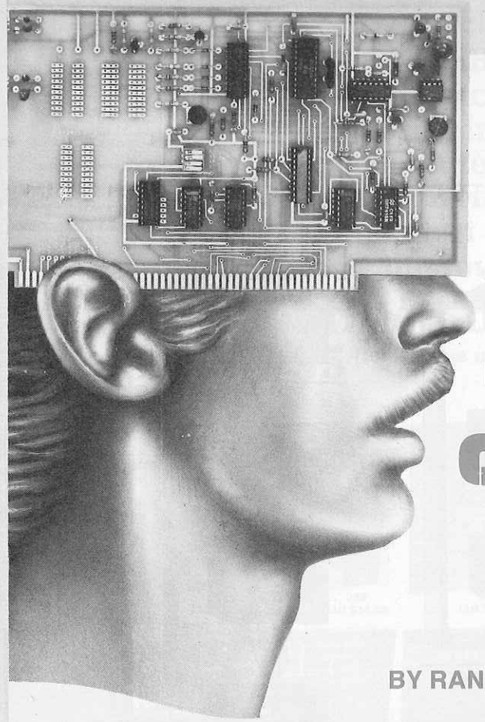
IBM SuperCalc. This spreadsheet takes advantage of the color capability of the IBM Personal Computer. The additional memory allows users to fill in all 16,000 cells with 5-digit numbers, and will allow 10 year projections month by month. Negative values and diagnostic messages are displayed in red, with protected formulas displayed in yellow. **Address:** Sorcim, 405 Aldo Avenue, Santa Clara, CA 95050. (Tel: 408-246-2181).

HP85 Utility. The Professional Organizer is a personal data base management program for the HP-85 that does not have a disk. Data may be manipulated using ADD, DELETE, LIST, CHANGE, INSERT, and TALLY commands. Data files may be saved on and restored from tape cartridges. A linking program enables qualified BASIC programmers to interface with the program. It is supplied on a tape cartridge. $149. **Address:** SCELBI Inc., 35 Old State Road, Oxford, CT 06483. (Tel: 203-888-1946).

VisiCalc Utility. The Consolidator links VisiCalc files and allows manipulation of totals without requiring the user to re-enter information. It will also print out VisiCalc commands, formulas, and locations where they apply. It will handle any matrix size, column widths, rows and columns that can be accomodated on the Apple. $49.95. **Address:** Omega MicroWare Inc., 222 S. Riverside Plaza, Chicago, IL 60606 (Tel: 312-648-4844).

ZX80/ZX81 Stock Programs. These programs help make intelligent decisions on stock market and call option strategies. One program keeps an up-to-date portfolio of up to ten different stocks and calculates accrued dividends, gains, yields, and length of time each stock held. The second program analyzes call option strategy when purchasing a stock and selling a call option against the same stock. Both programs account for broker commission, and have COPY commands for the ZX printer. Both programs require 16K of RAM and are supplied on cassette. $29.95. **Address:** M.H. Marks Ent., 315 Throneberry Court, Pittsburgh, PA 15237 (Tel: 412-486-1694).

Check Accounting. MAXI CRAS is a personal accounting program that can print checks, balance the account, and reconcile it with bank statements. It can handle an almost unlimited number of checks and deposits each month. As many as 223 income and expense accounts are supported. It also interfaces with VisiCalc. Requires a 48K TRS-80 Model I or III with two disk drives and printer, $99.95. **Address:** Adventure International, Dept. G., Box 3435, Longwood, FL 32750 (Tel: 800-327-7172).



Popular Electronics
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A speech synthesizer you can build for use with an S-100 bus computer

THIS IS YOUR COMPUTER SPEAKING

PART 2

BY RANDY CARLSTROM

LAST month, in Part 1 of this article, we discussed some of the principles of speech production and synthesis and developed a circuit for your computer to accomplish such synthesis. Here is a description of the software required and several practical applications for the project.

Software. The 64 phonemes produced by the SC-01 synthesizer chip are given in Table I. Accompanying each hex phoneme code is its symbol, average duration in milliseconds for a 720-kHz clock, and an example word. The italic segments of the example words demonstrate the use of the particular phoneme.

The assembly listing of a vocabulary development program, written in 8080 machine language, and too long to be reproduced here, is available at mailing cost as shown in the Parts List. The operation of the program can be understood from the comments in the source listing.

Five commands are available via the program. The first (XAn; n=0-3) sets the amplitude (audio output power) of the system from zero through two discrete volume settings to full audio output; the second (XFn; n=1-16) adjusts the synthesizer clock frequency in 16 discrete steps to make possible many different intonation variations; the third (XIn; n=1-4) sets the inflection (pitch) of the audio output; the fourth (XE) sets the synthesizer in the sound-effects mode to create all types of human and nonhuman sounds; while the fifth (XS) sets the synthesizer to the normal (speech) mode.

Any of these commands may be used an unlimited number of times in phoneme sequences for dynamic parameter control of the synthesized signal such as intonation and stress pattern variations during the production of words.

There are also two control functions available to the user. Striking the ESC key will cause the current phoneme sequence to be repeated while control-C exits the program and returns to a user-defined memory location (see line 0415 of the program source listing).

Words are programmed into the synthesizer via the system keyboard by entering the appropriate sequences of phoneme symbols from Table I. All phoneme symbols, including any commands used, must be separated by commas. Typing a carriage return (RET) will terminate the current phoneme input sequence and initiate its execution. Commands appearing in a sequence do not go into effect until the next phoneme in the sequence is encountered. Parameter values altered by the various commands remain current until changed otherwise.

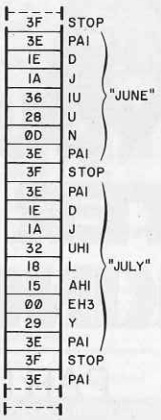
As an example of phonetic programming, try entering the following familiar words: "PA1,P,AH1,UH3,P,Y1, IU,L,ER,PA0,EH3,L,EH1,K,T,R, AH1,UH3,N,I2,K,S,PA1 RET;" or this sequence, which uses one of the parameter control commands for a special effect: "PA1,XA3,EH,K,O,XA2,EH, K,O,XA1,EH,K,O,PA1 RET."

Note the PA1 (pause) phoneme appearing at the beginning and ending of both phoneme sequences. This is necessary for proper operation of the SC-01's dynamic articulation controller, to maintain articulation of the first and last sounds in the sequences. The program automatically inserts a PA1 phoneme at the beginning and ending of phoneme sequences, but it is good practice to also explicitly include the PA1 phonemes, should the sequences be later transferred to a ROM (or other type of storage media) for use without the program.

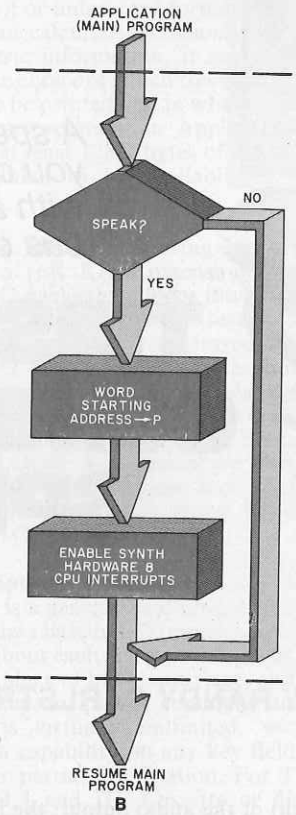
A PA0 (short pause) phoneme may be used between words for rhythm, as was done in the first example. This phoneme is also sometimes used to separate fricative stop sounds (T,DT,K, and P) when they occur consecutively in a phoneme sequence. An example of this usage is in the word *affect* (UH1, F,EH,K,*PA0*,T).

Developing vocabulary words for the synthesizer is basically a trial-and-error method. Slowly pronounce the words to be synthesized out loud several times, noting the different sounds com-

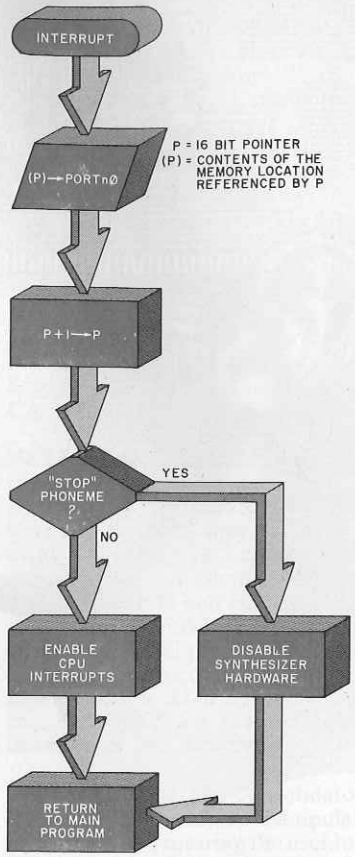
Fig. 8. At (A) is an extract of a typical vocabulary table (numerical values are hexadecimal). (B) A modification of an application program to include vocal output. (C) A speech driver interrupt-servicing routine.



A



B



C

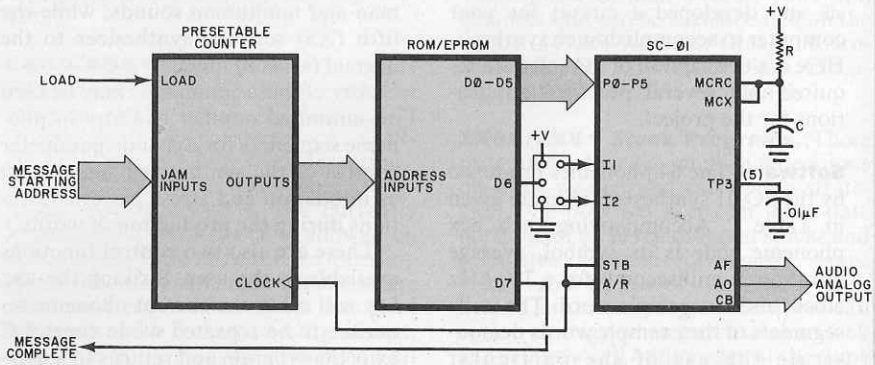


Fig. 9 Block diagram of a stand-alone, multiple-message speech synthesizer.

prising each word. Using Table I, select the phoneme symbols corresponding to each word sound, and enter them into the computer in the order of their occurrences in the words. Carefully listen to the synthesizer's output, paying particular attention to the proper durations of syllables and the rhythm of each word. Adjust the phoneme sequence as many times as necessary to achieve the desired pronunciation. Here are two examples:

Word: intruder
Initial sequence:I,N,T,R,U,D,ER
Refined sequence:
I1,I3,N,T,R,IU,U1,U1,D,ER,R
Word: amplifiers
Initial sequence:
AE,M,P,L,I,F,Y,ER,S
Refined sequence:
AE1,EH3,M,P,L,I3,F,AH1,EH3,AY,ER,Z

Once vocabulary words have been developed, the binary phoneme codes can be transferred to a ROM or look-up table in the computer's RAM for use with other programs. Fig. 8B illustrates a method of using the synthesizer with user-defined application programs, and a vocabulary look-up table (Fig. 8A). When a word is to be synthesized, the main program initializes an index pointer *P* to the beginning address (the first phoneme) of the desired word in the look-up table.

The computer's interrupt system and synthesizer hardware are enabled, and the main program resumes execution. The synthesizer servicing routine of Fig. 8C is called each time the synthesizer hardware interrupts the CPU, i.e., whenever the synthesizer is ready to accept a new phoneme. Each time the routine is entered, the contents of the memory location referenced by the index pointer is sent to the phoneme data port of the synthesizer. The pointer is then incremented to the next location in the table, in anticipation of sending the next phoneme. A STOP phoneme (3FH) signals the end of the phoneme sequence for the particular word, and the CPU's interrupt system is re-enabled or left disabled depending on whether the end of the word has been reached. Note that the two inflection bits (XIn) are included in bits 6 and 7 of the phoneme data byte (bits 0 through 5 are reserved for the actual phoneme code). The parameter control bits can also be updated in a similar manner.

Applications. Now that we have a means of developing vocabulary words for the synthesizer, let's explore some ways in which the synthesizer can be used. The most obvious is a talking computer terminal. With it, you can finally give your infallible electronic

TABLE I.—PHONEME CHART

Phoneme Code	Phoneme Symbol	Duration (ms)	Example Word	Phoneme Code	Phoneme Symbol	Duration (ms)	Example Word
00	EH3	59	jacket	20	A	185	day
01	EH2	71	enlist	21	AY	65	day
02	EH1	121	heavy	22	Y1	80	yard
03	PA0	47	no sound	23	UH3	47	mission
04	DT	47	butter	24	AH	250	mop
05	A2	71	made	25	P	103	past
06	A1	103	made	26	O	185	cold
07	ZH	90	azure	27	I	185	pin
08	AH2	71	honest	28	U	185	move
09	I3	55	inhibit	29	Y	103	any
0A	I2	80	inhibit	2A	T	71	tap
0B	I1	121	inhibit	2B	R	90	red
0C	M	103	mat	2C	E	185	meet
0D	N	80	sun	2D	W	80	win
0E	B	71	bag	2E	AE	185	dad
0F	V	71	van	2F	AE1	103	after
10	CH*	71	chip	30	AW2	90	salty
11	SH	121	shop	31	UH2	71	about
12	Z	71	zoo	32	UH1	103	uncle
13	AW1	146	lawful	33	UH	185	cup
14	NG	121	thing	34	O2	80	for
15	AH1	146	father	35	O3	121	aboard
16	OO1	103	looking	36	IU	59	you
17	OO	185	book	37	U1	90	you
18	L	103	land	38	THV	80	the
19	K	80	trick	39	TH	71	thin
1A	J*	47	judge	3A	ER	146	bird
1B	H	71	hello	3B	EH	185	get
1C	G	71	get	3C	E1	121	be
1D	F	103	fast	3D	AW	250	call
1E	D	55	paid	3E	PA1	185	no sound
1F	S	90	pass	3F	STOP	47	no sound

/T/ must precede /CH/ to produce CH sound.
/D/ must precede /J/ to produce J sound.

chess companion a personality with a voice. You can warp around an uncharted region of space as captain of the USS Enterprise as you receive verbal status reports from your crew. Realistic, simulated sounds of phaser fire, explosions, red alerts, etc. are also possible with the sound effect abilities of the synthesizer.

There are also many practical applications of the speech synthesizer. How about using its multilingual ability in a translation application, or giving a verbally impaired person a voice? There are many areas of education where a speech synthesizer might also be employed.

The SC-01 chip can be used in a stand-alone voice system by supplying it with phoneme-select code sequences from an address counter/ROM circuit, as shown in Fig. 9. Typical applications of such a system would be a talking clock or in robotics, where fixed vocabularies are acceptable.

As a final application example, let's see how a speech synthesizer can be used in the home.

Using an 8080-based CPU module (See "Designing with the 8080 Microprocessor, Part 2," POPULAR ELECTRONICS, October 1981, p.80) an "electronic helpmate" can be constructed. The operating program, speech recognition word templates, and speech synthesizer vocabulary (look-up) tables are stored in the CPU module's EPROM memory. Lights and appliances can be controlled from a remote control system (such as Radio Shack's *Plug'n Power* control center), which is interfaced to an output port of the CPU module. A 12-V battery back-up circuit powers the critical security portion of the system in the event of a power failure as shown in Fig. 10.

In this approach, the primary inputs to the system are verbal commands via

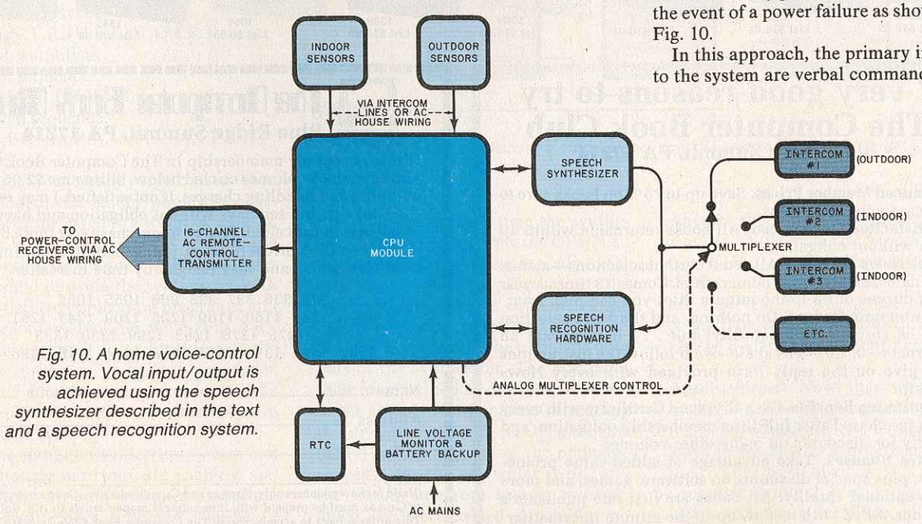


Fig. 10. A home voice-control system. Vocal input/output is achieved using the speech synthesizer described in the text and a speech recognition system.

intercoms located in strategic locations of the house. The CPU module "decodes" the verbal commands using an integrated speech-recognition system and processes them accordingly. The speech synthesizer's output is also piped throughout the house using the intercom system. If but even one *wireless* intercom is used, adding a "terminal" at any location is as easy as plugging the intercom into the nearest outlet. This technique may be carried a step further to even include two-way radio links to the CPU module. Thus, there are many applications possible with this type of I/O.

A real-time clock (RTC) can be employed to facilitate time and date-related functions of the system. These functions may include remembering an appointment, pseudo-randomly turning house lights on and off as a security measure, turning an electric blanket or coffee pot on or off, or announcing the time. These functions can be invoked by verbal commands from any intercom location in the house.

Various sensors installed around the house and premises communicate with the CPU module via the intercom system or via simple remote transmitters installed in the vicinity of each group of sensors. Each sensor generates a unique frequency (in the ultrasonic range) when triggered, thereby enabling the CPU module to identify the triggered sensor(s) and take appropriate action.

To eliminate much of the unsightly wiring, each sensor may utilize an infrared emitter, which is driven at the sensor's unique assigned frequency. An infrared detector in each remote transmitter (or intercom) receives this infrared energy, and relays the sensor's frequency ("device code") to the CPU module via the house wiring (or intercom system) for detection. The detection circuitry basically consists of a frequency-to-voltage converter connected to the input of a dot/bar display driver IC operating in the "dot" mode. The outputs of the display driver are connected to an input port of the CPU module for sampling. LEDs connected to these outputs also provide a visual indication of the sensors' status.

Besides the types of sensors depicted in Fig. 10, the sensors may also include dual infrared beams across doorways, allowing the CPU module to keep track of the number of people in each room of the house. The CPU module may use this data to turn lights off automatically when the last person has left the room, or to "talk" a burglar out of the house (such as after a pre-specified time of night or whenever the house is supposed to be unoccupied). ◇