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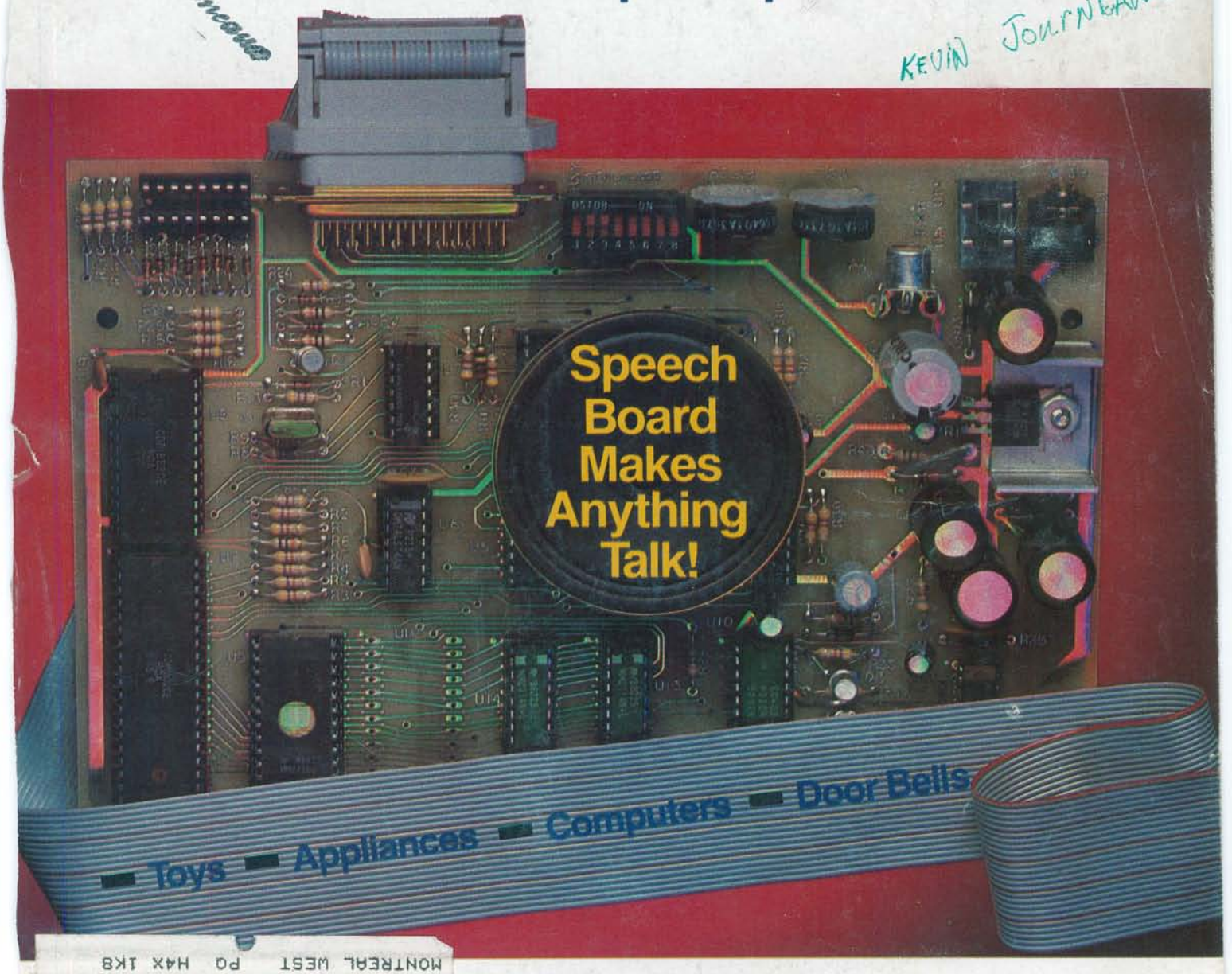

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SPEECH BOARD MAKES *ANYTHING* TALK!

Synthesizer enables you to create speech as a stand-alone device or with virtually any computer

By Ron Reese and Scott Keller

THE "Speak-Easy" synthesized speech system to be discussed here is not limited to use with a computer. It can act as a stand-alone talker for a host of applications—a talking electric train model ("The next stop will be Baldwin"), a talking door-bell responder ("Merry Christmas from the Andersons!"), and so on. It also operates in conjunction with any computer or terminal that has RS232C or parallel input/output ports. (Interfaces

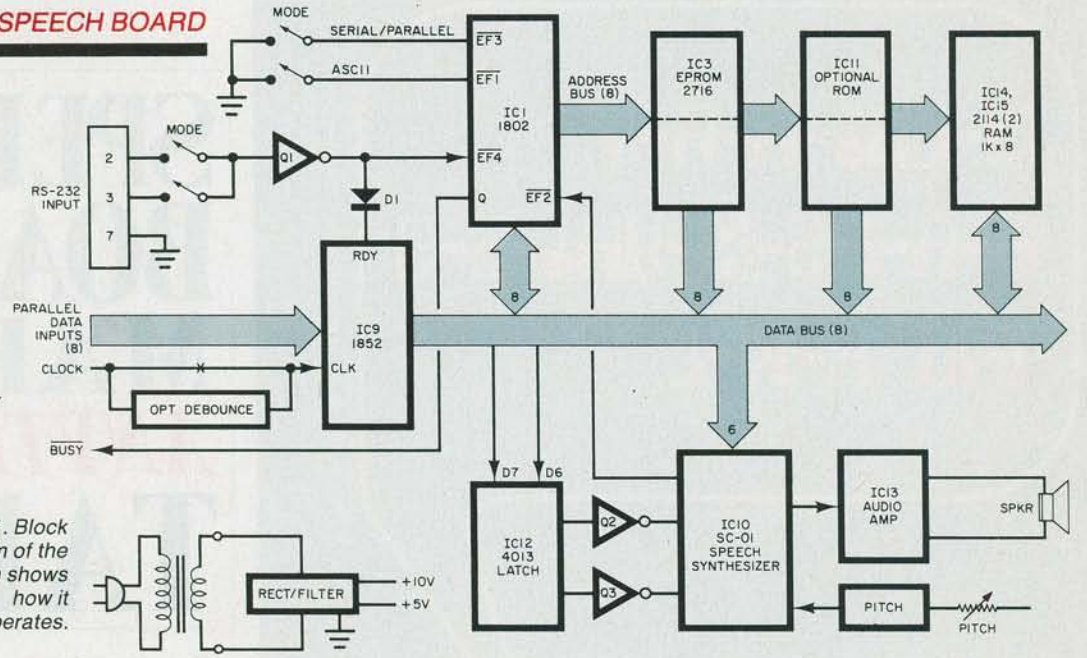


Fig. 1. Block diagram of the system shows how it operates.

to allow major personal computers to use the latter will be published in an upcoming issue.)

A phoneme-oriented approach is used to generate speech that is based on a single CMOS chip, the Votrax SC-01 large-scale IC. The Speak-Easy system uses an 1802 CPU that provides direct phoneme data entry with no code conversions. It also includes a built-in ROM vocabulary of 127 commonly used words, speech inflection control, parallel and serial (RS232C) inputs and automatic baud rate select. It is easily interfaced through any high-level language that includes PRINT, PEEK, or POKE statements (or their equivalents), and can accept binary code via a simple switchbox to be described or ASCII outputted from a computer or terminal.

The block diagram shown in Fig. 1 illustrates circuit operation. Using this approach, phonemes can be directly entered by symbol rather than by hex code. For example, the symbols in the artwork on the first page of this article, which are the phoneme symbols for Merry Christmas . . ., can be directly entered via the RS232 terminal with the 1802 handling the code conversions. Using such mnemonics minimizes chances of making an error. (The phoneme chart with each sound's symbol and hex code is supplied with the speech chip and was published in our past October 1982 issue.) Since the Speak-Easy automatically adjusts for baud rate, any computer-related device operating between 300 and 4800 baud can be used for entry.

Another enhancement of the Speak-Easy is the ability to mix phoneme-constructed words with pre-programmed words (127) stored in the system's ROM. Any message can easily be repeated, and the inflection changed to any of four different levels if required. The input buffer can store up to 1023 characters. A command allows individual words or phonemes to have different pitches to provide variation in speech inflection. Since the EPROM used contains 532 unprogrammed bytes, it is possible for the user to expand the system's vocabulary. Address labels 00 to 75 hex are used by pre-programmed words, with the 40 addresses between 77 to 9F hex available for user-defined words. Although a maximum of only 40 separately referenced words may be stored, each word could consist of a single phoeneme or a group of phonemes in the form of a word or phrase. Conceivably, one label could address a phrase consisting of all 532 bytes. Each new word must be written in phoneme code, not as a word address.

Circuit Operation. The microprocessor (see Fig. 2) is responsible for receiving and interpreting the input signals and providing control for the speech synthesizer chip. The clock oscillator is formed from elements of *IC7* operating at 4 MHz. This is fed to divider *IC6* to drive the clock input of *IC1*. Two flag lines ($\overline{EF1}$ and $\overline{EF3}$) are selected for either serial/parallel or binary/ASCII modes.

The EPROM (*IC3* in Fig. 3) contains the operating system and the pre-programmed words. (Provisions are made for an optional EPROM, *IC11*, for future expansion.) The two RAM chips, *IC14* and *IC15*, provide a 1023-byte buffer with one word reserved for stack and I/O operations. Since the 1802 uses a multiplexed address bus, the upper byte of the address is latched in *IC2* with *IC5* acting as the address decoder that selects either the EPROM or the RAM, depending on the address.

Like most microprocessor-based systems, a power-up reset is required to give the clock oscillator time to stabilize and other elements time to initialize. This power-up circuit consists of *IC4F* and *IC8C*, shown in Fig. 4.

The RS232 inputs at connector *P2* consist of *Q1, R22,* and *R23.* The parallel data enters via *P1* and is di-

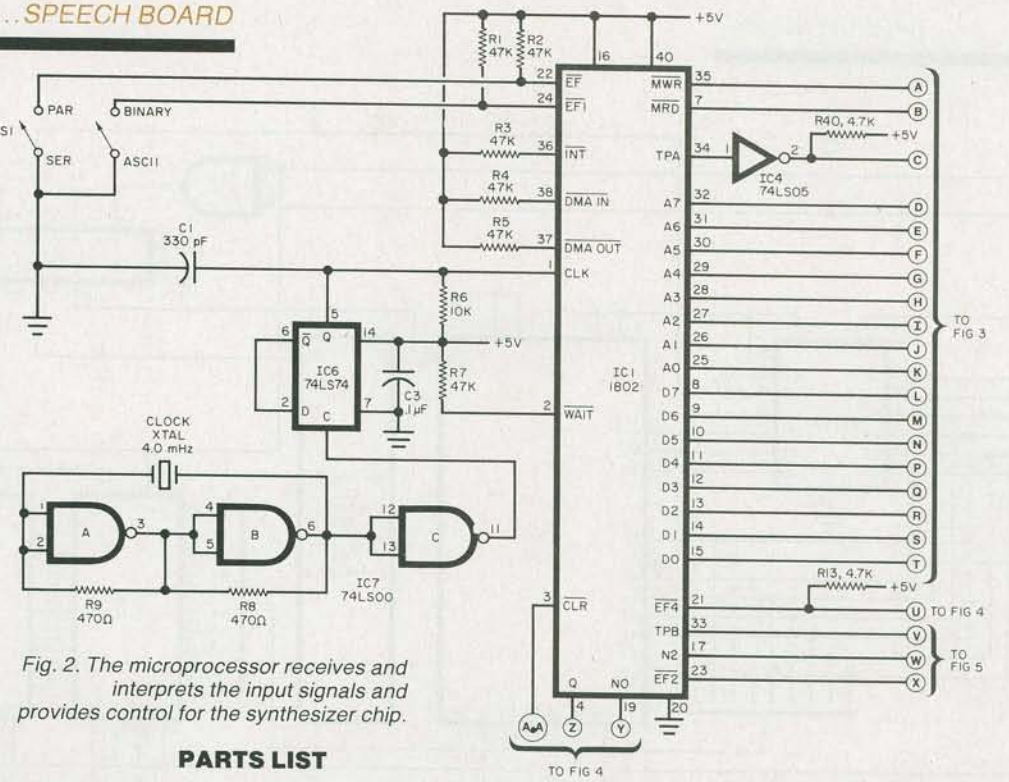


Fig. 2. The microprocessor receives and interprets the input signals and provides control for the synthesizer chip.

PARTS LIST

C1—330-pF disc capacitor
C2,C4,C10,C13—10-μF, 16-V electrolytic
C3,C5,C7—0.1-μF disc capacitor
C6—220-μF, 16-V electrolytic
C8,C9—100-μF, 25-V electrolytic
C11—220-pF disc capacitor
C12—1000-μF, 10-V electrolytic
C15 through C19—0.01-μF disc capacitor
C14,C20—100-μF, 16-V electrolytic
D1 through D11—1N4148
D12,D13,D14,D15—1N4001
D16—1N758, 10-V zener
IC1—1802 CMOS microprocessor
IC2—74LS174 hex latch
IC3—2716 EPROM
IC4—74LS05 hex inverter, open collector
IC5—74LS138 3-to-8 decoder
IC6—74LS74 flip-flop
IC7—74LS00 quad 2-input NAND
IC8—4011 CMOS quad 2-input NAND
IC9—1852 CMOS 8-bit port
IC10—SC-01A Votrax speech synthesizer
IC11—Reserved for expansion
IC12—4013 CMOS flip-flop
IC13—LM386 audio amplifier
IC14,IC15—2114L 1K x 8 RAM
IC16—7805 5-V regulator
P1—16-pin DIP socket
P2—Female DB-25, right-angle connector
Q1,Q2,Q3—2N4384 transistor
The following are ¼-W, 10% resistors unless otherwise noted:
R1 through R7,R11,R12,R30 through R33—47 kilohms
R6,R22,R23,R26,R42—10 kilohms
R8,R9—470 ohms
R10—220 kilohms
R13,R14 through R21,R24,R25,R27,R34,R40,R41, R44—4.7 kilohms
R29—10 ohms
R35—820 kilohms
R36—390 kilohms
R37—22 kilohms
R39—1 kilohm
R43—470 ohms, ½ W
R28,R38—5-kilohm potentiometer
S1 through S6—8-position DIP switch
SPKR—8-ohm speaker
XTAL—4.0-MHz crystal
Misc.—Sockets (1 40-pin, 2 24-pin, 1 22-pin, 2 18-pin, 3 16-pin, and 5 14-pin), power transformer (8.5 V at 200 mA), mounting hardware, etc.

Note: The following is available from Netronics, 333 Litchfield Rd., New Milford, CT 06776: complete kit of parts including double-sided pc board at $149.95 plus $3 postage and handling. Also available separately: pc board at $32 plus postage and handling; Votrax SC-01A at $59.95 plus $2 p/h; cabinet and wall transformer at $9.95, each, plus $2 p/h; source code for the EPROM at $4. On Canadian orders, double postage. Connecticut residents add 7.5% sales tax. Also available free with SASE from the same source are the foil patterns for the pc board.

ode connected to *IC9*. The serial and parallel data ready signal share the same input line ($\overline{EF4}$) of the CPU. In the serial mode, this input receives the data stream while in the parallel mode it is used as a signal that a byte of data has been strobed into the parallel port. This port requires a positive-going pulse to latch the data applied to the data input.

While the system is processing a byte of data, or talking, it cannot receive new data. Therefore, a busy signal (active low) is asserted during these times to give the controlling device an indication not to transmit data. Once the speech synthesizer completes its current task, the BUSY line goes high. This drives *IC4G*, which has an open collector that allows it to be shared. *IC4H* and *IC8A* form a de-bouncing circuit used with the manual pushbutton entry system.

As shown in Fig. 5, the speech synthesizer (*IC10*) receives the required data and delivers its output signal to a simple audio signal amplifier (*IC13*). Since *IC10* is a CMOS device, and the data lines are at TTL level, level shifters are required to convert these to the 10-volt level required by the inflection inputs *I1* and *I2*. This shifting is provided by *IC12* and transistors *Q2* and *Q3*. The pitch control is supplied by the *IC4I* circuit.

The power supply shown in Fig. 6 requires the use of a wall-socket-mounted transformer that can deliver 8.5 volts at 200 mA.

Using the Speak-Easy. Operation is simple once a few basic rules

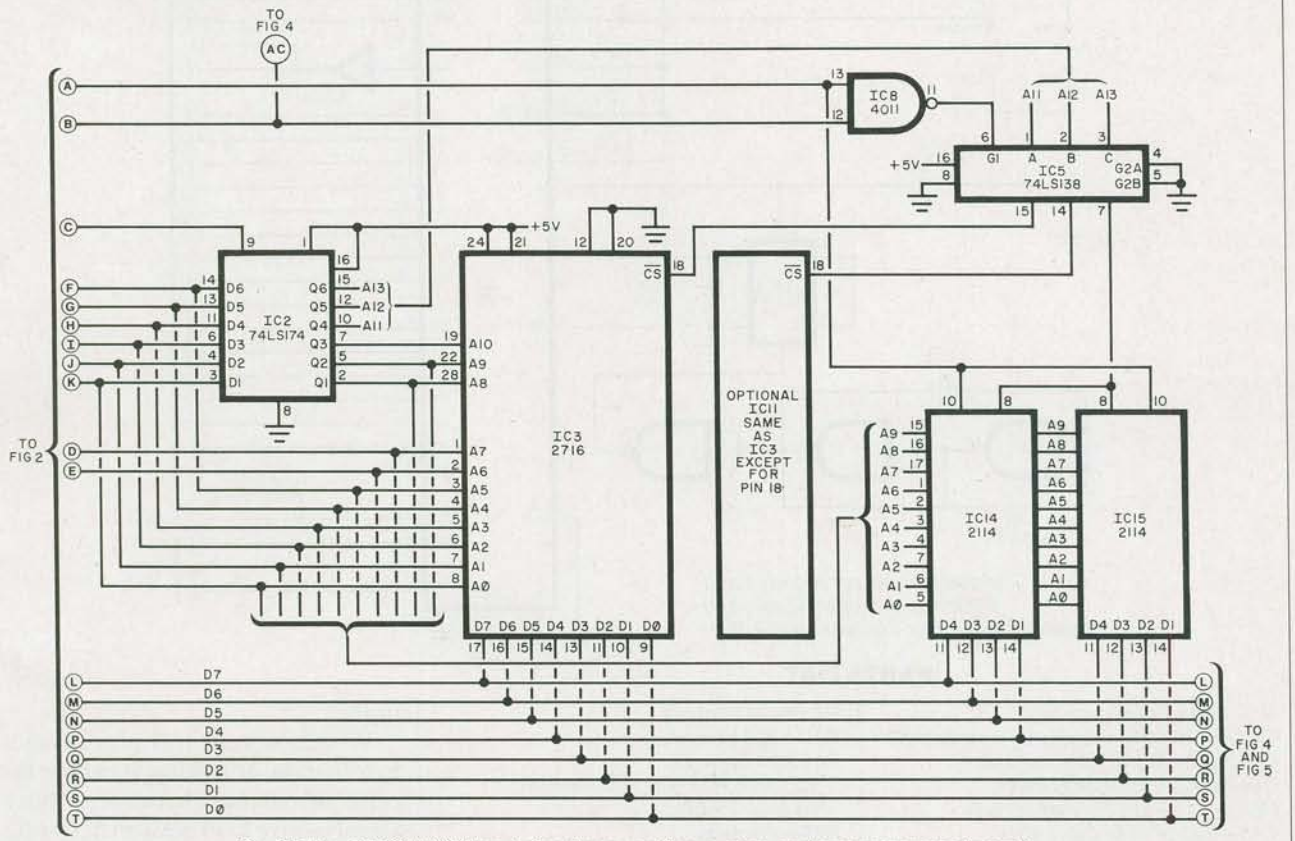


Fig. 3. The EPROM (IC3) contains the operating system and preprogrammed words.

readily be used as a speech-development system owing to the ease and speed with which words and phrases can be constructed. In the ASCII mode, an ASCII keyboard, terminal, or a computer that outputs ASCII can be used. Though a simple serial or parallel ASCII keyboard may be used, an RS232 terminal is advantageous because it provides visual feedback, allowing a user to easily employ the Speak-Easy's error-correction feature.

Before powering up, set mode switches to the settings that match the hardware being connected (serial/parallel, ASCII/binary, RS-232), as shown in Table I. There is only one difference between serial and parallel operation. In the serial mode, the first entry after power-up must be a carriage return (CR). The system uses the CR character to measure the baud rate of the serial transmission. Other than this, the serial and parallel modes are identical in operation. The following discussion applies to both modes.

The Speak-Easy powers up in an off-line mode, which means it must be brought on line before it will respond. This is done by sending the unit a control-A character (press A while the control key is pressed). Each time a message finishes speaking, the unit returns to its off-line state. Therefore, each message or command must be preceded by a CONTROL A.

Messages can be made up of phonemes, pre-programmed words, or any combination of the two. As an example of a message using only the ROM's canned words as listed in Table II, the phrase "How are you" can be generated by entering appropriate ASCII codes (CONTROL A 4C 66 74.). See the BASIC program in Table III.

The CONTROL A brings the system on line, while the 4C is the word label for "How"; 66 is the word label for "are"; 74 is the word label for "you"; and the period "." terminates the message string and starts the speech. To repeat the message simply enter CONTROL A".".

Words may be formed with phonemes too by selecting the appropriate phoneme symbols from an SC-01's table. For example, "Hello" can be generated by doing a "CONTROL A" and entering the following: (H EH1 L L O PA0.). Be sure that the message is preceded by a CONTROL A and terminated by a ".". Furthermore, unlike word labels, every phoneme symbol must be followed by a space, as indicated in the foregoing example. Also notice that a PA0 (pause) is used. Also, a PA1 or PA2 may be used at the end of a phoneme to improve the quality of the last phoneme. As with canned words, the message can be repeated by entering (CONTROL A and ".").

A special feature of the Votrax chip, which has been incorporated in the Speak-Easy, is the four different pitch levels available. Additionally, the speed of the talker can be altered by adjusting the clock frequency control. Four pitch-control characters can be used before indi-

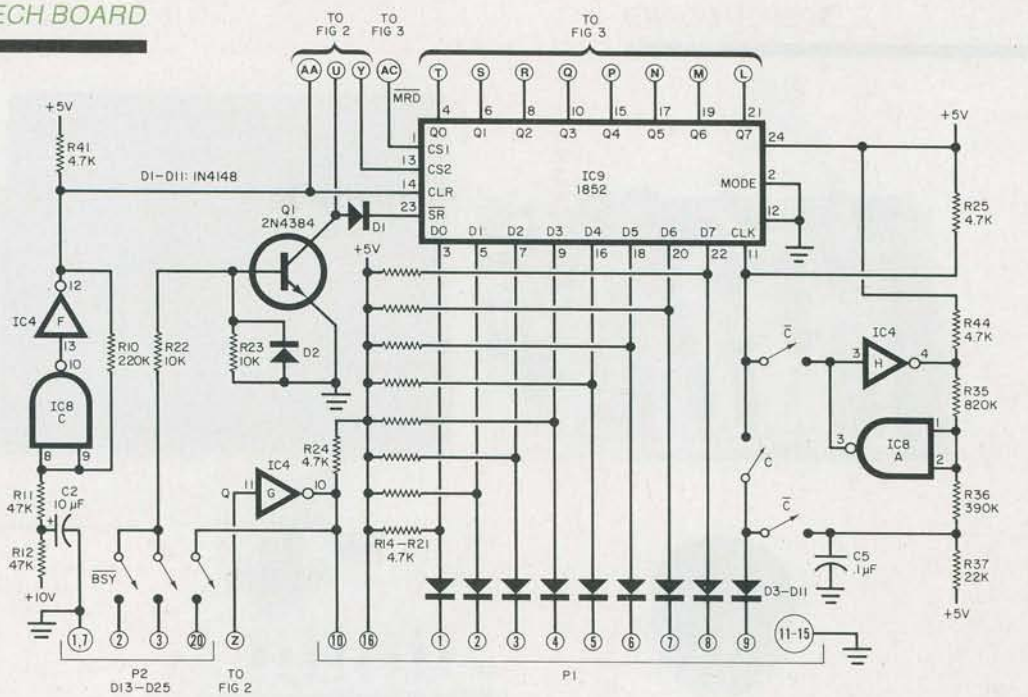
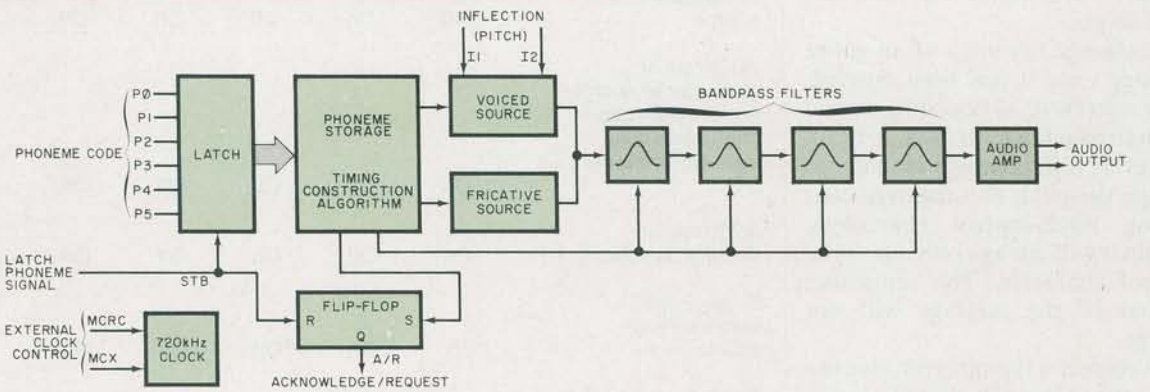


Fig. 4. Parallel data enters at P1 and is connected to IC9 through diodes.

vidual phonemes, groups of phonemes, or words to add inflections or variations to the speech. The pitch of an entire message can be changed even after the phrase has been entered provided it does not contain any pitch-control characters.

To change the pitch of individual phoenemes or words, enter a pitch-control character (#, $, %, &) immediately before the phoneme or word label. No space is needed between the pitch-control character and the phoneme. As an example, the word "Hello" will change pitch four times when typed in as: "#H $EH1 %L L &0 PA0." (Quotation

THE SPEECH CHIP



The Votrax SC-01 speech synthesizer chip used in this project is a phoneme type. It contains two voicing generators (voiced and fricative), four speech bandpass filters, a clock generator (710-kHz optimum), and a low-level audio amplifier. There are 64 stored phonemes in seven categories—the first six cover voiced, fricatives, and nasal sounds, while the seventh is silence.

The six-bit phoneme code is applied to inputs P0 through P5. After a 450-ns interval to allow for data settling, the inputs are latched on the rising edge of the strobe line (STB). The acknowledge/request (A/R) line switches from a high to a low one-clock cycle following the leading edge of STB to indicate that the chip has received the phoneme to be outputted.

Based on the chosen phoneme and the pitch (inflection) level selected, the words are synthesized by a construction algorithm controlling the fricative source ("airy" consonants such as F or S) and the voiced source (vowels like O or I). These signals are passed through a bandpass filter combination that simulates the opening and closing of the human throat. The speech is then amplified and outputted to the speaker or external audio amplifier.

As each phoneme is completed, the A/R line goes high to signal the external digital logic that the speech synthesizer is ready for the next phoneme. All SC-01 inputs, except for I1 and I2, the inflection inputs, are compatible with CMOS or TTL with pull-up resistors. The I1 and I2 inputs require level shifting for proper logic levels.

Besides speech (obviously in any language), the SC-01 can produce "sound effects" by a random choice of phonemes. In the phoneme listing shown here, phoneme length varies from 47 to 250 ms based on the recommended 720-kHz clock. This includes voice sounds as well as "stop," and end-of-word sounds that are important in creating natural sounds. ◇

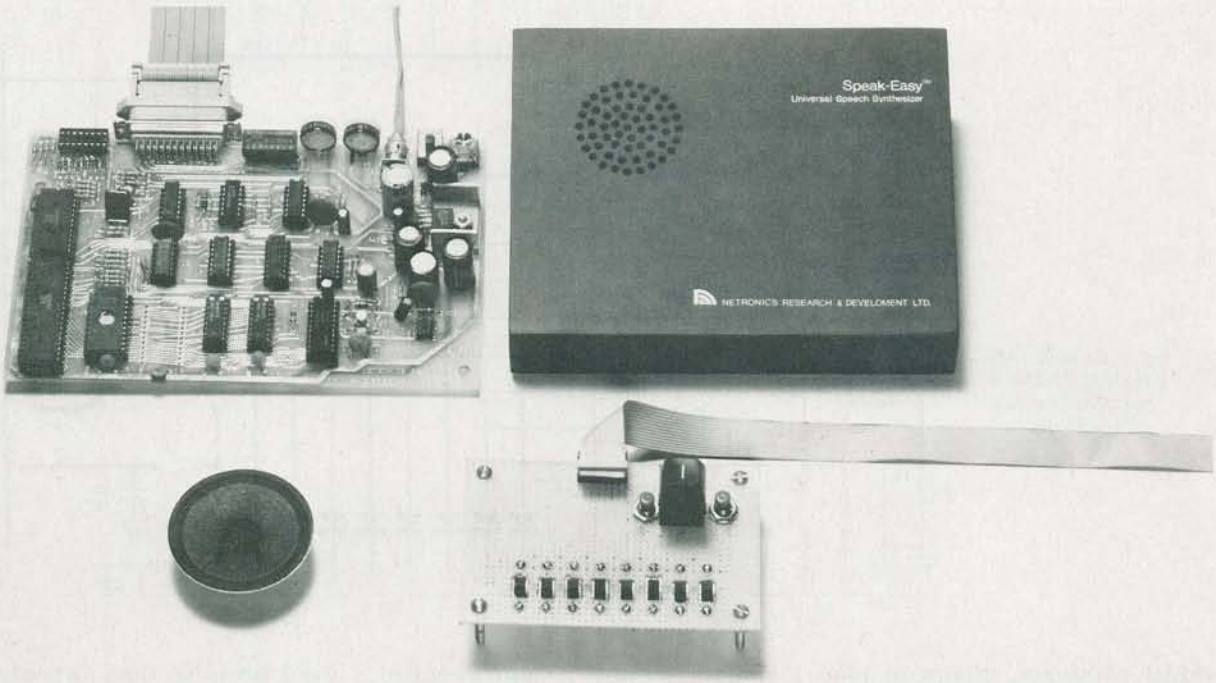


Photo of the prototype board with speaker and phoneme keyboard.

marks should not be entered, of course.) Similarly, for a pre-programmed word, entering "CONTROL A #48 $48 %48 & 48" says "Hello" four times at four different pitch levels.

To change the pitch of an entire message once it has been entered, enter CONTROL A, CONTROL P, and the desired pitch level (3, 4, 5, or 6). However, if an attempt is made to change the pitch of a message containing pitch-control characters, the pitch will change only up to the control character. The remaining portion of the message will not change.

To correct a typing error, use the delete (DEL) key. The last character entered is removed. Each previously entered character is removed in succession with each DEL key stroke. Once the message has been terminated with a "." though, the only way to correct an error is to re-enter the entire message.

Binary Mode. In the binary mode, phonemes must be entered by phoneme code rather than phoneme symbols. Any device, computer terminal, etc., capable of sending binary codes to the Speak-Easy can be

TABLE I—SWITCH POSITIONS

	BSY[1]	3[2]	2[3]	C[4]	B[5]	P[6]
ASCII/serial; computer as source.	Off	On	Off	Off	Off	Off
ASCII/serial; computer as source and program can interrogate busy signal at computer I/O.	On	On	Off	Off	Off	Off
ASCII/serial; terminal as source.	Off	Off	On	Off	Off	Off
Binary/serial; computer as source.	Off	On	Off	Off	On	Off
Binary/parallel; computer bus as source.	Off	Off	Off	Off	On	On
Binary/parallel; stand alone with switch debounce.	Off	Off	Off	On	On	On
ASCII/parallel; computer bus as source.	Off	Off	Off	Off	Off	On

(1) Busy to RS232, pin 20
(2) Serial communications via RS232, pin 3
(3) Serial communications via RS232, pin 2
(4) Negative clock for stand-alone input
(5) Binary/ASCII switch
(6) Parallel/Serial switch

used to operate it in the binary mode.

Again, before powering up the unit, set the mode switches to configure the Speak-Easy to the hardware being used, note that the ASCII/BINARY switch (*S1*, Fig. 2) must be in the BIN position. In the serial mode, the first entry must be 0D (hex). This character is used to measure the baud rate of the terminal or computer. Except for this entry, the parallel and serial modes are identical in operation.

As in the ASCII mode, the unit powers up in the off-line state. However, once turned on, it remains online until it receives an off-line com-

TABLE II—WORD TABLE

Memory Address	Line Number	Phoneme Codes	Word	ASCII	Binary
0324	0456				
0324	0457	WDTAB: ,#123C2B353703	ZERO	00	40
032A	0458	,#2D34320D03	ONE	01	41
032F	0459	,#2A36362803	TWO	02	42
0334	0460	,#382B2C03	THREE	03	43
0338	0461	,#1D262B03	FOUR, FOR	04	44
033C	0462	,#1D153C0F03	FIVE	05	45
0341	0463	,1F27191203	SIX	06	46
0346	0464	,#1F3B0F020D03	SEVEN	07	47
034C	0465	,#0521292A03	EIGHT	08	48
0351	0466	,#0D153C0D03	NINE	09	49
0356	0467	,#2A3B0D03	TEN	0A	4A
035A	0468	,#3C183B0F330D03	ELEVEN	0B	4B
0361	0469	,#2A2D0123180F03	TWELVE	0C	4C
0368	0470	,#38232B2A2A3C3C0D03	THIRTEEN	0D	4D
036F	0D03;	0470			
0371	0471	,#1D352B2A2A3C3C0D03	FOURTEEN	0E	4E
037A	0472	,#1D271D2A3C3C0D03	FIFTEEN	0F	4F
0382	0473	,#1F2719122A3C3C0D03	SIXTEEN	10	50
038B	0474	,#1F3B0F020D2A3C3C0D03	SEVENTEEN	11	51
0395	0475	,#21292A2A3C3C0D03	EIGHTEEN	12	52
039D	0476	,#0D153C0D2A3C3C0D03	NINETEEN	13	53
03A6	0477	,#2A2D0B0D2A2903	TWENTY	14	54
03AD	0478	,#38232B2A2903	THIRTY	15	55
03B3	0479	,#1D352B2A2903	FORTY	16	56
03B9	0480	,#1D0B1D2A2903	FIFTY	17	57
03BF	0481	,#1F27191F2A2903	SIXTY	18	58
0306	0482	,#1F3B0F020D2A2903	SEVENTY	19	59
03CE	0483	,#0621292A3C03	EIGHTY	1A	5A
03D4	0484	,#0D153C0D2A2903	NINETY	1B	5B
03DB	0485	,#1B32230D1E2B001E03	HUNDRED	1C	5C
03E4	0486	,#3915233712000D1E03	THOUSAND	1D	5D
03ED	0487	,#0C0B091829230D03	MILLION	1E	5E
03F5	0488	..			
03F5	0489	,#06212903	A	1F	5F
03F9	0490	,#320E3108372A03	ABOUT	20	5F
0400	0491	,#2F001E03	ADD	21	5F
0404	0492	,#2F001E2B02001F03	ADDRESS	22	5F
040C	0493	,#311C27000D03	AGAIN	23	5F
0412	0494	,#0818233A2A03	ALERT	24	5F
0418	0495	,#2E0C03	AM	25	5F
041B	0496	,#2F000D1E03	AND	26	5F
0420	0497	,#2E2A03	AT	27	5F
0423	0498	..			
0423	0499	,#0E3C2903	B,BE	28	5F
0427	0500	,#0E02000D03	BEEN	29	5F
042C	0501	,#0E291D34342B03	BEFORE	2A	5F
0433	0502	,#0F02002A34A3	BETTER	2B	5F
0439	0503	,#0E332A03	BUT	2C	5F
043D	0504	..			
043D	0505	,#1F3C2903	C, SEE, SEA	2D	
0441	0506	,#190621290C03	CAME	2E	
0447	0507	,#192F000D03	CAN	2F	
044C	0508	,#19022B02192A3A03	CHARACTER	30	
0454	0509	,#191835371203	CLOSE	31	
045A	0510	..			
045A	0511	,#1E20220D1E1A3A2B03	DANGER	32	
0463	0512	,#1E2C1C2B2C03	DEGREE	33	
0469	0513	,#1E02000F2308291F03	DEVICE	34	
0472	0514	,#1E283703	DO	35	
0476	0515	,#1E24183A03	DOLLAR	36	
047B	0516	,#1E2F08320D03	DOWN	37	
0481	0517	..			
0481	0518	,#0200181F03	ELSE	38	
0486	0519	,#01000D1E03	END	39	
048B	0520	,#2C192D131803	EQUAL	3A	
0491	0521	,#023A2B03	ERROR	3B	
0495	0522	..			
0495	0523	,#1D13182A03	FAULT	30	
049A	0524	,#1D3A2B1F2A03	FIRST	3D	
04A0	0525	,#1D153018353703	FOLLOW	3E	
04A7	0526	..			
04A7	0527	,#1E1A3C2903	G	3F	
04AC	0528	,#1C0521290C03	GAME	40	
04B2	0529	,#1C02002A03	GET	41	
04B7	0530	,#1C263703	GO	42	
04BB	0531	,#1C263C1403	GOING	43	
04C0	0532	,#1C16161E03	GOOD	44	
04C5	0533	,#1C2B06212A03	GREAT	45	
04CB	0534	..			
04CB	0535	,#1B2E001E03	HAD	46	
04D0	0536	,#1B2F000F03	HAVE	47	
04D5	0537	,#1B002318353403	HELLO	48	
04DC	0538	,#1B21092B03	HERE	49	
04E1	0539	,#15000903	HIGH	4A	
04E5	0540	,#15352B03	HOUR, OUR	4B	
04E9	0541	,#3D3703	HOW	4C	
04EC	0542	..			
04EC	0543	,#1500092903	I, EYE	4D	
04F1	0544	,#0B091D03	IF	4E	
04F5	0545	,#0B090C2534342B2A000D	IMPORTANT	4F	
04FF	0546	,#2A03			
0501	0547	,#0B010D03	IN, N	50	
0505	0548	,#09000D2A2B371E3A03	INTRUDER	51	
050E	0549	,#271203	IS	52	
0511	0550	,#0B002A03	IT	53	
0515	0551	..			
0515	0552	,#0B010D03	K	54	
0519	0553	..			
0519	0554	,#183B1D2A03	LEFT	55	
051E	0555	,#1835343703	LOW	56	
0523	0556	..			
0523	0557	,#0C020D022A03	MINUTE	57	
0529	0558	,#0C320D2C03	MONEY	58	
052E	0559	..			
052E	0560	,#0D20290C03	NAME	59	
0533	0561	,#0D3B191F2A03	NEXT	5A	
0539	0562	,#0D35343703	NO	5B	
053E	0563	,#0D15082A03	NOT	5C	
0543	0564	,#0D320C0C0E3A03	NUMBER	5D	
054A	0565	..			
054A	0566	,#240F03	OF	5E	
054D	0567	,#08301D03	OFF	5F	
0551	0568	,#13230D03	ON	60	
0555	0569	,#3525270D03	OPEN	61	
055A	0570	,#35342B03	OR	62	
055E	0571	,#2308372A03	OUT	63	
0563	0572	,#260F3A03	OVER	64	
0567	0573	..			
0567	0574	,#25182C1203	PLEASE	65	
056C	0575	..			
056C	0576	,#153A03	R, ARE	66	
056F	0577	,#2B15292A03	RIGHT	67	
0574	0578	,#2B3C25212A03	REPEAT	68	
057A	0579	,#2E02001E2903	READY	69	
0580	0580	..			
0580	0581	,#1F0219230D2A03	SECOND	6A	
0587	0582	,#1F2A152B2A03	START	6B	
058D	0583	,#1F2A15232503	STOP	6C	
0593	0584	..			
0593	0585	,#392F010D03	THAN	6D	
0598	0586	,#392F012A03	THAT	6E	
059D	0587	,#39092C03	THE	6F	
05A1	0588	,#380B000D03	THEN	70	
05A6	0589	,#390B0A1F03	THIS	71	
05AB	0590	,#2A1500210C03	TIME	72	
05B1	0591	,#2A2B150A03	TRY	73	
05B6	0592	..			
05B6	0593	,#2236373703	U, YOU	74	
05BB	0594	,#332503	UP	75	
05BE	0595	..			
05BE	0596	,#2D352B0D0B1403	WARNING	76	
05C5	0597	,#2D23322A03	WHAT	77	
05CA	0598	,#2D02000D03	WHEN	78	
05CF	0599	,#2D0005002B03	WHERE	79	
05D5	0600	,#1B36373703	WHO	7A	
05DA	0601	,#2D150B03	WHY	7B	
05DE	0602	,#2D36361E03	WOULD, WOOD	7C	
05E3	0603	..			
05E3	0604	,#2934342B03	YOUR	7D	
05E8	0605	,#2200021F03	YES	7E	

mand. A list of the commands used in the binary mode is shown in Table IV.

Since the unit powers up in the off-line mode, it must first be turned on by sending it F0. When the unit is on-line, words or phonemes may be entered. For example, to say "How are you," the appropriate word labels may be selected from the word list. Note that the binary word labels are different than the ASCII labels. The sequence to be entered from the binary column is: F0 8C A6 B4 F5 (all hex).

When F5 is received the Speak-Easy will begin talking. When it is finished, it will remain in the on-line state. To go off-line, add the code FF to the string. Phonemes may also be used to form words. For example, the following phonemes will produce the sound "George":

F0 1E 1A 26 2B 1E 1A 03 F5

Recall that the F0 would only be necessary if the unit had not been previously turned on. No spaces are required between codes—they are included above in the interest of clarity.

Individual phonemes or words may be preceded by a pitch-control command (F1 to F4) to change the pitch of the phoneme or word. As many pitch-control commands may be used as desired within a message. Another way the pitch-control commands can be used is to change the pitch of the entire message. This use has the constraint that there can be no pitch-control commands within the message itself. Once the message has been entered (without pitch-control commands), enter F5 (hex) and the message will be repeated. Then enter F1, F5 to repeat the message at pitch level 1. Likewise, F2, F5, F3, F5, F4, and F5 will repeat the message at the respective pitch levels. Words and phonemes may be mixed within a message.

Vocabulary Expansion. As previously mentioned, there are 532 unprogrammed locations in the system's EPROM that can be used for custom vocabulary expansion. Therefore, as new words, phrases, or sentences are developed they can

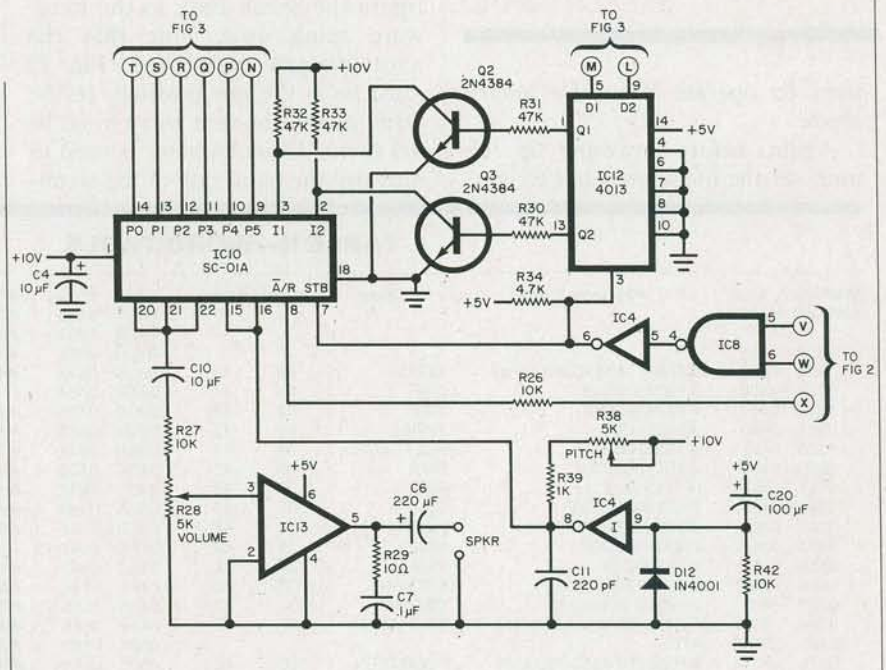


Fig. 5. The speech synthesizer (IC10) takes the required input data and delivers an output signal to a simple audio signal amplifier.

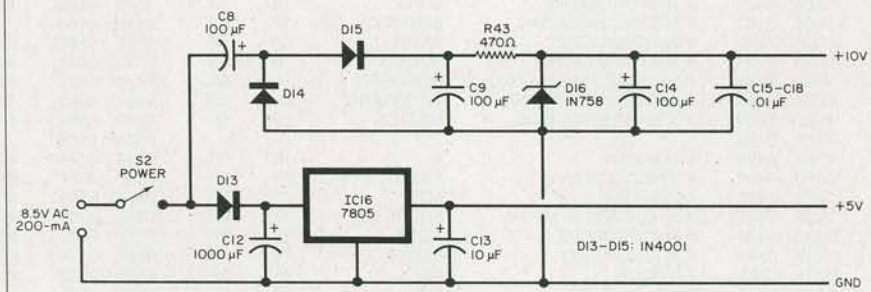


Fig. 6. Use this circuit for a power supply to drive the Speak-Easy speech board.

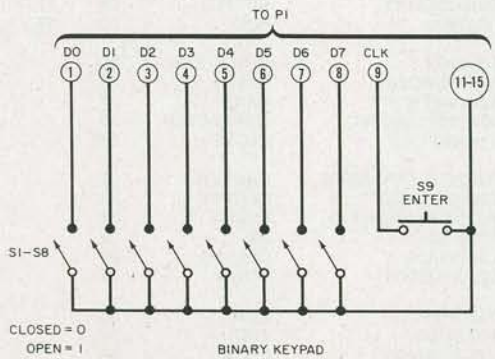


Fig. 7. For the stand-alone mode, this keyboard to enter phonemes must be built.

be added to the pre-programmed word list and called by a particular word label. (A separate EPROM programmer is required to do this.)

Valid word labels are from 00 to 7E (hex), with the remainder of the ROM for user-defined words. This means that 33 labels, 7F to 9F (hex), are available for expansion; that is, up to 33 words or messages may be added.

New entries to the pre-programmed word list are not limited to a single word per label, but can be a word, phrase, sentence, or even a whole paragraph for that label. For example, the sentence, "Good morning how are you" could be entered under a single word label.

TABLE III—BASIC PROGRAM

```
 10 PRINT CHR$ (13)
 20 REM OUTPUTS CARRIAGE RE-
    TURN FOR BAUD RATE
    INITIALIZATION
 30 PRINT "ENTER REQUIRED WORD
    ADDRESSES, END WITH
    PERIOD"
 40 REM FOR EXAMPLE 4C 66 74 WILL
    OUTPUT 'HOW ARE YOU'
 50 INPUT A$
 60 REM NEXT LINE OUTPUTS
    CONTROL-A CHARACTER
 70 PRINT CHR$ (01)
 80 PRINT A$
 90 REM LINE 80 OUTPUTS WORDS
    OR PHRASES
100 GOTO 50
```

TABLE IV—BINARY MODE COMMANDS

Command (Hex)	Result
0D	Auto baud rate test character (serial only)
F0	Turns unit on line
F1-F4	Pitch control
F5	String Terminator (similar to "," in ASCII mode
FF	Turns unit off line

There are a few limitations to the messages. The total length of all added messages cannot exceed 532 bytes, and messages must contain only hexadecimal phoneme codes (no ASCII codes or word labels). Also, if a pause is needed within a message, the phoneme pause PA1 (3E hex) must be used since the short pause PA0 (03 hex) is used to terminate all labeled phrases. Word labels must be consecutive, with no skipping. Similarly, memory locations cannot be skipped between messages or within a message.

Here's an example to illustrate vocabulary expansion. Suppose the phrase "Danger intruder alert" is to be stored in the EPROM vocabulary. Note that all three of these words are in the pre-programmed word list. Consequently, the phoneme codes can be copied directly from the word list as:

Danger . . .1E20220D1E1A3A2B03
intruder . .09000DA2B371E3A03
alert 0818233A2A03

If a word is chosen that is not contained in the word list, the phoneme codes for the word must be developed before proceeding. The pause 03 (PA0) at the end of the "Danger" and the "intruder" phoneme code strings should be replaced with 3E (PA1). Remember, this is to be a three-word message under one label. Therefore, 03 cannot be used within the message. The pause 3E (PA1) will produce a slightly longer pause between words. The 03 (PA0) at the end of the "alert" phoneme listing will terminate the message. The phoneme string for the message then becomes:

1E20 220D 1E1A 3A2B 3E09 000D 2A2B 371E 3A3E 0818 233A 2A03.

The space between each four characters is for visual clarity only. The phoneme string must go in the EPROM at the first available EPROM address, as previously discussed. The last entry is "yes" at address location 05E8. The phonemes that comprise "yes" require five bytes of memory, 05E8 to 05EC (hex), so the next available EPROM address is 05ED. The phoneme string for "Danger intruder alert" should be programmed into the EPROM from addresses 05ED through 0604 (hex). Since the last

label used for a "canned" phrase is 7E (hex), the label for this message will automatically be 7F (hex). Once the codes are stored in the EPROM, CONTROL A 7F (period) will produce the spoken message.

Stand-Alone Mode. The Speak-Easy can be used as a stand-alone talker with all the features of the binary mode, including phoneme, word, combined word and phoneme messages, message repeat, and pitch control. The only difference between the binary parallel mode and the stand-alone mode is that the phoneme/word data is entered with a small keyboard such as shown in Fig. 7.

The eight spst switches, *S1-S8,* are used to apply phoneme codes to the Speak-Easy's input port. An open switch applies a logic 1 and a closed switch applies a logic 0. Thus, the eight switches are set for the desired phoneme code, and ENTER switch (*S9*) is used to strobe the phoneme data into the input port. The ENTER switch must be debounced to prevent multiple entries of the data. Therefore, a switch debounce circuit is jumped between the ENTER switch and the strobe input of the I/O port.

Once the unit is powered, set switches *S1-S8* for 1111 0000 (F0 hex) and press ENTER to bring the unit on-line. Next, set the switches for 0000 0000 (00 hex) to select "zero" from the pre-programmed word list, and press the ENTER switch. Last, set the switches for 1111 0101 (F5 hex), press ENTER, and the unit will say "zero." It will respond this way every time ENTER is pressed as long as the switches are set for F5. It is important to recognize that the ENTER switch can be any electric switch, mechanical or electronic, that can close momentarily for about 200 ms.

One example of how this repeat feature can be used is for a speaking doorbell. The ENTER switch could be paralleled with a doorbell switch to initiate a message when the doorbell button is pressed. (The door switch should not be connected to anything else!) The sequence shown in Table V would produce the message "Hello, who is it" when the ENTER switch or alarm contacts are activated.

Set the switches for each code shown in the Table and ENTER it using the ENTER key. When the last entry (7) is set and the ENTER key is pressed, the message will be spoken. As long as the switches remain set to F5 (hex)—the start command—the message will be spoken every time the door switch (or ENTER) is pressed. Although this example uses only pre-programmed words, phoneme codes could also be used to construct the words. In fact, 3E (PA1) in Table V is actually the phoneme word for a pause.

The pitch can be changed by setting the switches to the desired pitch level, F1-F4 (hex), and pressing the ENTER key. Then set the switches back to F5 (hex) and press the ENTER key. Observe that the message says the same thing but at a different pitch level. Other messages may be entered in a similar manner. The message can also contain individual pitch-control codes, F1-F4 (hex) for effects. For example, the second sequence shown in Table V would produce a different pitch level for each word. However, the pitch of the entire message cannot be changed as before because the message itself contains pitch-control characters. A message can be up to 1023 characters in length including phoneme codes, word labels, and pitch-control characters.

As you can see, speech synthesis has become a practical system at moderate cost, whether or not you own a computer. You can build the programmable electronic talker described here on perforated board using point-to-point wiring or on a double-sided printed circuit board. Patterns for the latter are not included here because of their complexity. However, they can be obtained free of charge on request, with a self-addressed stamped envelope, from the source given in the Parts List. ◇

TABLE V—"HELLO, WHO IS IT"

Basic Switch Sequence

Entry	S8	S7	S6	S5	S4	S3	S2	S1	Action
1	1	1	1	1	0	0	0	0	Bring unit on line (if off-line)
2	1	0	0	0	1	0	0	0	Binary label for "Hello"
3	0	0	1	1	1	1	1	0	Phoneme code for PA1
4	1	0	1	1	1	0	1	0	Binary label for "who"
5	1	0	0	1	0	0	1	0	Binary label for "is"
6	1	0	0	1	0	0	1	1	Binary label for "it"
7	1	1	1	1	0	0	0	0	Binary command to start speech (switches must be left in this position).

Changing Pitch Levels

S8	S7	S6	S5	S4	S3	S2	S1	Action
1	1	1	1	0	0	0	0	on line command
1	1	1	1	0	0	0	1	select pitch level 1
1	0	0	0	1	0	0	0	"hello"
1	1	1	1	0	0	1	0	select pitch level 2
0	0	1	1	1	1	1	0	PA1 (pause)
1	0	1	1	1	0	1	0	"who"
1	1	1	1	0	0	1	1	select pitch level 3
1	0	0	1	0	0	1	0	"is"
1	1	1	1	0	1	0	0	select pitch level 4
1	0	0	1	0	0	1	1	"it"
1	1	1	1	0	1	0	1	start command