Remarkable new speech-synthesising chip

$60 teaching aid has computer speech!

Beneath the orange-plastic exterior of a new word-teaching device called Speak & Spell, Texas Instruments has hidden an impressive new speech-synthesising chip. The first application of the new chip is impressive, but it's the potential for the future that's really exciting.

by GREG SWAIN

"Spell 'hygiene'," commands the voice inside the orange plastic box. I key in the appropriate letters and they appear instantly on the green fluorescent display, the machine pronouncing each letter in turn: **"h-y-g-i-e-n-e.** Press the enter button and the response is an immediate **"You are correct. Now spell 'anything'."** This new prduct from Texas Instruments is a winner; you can't help but be impressed!

I hope you'll forgive my enthusiasm. You see, I've just spent the last couple of hours playing with an incredible new gadget.

That new gadget, called "Speak & Spell", must surely be one of the most innovative products to come out of Texas Instruments — or from any other electronics company for that matter — in years. Basically, it is a teaching aid, designed to teach young children the alphabet, word spelling and word pronunciation. What's causing all the fuss is that the device can actually speak, without having to resort to anything as crude as a pre-recorded message on a disc or tape.

Essentially a dedicated microcomputer, Speak & Spell stores more than 200 words in its semiconductor memory, and employs a patented one-chip voice synthesiser that many scientists had believed was years off. The device reads out its 200 words randomly for various exercises which are selected by means of a keyboard. These exercises include a spelling quiz with four levels of difficulty, hangman (a spelling game), and various other word games.

The voice inside the orange case spelt instant fascination for Editor Jim Rowe's young children. From left: Anne (11), Penny (5) and Grant (9).

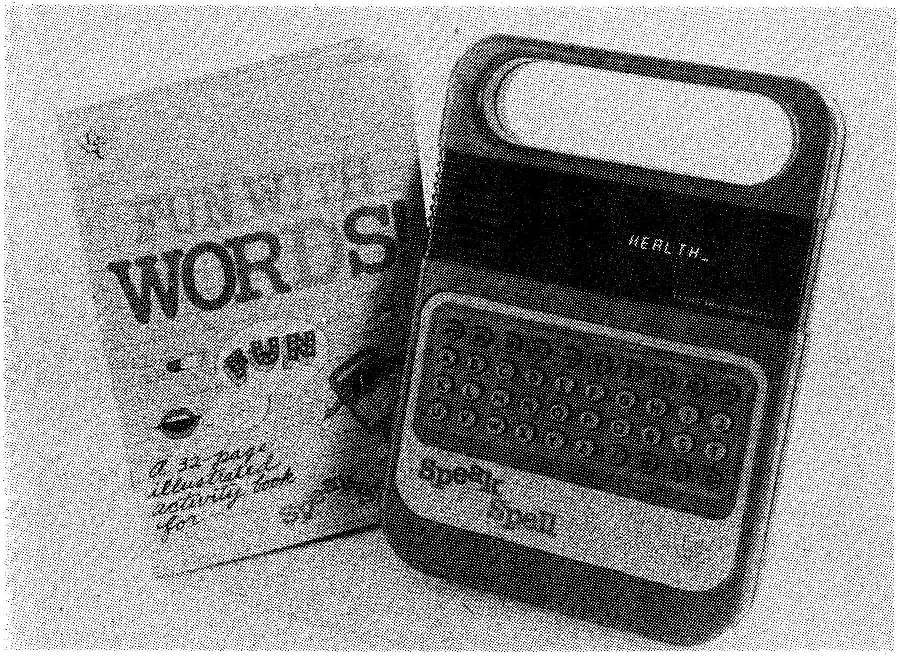
TI says that the words programmed into Speak & Spell are common reading and spelling stumbling blocks. They're words like *anxious, ocean, language, obey* and *learn.* "They're not uncommon words", says TI. "They're problem words."

The device is simple to use. Press the "ON" button, and Speak & Spell turns on in the "Spell A" mode; that is, the least difficult spelling quiz. Three further levels of increasing difficulty of about 50 words each can be selected by punching in the letters B, C and D. Punch the "GO" button, and the unit pronounces the first word to be spelt.

The child, using the keyboard, now attempts to spell the word. The unit pronounces each letter at it is entered, and displays it on the fluorescent readout. A correct spelling is verbally acknowledged by the machine, which then gives the next word to be spelt. An incorrect spelling is met with **"Wrong, try again",** and the word repeated.

If the child fails after two tries, Speak & Spell says **"That is incorrect",** and goes on to spell the word, pronouncing each letter and the entire word. At the end of every 10 words,Speak & Spell announces the score and shows it on the display. The unit praises a perfect score, and announces the score in a "matter-of-fact" way for poor performances.

The word guessing game, or hangman, is one well known to children (and to most adults as well). Dashed lines on the fluorescent display indicate the number of letters in the mystery word selected at random by the machine, and if you key in seven in-



Speak & Spell comes with a 32-page activity book. Unit reads out its 200 words randomly for various spelling exercises selected via the keyboard.

correct letters you lose. A correct letter guess is greeted by musical tones and is shown in its appropriate position on the display.

At the end of the game, the unit declares the winner by announcing "You win", or "I win".

If all that sounds impressive, consider the following:

- the unit varies its response at the end of each correct spelling;
- it can code and decode words and phrases;
- optional plug-in modules allow the vocabulary to be expanded;
- a single word or an entire list of 10 words can be repeated at the touch of a key;
- there is provision for a pronunciation drill. A word is displayed, the unit says **"Say it"**, then pauses while the student pronounces the word. It then gives the correct pronunciation;
- the unit can provide random letters for a variety of games; and
- words that sound the same but are spelt differently are defined.

Take the lastpoint, for example. One of the words in the spelling test is "yolk", and the command is **"Spell 'yolk' as in egg"**. This is to avoid any possible confusion with the word "yoke", which has quite a different meaning.

The way in which the machine varies it's response at the end of a correct spelling is most intriguing. In fact, it's almost human in this aspect of its behaviour, varying the response from **"That is right,"** to **"That is correct"**, or **"You are correct"**, or **"You are right"**. The command to spell a new word is similarly varied.

Another interesting point is that the letters on the keyboard are arranged in alphabetical order, rather than in typewriter-keyboard fashion. Why? The reason presumably has to do with the fact that this would be an excellent unit for teaching the alphabet to young children. Used in this mode, it is only logical for the letters to be in alphabetical order.

The appearance of the unit is disarmingly simple. A bright orange case of rugged, high impact plastic is used to house the electronics. Colour-coded keys set against a blue, orange and yellow background, together with the fluorescent display, combine to produce a toylike appearance. It is, after all, designed to be used by children.

But the simple appearance of Speak & Spell belies the complex electronic technology hidden inside that bright orange exterior. Heart of the system is the new one-chip voice synthesiser. It reproduces words uttered by a male voice, has a distinct nasal sound and — you've guessed it — has an American accent!

In fact, it sounds like an American male with a bad cold!

The voice synthesiser chip, which TI calls the TMC0280, is a MOS device containing an entire digital signal processor with timing and decoding circuits, a 10-stage digital filter and a D/A converter. Used in conjunction with a pair of 128k ROMs and a special version of the TMS1000 8-bit microcomputer, the silicon chip can produce a total of 200 seconds of sounds for the 200-word vocabulary. However, it is capable of accessing a lot more memory — as much as 2.1 megabytes in fact.

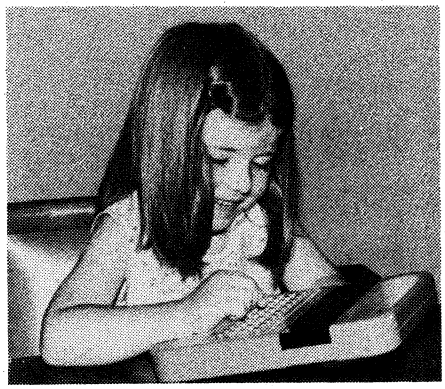
Since the speech generator uses memory at a maximum rate of only 1200 bits per second, it could be designed to speak for as long as 30 minutes.

The data used to make up the spoken words is encoded into the two ROMs by means of a complex mathematical procedure. This procedure, called linear predictive coding (or LPC), divides the analog signal representing each word into a number of slices and digitises the most significant characteristics for storage in ROM.

Speech is first broken down into voiced and unvoiced sounds. Voiced sounds like *l, o,* and *m* have a definitie pitch and include vowels and fricatives that can be represented by low-frequency, high amplitude signals. Unvoices sounds, like *s, f* and *sh,* are represented by low-amplitude, random high-frequency signals similar to white noise.

In use, the new "talking" chip randomly takes data from a ROM every 20ms — from 4 to 49 bits, depending on the complexity of the sound — and uses this data to synthesise an analog waveform with sufficient fidelity for intelligible speech. The characteristics of the vocal tract are simulated by processing the data stored in ROM through what is effectively a variable formant filter.

Impressive, clever, innovative — all these adjectives apply now to Speak &



Speak & Spell is easy to use. Even five-year-old Penny can have fun learning the letters of the alphabet.

Spell. But as impressive as the product is, it's the potential of the basic speech synthesising system for the future that really makes one stop and wonder. In fact, the voice synthesis and semiconductor technology behind Speak & Spell has so much market potential that it has stunned competitors.

Although tight-lipped about future product plans, TI must surely view a near future in which spoken words will replace warning lights in cars and airplanes, or just about any place where recorded message and answering systems are needed. One promising near term application is a machine that could teach foreign languages.

Gazing further into the crystal ball, one sees such products as dictionaries

(Continued on p126)

HERE IT IS!
THE SYNTHESIZED VOICE

SPEECH IS CREATED THROUGH THE NEW REVOLUTIONARY "VOICE SYNTHESIZER IC" FROM TEXAS INSTRUMENTS, WHICH SCIENTISTS BELIEVED TO BE YEARS AWAY.

THE MOST INNOVATIVE PRODUCT, WHICH MAKES USE OUT OF THIS BREAKTHROUGH TECHNOLOGY, IS "SPEAK & SPELL" from TEXAS INSTRUMENTS. It contains:- two 128k ROM's, storing more than 200 words (provision for expansion), special version of the TMS 1000 Microprocessor IC (capable of addressing up to 2.1 megabytes), Voice-Synthesizer IC with 10-stage digital filter and digital to analogue converter, 8-digit alpha-numeric Display etc. After seeing, operating and hearing "Speak & Spell" you will agree, that it is the ultimate in Self-Teaching-Aids for children, also blind poeple will find it of invaluable help.

SPEAK & SPELL MOTIVATES THE STUDENT TO BECOME A BETTER SPELLER AND READER.
Speak & Spell is a confidence builder. It can give students an edge in spelling and pronouncing words normally difficult for their age and grade levels.
Speak and Spell is an interest builder too, It helps encourage longer study sessions by providing instantaneous grading and words of praise. Happy musical tones precede each new activity selected and accompany student scores.

Teaches the everyday words most often misspelled.
More than 200 of the most common reading and spelling stumbling blocks are programmed in Speak & Spell's computer-like memory. They're the words the noted educators report to be most frequently misspelled from beginning spelling through adulthood. They're words like anxions, ocean, language, obey and learn. They're not uncommon words; they're "problem"words. These exceptions to the rules typically have to be learned by rote.

Here's how it works.
Speak & Spell pronounces the word. Student keys-in the spelling. Speak & Spell praises students for right answers and encourages them to try again when they miss. Pressing a key can have a word repeated ("Repeat" key). Another key can get an entire list replayed ("Replay" key). Another key can change the spelling before it's entered and scored ("Erase" key).
After every set of 10 words, the "voice" of Speak & Spell announces the score as it's shown on the display. The unit praises students for good scores and encourages them to try again when they miss.

Speak & Spell provides 4 levels of spelling achievement. For beginning spellers and up.
Students progress through four levels of about 50 words each, setting their own pace. Level one starts with words students encounter as beginning spellers. As they gain confidence and skill, they progress up the range to tougher, more challenging words.

Pronunciation drill improves vocabulary.
Speak & Spell is converted to a pronuciation quiz instantly with the "Say-It" key. A word is displayed, the unit says, "Say it", then pauses while the student pronounces the word. It then gives the correct pronuciation.

Games add extra dimension of fun.
Speak & Spell is a "must" for rainy days and long trips. The student can complete in a number of games against the unit alone or in a group with friends or family.

"Mystery Word".
Similar to the age-old Hangeman game, Speak & Spell lets players guess words one letter at a time. Pressing a "Clue" key can give the player hints and turn this into a new game. At the end of the game, the unit declares the winner by announcing, "You win", or "I win".

Secret Code.
Speak & Spell codes and decodes words and phrases. Children can use Speak & Spell as a "secret agent" device. Older youngsters and adults can use it to play "Cryptograms."

Letters.
Speak & Spell provides random letters for a variety of games which are covered in the activities booklet and that children make up themselves.

Expandability.
Provison for future plug-in modules.

Children have fun learning spelling, pronunciating and reading.
As spelling and pronuciation skills improve, reading comprehension is improved as well. Speak & Spell has been created scientifically with the guidance of leading educators to sharpen world skills scientifically. It involves the student three ways: hearing the word, spelling the word, and seeing the word. Speak & Spell is designed to impress a word on a child's mind in a lasting manner. It helps extend the student's classroom experience in a fascinating way that's never been possible before.

Special Activities booklet.
Speak & Spell comes with a 32-page illustrated book, "Fun with Words," filled with stimulating spelling games and activities for young students. Easy-to-understand instructions coupled with colourful graphics make this educational addition to each Speak & Spell package a very special bonus.

Power requirements & Warranty.
4 C cell batteries, Warranty - one year.

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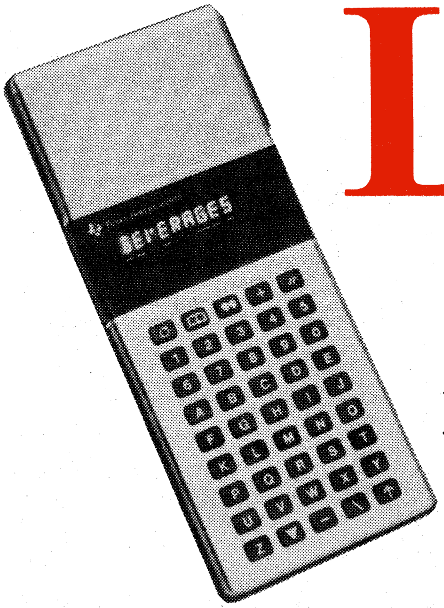


Language

Recently introduced into Australia, Texas Instrument's talking language translator can actually speak over 500 words and 3000 phrases in English, French, German and Spanish. Modules are also available for Chinese and Japanese. Suggested retail price is around $300. Enquiries to Texas Instruments Australia Ltd, PO Box 106, North Ryde, NSW 2113.

Translation and instant information are just the beginning. New models promise much more, with graphics displays and interfaces to computers. Soon even talking translators will be available.

by BILL HAWKINS

"Want to try a Ramos Fizz?" asked Eliot Hess, a representative for the Craig Corporation, as he pushed a couple of buttons on his hand-held language translator. The display blackened for a moment and then, like a Times Square billboard, began spewing the secret ingredients to a drink I didn't even know existed. Not only did it tell me I needed such things as one-half teaspoon of orange-flower water; it also told me how to mix and serve the concoction.

What business does an exotic drink have in a language translator? Lots, says Hess (millions of dollars of business, in fact), and playing bartender is just one trick these new portable information centres can do.

A translator could plan your next dinner, help you choose a wine, and actually speak to a waiter in his native language to order the meal. It could play chess while you're waiting, teach you a language as you eat — even prescribe medical remedies for the indigestion later.

And that's just the beginning. Now there are new models from which to choose, each with the ability to hold virtually any information you need.

Sure, they still translate languages, but even that's being improved. The newest plans call for increased capability to conjugate verbs, get the proper gender, and even correct syntax through the use of more phrases. But even with advances, language translations are quickly becoming just one of their varied functions.

Recently Craig has been joined by Nixdorf (formerly Lexicon), Sharp, and Texas Instruments, with Panasonic readying a version at this writing. All the translators look and feel like oversize pocket calculators. A keyboard lets you enter your question; a digital display gives you the answer.

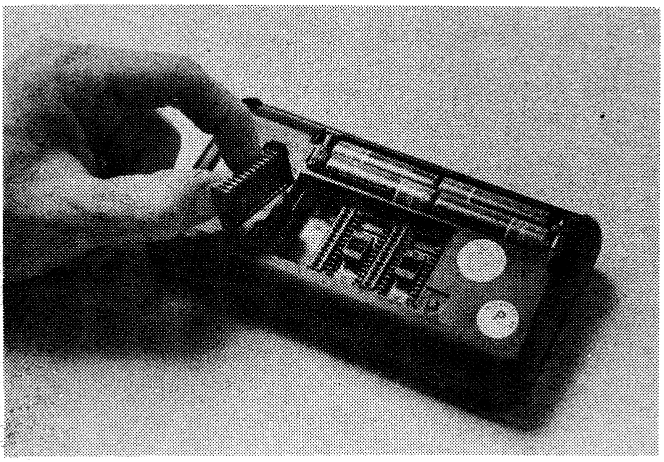
But the secret to their ability and what can make each one different is in their programming – the individual instructions and raw data used by the translator's microprocessor.

Module mania

Like the plug-in cartridges of a video game, these translators are programmed for a specific function with one or more plug-in modules. While one module may teach it the basics of Italian, another may contain statistics on the Olympic games.

The modules are the key to the versatility of these machines, so manufacturers are in a frenzy to "digitise" as much data on as many different subjects as possible.

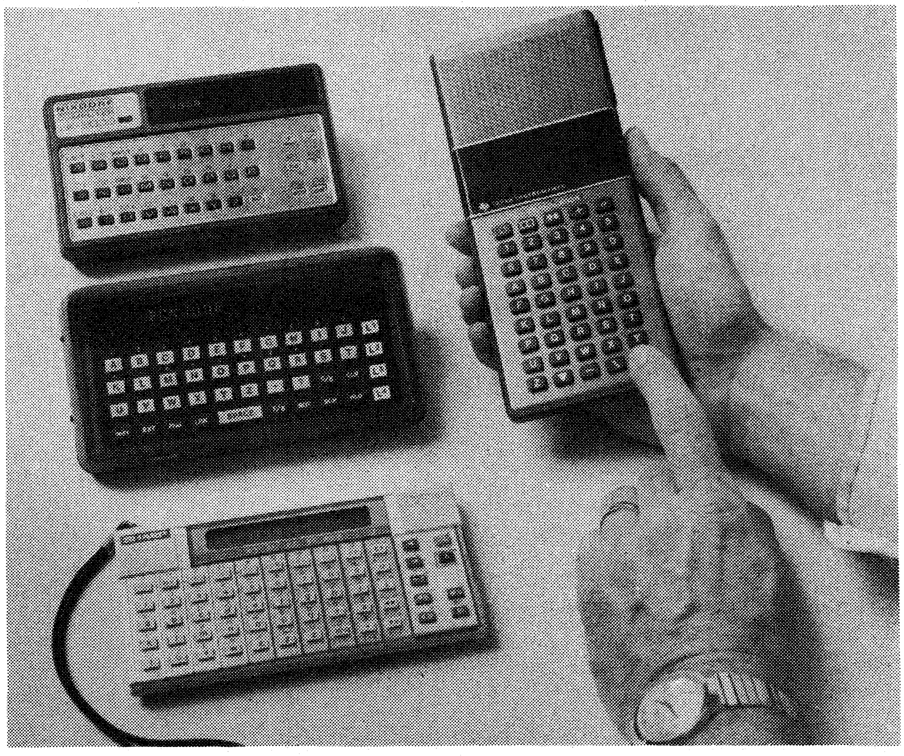
For example, besides the bar/wine and diet/nutrition module, the Craig unit will translate Spanish, French, German, Italian, and Japanese literally – and with an additional module, it will display the words



The Craig translator accepts up to three modules at once for cross-translations and phonetic spellings. US price is $200.

Nixdorf unit ($US140) accepts language modules ($US60) or interface connectors ($US150) for attaching it to a computer.

Translators



ENTER WORDS or phases in one language; get a literal translation in another. Pictured are translators from Nixdorf, Craig, Sharp and Texas Instruments.

phonetically, making it easy for you to say them.

The Nixdorf translator accepts French, Spanish, and German modules, along with data modules that let you add your own information if you wish. Plug in the European soccer-league module, for example, and you can update it yourself at the end of the next ball game.

The Nixdorf also accepts interface modules. These are special connectors that allow you to attach the unit (directly or by phone) to a large conventional computer. For now, on-the-road salespeople, for example, could use this attachment. And not long from now, a quick connection to your home computer could load the unit with an updated shopping list or your daily appointments.

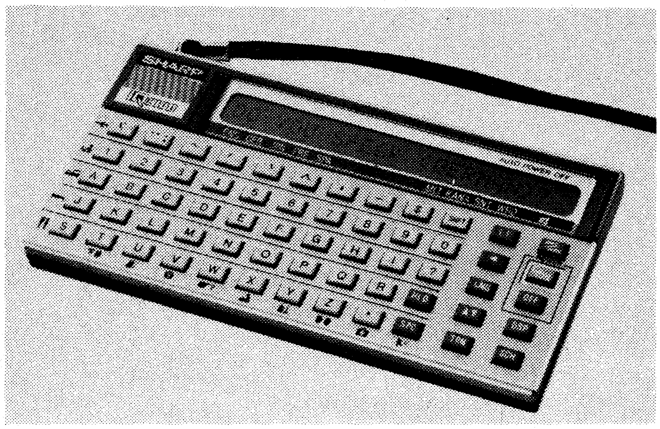
The Texas Instruments' translator also accepts Spanish, French, and German modules, but what it does with them could make you the envy of any linguist: It talks. Each module contains digital information to represent human phonetic sounds. When put together electronically, they become about 300 spoken words that will make up some 3000 phrases.

Now if all this sounds quite incredible, I should tell you that everyone I spoke to emphasised that this is just the start. Future plans from Panasonic, for example, include add-on devices such as a printer or video-display terminal along with educational and game modules.

Sharp designers have a speaking translator in the lab, and their present model has a curious dot-matrix display. The designers aren't talking – in any language – but it could display a lot more than just conventional letters and numbers.

At present, the limitation is the memory capacity inside each module, but that's sure to change. Within just the next couple of months, both Craig and Nixdorf plan to switch to a newer, double-density module. For translations, it means more words and verb conjugations. It could mean virtually anything in the data modules.

And what will happen with even higher-density memories, such as bubble technology? "We see it as the ultimate traveller's aid," said a TI spokesman. "And the day will come when you'll simply speak into one end – like a tape recorder. The translation will come out the other."



Sharp's latest translator, the IQ3100, should be available in Australia by July. It will feature modules able to translate from English to Japanese, German, Spanish and French.

The RL-T500 from Panasonic can accommodate up to three memory capsules simultaneously and features an in-built four-function calculator. Unit is not yet available in Australia.

AMAZING BOO-BOO

A manufacturer's mistake means we can sacrifice these incredible CRAIG language translators at a staggering

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SAVE $180
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SPELLS THE WORDS AS THEY ARE PRONOUNCED
Cat. Y-1347
$12.00

How would YOU like to be able to convey your thoughts, needs and questions in another language? Well now you can! The CRAIG M100 enables you to type in a message and at the touch of a button translate that message into another language. It even has whole phrases that can be called up at the touch of a button and partial phrases to which you can add your own ending. A truly remarkable unit that can calculate (e.g. currency conversions) and it has inbuilt metric conversions, a great boon! The Craig M100, a true hand-held language computer with RAM, ROM and CPU! Ideal for businessmen on overseas trips, students studying languages etc.

YOU REAP THE BENEFIT

It is recommended that you use 4 Duracells (Cat. S-3280) at $2.78 or 4 NiCads (Cat. S-3300) at $2.05 each. If using the NiCads they can be recharged in the Craig M100 by using the M-9525 battery eliminator which also serves to power the unit from the AC. The M-9525 is great value at $6.90.

LANGUAGE CARTRIDGES

French (Y-1341):
Japanese (Y-1342):
German (Y-1343):
Italian (Y-1344):
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SAVE 60%
Normally $35 ea.
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Add speech to any computer with the

Compuvoice computer speech synthesiser

The time has come for computers to speak for themselves! Our speech synthesiser project can be used with any computer that has a Centronics type parallel interface and adds a versatile, easy to use voice — with an almost unlimited vocabulary.

by PETER VERNON

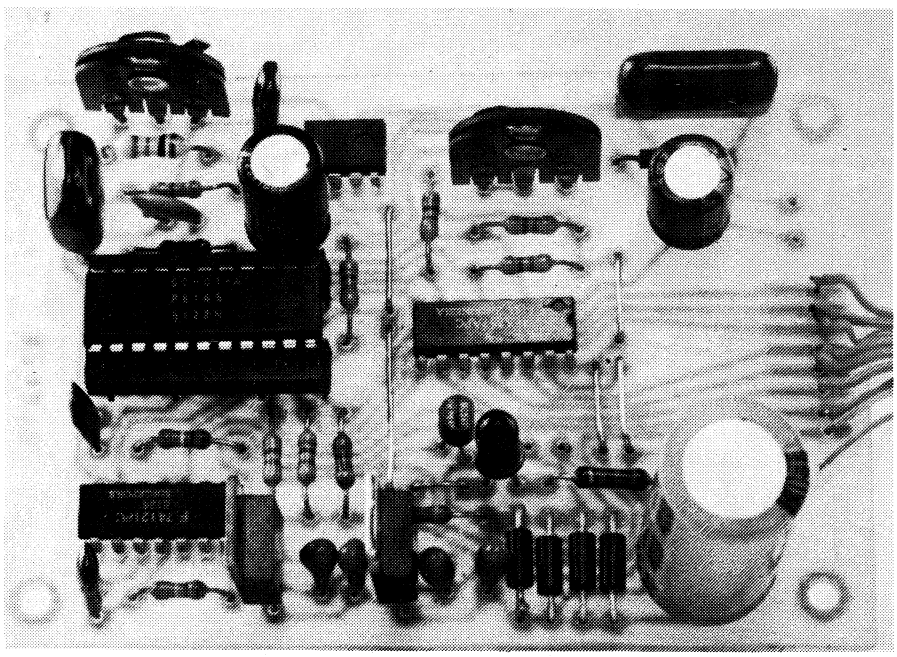
Talking computers are not new — systems with limited vocabularies have been available, at a price, since the 1960s. What is new is the low cost and versatility of single chip speech synthesisers.

Apart from the challenge to experimenters and the sheer fun of speaking computers, voice synthesis has some serious applications. Obviously, speaking computer terminals are useful for conveying information to a user who cannot sit with eyes glued to the screen. Speech can also provide computer facilities to the blind and visually handicapped, and there are a number of talking calculators available for this purpose.

Voice Input/Output also seems to be the coming thing for consumer items. Already announced in Japan are a television set which responds to voice commands, and a microwave oven that actually tells you "dinner is ready"!

What is lacking though, is a low cost set-up for the experimenter. Tandy's voice synthesiser for TRS-80 machines, and the Type 'N-Talk for the System-80 are available, but these devices cost over $500, and are designed for use with particular computers.

Both devices are based on chips from the Votrax division of the Federal Screw Works, a United States company which also manufactures the Votrax SC-01 single chip speech synthesiser.



The speech synthesiser can be connected to a standard Centronics port.

This project is based on the SC-01 chip, and can be connected to any computer which has a Centronics-compatible parallel output port. With our design you can have a computer-controlled speech synthesiser for around $100-$150, depending on what sort of case, loudspeaker and connectors you choose.

Since the Votrax chip produces individual sound units, or "phonemes" on command, and these can be strung together in any combination, our speech synthesiser can produce any word at all, unlike systems such as the National "Digitalker" which store whole words in ROM, and hence have a fixed and limited vocabulary.

Votrax SC-01

The 22-pin Votrax SC-01 chip contains a phoneme controller and a series of filters which form an electronic analog of the human vocal tract. The phoneme controller translates a six-bit phoneme code into a series of parameters for the vocal tract model, while two inflection bits control the pitch of the noise tone sources fed to the filters.

Overall, the output pitch of the phonemes is controlled by the frequency of the clock signal, set with an external resistor/capacitor combination. We did not make use of the two inflection inputs (pin 2 and 3 of the SC-01) as we have found that the automatic inflection provided by the chip itself is satisfactory.

A phoneme sound is produced when a six-bit phoneme code is placed on the control register input lines (P0 to P5) and latched by a pulse on the strobe (STB) input. Each phoneme sound has a duration of from 47 to 250ms, and variations in the clock frequency affect this duration.

The six-bit digital code gives 64 possible codes. There are 25 different consonant sounds ("c", "p" etc), 36 vowel sounds, two pause codes and a "stop synthesis" code.

In the English language, there are five vowels ("a", "e", "i", "o", "u"), so some of the 36 vowels of the SC-01 are the same

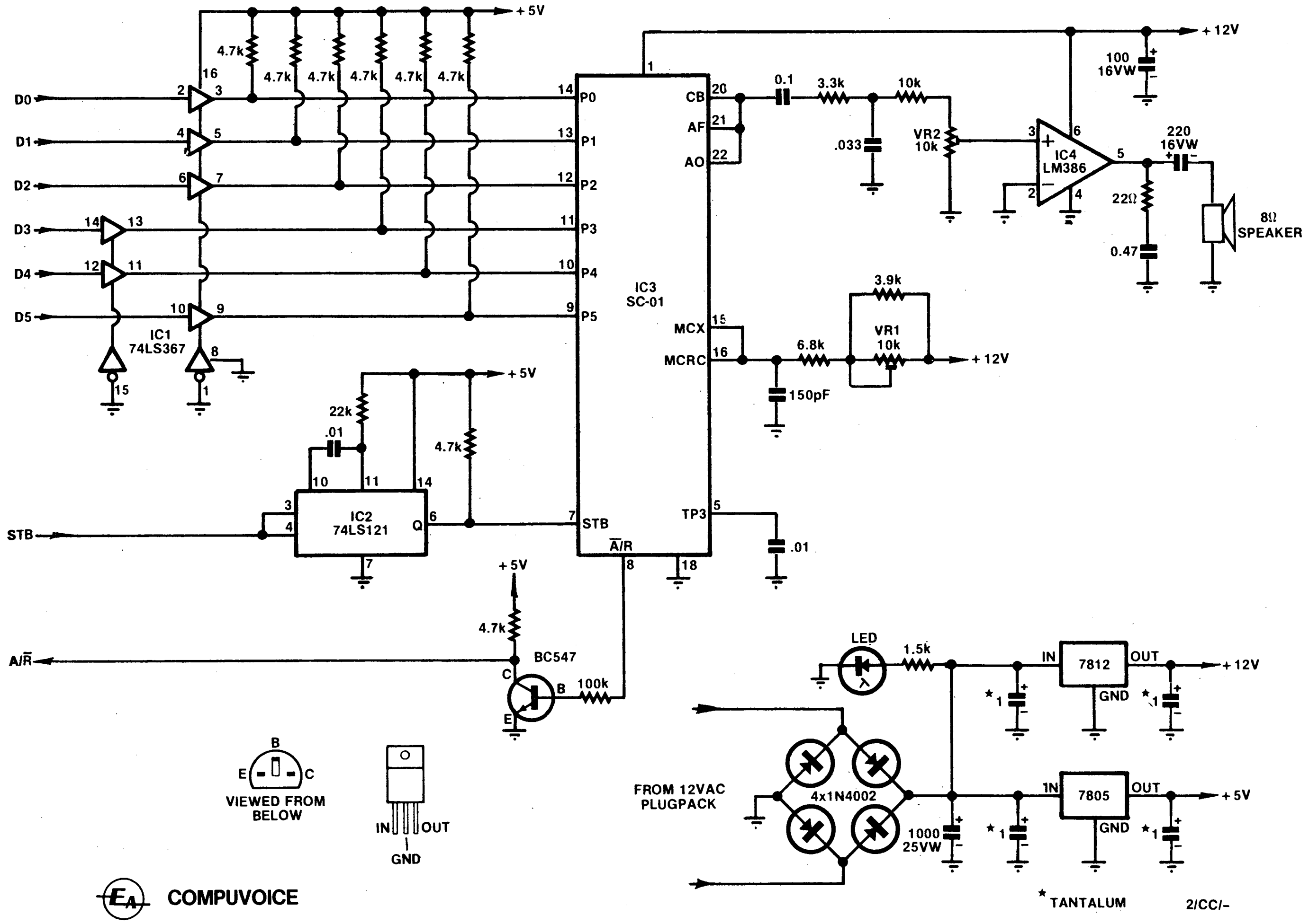


Fig. 1: the full circuit diagram is shown above. Note that inflection inputs of SC-01 are not used.

basic sound with differing durations. For example, while EH is the phoneme symbol for the "eh" sound in "ready", EH1, EH2 and EH3 are the same sound with progressively shorter durations. EH3 is the shortest, as in "jacket". Table 1 shows the various phoneme symbols, the sounds they make and the ASCII character for each phoneme.

By selecting the appropriate phonemes in the correct order, any word in the English language can be produced by the SC-01, plus words in many other languages. (Swahili is a bit beyond the SC-01 because it can't produce the nasal click sounds, but French and German should be quite feasible with careful programming.)

How it works

As shown in Fig. 1, a data buffer (IC1) drives the phoneme code inputs of the SC-01, with external pull-up resistors on the buffer outputs to ensure compatibility with the synthesiser chip. The data is latched on the rising edge of the positive-going strobe pulse on pin 7 of the SC-01, the STB input line.

The SC-01 requires some setup time before it can accept the strobe signal. The data on the phoneme input lines must be stable for at least 450ns before the rising edge of the strobe pulse and the logic level on the STB input must be low for approximately 100 microseconds (72 clock periods) before it goes high for the strobe pulse.

Many strobe pulses used with printer interfaces do not fulfil these requirements, which is the reason for the inclusion of IC2, a monostable which "stretches" the strobe pulse from the printer interface to around 100 microseconds before passing it to the SC-01.

The A/R output of the SC-01 is at logic 1 when the synthesiser is ready to accept data, and goes to a logic 0 while a phoneme is being produced. This line serves the same purpose as the BUSY signal produced by a printer.

The A/R line produces a CMOS compatible signal, swinging almost to the full supply voltage of the SC-01. This is not suitable for connection to the TTL circuitry of the typical printer port, so a transistor is used to translate this level to +5V. The transistor also inverts the A/R signal, so the final output is 1 when a phoneme is sounding and 0 when the synthesiser is ready to accept a new phoneme code. This corresponds with most printer drivers.

An external capacitor/resistor combination on pins 15 and 16 of the SC-01 set the frequency of the internal clock circuit of the speech synthesiser. The frequency of the clock (nominally 720kHz) affects the pitch of each individual sound and also the rate at which phonemes are sounded. By varying VR1 through its range, the speed of speech can be controlled, from "chipmunk style" to very slow.

The SC-01 has three audio outputs which can be configured to drive simple class-A or complementary class-B amplifier stages. In our version, these three outputs are connected together, passed through a simple RC filter and fed to an IC power stage, IC4. This is an LM386 which is capable of delivering up to 700 milliwatts into an 8Ω load. It has an internal network giving a fixed gain of 20. A Zobel network across the amplifier output consisting of a 22Ω resistor and 0.47μF capacitor helps ensure circuit stability.

A 12VAC plug pack adapter provides the power supplies for the project. The TTL circuits of course require 5V, while the CMOS Votrax chip and the integrated circuit amplifier require a supply voltage between 7V and 14V. We have chosen 12V.

We are presenting the project as a PCB only, leaving constructors to make their own decisions about a box for the synthesiser and loudspeaker.

Begin construction with the power supply section, taking care that the diodes, regulators and electrolytic capacitor are installed with the correct polarity, as shown in the component overlay diagram. We have included a LED in the +5V line as a "power on" indicator, and this too must be correctly oriented.

When this section is complete (not forgetting the bypass capacitors on the input and output of both regulators) connect the plugpack and check the voltages supplied by the regulators. If all is well, disconnect the plug pack and continue with construction of the speech synthesiser.

Install the resistors and capacitors as shown on the overlay diagram, again taking care that the electrolytic and tantalum capacitors are correctly oriented. The two 10kΩ trimpots can also be installed at this point.

As shown on the circuit diagram, VR1 controls the clock frequency of the Votrax chip, affecting the pitch and duration of the sounds produced. VR2 is the volume control, and may be replaced with a 10kΩ potentiometer mounted on the front of the case if you require an accessible volume control. Keep the wiring to the potentiometer as short as possible if you elect to do this.

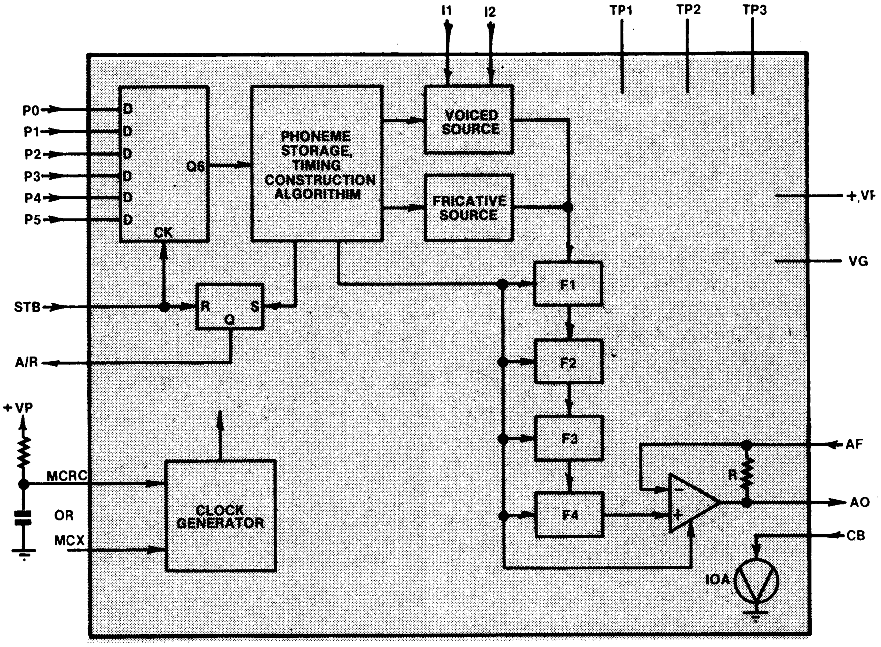
We found in practice that once the trimpot is adjusted for a comfortable volume level further adjustment was unnecessary, so we did not mount an external volume control.

There is one transistor to be installed, and this must, of course, be mounted the correct way round. The circuit diagram shows the lead configuration.

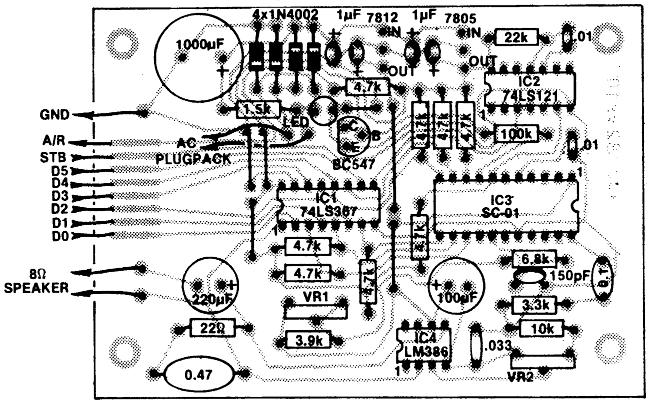
At this stage the integrated circuits can be installed – except for the SC-01. We elected to use a socket for the Votrax chip but had difficulty finding a source of 22-pin IC sockets. As an alternative, we obtained a strip of single-in-line wirewrap sockets and cut two lengths to suit. Molex pins could also be used.

Install IC1, IC2 and IC4, and whatever socket you decide to use for IC3 (the SC-01). Before proceeding connect the plugpack and power up again. Check for 12V on pin 1 of the socket and ground on pin 18. Turn off the power.

The Votrax chip is a CMOS device, and is sensitive and very expensive as you will be aware if you purchase this kit. Do not remove it from its conductive foam or foil package until you are ready to install it in its socket. Take the usual precautions against static discharge (ground yourself by touching an earthed appliance before handling the SC-01) and try not to touch the pins of the chip as you install it.



Internally the SC-01 consists of a phoneme storage unit and a series of digital filters, simulating the human vocal tract.



The component overlay diagram is shown at right.

Our synthesiser is connected to the computer by a ribbon cable terminated in a 34-way double-sided edge connector. There are six data input lines to the board, a strobe signal and a BUSY signal from the synthesiser to the computer, in addition to the ground connector. The pin connections we have shown in Fig. 3 suit the standard Centronics parallel format as used by most computer systems that incorporate a parallel printer port, including the System-80 expansion interface, the Super-80 printer interface and our TRS-80 parallel interface project (September 1981).

PIN		FUNCTION
1		STROBE
3	DATA	D0
5	"	D1
7	"	D2
9	"	D3
11	"	D4
13	"	D5
15	"	D6
17	"	D7
19		not used
21		BUSY (from synthesiser)
23-33		not used
2-24		GROUND
26-34		not used

Centronics edge connector pin-outs

Programming in phonemes

As shown in Table 1, each phoneme that the SC-01 can produce may be represented in three ways. Column one of the table shows the six-bit hexadecimal code for each basic sound, while column two shows the Votrax "phoneme symbol".

Column three shows the particular ASCII character whose six lowest bits correspond to the hexadecimal phoneme code. For instance, the hexadecimal 01 code corresponds to the phoneme code "EH2" and the ASCII code for "A" (ASCII "A" is 41 in hexadecimal – the six lowest bits give us 01, the hex phoneme code). Column four of the table gives one example of a word in which each corresponding phoneme (bracketed) occurs.

The most convenient way of programming the speech synthesiser is to send it the ASCII characters corresponding to the phoneme codes we want to produce.

"LPRINT", a statement contained in most versions of Basic, will transmit to a printer anything between quotation marks, except for the quotation marks themselves and a few control characters, whether it is a valid word or not. This means that driving the speech synthesiser is as simple as writing;

```
LPRINT "]B#X#57"; "?";
```

If you try this the synthesiser will say "hello".

The semi-colons in this statement are quite important. The SC-01 will continue to produce the sound of the last phoneme code it receives until a new code is sent. Basic normally sends a Carriage Return character after each LPRINT statement, and a carriage return (OD in hex) is the ASCII code for the "N" phoneme. The first semi-colon suppresses the transmission of a carriage return, while the "?" represents the STOP code which silences the synthesiser. Don't forget the final semi-colon.

A test routine to make phoneme sounds or complete words can use the following program;

```
10 INPUT A1$
20 IF A1$="END" THEN END
30 LPRINT A1$; "?";
40 GOTO 10
```

Line 20 allows us to exit the test program by typing END. Otherwise the program continues to loop, asking for a sequence of ASCII codes and sending them to the synthesiser.

Words can also be constructed by selecting the phoneme codes which correspond to each syllable of the desired word and constructing a string of the equivalent ASCII codes for transmission to the speech synthesiser.

Several lists of words and their corresponding phoneme codes have been published, such as in Byte magazine for June 1981. Unfortunately lack of space prevents us from publishing our own list this month. Look for it in the next issue

Phonemes can be put together to produce almost any word. But the problem then is to translate the phoneme code to ASCII. We have solved that problem by using the computer.

We have produced a program (listing 1). This takes a sequence of phoneme codes, looks up the corresponding ASCII code, and then sends it to the speech synthesiser. It was developed on a Super-80 fitted with a printer interface board and driven by the parallel printer program published in EA, May 1982.

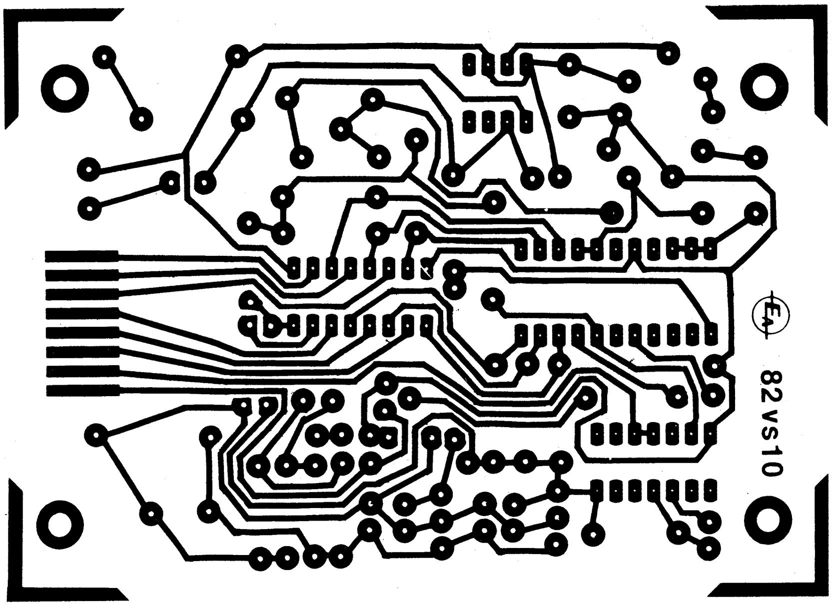
Users of other computers will notice a couple of differences in the string hand-

Table 1: Votrax phoneme codes

Hex Phoneme Code	Phoneme Symbol	ASCII Character	As in Example
ØØ	EH3	@	jack(e)t
Ø1	EH2	A	(e)nlist
Ø2	EH1	B	h(ea)vy
Ø3	PAO	C	no sound
Ø4	DT	D	bu(tt)er
Ø5	A2	E	m(a)ke
Ø6	A1	F	pa(i)l
Ø7	ZH	G	plea(s)ure
Ø8	AH2	H	h(o)nest
Ø9	I3	I	b(i)t
ØA	I2	J	(i)n
ØB	I1	K	(i)t
ØC	M	L	(m)at
ØD	N	M	su(n)
ØE	B	N	(b)ag
ØF	V	O	(v)an
1Ø	CH	P	(ch)ip
11	SH	Q	(sh)op
12	Z	R	(z)oo
13	AW1	S	l(aw)
14	NG	T	thi(ng)
15	AH1	U	f(a)ther
16	OO1	V	l(oo)king
17	OO	W	b(oo)k
18	L	X	(l)and
19	K	Y	tric(k)
1A	J	Z	(j)u(dg)e
1B	H	(left square bracket)	(h)ello
1C	G	(slash)	(g)et
1D	F	(right square bracket)	(f)ast
1E	D	(up arrow)	pai(d)
1F	S	(back arrow)	pa(ss)
2Ø	A	(space)	t(a)me
21	AY	!	j(a)de
22	Y1	"	(y)ard
23	UH3	#	miss(i)on
24	AH	$	m(o)p
25	P	%	(p)ast
26	O	&	c(o)ld
27	I	'	p(i)n
28	U	(	m(o)ve
29	Y	)	an(y)
2A	T	*	(t)ap
2B	R	+	(r)ed
2C	E	,	m(ee)t
2D	W	-	(w)in
2E	AE	.	d(a)d
2F	AE1	/	(a)fter
3Ø	AW2	Ø	s(a)lty
31	UH2	1	(a)bout
32	UH1	2	(u)ncle
33	UH	3	c(u)p
34	O2	4	b(o)ld
35	O1	5	ab(oa)rd
36	IU	6	y(ou)
37	U1	7	J(u)ne
38	THV	8	(th)e
39	TH	9	(th)in
3A	ER	:	b(ir)d
3B	EH	;	r(ea)dy
3C	E1	<	b(e)
3D	AW	=	c(a)ll
3E	PA1	>	pause
3F	STOP	?	no sound

Compuvoice: Program listing 1

```
00010 CLS
00100 DIM B0(50),B(50)
00110 PRINT "ENTER PHONEME CODES"
00120 PRINT "SEPARATED BY SPACES."
00130 PRINT "PRESS RETURN AT END."
00140 PRINT"TO QUIT PRESS RETURN"
00150 PRINT "WITH NO ENTRY"
00160 C=0:PRINT
00170 INPUT A0$
00180 A0$=A0$+" "
00200 IF LEN(A0$)=0 THEN GOTO 400
00210 C=C+1
00220 FOR I=1 TO LEN(A0$)
00230 IF A0$(;I,I)<>" " THEN NEXT I
00240 B0$(C)=A0$(;1,I-1)
00250 A0$=A0$(;I+1)
00260 GOTO 200
00400 IF C=0 THEN GOTO 700
00410 FOR A=1 TO C
00420 READ A1$,D
00430 IF A1$="OUT" THEN GOTO 600
00440 IF A1$<>B0$(A) THEN GOTO 420
00450 B(A)=D:RESTORE:NEXT A
00460 PRINT"IN ASCII CODES THAT'S"
00470 FOR A=1 TO C
00480 E=B(A)
00490 LPRINT[A1 E];
00500 PRINT [A1 E];
00510 NEXT A
00520 LPRINT"?";
00530 GOTO 160
00600 PRINT "ERROR - NO ";B0$(A);" CODE":END
00700 PRINT "NO ENTRY?":END
01000 DATA "EH3",64,"EH2",65
01010 DATA "EH1",66,"PA0",67
01020 DATA "DT",68,"A2",69
01030 DATA "A1",70,"ZH",71
01040 DATA "AH2",72,"I3",73
01050 DATA "I2",74,"I1",75
01060 DATA "M",76,"N",77
01070 DATA "B",78,"V",79
01080 DATA "CH",80,"SH",81
01090 DATA "Z",82,"AW1",83
01100 DATA "NG",84,"AH1",85
01110 DATA "OO1",86,"OO",87
01120 DATA "L",88,"K",89
01130 DATA "J",90,"H",91
01140 DATA "G",92,"F",93
01150 DATA "D",94,"S",95
01160 DATA "A",32,"AY",33
01170 DATA "Y1",34,"UH3",35
01180 DATA "AH",36,"P",37
01190 DATA "O",38,"I",39
01200 DATA "U",40,"Y",41
01210 DATA "T",42,"R",43
01220 DATA "E",44,"W",45
01230 DATA "AE",46,"AE1",47
01240 DATA "AW2",48,"UH2",49
01250 DATA "UH1",50,"UH",51
01260 DATA "O2",52,"O1",53
01270 DATA "IU",54,"U1",55
01280 DATA "THV",56,"TH",57
01290 DATA "ER",58,"EH",59
01300 DATA "E1",60,"AW",61
01310 DATA "PA1",62,"STOP",63
01320 DATA "OUT",64
```



The full size printed circuit board pattern in shown above.

ling statements of Super-80 Basic, and will need to make the changes which follow.

First of all, Super-80 Basic uses the same arrays for numbers and strings (alphabetic characters). In line 100 of listing 1, B0(50) is used to dimension a string array – so change this to DIM B0$(50) for use with other versions of Basic. You may also have to insert a CLEAR 100 statement to clear sufficient space for the string arrays used in the program. All string variables in Super-80 Basic consist of a letter followed by a number, which may not be required in other Basic versions.

In line 230 of the program, A0$(;I,I) is equivalent to MID$(A0;$I,1). It returns the character in position I of the string. In line 240, A0$(;1,I-1) is equivalent to LEFT $(A0$,I-1), and returns the first I characters of the string, less one. Line 250 of the listing has A0$=A0$(;I+1) and is replaced by A0$= MID$(A0$,I+1, 100). The "100" is arbitrary – it just makes sure that we get all the characters from position I+1 to the end of the string.

Finally, LPRINT [A1 E] in Super-80 Basic is equivalent to LPRINT CHR$(E) in other versions of Basic.

The program in listing 1 displays the ASCII character correspondening to each phoneme code as it is spoken. By noting down these ASCII characters and placing them in DATA statements any sort of vocabulary can be created.

COST ESTIMATE: $90. This does not include the cost of a loudspeaker, plugpack supply or case.

PARTS LIST

1 Printed circuit board, code 82VS10, 105mm x 71mm
1 loudspeaker
1 45cm length of 9-way ribbon cable
1 34-way printed circuit board edge connector to suit Centronics type parallel interface
1 12V AC plug pack
1 22-pin socket (see text)

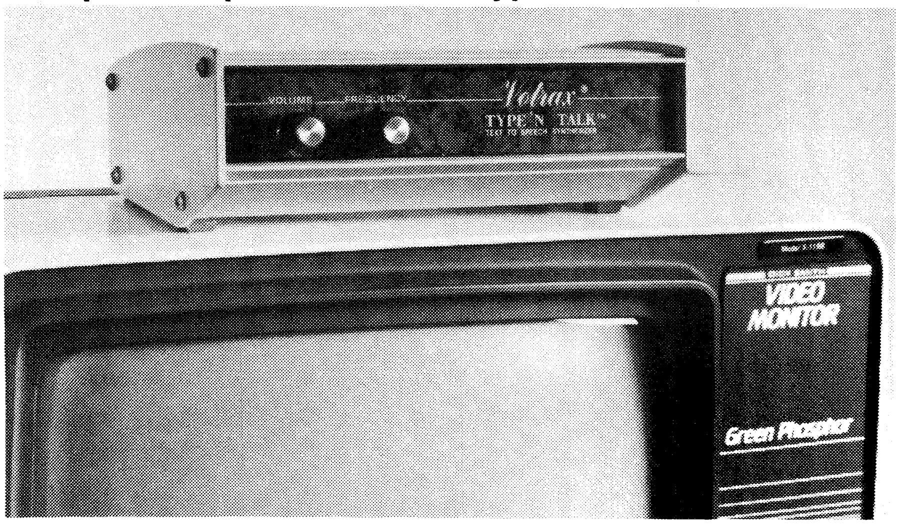
SEMICONDUCTORS
1 74LS367 hex bus driver
1 74LS121 monostable multivibrator
1 SC-01-A speech synthesiser
1 LM386 audio amplifier
1 BC547 NPN transistor
1 7805 +5V voltage regulator
1 7812 +12V voltage regulator
4 IN4002 diodes
1 light emitting diode

CAPACITORS
1 1000μF/25VW electrolytic
1 220μF/16VW electrolytic
1 100μF/25VW electrolytic
4 1μF tantalum
1 0.47μF greencap
1 0.1μF greencap
1 .033μF greencap
2 .01μF greencap
1 150pF ceramic

RESISTORS (¼W, 5% unless stated)
1 x 100kΩ, 1 x 22kΩ, 1 x 10kΩ, 1 x 6.8kΩ, 8 x 4.7kΩ, 1 x 3.9kΩ, 1 x 3.3kΩ, 1 x 1.5Ω, 1 x 22Ω, 2 x 10kΩ large vertical trimpots.

Microcomputer News & Products

Computers speak out with Type-'N'-Talk



After some delays (see Column 80 for December, 1980), the Votrax Type-'N-Talk is now avaiable from Dick Smith Electronics.

The Type-'N-Talk speech synthesiser unit enables computers to talk – with an unlimited vocabulary. English text is automatically translated into electronic speech by typing ASCII codes which represent various phonemes (sound units). By carefully selecting phonemes an unlimited number of words can be built up by the computer.

A built-in microprocessor and a 750 character buffer in the Type-'N-Talk allows the host computer to generator strings of spoken words while continuing to run a program. No host computer time is taken up with time consuming text translation. Interface to the host is via an RS-232C Serial interface.

Speech can add a whole new role to a computer. Computers for the blind, language teaching (the Votrax can be programmed to speak in any language) and computer aided teaching with voice responses are just some of the applications. Games can really come to life with spoken warnings, threats and instructions.

The Votrax, Dick Smith Electronics Catalog No. X-3290, is supplied with a 240V power supply and a user manual. The user must supply a speaker and a cable to connect the device to their computer or terminal.

Cat X-3290

TYPE-'N-TALK™ IS T.N.T.

The exciting text-to-speech synthesizer that has every computer talking.

- **Unlimited vocabulary**
- **Built-in text-to-speech algorithm**
- **70 to 100 bits-per-second speech synthesizer**

Type-'N-Talk™, an important technological advance from Votrax, enables your computer to talk to you simply and clearly — with an unlimited vocabulary. You can enjoy the many features of Type-'N-Talk™, the new text-to-speech synthesizer, for just $525.00.
You operate Type-'N-Talk™ by simply typing English text and a talk command. Your typewritten words are automatically translated into electronic speech by the system's microprocessor-based text-to-speech algorithm.

The endless uses of speech synthesis.

Type-'N-Talk™ adds a whole new world of speaking roles to your computer. You can program verbal reminders to prompt you through a complex routine and make your computer announce events. In teaching, the computer with Type-'N-Talk™, can actually tell students when they're right or wrong — even praise a correct answer. And of course, Type-'N-Talk™ is great fun for computer games. Your games come to life with spoken threats of danger, reminders, and praise. Now all computers can speak. Make yours one of the first.

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English text is automatically translated into electronically synthesized speech with Type-'N-Talk™. ASCII code from your computer's keyboard is fed to Type-'N-Talk™ through an RS-232C interface to generate synthesized speech. Just enter English text and hear the verbal response (electronic speech) through your audio loud speaker. For example: simply type the ASCII characters representing "h-e-l-l-o" to generate the spoken word "hello".

TYPE-'N-TALK™ has its own memory.

Type-'N-Talk™ has its own built-in microprocessor and a 750 character buffer to hold the words you've typed. Even the smallest computer can execute programs and speak simultaneously. Type-'N-Talk™ doesn't have to use your host computer's memory, or tie it up with time-consuming text translation.

Data switching capability allows for ONLINE usage.

Place Type-'N-Talk™ between a computer or modem and a terminal. Type-'N-Talk™ can speak all data sent to the terminal while online with a computer. Information randomly accessed from a data base cn be verbalized. Using the Type-'N-Talk™ data switching capability, the unit can be "de-selected" while data is sent to the terminal and vice-versa —permitting speech and visual data to be independently sent on a single data channel.

Selectable features make interfacing versatile.

Type-'N-Talk™ can be intefaced in several ways using special control characters. Connect it directly to a computer's serial interface. Then a terminal, line printer, or additional Type-'N-Talk™ units can be connected to the first Type-'N-Talk™, eliminating the need for additional RS-232C ports on your computer. Using unit assignment codes, multiple Type-'N-Talk™ units can be daisy-chained. Unit addressing codes allow independent control of Type-'N-Talk™ units and your printer.

Look what you get for $525.00. TYPE-'N-TALK™ comes with:

- Text-to-speech algorithm
- A one-watt audio amplifier
- SC-01 speech synthesizer chip (data rate: 70 to 100 bits per second)
- 750 character buffer
- Data switching capability
- Selectable data modes for versatile interfacing
- Baud rate (75-9600)
- Data echo of ASCII characters
- Phoneme access modes
- RS-232C interface
- Complete programming and installation instructions

The Votrax Type-'N-Talk™ is one of the easiest-to-program speech synthesizers on the market. It uses the least amount of memory and it gives you the most flexible vocabulary available anywhere.

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The Votrax Personal Speech System

by PETER VERNON

Several years ago computer enthusiasts were introduced to the first speech synthesisers. Now the second generation has arrived and we asked Peter Vernon to take a look (listen) to the new Votrax Personal Speech System.

The Votrax Personal Speech System (PSS) may well be the last word in "phoneme-based" speech synthesis. The PSS uses the popular Votrax SC-01 chip, but with its own on-board Z80 microprocessor, "text-to-speech" translation software in 32K of ROM and both parallel and RS-232C serial interfaces, the PSS offers flexibility and versatility unmatched by previous equipment.

In additon to speech direct from ASCII text with a wide range of pitch and intonation controls, the PSS provides music and sound effects and a "talking clock" mode. User-accessible RAM and provision for down-loading other programs to the controller also mean that the PSS can be used as a printer buffer, communications converter or dedicated microprocessor-based controller.

Physically the Votrax Personal Speech System is an attractive unit. Measuring 312×116×65mm (W×D×H) in a grey metal cabinet, the PSS comes ready to use, with a Ferguson plugpack providing operating power of 18VAC and 12V-DC. The power pack has a 1.5m cable terminated with a two pin mains plug and a 40cm cable to the Votrax unit, connected by a 5-pin DIN plug.

The front panel is bare except for a small volume control knob and a red "Power On" indicator. At the rear is the connection for the power supply, a pushbutton on/off switch, parallel and RS-232C serial interface connectors, a cut-out to provide access to the 8-way DIP configuration switch and a socket for an external speaker.

The DIP switches are used to specify whether the parallel or serial interface will be the primary input port, set parameters for the serial port, activate a self-test mode and select whether the unit will produce a "ready" message when first switched on. For serial communications, the switches can select baud rates from 110 to 9600 bps, with XON/XOFF or RTS handshaking and a 7 or 8 bit word length. No parity is used.

Installing the Personal Speech System is easy if you have or can make the proper cables and have details of the configuration of the parallel or serial port of your computer. The slim but comprehensive manual supplied with the speech unit contains full details of the connections which are required and connecting cables for particular computers are available as an optional extra.

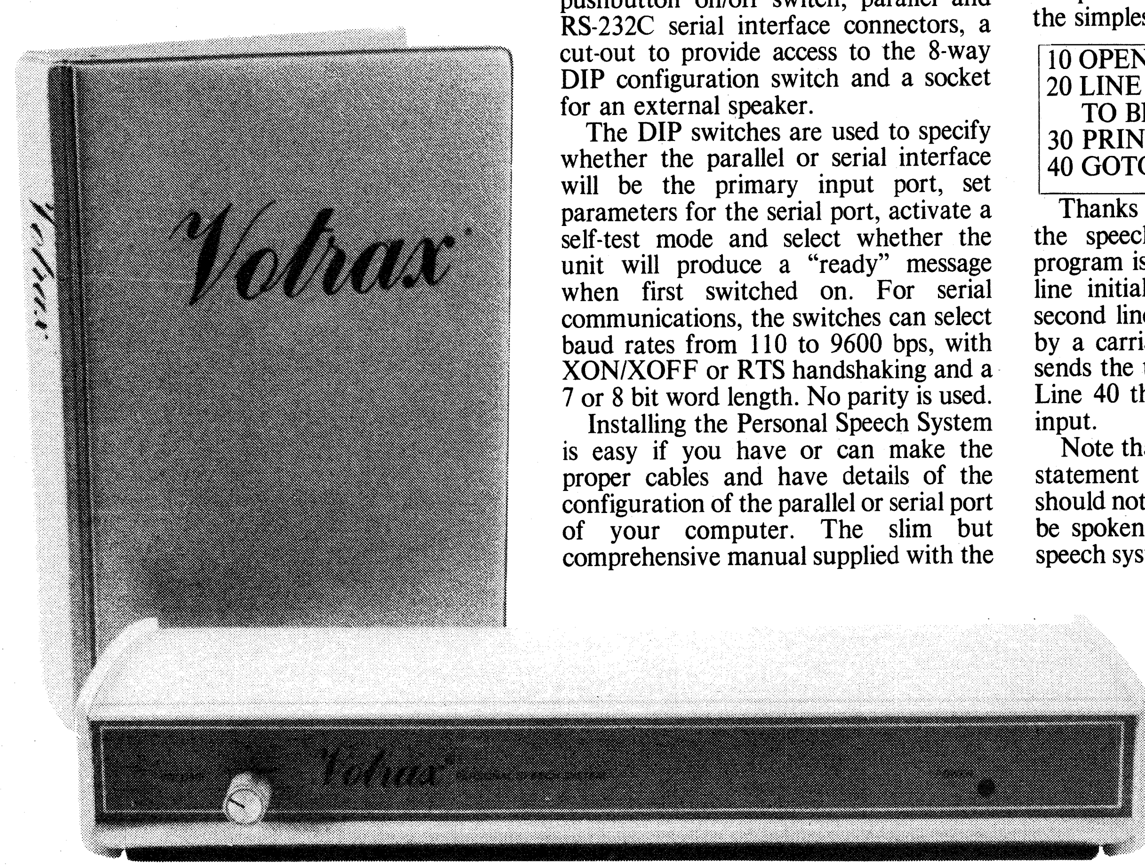
For this review we used the serial port, setting the DIP switches for communication at 9600 baud with RTS (Ready To Send) hand-shaking. The Personal Speech System has its own command buffer, but at high transmission rates some form of hand-shaking is necessary so that the speech system can indicate to the host computer that the buffer is full. The host should then stop sending instructions or speech codes until there is again space in the buffer.

The manual also includes examples of software for driving the Personal Speech system. Once communication is established the procedure is simple thanks to the translation routine built into the PSS. This routine, the text-to-speech translator, takes text in standard ASCII code and produces speech output. For the IBM PC and compatible computers using serial communications the simplest demonstration program is:

```
10 OPEN "COM1:9600,N,8,1" AS #1
20 LINE INPUT "ENTER PHRASE
   TO BE SPOKEN";A$
30 PRINT #1,A$
40 GOTO 20
```

Thanks to the on-board software of the speech system, the simple Basic program is all that is required. The first line initialises the PC serial port, the second line accepts a phrase terminated by a carriage return and the third line sends the text to the speech synthesiser. Line 40 then loops to wait for another input.

Note that although the LINE INPUT statement can accept punctuation, you should not use punctuation in any text to be spoken directly. This is because the speech system uses punctuation marks to



The last word in phoneme-based speech synthesis? Votrax PSS uses the SC-01 chip and an on-board Z-80 microprocessor for a wide variety of programmable effects.

activate special functions of the synthesiser. An exclamation mark for example, is used to begin a special command string, and a full stop terminates a command string, although the control characters can be re-defined if required.

A wide variety of programmable effects can be applied to the speech produced by the Votrax chip. Amplitude, rate of speech and inflection can be controlled by sending a control character (the ASCII @ symbol) followed by a hexadecimal number. In the case of amplitude, the rate at which the sound fades can also be controlled.

Two additional conversion modes are also available to override the standard text to speech translation mode. Conversion mode 1 allows the use of an "exception table", a user-defined table of words and their phonetic equivalents which can be accessed in place of the standard ASCII translation. Conversion mode 2 corrects the pronunciation of strings of numbers. In the standard mode, a number such as 12,345 is pronounced correctly as twelve thousand ... etc, but the numbers 12345 will be spoken as separate digits. Conversion mode 2 corrects the translation of unpunctuated numbers.

One of the most interesting abilities of the PSS is the "vochord mode", which feeds the output of the internal musical tone generator to the clock input of the SC-01 chip. This procedure allows the production of special effects such as musical voices.

Music and Sound Effects too

As well as the SC-01 speech synthesiser chip the Personal Speech System includes a General Instruments AY-3-8910 musical tone generator chip which provides music and sound effects on three independently programmable channels. Music is programmed by sending a "non-speech control character", which is normally defined as an exclamation mark. To play a phrase of music for example, the Basic code would be:

LPRINT"!T10:E1040:1363100."

The exclamation mark indicates that the following characters are to be interpreted as control codes rather than speech. T10 sets the tempo in "clock ticks" of 8.19ms each and E sets the envelope shape of the sound produced. Notes are specified as numbers between 0 and 96, and duration, amplitude and "glide" can also be set. "Glide" allows notes to glide from one pitch to another without a definite break between them.

Extensive envelope controls are available, with attack, decay, sustain and release times separately programmable for each of the three sound channels. Using this feature it is possible to make music produced by the PSS resemble a flute, trombone or harpsicord, for example.

SPECIFICATIONS

Microprocessor	Z80
Memory	32K ROM (translation software)
Interface	Parallel and RS-232C serial
Features	Speech synthesis, music and sound effects, talking clock
Dimensions	312mm x 116mm x 65mm (W x D x H)
Price	$699

Any of the three channels of the musical tone generator can also be used to produce noise by specifying note number 97 while an envelope setting is in effect. Twenty-six "noise values" are available, ranging from hisses to gunshots, all of which can be tailored with appropriate envelope settings.

Even more special effects are possible by controlling the setting of the system's on-board filter. In normal (mode 0) speech the filter setting will change both the pitch and resonance of the sound produced by the system. In the Vochord mode the sound spectrum of the speech will be derived from a specified music channel, opening the way to all sorts of programmed effects and even singing.

A talking clock?

A programmable clock on board the PSS will maintain the correct time for as long as the system is on. The time can be set in either 12 or 24 hour format and spoken on command. Up to eight alarm calls are also available, combining a clock reading with programmed speech, and the system can also be set to announce the time or sound a chime at regular intervals.

Speech Quality

For all its capabilities, however, the worth of a voice synthesiser system must still be judged by the intelligibility of the speech it produces. Intelligibility is a subjective matter, and a person who is familiar with the speech system is not necessarily the best judge. Almost unconsciously the ear becomes accustomed to the mechanical inflection of standard Votrax speech so that after a very short time it becomes perfectly clear and understandable. A person coming fresh to the system however, may only hear gibberish unless they know what the system is supposed to be saying.

This problem in common to all methods of speech synthesis. Recently, a Texas Instruments engineer was quoted as saying "Three or four engineers may all agree that pronunciation is perfect, that speech is understandable, while another person cannot make out what is being said".

Be assured however that if you use the speech system regularly you will quickly come to understand it completely, even when the text being spoken is unfamiliar. You may even find it hard to believe that someone else has difficulty in making out what the system is saying. A number of visually handicapped people are already using the system and have found it an invaluable aid, as it allows them to work with computers in ways that would otherwise be impossible.

(These comments on intelligibility apply only to the standard speech mode, with flat inflection and no special pitch and amplitude controls. Programming which takes account of these features can greatly improve the "first-time" recognition rate of the Votrax speech system.)

While considering intelligibility, note that there are some words that the Votrax system just *cannot* say. Incredibly, the standard text-to-speech translation algorithm has a censor built-in! One popular expletive, for example, is pronounced "Sugar", regardless of what is sent to the unit — the Votrax speech system is something of a wowser.

Price and Conclusion

This minor shortcoming(?) aside, the Votrax Personal Speech System is one of the most versatile and powerful sound systems we have seen. The text-to-speech translation software is accurate in around 90% of cases, and difficult words can be programmed phonetically or added to the on-board exception table to further increase the range of the system. The music and sound effects capabilities are on a par with the best dedicated music generators available for microcomputers, and the addition of a clock mode is a further bonus. Many other features of the system have only been touched on here, including the user-programmable mode, which would keep an enthusiastic programmer occupied for months. No doubt at the end of that time there would still be many avenues to explore. Overall, in spite of the retail price of $699, the Votrax Personal Speech System offers good value for money.

The Votrax PSS is available from Mike Boorne Electronics, 61A Hill St, Roseville, NSW, 2069. Phone (02) 46 3014.

Project 677

THE CHATTERBOX

Computer voice synthesiser

Tom Moffat
39 Pillinger Drive, Fern Tree, Tas.

Until the Chatterbox, voice synthesis for the inveterate computer hacker involved either economically out-of-reach hardware or an unsatisfactory software fudge. This project solves all that. And if you want to get into it at the rock-bottom price, a kit is available on special offer.

THE MIGHTY MICROBEE can do just about anything else, so you may as well teach it to talk. Imagine the thing jabbering away through some space game, warning you of impending perils; or announcing the results of calculations, instead of just displaying them on the screen. All these things are possible with the device to be described, nick-named the "Chatterbox". As well as the Microbee, the unit should be useful with other computers that use a "Centronics" printer port.

Just another speech synthesizer? Not really, it goes a bit deeper than that. There's synthesizers, and theh there's synthesizers. Perhaps an explanation is in order. Anyone wanting a full-scale discussion of the subject should read the article on the Turtle Talk speech synthesizer by Allan Branch in September 1982 ETI. This gave a complete rundown on the theory of getting human speech into and out of a computer.

Synthesis techniques

Speech synthesizers come in three basic types. There's *waveform digitization,* used in National's 'Digitalker' chip set (not to be confused with a Microbee program called "Digitalker"). National's system was used in Flexible Systems' Turtle Talk speech board. Another method is *Linear Predictive Coding,* used in the Texas Instruments "Speak and Spell". The third method is *Phoneme Reconstruction,* used in the Votrax SC-01 synthesizer chip, the basis of the ETI-677 Chatterbox.

The Digitalker system is generally recognized as providing the very best speech quality, but at a price . . . the vocabulary has to be stored in advance, in read only memory, so it's limited to a few hundred common words at the most. Unless you can incorporate (and afford) heaps of ROMs.

Linear Predictive Coding is much the same. The words that are stored were originally spoken by humans, and then squashed down to fit in the ROMs. So any words are possible, in any language, even those African languages that have decidedly non-English (!Kung) sounds. But any non-standard word list must be manufactured by the thousands to be economically worthwhile.

Electronic vocal tract

The Votrax system, on the other hand, generates human-like sounds in an electronic model of the human vocal tract. The programmer has available a list of sounds which are strung together to make words. This means just about any word is possible by using the right combination of the sounds, called "phonemes".

The Votrax is a true synthesizer, as the words it speaks and the phonemes it generates have never been spoken by humans . . . they're cooked up, on the spot, strictly by electronic means. The quality of speech generated by the Votrax isn't quite up to that of the "stored speech" systems. It sounds exactly like you'd expect a computer to sound, speaking in a mechanical monotone (although the Chatterbox design overcomes this somewhat by using "inflection" inputs). People who hear the Chatterbox for the first time say it sounds like it's got a bad cold. But it's the only system that can say those well known television robot phrases like "EXTERMINATE!" (Dr. Who) and "Hello Sexy Bum, Boogie-Boogie" (Metal Mickey). Any serious computer hacker will realize that the ability to say these phrases (and certain others) is quite valuable.

How it works

The phonemes are generated in the Chatterbox by sending it 8-bit words through the computer's parallel port. Bits 0 through 5 tell the Votrax chip which phoneme is required. This remarkable chip strings the phonemes together and adds a kind of "automatic inflection" to the resulting phrase. Bits 6 and 7 of the control word can be used to force an inflection. The two bits allow four levels of inflection to be expressed. In the BASIC version of the Chatterbox software, bit 6 is set high and 7 is set low, producing inflection at the second level. With some fiddling, bit 7 can be set high as well, making the Chatterbox bellow with a strong sense of urgency (EXTERMINATE!). Or you can set bit 6 low in the second phoneme of a phrase like "Oh'oh", making it inflect downwards.

The synthesis process is triggered off by a strobe pulse from the computer, and the Chatterbox sends back a busy signal to the computer while it's speaking. This "handshaking" system is put to a useful purpose in the machine code version of the software.

The Votrax chip contains its own clock circuit, with the clock speed being controlled around a nominal 720 kHz by RV1. Changing the control raises or lowers the pitch, and the speed, of the speech. You set it to your preference. The other control, RV2, is the volume control to the LM386 audio amplifier, IC4.

Two sections of IC2, a 4001 NOR gate, invert the "inflection" signals, which are inverted again in the two transistors that change the logic levels to those required by that part of the SC-01. The other two sections of IC2 are used to change a positive-going strobe signal from the computer into a trigger pulse of about three microseconds for the SC-01. The Microbee holds the RDY line high for the duration of the phoneme; Centronics ports pulse the line low, so the SC-01 begins speaking on the end of this pulse.

The SC-01 sends its A/R line low for the duration of each phoneme. This means the chip is in total control of speech timing if the computer monitors the state of A/R and sends the next phoneme to the SC-01 when the line goes high. In the Microbee a low-to-high transition on BSY triggers an interrupt, a feature that is put to good use in the machine code version of the software. Centronics ports want BSY the other way around. The logical levels from the SC-01 chip are once again wrong, so two more transistors are used to "invert and convert". You use both transistors for the Microbee, but take the signal out after the first one for Centronics ports.

IC3 is simply a buffer to make sure no part of the SC-01 is exposed to the nasty influences of the outside world. P0 through P5 on the SC-01 could have been fed directly since they will respond to +5/0 volt logic levels. But considering the high cost of an SC-01 chip, a 4050 was considered cheap insurance.

The SC-01 power supply can be anything between 7 and 14 volts, so power can be pinched directly from the computer. This voltage is regulated down to 5.6 volts by a simple zener diode arrangement to supply the "logic level" circuits. Being CMOS or simple transistors their current drain is next to nothing.

To use the Chatterbox on a Microbee, you'll need to see that 12 V is available on pin 9 of the parallel port. Check with a multimeter. Series II and III 'Bees have it, but not Series I. If you have the early model, make the following modification.

Under the 'Bee's main circuit board, run a wire from pin 9 of the parallel port connector to the 'Bee's (nominal) +12 volt line. You'll probably find it closer to nine or 10 volts with a fair bit of ac ripple on it (which is why there's so much filtering in the Chatterbox). A good place to tap off the voltage is directly from the filter capacitor. If you don't want to attack your 'Bee in this way you can power the Chatterbox from a small 9 volt plugpack.

Many computers, such as the Apple, have a 12 volt supply brought out to a slot or expansion interface connector. Some, such as the Commodore 64, provide a 9 volt ac supply that can be rectified to power the Chatterbox.

Well, so much for the hardware. Let's get into the good stuff, making the thing talk.

Blah-blah-blah

Early attempts at using the SC-01 were fraught with frustration. I wrote a BASIC program to send a short series of phonemes out the parallel port. The Microbee promptly locked up because it wasn't getting its strobe signal back from the SC-01. Eventually the project progressed to the stage where the SC-01 would say such things as "SSSSS" and "AHRRR" and "OOGLE-OOGLE" as "Syntax error" popped up.

Then one night it said "Whiskey"!

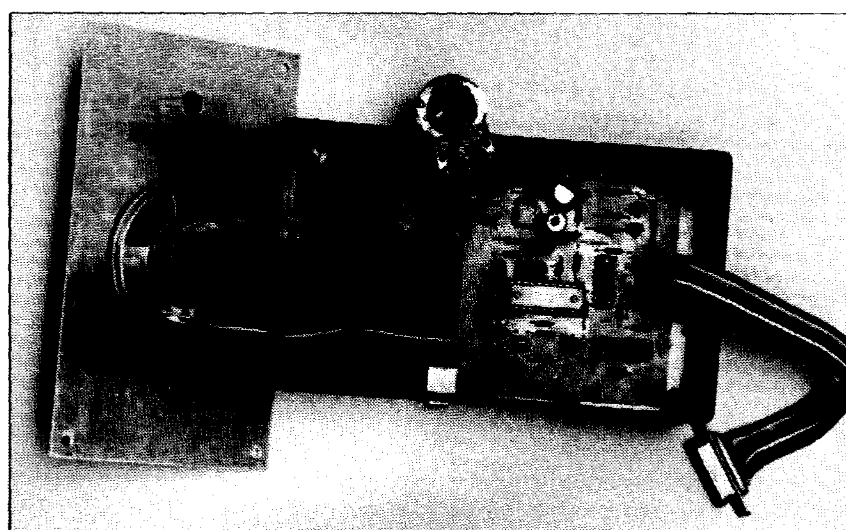
That was a real shock. It was as if my dog had looked up at me and said "Whiskey". You know what the chip's meant to do but it's still a real thrill when the thing actually talks for the first time. The wonders of modern technology!

Soon the Chatterbox, haywired together on proto-board, was rattling off the names of everyone in the family, including the dog, but it wasn't very good. It seems that programming the Chatterbox is like playing the saxophone. Your early attempts might produce something recognizable, but they sound bloody awful. Practice, practice, and more practice will soon bring your efforts up to standard.

To make the programming task easier, we now present the CHATTERBOX PHRASE COMPOSER program; for the Microbee it's Listing 1, for the Apple, it's Listing 2.

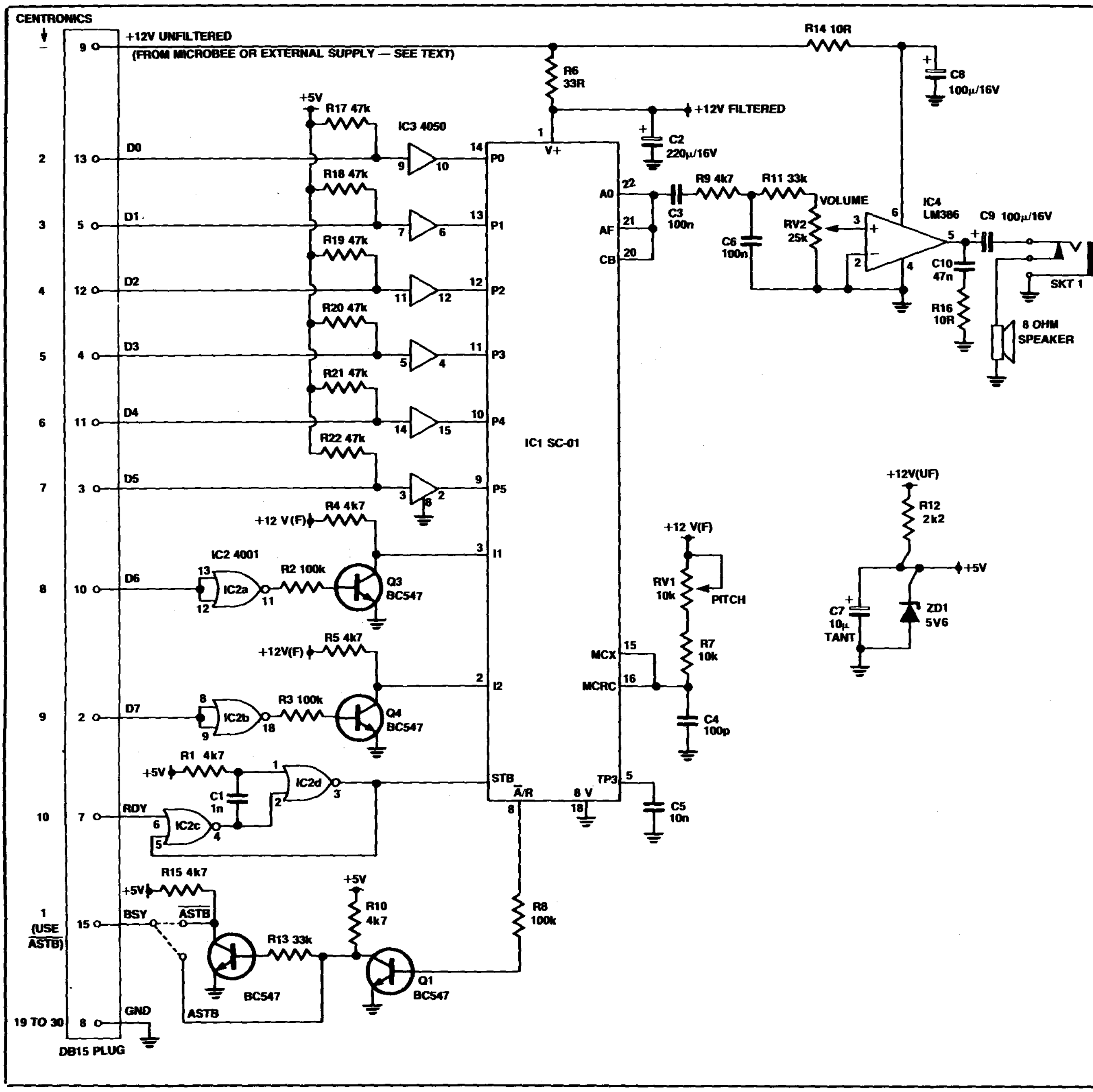
Let's take the Microbee first. When the program is first run, the Chatterbox should say "testing". Hit and key except <ESC> and <P>, and the Chatterbox will repeat "testing" and the phonemes responsible for it will appear on the screen. Hit <P> and the phonemes, and an ASCII string, will be sent to a 1200 baud printer and shown on the screen as well.

The ASCII string is the finished product of the composer program. Every character in it can be generated by the Microbee's keyboard ("—" is shift/delete). When you want the phrase you've just composed to be ▶



Bunged in a box! This project is different. You get your pre-built board from Flexible Systems (see Special Offer), hookup a speaker, the volume vontrol and computer interface connector, bung it all in a box — and start talking! ETI's prototype was housed in a standard zippy box measuring 158 x 95 x 53 mm. The front panel was dressed up with a Scotchcal label. Audio output is a few hundred milliwatts so volume from the 50 mm speaker is quite low. It works much better into a larger, more efficient speaker in a proper enclosure. A test on the ETI-1422 4-speaker PA brought most of the staff crowding into the ETI lab!

To house the unit as shown, drill several large holes about the centre of the panel, where the 50 mm speaker is to mount. Also drill a hole for the volume control — using the front panel artwork as a guide. Drill a hole in the side of the case for the external speaker socket and mount it. Apply the Scotchcal over the panel and cut out the *volume pot hole only*. The sound from the speaker goes pretty well straight through the Scotchcal. Complete the wiring up, file a slot in the box to let the ribbon cable pass through, and screw it all together. The box we used, from Altronics, has 'press-fit' thingos on the walls so the board need not be bolted in place. Just push it in!



spoken in some BASIC program you're writing, you initialize the parallel port near the start of the program with "OUT#1" and then LPRINT the ASCII string every time the phrase is to be spoken. What could be easier? The ASCII character that represents each phoneme is shown in the second column of the phoneme list (see accompany panel).

The Phrase Composer looks up the ASCII characters for you (using a binary search) and then lets you hear the phrase. Now here comes the good bit: If you press <ESC> the screen will display:

00150 A0$="T EH S T I NG"

The Microbee is now in the EDIT mode and you can chop and change your phrase, as A0$, to your heart's content. You RUN the program again to hear your changed phrase. The phonemes of course must come from the list, and they must be separated by one space. If you mess something up in this area the Chatterbox will tell you all about it!

You'll notice that the ASCII string coming out of the program has a tilde (~) at the start and finish of the phrase. This is a pause, and it's necessary for proper operation of the synthesizer. If you leave it off you'll notice the speech sounds clipped. You should also turn off the the synthesizer with the *shut-up* code (3F) when finished. Also, terminate all the BASIC "LPRINT" lines with a ";". This suppresses the RETURN signal which would otherwise turn the Chatterbox back on with an "AHHH" sound.

Listing 2 is a Chatterbox phrase composer program for the Apple II. This produces a similar result to the Microbee phrase composer, although the details of operation have had to be changed somewhat to work within the syntax of Applesoft BASIC. In this case the Chatterbox is driven via a serial card and a "serial to Centronics" converter (see ETI, January '84, Project 675, pages 52-55).

The Apple program uses the normal Apple edit keys, <CONTROL> I, J, K, and M to edit the phoneme string. You print the results (on the screen only) with <CONTROL> P <RETURN>, and bail out of the program with <CONTROL> C <RETURN>.

Now, just to see how all this works, let's arm ourselves with the phoneme list and compose a phrase. Assume that our new BASIC program is to issue an appropriate verbal insult, possibly as a result of an "ON

ERROR GOTO 1000" statement. We will now work out what line 1000 is to be.

Let's start by entering the phrase in proper English spelling, with the phonemes separated by spaces and the words separated by pauses. Run the program, and replace "T EH S T I N G" with:

B I T E PA1 Y O U R PA1 B U M

Now RUN, and the Chatterbox will respond with "BITTEY, YEWER, BOOM". That's not right at all. Let's butcher the phrase a bit, and enter it more like it sounds:

B AY T PA1 Y ER PA1 B UH M

That comes out as "BITT, YER, BUM". Pretty close, but the first word is still wrong. We know (have learned from experience) that the "AY" as in "tie" can be produced with a combination of two phonemes. Lets try it:

B AH1 I2 T PA1 Y ER PA1 B UH M

That's pretty good, but the Chatterbox is still saying the phrase as three unrelated words. We want "BITEYERBUM" so lets take the pauses out:

B AH1 I2 T Y ER B UH M

Spot on! The sweet sound of success. Now we hit the <P> key, and we get on the printer, and the screen:

PHONEMES:
B AH1 I2 T YER B UH M

ASCII:
NUJjizNsL

So line 1000 in our new program will look like this:

```
01000 LPRINT "  NUJjizNsL  ?";
```

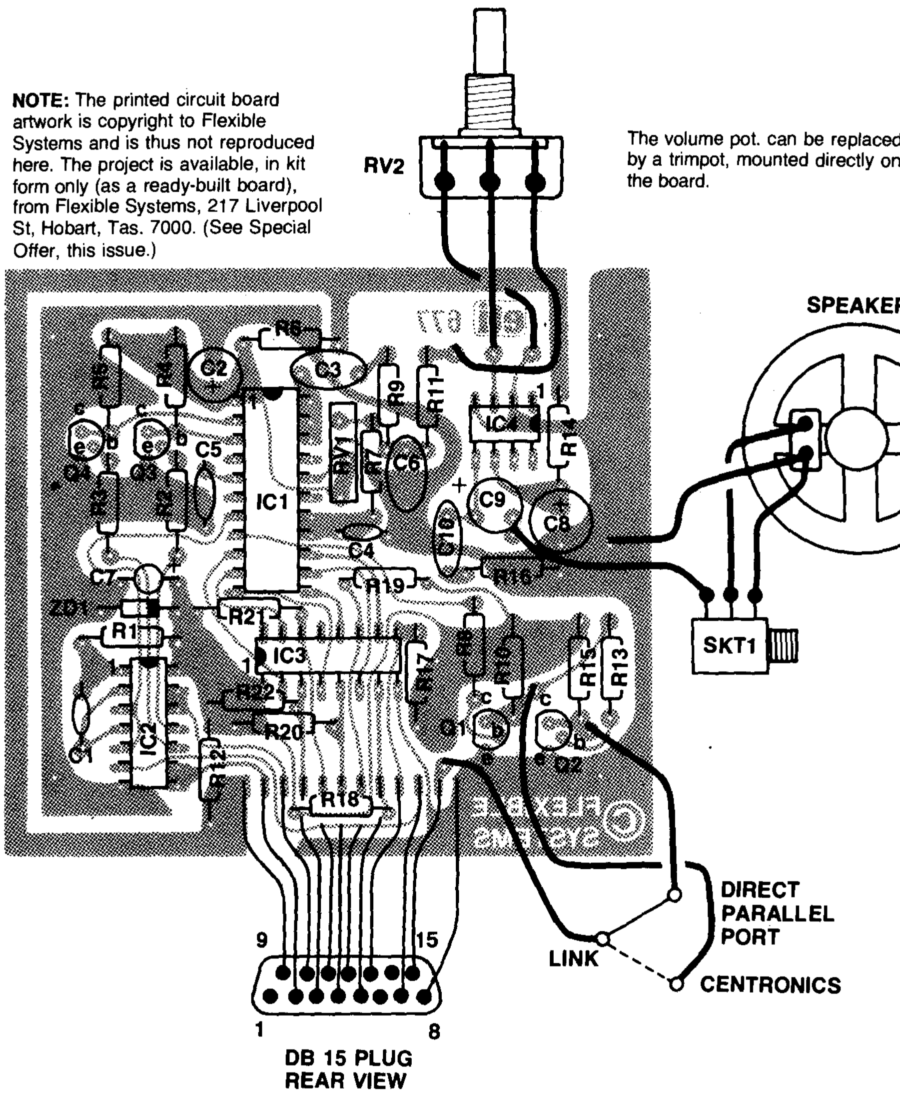
And of course, near the start of the program we use an "OUTL#1" to initialize the parallel port.

To further demonstrate the capabilities of the Chatterbox, we present in Listings 4 and 5, "Sayings of the Daleks", in both Apple and Microbee versions. If you are a young keen computerist, this program will *drive your parents mad!* If you are a bit older you will drive *yourself* mad.

The program makes the Chatterbox rattle off some of the more familiar (and silly) utterances from those nasty little creatures of the Dr Who television series. All of the data in this program were collected from one episode of Dr Who. It was a particularly good night for Daleks and I spent the whole time scribbling "quotes" as fast as I could into my trusty reporter's notebook.

"Sayings of the Daleks" are spoken without external inflection because, well, that's the way Daleks speak! Both programs print the text onto the screen as the Chatterbox speaks. The Microbee program uses ASCII strings to store the phoneme data; these can be seen in the program listing directly below the text of each sentence to be spoken. The

NOTE: The printed circuit board artwork is copyright to Flexible Systems and is thus not reproduced here. The project is available, in kit form only (as a ready-built board), from Flexible Systems, 217 Liverpool St, Hobart, Tas. 7000. (See Special Offer, this issue.)



Apple program uses phoneme numbers in DATA statements to generate the speech.

If you use the BASIC editing program for long, you'll notice you seem to be spending an awful lot of time waiting for something to happen. You will also notice that it's not possible to use the Chatterbox inflection inputs when making it speak unmodified ASCII strings. However, there is a solution in the form of a flashy real-time fully interactive phoneme editor/composer program for the Microbee, written in machine code. (Did you like all those buzz-words?)

You can type in your phonemes using a full screen editor (just like in Wordbee) and when you want to hear your sentence spoken you hit RETURN. The Chatterbox speaks instantly, without affecting the position of your edit cursor or anything else. You can edit-in inflection levels by adding a number between 1 and 4 to the front of the phoneme.

The finished sentence (which can occupy the whole page if necessary) can then be printed as the string of phonemes, followed by their equivalent numbers (with inflection included), both in hexidecimal and decimal format.

The source code alone for this monster runs to seven pages, so we won't be publishing it here. But, if you'd like a ready-to-run cassette of the machine code editor program, $13.50 to the author will speed one on its way, postpaid.

Machine code magic

Making a BASIC program talk is quite easy, but what about one of those high speed machine code arcade style games, like Asteroids Plus? Wouldn't it be good, as space objects converge on you from all directions, for the Chatterbox to bellow, "DANGER! DANGER! PUT UP YOUR SHIELDS!"?

This involves doing two things at once. After all, you can't stop the screen action while the Chatterbox talks. So we'll use a technique called "interrupt processing" to give the appearance of doing two things at once.

You may remember that we said the Chatterbox causes an interrupt in the Microbee after each phoneme is spoken. The interrupt has its own hotline straight into the Z-80 microprocessor. When the Z-80 is attacked in this way it suspends whatever it's doing and jumps to a new address that was specified earlier in the program. At this address is a short routine that gets the next sound to be spoken and squirts it out the parallel port. The processor then picks up where it left off when the interrupt occurred, displaying nasties on the screen or whatever. *Meanwhile*, the Chatterbox is speaking the phoneme just sent to it. Two things at once.

Actually, the screen display did stop as the phoneme was sent. But the routine took only a few microseconds, and the viewer would never notice the pause. And considering the length of time before another phoneme is required by the Chatterbox, the interrupt condition exists for maybe a thousandth of the time. The rest of the time the processor is working normally.

These concepts are shown in the assembly language program in Listing 1. The program parts can be "lifted" and used in a machine code program you're writing. The "model main program" isn't quite up to Asteroids standard. All it does is print the alphabet on the screen as the Chatterbox delivers a message. But it clearly shows the concept of "two things at once".

The message is entered just as in BASIC and the assembler lays it into memory as a data table. For what it's worth, there's enough memory in a 32K Microbee to keep the Chatterbox talking for 55 minutes; long enough to out-bluster even the most long-winded politician (well . . . except for Barry Jones, Minister for Science and Technology, perhaps).

There is a small problem here. The Microbee editor/assembler won't let you enter an up arrow (^) From the keyboard, since it's interpreted as the control character to step backwards through a file. the "^" is the ASCII character for the phoneme "D" so you'll be needing it. The solution is to enter a dummy character such as "—" (shift/delete) and then use the Microbee's monitor to search it down and change it manually.

Changing memory manually is the way you can change the inflection of a phrase. Listing 2 is a direct hexadecimal memory dump of the machine code program of Listing 3. You can use this memory printout to enter the program in your own computer. Listing 3 is the same thing, although inflection has been added by manipulating bits 6 and 7 of the bytes that have been shaded. You can enter this new listing to see the difference added inflection makes to the speech.

Of course, if you're using the you-beaut Microbee machine code editor program mentioned earlier, the inflection is provided automatically within the phoneme numbers. You can forget about ASCII strings and enter the numbers directly as "DEFB" or "DEFW" statements with an assembler, or record them directly as a data table with a monitor.

Getting your chatterbox

Now, after reading all this, you must have decided that life won't be worth living any longer without your very own Chatterbox. Well, this must be your lucky day. Electronics Today, in conjunction with Hobart manufacturer Flexible Systems, is offering the Chatterbox as a board-level computer peripheral, for a miserly $75.

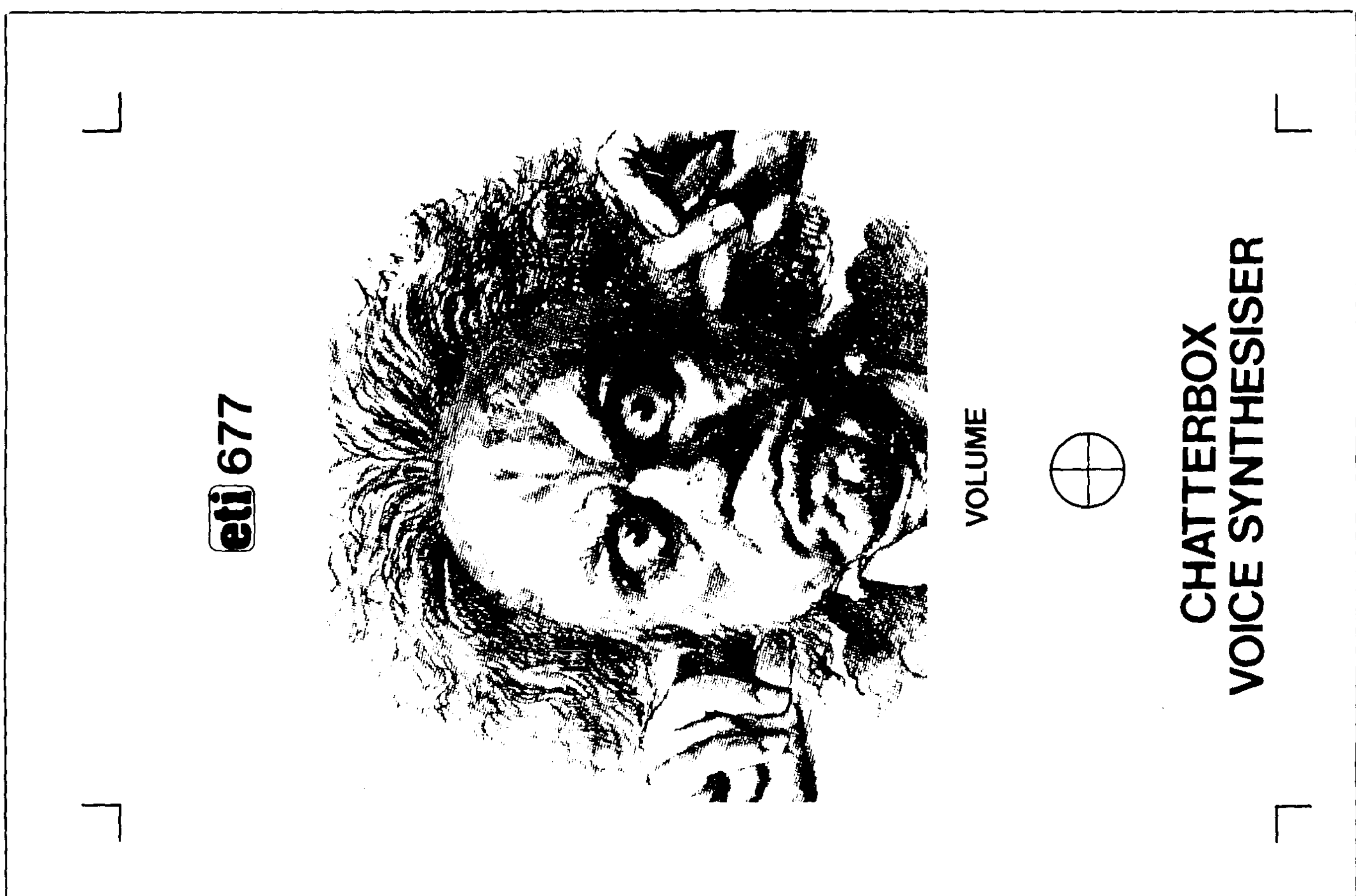
You get a ready-built pc board (not a kit), ready to take an edge connector or D plug to interface to your computer. However, you must supply your own power supply arrangements, box, and speaker. See the special reader offer elsewhere in this issue.

As a grand finale, here is the last word from Chatterbox:

"Llanfairpwllgwyngyllgogerychwyrndrobwyllllantysiliogogogoch".

It's a small Welsh town with the biggest name in the world. If you want to know how to pronounce it, feed this ASCII string to your Chatterbox:

"—sLNUIieWQYmKM\KQC\rX\{zKY [YmUM^kceckQoM—I—IXlu^\Y^\Y^ \Y~".



CHATTERBOX SOFTWARE LISTINGS

LISTING 1

```
00100 REM CHATTERBOX PHRASE COMPOSER
00110 REM  by Tom Moffat, 24/7/84
00120 REM
00130 OUTL#1: DIM T0(63),T(63): STRS (512): ON ERROR GOTO 350
00140 FOR I=0 TO 63: READ T0$(I),T(I): NEXT I: LPRINT "?";
00150 A0$="T EH S T I NG"
00160 A=1: B=0: A0$=A0$+" ": C0$=""
00170 C=B: B=SEARCH(A0$," ",A)
00180 IF B=0 THEN 250
00190 A=A+1: B0$=A0$(;C+1,B-1)
00200 K=32: N=0: FOR I=1 TO 6
00210 IF B0$=T0$(N) THEN NEXT*I 240
00220 IF B0$>T0$(N) THEN LET N=N+K ELSE LET N=N-K
00230 K=K/2: NEXT I
00240 C0$=C0$+CHR$(T(N)): GOTO 170
00250 V0$="~"+C0$+"~"
00260 PRINT A0$: LPRINT V0$;: LPRINT "?";
00270 K0$=KEY$: IF K0$="" THEN 270
00280 IF K0$=CHR$(27) THEN EDIT 150
00290 IF K0$="P" OR K0$="p" THEN 310
00300 GOTO 260
00310 CLS: OUT#5 ON
00320 PRINT "PHONEMES:": PRINT A0$: PRINT
00330 PRINT "ASCII:": PRINT V0$: PRINT
00340 PRINT: PRINT: PRINT: OUT#5 OFF: GOTO 270
00350 LPRINT "~Bz5+>~P(YCXUJMmrMJJJK>~?";: EDIT 150
01000 DATA "A",96,"A1",70,"A2",69,"AE",110,"AE1",111
01010 DATA "AH",100,"AH1",85,"AH2",72,"AW",125,"AW1",83
01020 DATA "AW2",112,"AY",97,"B",78,"CH",80,"D",94
01030 DATA "DT",68,"E",108,"E1",124,"EH",123,"EH1",66
01040 DATA "EH2",65,"EH3",64,"ER",122,"F",93,"G",92
01050 DATA "H",91,"I",103,"I1",75,"I2",74,"I3",73
01060 DATA "IU",118,"J",90,"K",89,"L",88,"M",76
01070 DATA "N",77,"NG",84,"O",102,"O1",117,"O2",116
01080 DATA "OO",87,"OO1",86,"P",101,"PA0",67,"PA1",126
01090 DATA "R",107,"S",95,"SH",81,"T",106,"TH",121
01100 DATA "THV",120,"U",104,"U1",119,"UH",115,"UH1",114
01110 DATA "UH2",113,"UH3",99,"V",79,"W",109,"Y",105
01120 DATA "Y1",98,"Z",82,"ZH",71,"ZZZ",0
```

LISTING 2

```
100  REM
110  REM - CHATTERBOX SPEECH EDITOR -
120  REM
130  REM -    BY CRAIG FORD-KING    -
140  REM
150  REM -        13/10/'84         -
160  REM
170  REM
180  REM  SERIAL CARD DRIVER
190  REM
200  POKE 768,169: POKE 769,16: POKE 770,44: POKE 771,161
210  POKE 772,192: POKE 773,240: POKE 774,251: POKE 775,96
220  REM
230  REM  INITIALIZE SERIAL CARD
240  REM
250 W =  - 16224: POKE W + 3,152: POKE W + 2,11
260  DIM A1$(255),B1(255)
270  HOME
280  REM
290  REM  SAY 'TESTING' WHEN INITIALIZED
300  REM
310 A$ = "T EH S T I NG": GOTO 330
320  INPUT A$
330  IF A$ = "" THEN 770
340  IF A$ =  CHR$ (16) THEN 850
350 WC = 0:LC = 1
360  FOR I = 1 TO 255:A1$(I) = "": NEXT I
370  IF  MID$ (A$, LEN (A$),1) = " " THEN 390
380 A$ = A$ + " "
390 LA =  LEN (A$)
400  REM
410  REM  FIND NUMBER OF PHONEMES
420  REM
430  FOR I = 1 TO LA
440  IF  MID$ (A$,I,1) = " " THEN WC = WC + 1
450  NEXT I
460  REM
470  REM  SEPERATE THE PHONEMES FROM THE STRING
480  REM
490  FOR I = 1 TO WC
500 A1$(I) = A1$(I) +  MID$ (A$,LC,1)
510 LC = LC + 1
520  IF  MID$ (A$,LC,1) <  > " " THEN 500
530 LC = LC + 1
540  NEXT I
550  HOME
560  REM
570  REM  SEARCH FOR PHONEME IN DATA
580  REM  AND GIVE IT A VALUE
590  REM
```

▶

LISTING 3 PHONEME CODE LIST

PHONEME	ASCII	EXAMPLE	HEX	DEC	DURATION
A	`	tAme	60	96	185
A1	F	pAil	46	70	103
A2	E	mAke	45	69	71
AE	n	dAd	6E	110	185
AE1	o	After	6F	111	103
AH	d	mOp	64	100	250
AH1	U	fAther	55	85	146
AH2	H	hOnest	48	72	71
AW	}	cAll	7D	125	250
AW1	S	lAwful	53	83	146
AW2	p	sAlty	70	112	90
AY	a	jAde	61	97	65
B	N	Bag	4E	78	71
CH	P	CHip	50	80	71
D	^	paiD	5E	94	55
DT	D	buTTer	44	68	47
E	l	mEEt	6C	108	185
E1	¦	bE	7C	124	121
EH	{	rEAdy	7B	123	185
EH1	B	hEAvy	42	66	121
EH2	A	Enlist	41	65	71
EH3	@	jackEt	40	64	59
ER	z	bIRd	7A	122	146
F	]	Fast	5D	93	103
G	\	Get	5C	92	71
H	[	Hello	5B	91	71
I	g	pIn	67	103	185
I1	K	inhIbit	4B	75	121
I2	J	Inhibit	4A	74	80
I3	I	inhibIt	49	73	55
IU	v	yOU	76	118	59
J	Z	JudGe	5A	90	47
K	Y	triCK	59	89	80
L	X	Land	58	88	103
M	L	Mat	4C	76	103
N	M	suN	4D	77	80
NG	T	thiNG	54	84	121
O	f	cOld	66	102	185
O1	u	abOArd	75	117	121
O2	t	bOld	74	116	80
OO	W	bOOK	57	87	185
OO1	V	lOOKing	56	86	103
P	e	Past	65	101	103
R	k	Red	6B	107	90
S	_	paSS	5F	95	90
SH	Q	SHop	51	81	121
T	j	Tap	6A	106	71
TH	y	THin	79	121	71
THV	x	THe	78	120	80
U	h	mOve	68	104	185
U1	w	jUne	77	119	90
UH	s	cUp	73	115	185
UH1	r	Uncle	72	114	103
UH2	q	About	71	113	71
UH3	c	Under	63	99	47
V	O	Van	4F	79	71
W	m	Win	6D	109	80
Y	i	anY	69	105	103
Y1	b	Yard	62	98	80
Z	R	haZe	52	82	71
ZH	G	aZure	47	71	90
PA0	C	(sil)	43	67	47
PA1	~	(sil)	7E	126	185
STOP	?	-----	3F	63	47

LISTING 4

```
00100 REM *** SAYINGS OF THE DALEKS ***
00110 REM
00120 REM --- Tom Moffat, October 18, 1984
00130 REM
00140 OUTL#1: REM Establish parallel "list" data output
00150 X=INT(RND*16): REM Random number between 0 and 15
00160 X=1000+(X*10): REM Index to data statements at line 1000
00170 RESTORE X: READ A1$: PRINT A1$
00180 READ A1$: LPRINT CHR(126); A1$; CHR(126);
00190 FOR T=1 TO 500: NEXT T: REM Pause between sayings
00200 GOTO 150
00210 REM
00220 REM TEXT AND VOTRAX DATA INDEXED TO LINE 1000
00230 REM
01000 DATA "The hostiles must be exterminated."
01005 DATA "ys[}_jUaX_Lr_jN!BY_jzLJMAajr^"
01010 DATA "The Daleks must be obeyed."
01015 DATA "ys^dXBY_Lr_jN!fN{a^"
01020 DATA "You must obey."
01025 DATA "ihLr_jCfN{a"
01030 DATA "Take the patient to the examination centre."
01035 DATA "jBaYyre`QrMjCjhy!B\Ro@LKMBaQqM_B@Mjz"
01040 DATA "You must cooperate. You must lie down."
01045 DATA "ivwLr_jYtmUecKAaj~~bvwLr_jXUb^UwM"
01050 DATA "You will remain silent."
01055 DATA "bvwmgXK!L`aM_UaXAMj"
01060 DATA "The Daleks are the superior being."
01065 DATA "yrC^dXBY_UKyr_vegKbzN1KT"
01070 DATA "We do not need assistance."
01075 DATA "m!^vwMUjM!^H_K_jHM_"
01080 DATA "You will assasinate the members of the High Council."
01085 DATA "ivwmKXH_n_JM`jyrLBLNzRrOyr[U@iYUcM_BX"
01090 DATA "We have been sent by the Supreme Dalek."
01095 DATA "m1[oON!M_BMjNUbxr_ivweK1L^UXBY"
01100 DATA "We obey Davros. He is our leader."
01105 DATA "m1fNBiC^oHOKU_~~[1g_UzX1^z"
01110 DATA "The prisoner is secured."
01115 DATA "yreKK_rM@zgRC_@Yivz^"
01120 DATA "EMERGENCY! EMERGENCY! The enemy must be destroyed!"
01125 DATA "!Lz^ZrM_1~!Lz^ZrM_1~y1{MqL1Lr_jN1^@_jKfi^"
01130 DATA "Nothing will interfere with the destiny of the Daleks."
01135 DATA "MqyJTmIX@Mjz]gzmJxyr^A_j@M!rOyr^UXBY_"
01140 DATA "The collapse of Earth society will soon occur."
01145 DATA "ysYUXne_rOzKy_u_UaBj!mJX_vhMuYzK"
01150 DATA "You have not won, Doctor. Join me and I will make you the ruler of the world."
01155 DATA "ivw[oOMUjmsM^SYjz~~ZuKML1CnM^UIimJXLEaYCivwysKhXzsOyrmzX^"
```

LISTING 5

```
100  REM  SAYINGS OF THE DALEKS
110  REM
120  REM    BY CRAIG FORD-KING
130  REM
140  REM          18.10.'84
150  REM
160  REM
170  REM - SERIAL CARD DRIVER -
190  REM
200  POKE 768,169: POKE 769,16: POKE 770,44: POKE 771,161: POKE 772,192: POKE 77
3,240: POKE 774,251: POKE 775,96
210  TEXT : HOME : VTAB 10: HTAB 13: PRINT "LOADING ARRAY"
220  REM
230  REM - INITIALIZE SERIAL CARD -
250  REM
260 W =  - 16224: POKE W + 3,152: POKE W + 2,11
270  DIM A1(30),A2(20),A3(13),A4(46),A5(36),A6(20),A7(47),A8(39),A9(33),A0(28)
280  REM
290  REM -READ DATA INTO ARRAYS-
300  REM
310  READ NI:A1(0) = NI: FOR C = 1 TO NI
320  READ NO:A1(C) = NO: NEXT C
330  READ NI:A2(0) = NI: FOR C = 1 TO NI
340  READ NO:A2(C) = NO: NEXT C
350  READ NI:A3(0) = NI: FOR C = 1 TO NI
360  READ NO:A3(C) = NO: NEXT C
370  READ NI:A4(0) = NI: FOR C = 1 TO NI
380  READ NO:A4(C) = NO: NEXT C
390  READ NI:A5(0) = NI: FOR C = 1 TO NI
400  READ NO:A5(C) = NO: NEXT C
410  READ NI:A6(0) = NI: FOR C = 1 TO NI
420  READ NO:A6(C) = NO: NEXT C
430  READ NI:A7(0) = NI: FOR C = 1 TO NI
440  READ NO:A7(C) = NO: NEXT C
450  READ NI:A8(0) = NI: FOR C = 1 TO NI
460  READ NO:A8(C) = NO: NEXT C
470  READ NI:A9(0) = NI: FOR C = 1 TO NI
480  READ NO:A9(C) = NO: NEXT C
490  READ NI:A0(0) = NI: FOR C = 1 TO NI
500  READ NO:A0(C) = NO: NEXT C
510  HOME
520  REM
530  REM - PICK A NUMBER 1 TO 10 -
540  REM
550 X =  INT ( RND (1) * 10) + 1
560  ON X GOSUB 580,600,620,640,660,680,700,720,740,760
564  REM
565  REM - PAUSE BETWEEN SAYINGS -
566  REM
570  FOR T = 1 TO 500: NEXT T: GOTO 550
580  HOME : VTAB 10: PRINT "     The Hostiles Must Be Exterminated"
590  FOR C = 1 TO A1(0): POKE W,A1(C): CALL 768: NEXT C: RETURN
600  HOME : VTAB 10: HTAB 7: PRINT "The Daleks Must Be Obeyed"
610  FOR C = 1 TO A2(0): POKE W,A2(C): CALL 768: NEXT C: RETURN
620  HOME : VTAB 10: HTAB 13: PRINT "You Must Obey"
630  FOR C = 1 TO A3(0): POKE W,A3(C): CALL 768: NEXT C: RETURN
640  HOME : VTAB 10: PRINT "  Take The Patient To The Examination": VTAB 12: HTA
B 13: PRINT "Centre. Proceed"
650  FOR C = 1 TO A4(0): POKE W,A4(C): CALL 768: NEXT C: RETURN
660  HOME : VTAB (10): PRINT "You Must Co-operate. You Must Lie Down"
670  FOR C = 1 TO A5(0): POKE W,A5(C): CALL 768: NEXT C: RETURN
680  HOME : VTAB 10: HTAB 9: PRINT "You Will Remain Silent"
690  FOR C = 1 TO A6(0): POKE W,A6(C): CALL 768: NEXT C: RETURN
700  HOME : VTAB 10: PRINT "   The Daleks Are The Superior Being.": VTAB 12: HTA
B 7: PRINT "We Do Not Need Assistance."
710  FOR C = 1 TO A7(0): POKE W,A7(C): CALL 768: NEXT C: RETURN
720  HOME : VTAB 10: PRINT " You Will Assasinate The Members Of The": VTAB 12: H
TAB 14: PRINT "High Council"
730  FOR C = 1 TO A8(0): POKE W,A8(C): CALL 768: NEXT C: RETURN
740  HOME : VTAB 10: PRINT "We Have Been Sent By The Supreme Dalek"
750  FOR C = 1 TO A9(0): POKE W,A9(C): CALL 768: NEXT C: RETURN
760  HOME : VTAB 10: PRINT "     We Obey Davros. He Is Our Leader"
770  FOR C = 1 TO A0(0): POKE W,A0(C): CALL 768: NEXT C: RETURN
780  REM
790  REM AND NOW THE VOTRAX DATA...
800  REM
810  DATA  29,121,115,91,125,95,106,85,97,88,95,76,114,95,106,78,124,66,89,95,10
6,122,76,74,77,65,97,106,114,94
820  DATA  19,121,115,94,100,88,66,89,95,76,114,95,106,78,124,102,78,123,97,94
830  DATA  12,105,104,76,114,95,106,67,102,78,123,97,67
840  DATA  45,106,66,97,89,121,114,101,96,81,114,77,106,67,106,104,121,124,65,92
,82,111,64,76,75,77,66,97,81,113,77,95,66,64,77,106,122,126,126,101,107,117,95,1
24,105,94
850  DATA  34,98,118,119,76,114,95,106,89,116,109,95,101,99,107,65,97,106,126,12
6,98,118,119,76,114,95,106,88,85,98,94,85,119,77,67
860  DATA  19,98,118,119,109,103,88,107,124,76,96,97,77,95,85,97,88,65,77,106
870  DATA  46,121,72,67,94,100,88,66,89,95 ,100,107,121,72,95,118,101,103,107,98
,122,78,108,75,84,126,126,109,124,94,118,118,77,100,106,77,124,94,72,95,103,95,1
06,72,77,95,67
880  DATA  38,105,118,118,109,103,88,72,95,118,95,74,77,96,106,121,66,76,66,76,7
8,122,95,100,79,121,85,91,85,64,105,89,85,99,77,95,66,88,67
890  DATA  32,109,108,91,111,79,98,124,77,95,66,77,106,78,72,64,105,121,64,95,10
5,118,119,101,107,108,76,94,85,88,66,89,67
900  DATA  27,109,108,102,78,66,105,67,94,111,79,107,85,95,126,126,91,108,103,95
,85,99,122,88,108,94,122,67
```

```
600  PRINT "SEARCHING FOR : ";
610  FOR I = 1 TO WC
620  PRINT A1$(I);" ";
630 E = 0
640  FOR J = 1 TO 63
650  READ B$,P
660  IF B$ = A1$(I) THEN B1(I) = P:E = 1:J = 63
670  NEXT J
680  IF E < > 1 THEN  PRINT : PRINT : PRINT "ILLEGAL PHONEME": GOSUB 920: PRINT
 :E = 0:I = WC:X = 1: PRINT
690  RESTORE
700  NEXT I
710  IF X = 1 THEN X = 0: GOTO 880
720  PRINT
730  REM
740  REM  ADD PAUSES TO FRONT AND END
750  REM  THEN SAY IT!
760  REM
770 B1(0) = 126:B1(WC + 1) = 126
780  FOR I = 0 TO WC + 1
790  POKE W,B1(I): CALL 768
800  NEXT I
810  POKE W,63: GOTO 870
820  REM
830  REM  PRINT OUT ASCII EQUIVILENT
840  REM
850  PRINT : PRINT "ASCII  ";
860  FOR I = 0 TO WC + 1: PRINT  CHR$ (B1(I));: NEXT I
870  PRINT : PRINT " ";A$: PRINT
880  GOTO 320
890  REM
900  REM  SAY ERROR MESSAGE
910  REM
920 E$ = "~youCKRCoMJX! HX]tmMBL~"
930  FOR I = 1 TO  LEN (E$)
940  POKE W, ASC ( MID$ (E$,I,1))
950  CALL 768: NEXT I: RETURN
960  REM
970  REM  CODES FOR PHONEMES
980  REM
990  DATA  "A",96,"A1",70,"A2",69,"AE",110,"AE1",111
1000  DATA  "AH",100,"AH1",85,"AH2",72,"AW",125,"AW1",83
1010  DATA  "AW2",112,"AY",97,"B",78,"CH",80,"D",94
1020  DATA  "DT",68,"E",108,"E1",124,"EH",123,"EH1",66
1030  DATA  "EH2",65,"EH3",64,"ER",122,"F",93,"G",92
1040  DATA  "H",91,"I",103,"I1",75,"I2",74,"I3",73
1050  DATA  "IU",118,"J",90,"K",89,"L",88,"M",76
1060  DATA  "N",77,"NG",84,"O",102,"O1",117,"O2",116
1070  DATA  "OO",87,"OO1",86,"P",101,"PA0",67,"PA1",126
1080  DATA  "R",107,"S",95,"SH",81,"T",106,"TH",121
1090  DATA  "THV",120,"U",104,"U1",119,"UH",115,"UH1",114
1100  DATA  "UH2",113,"UH3",99,"V",79,"W",109,"Y",105
1110  DATA  "Y1",98,"Z",82,"ZH",71
```

LISTING 6

```
ADDR   CODE     LINE   LABEL  MNEM    OPERAND

                00100 ;SPEECH SYNTHESIZER MACHINE CODE DRIVER ROUTINES
                00110 ;        - Tom Moffat, 16/7/83
                00120
0400            00130         DEFR    16
010E            00140 PNT     EQU     010EH   ;PHONEME POINTER
0400            00150         ORG     0400
                00160
                00170 ;Initialize PIO and interrupt vector for speech.
                00180
0400 3E0F       00190         LD      A,0FH   ;MAKE PIO OUTPUT
0402 D301       00200         OUT     (1),A
0404 3E80       00210         LD      A,80    ;GET VECTOR FROM 0080
0406 D301       00220         OUT     (1),A
0408 214404     00230         LD      HL,PHON ;SET INTERRUPT VECTOR TO "PHON"
040B 228000     00240         LD      (80),HL
040E AF         00250         XOR     A       ;CLEAR BUSY FLAG
040F 320901     00260         LD      (109),A
                00270
                00280 ;Model main program, prints the alphabet.
                00290
0412 215F04     00300         LD      HL,BLURB;POINT TO PHRASE
0415 220E01     00310         LD      (PNT),HL
0418 CD3904     00320         CALL    SPEAK   ;START SPEAKING
041B 3E41       00330         LD      A,41    ;START AT "A"
041D 061A       00340         LD      B,1AH   ;DO 26 LETTERS
041F CD4280     00350 LOOP    CALL    8042    ;REDIRECTED OUT TO VDU
0422 F5         00360         PUSH    AF
0423 110080     00370         LD      DE,8000 ;TIME DELAY
0426 1B         00380 DELAY   DEC     DE
0427 7A         00390         LD      A,D
0428 B3         00400         OR      E
0429 20FB       00410         JR      NZ,DELAY
042B F1         00420         POP     AF
042C 3C         00430         INC     A
042D 10F0       00440         DJNZ    LOOP    ;GET NEXT LETTER
042F 210886     00450         LD      HL,0B608;JUMP ADDR FOR BASIC I.S.R.
0432 228000     00460         LD      (80),HL ;RESTORE I.S.R. TO NORMAL
0435 2AA200     00470         LD      HL,(0A2)
0438 E9         00480         JP      (HL)    ;CLEAR OUT OF PROGRAM
                00490
                00500 ;Speak-a-phrase subroutine.
                00510
0439 3A0901     00520 SPEAK   LD      A,(109) ;GET BUSY FLAG
043C B7         00530         OR      A       ;TEST FOR BUSY
043D 20FA       00540         JR      NZ,SPEAK
043F 3EFF       00550         LD      A,0FFH  ;SET BUSY FLAG
0441 320901     00560         LD      (109),A
                00570
                00580 ;Interrupt routine, sends one phoneme to synthesizer
                00590
0444 F5         00600 PHON    PUSH    AF
0445 E5         00610         PUSH    HL
0446 2A0E01     00620         LD      HL,(PNT)
0449 7E         00630         LD      A,(HL)  ;GET A PHONEME
044A D300       00640         OUT     (0),A   ;SEND IT TO SYNTHESIZER
044C 23         00650         INC     HL
044D 220E01     00660         LD      (PNT),HL
0450 FB         00670         EI
0451 2F         00680         CPL                     ;INVERT IT
0452 E63F       00690         AND     3FH     ;TEST FOR SHUTUP CODE
0454 2005       00700         JR      NZ,CONT
0456 AF         00710         XOR     A
0457 320901     00720         LD      (109),A ;CLEAR BUSY FLAG
045A F3         00730         DI
045B E1         00740 CONT    POP     HL
045C F1         00750         POP     AF
045D ED4D       00760         RETI
                00770
                00780 ;ASCII data to generate synthesized message.
                00790
045F 7E         00800 BLURB   DEFM    '~[{XfwCyBk~~yg_KRs'
0471 4C         00810         DEFM    'LqQ]MYf^LB_J^Z]krLC'
0484 6A         00820         DEFM    'j}LCLS]qjROAk1YXBOck'
0498 4C         00830         DEFM    'LHIaYkfNIYrLe|vjck~~~~~
04AF 42         00840         DEFM    'B@YC_jckLAMBaj~?'
                00850
0000            00860         END
00000 Total errors

CONT   0458   DELAY  0426   LOOP   041F   SPEAK  0439
BLURB  045F   PHON   0444   PNT    010E
```

LISTING 7

```
0400   3E 0F D3 01  3E 80 D3 01  21 44 04 22  80 00 AF 32
0410   09 01 21 5F  04 22 0E 01  CD 39 04 3E  41 06 1A CD
0420   42 80 F5 11  00 80 1B 7A  B3 20 FB F1  3C 10 F0 21
0430   08 B6 22 80  00 2A A2 00  E9 3A 09 01  B7 20 FA 3E
0440   FF 32 09 01  F5 E5 2A 0E  01 7E D3 00  23 22 0E 01
0450   FB 2F E6 3F  20 05 AF 32  09 01 F3 E1  F1 ED 4D 7E
0460   58 7B 58 66  77 43 79 42  6B 7E 7E 79  67 5F 4B 52
0470   73 4C 71 51  6C 4D 59 66  5E 4C 42 5F  4A 5E 5A 5D
0480   6B 72 4C 43  6A 7D 4C 43  4C 53 5D 71  6A 52 4F 41
0490   6B 6C 59 58  42 4F 63 6B  4C 48 49 61  59 68 66 4E
04A0   6C 59 72 4C  65 7C 76 6A  63 6B 7E 7E  7E 7E 7E 42
04B0   40 59 43 5F  6A 63 6B 4C  41 4D 42 61  6A 7E 3F 00
```

LISTING 8

```
0400   3E 0F D3 01  3E 80 D3 01  21 44 04 22  80 00 AF 32
0410   09 01 21 5F  04 22 0E 01  CD 39 04 3E  41 06 1A CD
0420   42 80 F5 11  00 80 1B 7A  83 20 FB F1  3C 10 F0 21
0430   08 B6 22 80  00 2A A2 00  E9 3A 09 01  87 20 FA 3E
0440   FF 32 09 01  F5 E5 2A 0E  01 7E D3 00  23 22 0E 01
0450   FB 2F E6 3F  20 05 AF 32  09 01 F3 E1  F1 ED 4D 7E
0460   5B 78 58 66  77 43 79 42  2B 3E 7E 79  67 5F 4B 52
0470   73 4C 71 51  6C 4D 59 66  5E 4C 42 5F  4A 5E 5A 5D
0480   6B 72 4C 43  6A 7D 4C 43  4C 53 5D 71  6A 52 4F 41
0490   6B 6C 59 58  42 4F 63 6B  4C 48 49 61  59 6B 66 4E
04A0   6C 59 72 4C  65 7C 76 6A  63 2B 3E 7E  7E 7E FE E2
04B0   00 D9 C3 DF  EA E3 EB CC  C1 CD C2 E1  EA FE 3F 00
```