BY GEORGE STEBER

The MORSE-A-WORD

PART ONE: Theory and System Operation

LED readout displays words and numbers when Morse code is received

NOW YOU can literally sit back and read messages sent in International Morse even if you don't know the code. The "Morse-A-Word" project presented here automatically converts incoming dits and dahs from a communications receiver or telegraph key into alphanumeric symbols for display on a multicharacter LED readout. The display operates in moving-character fashion to make it easy to read the messages.

With this project, SWLs can listen in on commercial and amateur code traffic. And for beginning as well as veteran radio amateurs, the Morse-A-Word makes an excellent operating and code-training aid. Cost of a complete kit including a prepunched and lettered chassis and two two-character displays is $140. One or two additional displays can be added at moderate cost.

This project is similar to the Morse-A-Letter featured in the January 1977 issue of POPULAR ELECTRONICS. Its display capability has been expanded, however. At the builder's option, the Morse-A-Word can display two, four, six or eight characters simultaneously. All

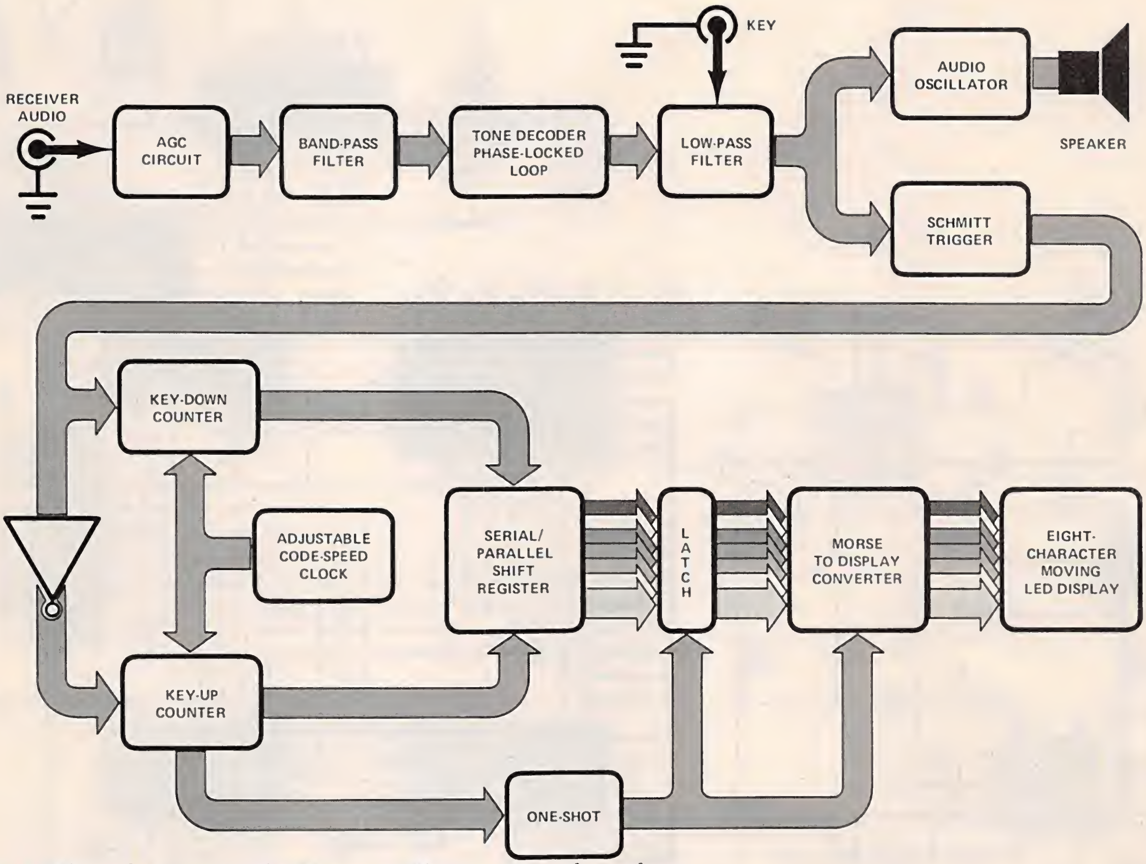

Fig. 1. Block diagram of the Morse-A-Word system shows how the incoming signal in code is processed for alphanumeric display.

characters—letters, numerals, punctuation marks and, if desired, word spaces—are displayed and shifted from right to left as new ones stream in.

Double-sided pc boards hold the LED display and main decoder circuits. A single-sided board accommodates the power supply.

It should be mentioned at the outset that the reliable conversion of Morse code radio signals into alphanumeric characters is not easy. Signal fading, atmospheric and man-made noise, and human errors present major difficulties. Consequently, no device can perfectly decode all received signals all of the time. The highly sophisticated Morse-A-Word circuit has been designed to provide a very high degree of accuracy, however, and will do a very creditable decoding job in far-from-ideal situations.

System Analysis. A block diagram of the Morse-A-Word is shown in Fig. 1. The complete schematic of the main decoding circuit is in Fig. 2, and the display circuit is shown in Fig. 3.

PARTS LIST: MAIN DECODING CIRCUIT

C1,C2,C5,C10,C12,C15,C17,C18 through C21,C23—0.1- or 0.05-µF disc ceramic
C3, C7—22-µF, 10-volt tantalum
C4—0.05-µF disc ceramic
C6,C9,C11—0.01-µF Mylar
C8—1-µF, 10-volt tantalum
C13—0.22-µF Mylar
C14—6.8-µF, 10-volt tantalum
C16—0.47-µF, 10-volt tantalum
C22—27-pF disc ceramic
D1,D2,D3—1N270 germanium diode
IC1, IC2—7495 4-bit shift register
IC3,IC6,IC15,IC17—74161 4-bit counter
IC4,IC8—741 operational amplifier (8-pin mini-DIP)
IC5—74174 hex D flip-flop
IC7—7414 hex inverting Schmitt trigger
IC9,IC10—7489 64-bit RAM
IC11—74121 monostable multivibrator
IC12—555 timer
IC13—567 PLL tone decoder
IC14—1702A PROM
IC16—7402 quad 2 input NOR gate
IC18—7483 4-bit binary adder
IC19—7485 4-bit magnitude comparator
J1,J2—Phono jack
LED1, LED2—Red light-emitting diode
Q1—2N3823 n-channel JFET
The following are ¼-watt, 10% tolerance fixed resistors.
R1,R4,R27—220 ohms
R2—10,000 ohms
R3,R13,R15—470 ohms
R5—15,000 ohms
R6,R17,R21 through R26—1000 ohms
R7—150,000 ohms
R8—330 ohms
R10—680 ohms
R11,R19—6800 ohms
R12—270,000 ohms
R16—47,000 ohms
R18—12,000 ohms
R9,R14—500-ohm pc trimpot
R20—5000-ohm pc trimpot
R28—500-ohm linear-taper potentiometer with ganged spst power switch
S1—Spst slide or toggle switch
SPKR—8-ohm dynamic loudspeaker
Misc.—Printed circuit board, IC sockets or Molex Soldercons, suitable enclosure, LED holders, pc standoff insulators, control knob, machine hardware, hookup wire, solder, etc.
Note—For parts and kit ordering information, refer to the Parts Availability list.

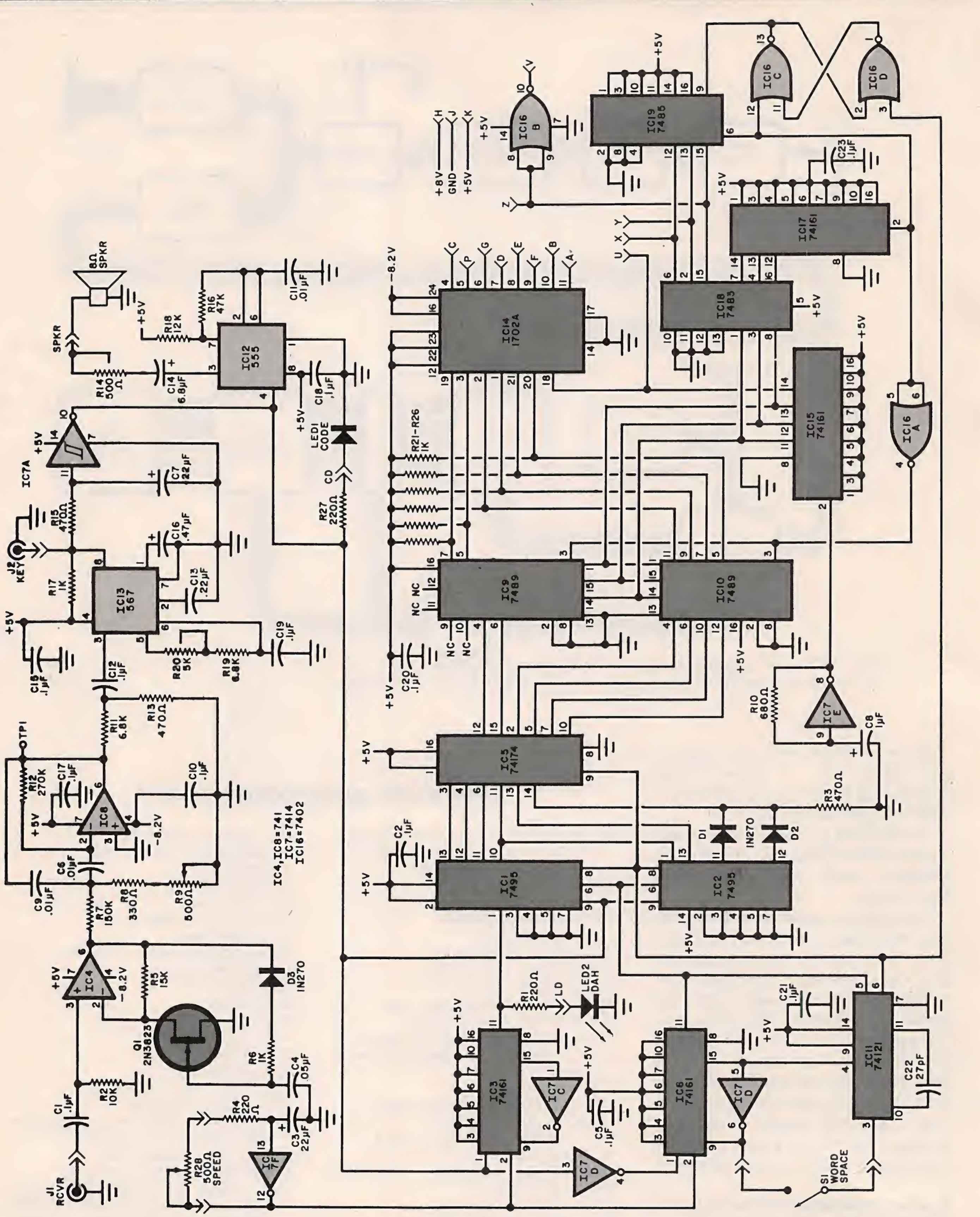

Fig. 2. Schematic diagram of the main decoder circuit. If the audio output of a radio receiver is used, it is applied to J1. An input from a telegraph key is applied to J2. Parts list is on facing page.

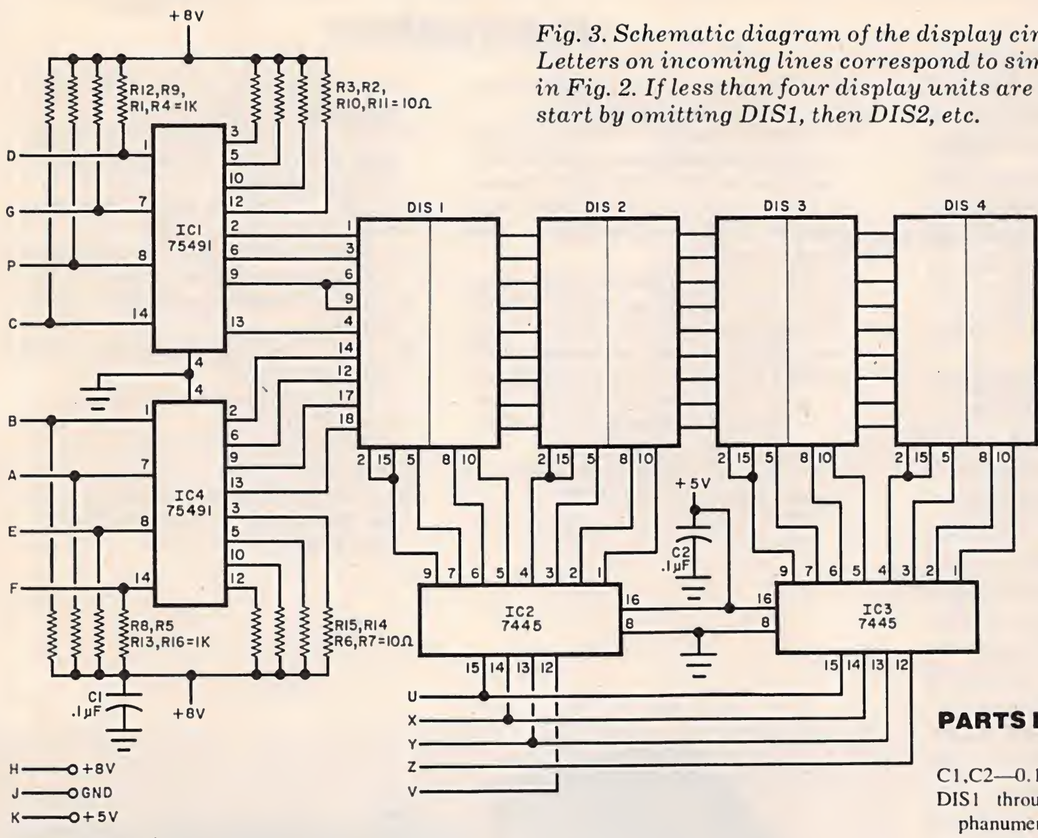

Fig. 3. Schematic diagram of the display circuit. Letters on incoming lines correspond to similar points in Fig. 2. If less than four display units are used, start by omitting DIS1, then DIS2, etc.

Referring to Fig. 1, the audio output of a radio receiver is applied to an agc stage which limits the amplitude excursions of the input signal. The output of the agc stage drives an active bandpass filter whose response is centered at 1200 Hz. A tone decoder with a phase-locked loop, whose response is also peaked at 1200 Hz, receives signals from a bandpass filter and demodulates them. This decoder generates a low voltage when the transmitter's telegraph key is down and a high voltage under key-up conditions. A low-pass filter smooths the output of the tone decoder and can accept a telegraph key input for code practice use.

Further signal processing is performed by a Schmitt trigger which "squares up" and inverts the signals applied to it. At the output of the Schmitt trigger, a logic 1 corresponds to a key-down condition, and a logic zero to a key-up condition. Signal processing is now complete, and clean, TTL-compatible Morse signals are available to the di-

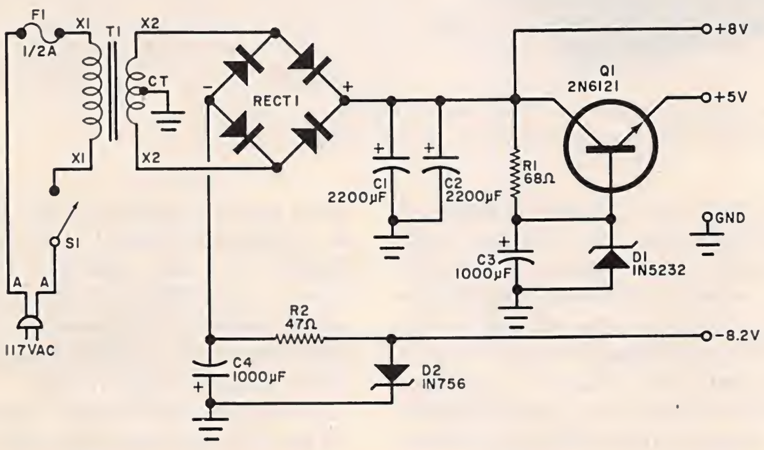

Fig. 4. Schematic diagram of power supply circuit. The main decoder requires 750 mA at 5 volts and 20 mA at −8.2 volts. Display is best with 8-volt supply.

PARTS LIST: DISPLAY CIRCUIT

C1,C2—0.1- or 0.05-μF disc ceramic
DIS1 through DIS4—IEE 1785R dual alphanumeric LED display
IC1,IC4—75491 MOS-to-LED display driver
IC2,IC3—7445 or 74145 BCD-to-decimal decoder/driver
The following are ¼-watt, 10% tolerance fixed resistors.
R1,R4,R5,R8,R9,R12,R13,R16—1000 ohms
R2,R3,R6,R7,R10,R11,R14,R15—10 ohms
Misc.—Printed circuit board, Molex Soldercons for displays, Soldercons or IC sockets for driver ICs, red bezel for displays, solid hookup wire, solder, etc.
Note—For parts and kit ordering information, refer to the Parts Availability list.

PARTS LIST: POWER SUPPLY

C1,C2—2200-μF, 16-volt upright electrolytic
C3—1000-μF, 10-volt upright electrolytic
C4—1000-μF, 16-volt upright electrolytic
D1—1N5232 5.6-volt zener
D2—1N756 8.2-volt zener
F1—½-ampere fast-blow fuse
Q1—2N6121 npn tab (TO-220) transistor
R1—68-ohm, ½-watt, 10% resistor
R2—47-ohm, ½-watt, 10% resistor
RECT1—1-ampere, 50-PIV modular bridge rectifier
S1—Spst power switch (part of main circuit R28)
T1—12.6-volt, 2-ampere center-tapped transformer (Stancor P8130 or equivalent)
Misc.—Printed circuit board, pc-mount heat sink for *Q1*, silicone thermal compound, fuseholder, pc standoff insulators, line cord and strain relief, hookup wire, machine hardware, solder, etc.
Note—For parts and kit ordering information, refer to the Parts Availability list.

gital decoding circuits.

The digitized Morse is first applied to two counters. One counter, but not both, will be enabled to count, depending on whether the key is up or down. These circuits count at a rate dependent on the frequency of an adjustable code-speed clock. The clock frequency should be adjusted to match the speed of the incoming code, but this adjustment can be off by as much as ±50% and still result in solid copy.

Whenever the key-up counter detects an element space, a condition that occurs when it counts less than eight clock pulses, it serially transfers a logic 0 or 1 to the next stage, an eight-bit serial/parallel shift register. The latter is always initialized with the binary word 00000001 so that the beginning of each Morse character will be uniquely decodable. Whether a logic 1 or 0 is transferred to the shift register in subsequent steps is determined by the condition of the key-down counter, which distinguishes between dits and dahs. If the key-down counter counts more than seven clock pulses, the code element is a dah and a logic 1 is transferred to the shift register. Otherwise, it is a dit and a logic 0 is transferred to the shift register. The detection scheme is similar to that employed in the Morse-A-Letter, and has been found to be very reliable.

This procedure continues until the key-up counter detects a space longer than an element space (longer than seven clock periods), whereupon the circuit determines that a complete character has been sent. The unique binary code present in the shift register can now be transferred to a latch for decoding and display. However, if the key-up counter continues to count more than 15 clock pulses, this is interpreted as a space between words and a blank character is inserted in the latch after the last character is received. Because many CW stations do not send word spaces, the circuit contains a switch to defeat the word-space feature.

A 16-element RAM (in which only 8 elements are used) stores the Morse characters obtained from the latch. The RAM is synchronized to the eight-character display by an address counter and a ROM which decodes the Morse characters for display. A standard multiplexed circuit is employed for display of stored characters, which appear on IEE 1785R two-character LED displays. The circuit has been designed to provide a moving-character type of display which introduces new characters at the rightmost position and moves each of the existing characters to the left, one position at a time, as characters are received. It takes just a few minutes to accustom yourself to reading this type of presentation. Once you get the hang of it, reading code is a breeze.

The Morse-A-Word's main decoder circuit power requirements are 750 mA at +5 volts and 20 mA at −8.2 volts. The display circuit also calls for 8 volts at approximately 100 mA. Voltages as low as 5 V can be used to power the display, but it will not be as bright. A suggested power supply is shown in Fig. 4.

In Part Two of this article, next month, we will describe how to assemble, align, and use the project. Programming instructions for IC14 will be included. ◇

PARTS AVAILABILITY

The following are available from Microcraft Corp., Box 513, Theinsville, WI 53092:

No. MAWK-1. Complete kit of parts, including prepunched and lettered cabinet and two dual-character IEE 1785R LED displays, $139.95. (One or two additional dual-character displays can be ordered at the builder's option.)

No. EPK-1. Essential parts kit including two (main and display) pc boards, preprogrammed ROM, all ICs, sockets, resistors and capacitors, one dual-character IEE 1785R LED display, but not including power supply, hookup wire, solder, loudspeaker, enclosure, control knob, jacks and miscellaneous hardware, $99.50.

No. PCBK-1. Set of three (main, display and power supply) pc boards, $24.00.

No. MB-1. Etched and drilled, double-sided, glass epoxy main pc board with plated-through holes, $12.50.

No. DB-1. Etched and drilled, double-sided, glass epoxy display pc board with plated-through holes, $7.00.

No. PSB-1. Etched and drilled, glass epoxy power supply pc board, $5.50.

No. PSK-1. Power supply kit, including pc board and all components, $22.00.

No. Rom-1. Preprogrammed 1702A ROM, $10.00.

No. DSP-1. One dual-character IEE 1785R LED display, $9.00.

No. CAB-I. Prepunched and lettered enclosure, $17.00.

No. CT-1. Alignment and code practice cassette tape, $6.00.

Prices include shipping and handling within the continental USA. Wisconsin residents, add 4% sales tax.

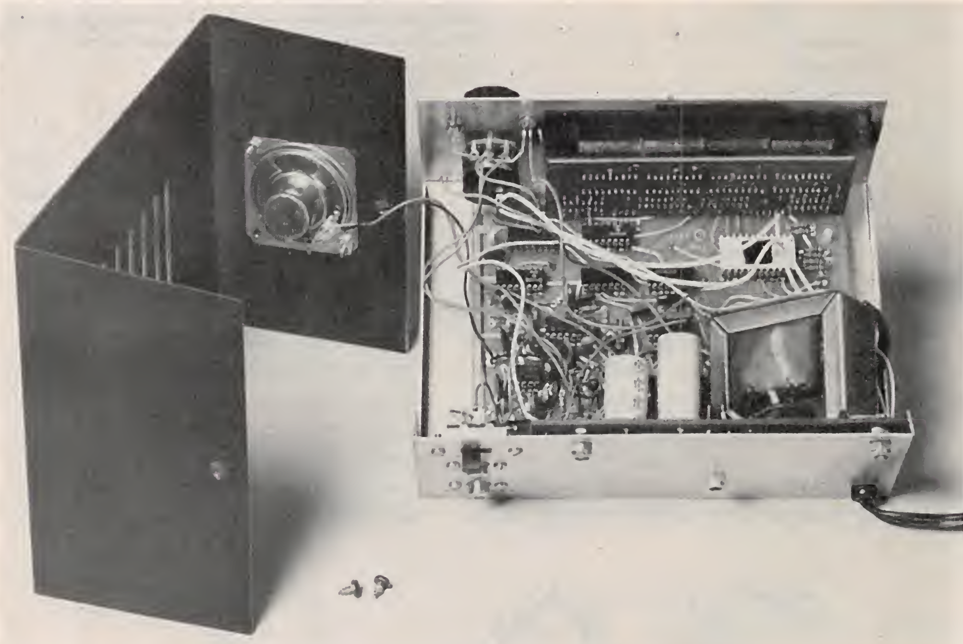

Photo shows internal assembly of the author's prototype. Display board is on front panel, power supply on back.

The MORSE-A-WORD

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PART TWO: Construction, Alignment, and Use

Construction. The Morse-A-Word is most easily assembled using printed circuit techniques. Three pc boards are required—a main circuit board, display board, and a power supply board. The parts placement guide for the main circuit board appears in Fig. 5. Etching and drilling guides are shown in Fig. 6. Similarly, etching and drilling guides for the double-sided display board are shown in Fig. 7. This board's parts placement guide appears in Fig. 8. Finally, the etching and drilling and parts placement guides for the power supply board appear in Figs. 9 and 10.

When soldering components to circuit board foils, use a low-wattage, fine-tipped soldering pencil and fine solder. Be sure to employ the minimum amount of heat and solder consistent with good connections, and take care not to inadvertently create solder bridges between adjacent foils. The use of IC sockets or Molex Soldercons is recommended.

Assemble the main pc board first. Start by inserting and soldering the IC sockets and Molex Soldercons. Install the smallest components next, gradually working up to the larger items. For example, start with the ¼-watt resistors, then install the diodes, the small capacitors and finally the larger capacitors. Be sure to observe the polarities of diodes and tantalum and electrolytic capacitors, and the pin basing of transistors and ICs. The board furnished by the kit supplier has plated-through holes so you need only solder component leads on the bottom side of the board.

Neither the power supply, the display circuits, the sidetone speaker, jacks, CODE and DAH LEDs or the SPEED control are mounted on the main pc board. Insulated wire leads of suitable lengths should be soldered to appropriate points on the pc board now for connection to these components.

Wire the display board next, referring to the parts placement diagram of Fig. 8. Use Molex Soldercons to mount the dual IEE 1785R LED displays. Make sure the Soldercons are properly aligned before soldering them to the board. This will ensure a good fit for the displays. Resistors, capacitors and IC sockets or Soldercons for the driver ICs should be installed and soldered next. The resistors should be mounted in a vertical position. Notice that there are a number of jumper wires to be soldered to this board. These are used to interconnect the display board and the main circuit board and to support the display board. The jumpers should be made of heavy solid wire, about ½" (1.3 cm) long, and bent into "L" shapes so they extend parallel to the board and point downward.

Position the display board perpendicular to the main pc board. Insert the jumper wires connected to the display board through the appropriate holes on the main pc board and push down the display board until it just touches the main board. Check the alignment of the display board and then solder the jump-

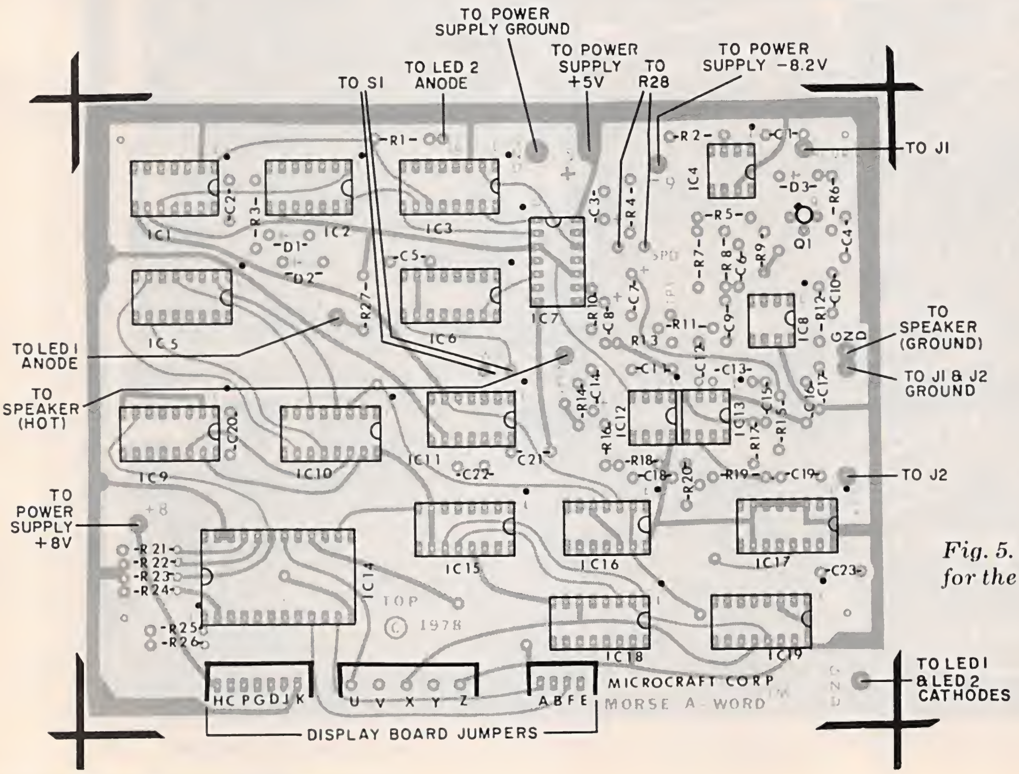


Fig. 5. Parts placement guide for the main circuit board.

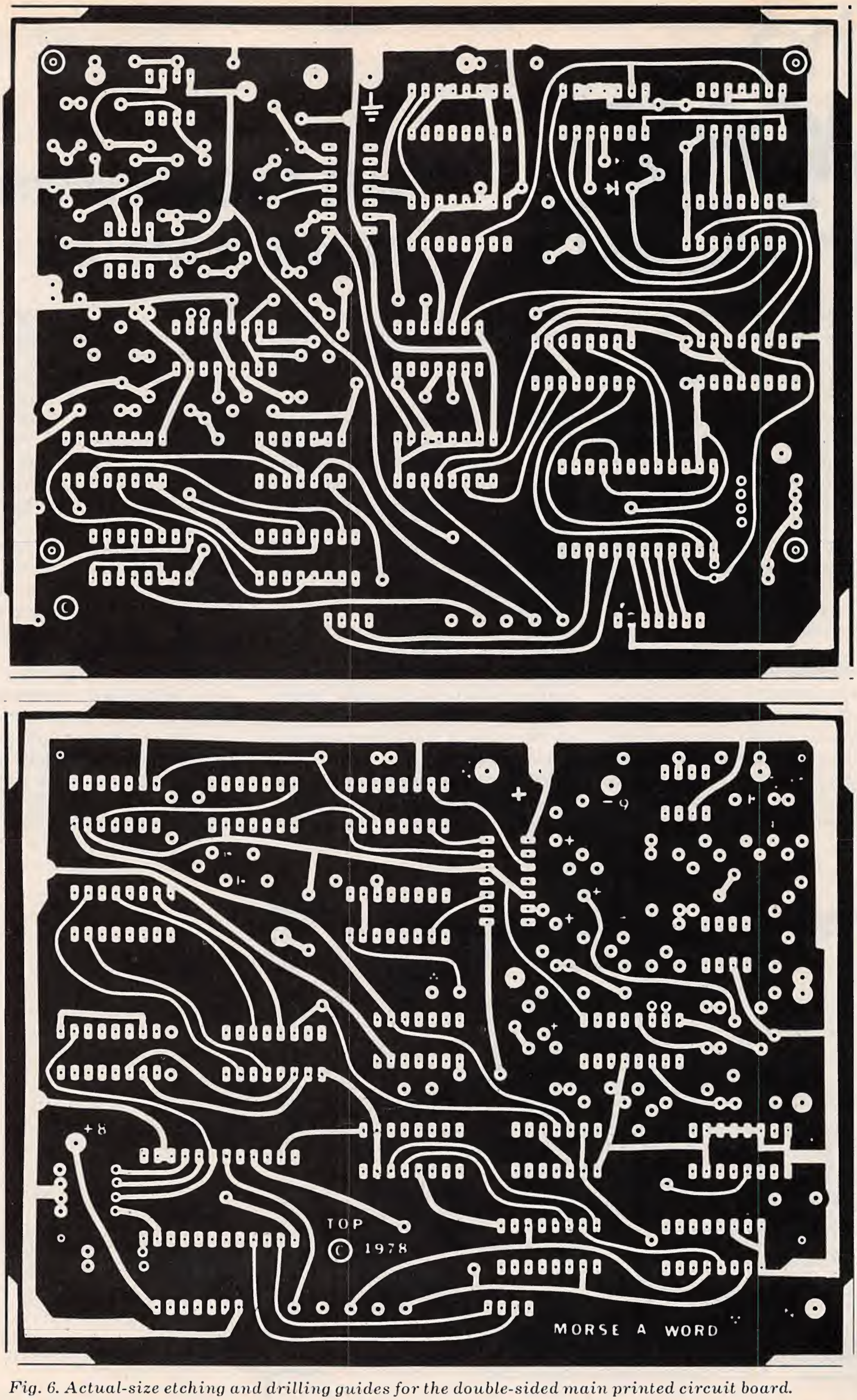
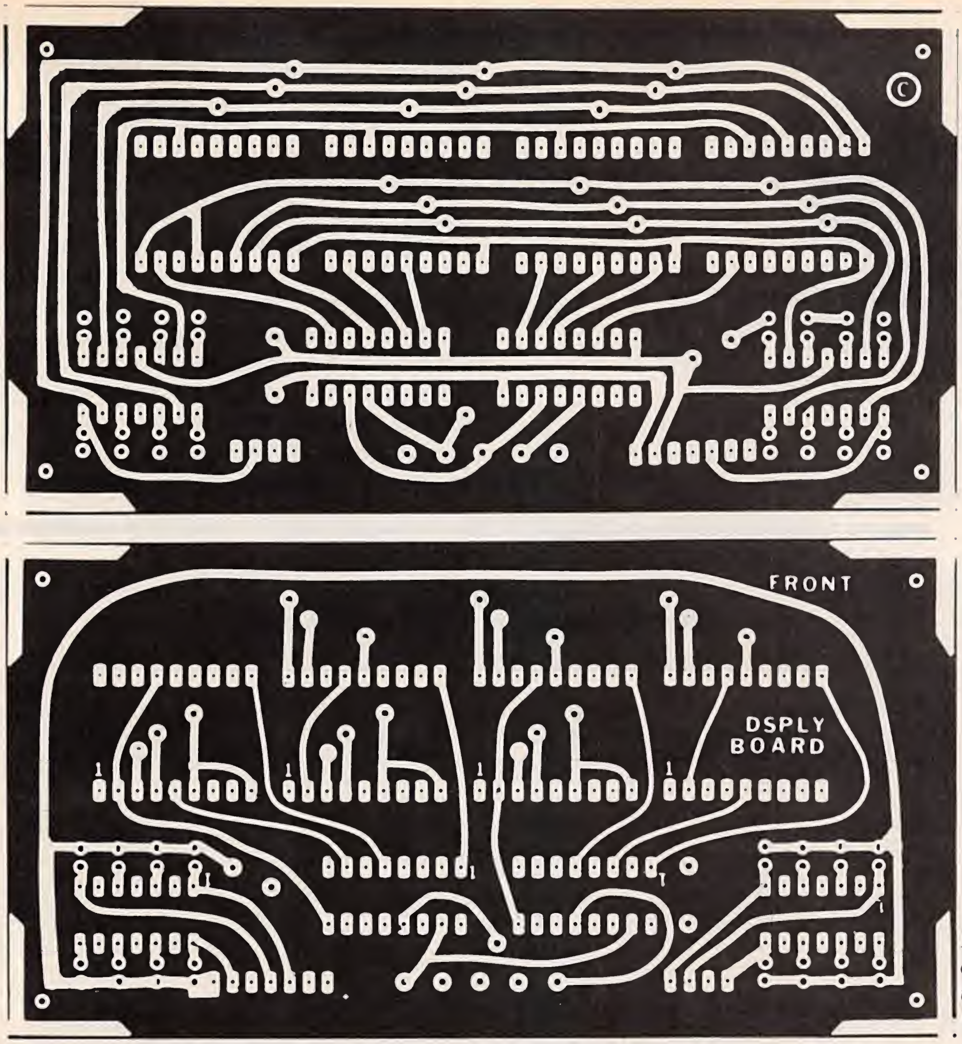


Fig. 6. Actual-size etching and drilling guides for the double-sided main printed circuit board.



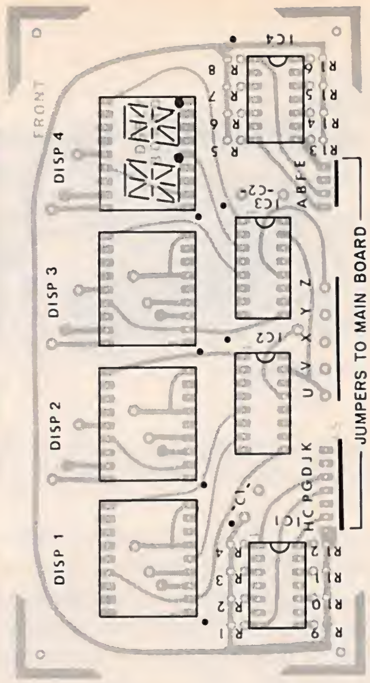


Fig. 8. Parts placement guide for front side of display board is above.

Fig. 7. Actual-size etching and drilling guides for the double-sided display board are at left.

ers to the foils on the bottom of the main pc board. Cut off excess jumper lengths.

For proper Morse decoding, the 1702A ROM must be programmed in accord with Table I. A construction article that appeared in the February 1978 issue of this magazine described a project that allows you to program your own blank ROMs. Some parts distributors will program the 1702A for you if the truth table accompanies your order. The kit supplier for the Morse-A-Word also offers a preprogrammed ROM.

Install the ICs and the dual-character IEE 1784R LED displays in their Soldercons. Make sure they are correctly oriented and take the usual precautions to avoid bending the leads or damaging the MOS ROM. It is not necessary to have a full eight-character display. Those builders with a tight budget, for example, can install only one dual-character IEE 1785R LED readout. However, a minimum of two readouts (four characters) is recommended. If fewer than four readouts are used, make sure they are right-justified (installed at the *DIS4*, *DIS4* and *DIS3*, etc.)

The remaining pc board, that for the power supply, should now be assembled. You will note that the board has space for extra components to be used in another project. These components

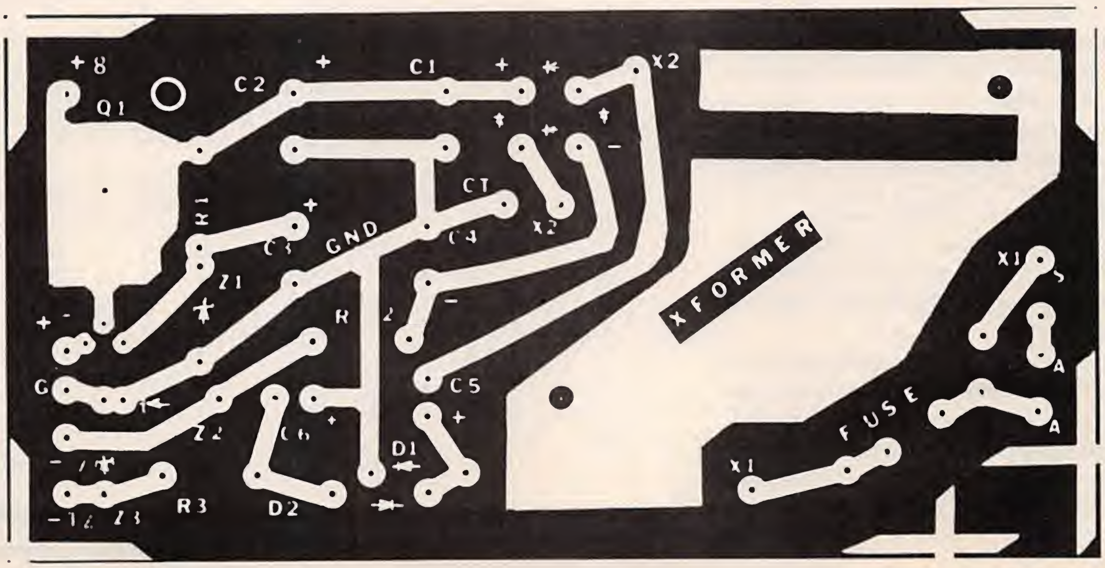


Fig. 9. Actual-size etching and drilling guide for the power supply board.

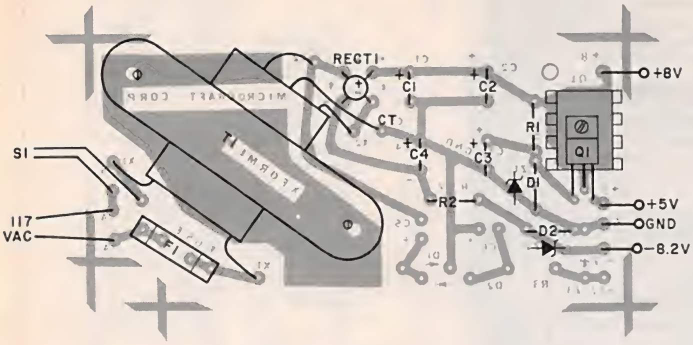


Fig. 10. Component placement for the power supply board shown above.

are not required in the Morse-A-Word and the pc locations for them should be ignored. When you have completed assembly of the board, apply line power to it and verify that the desired voltages are being produced. If the voltages are correct, remove line power and interconnect the supply and main pc boards with suitable lengths of color-coded hookup wire. Then mount the boards in the project enclosure and connect the free ends of the hookup wires already soldered to the main pc board to speaker, jacks, etc. A cutout for the displays must be made on the front panel of the enclosure. This can best be done with a nibbling tool. For those who prefer a prepunched enclosure, one is available from the kit supplier. Display contrast and project appearance will be enhanced by installing a bezel and red filter in the cutout.

Apply power to the project. Several or all of the dual-character displays should start to glow. If they don't, disconnect power and go back and thoroughly check for loose wires, cold solder joints, solder bridges, or incorrect wiring.

Alignment. The center frequency of the bandpass filter and the tone decoder's peak response frequency must be the same if the Morse-A-Word is to function properly. Any frequency between 800 and 2600 Hz is suitable, but the higher frequencies will produce a better circuit response. On the other hand, the higher frequencies tend to be more difficult to tune on a highly selective communications receiver. As a compromise, 1200 Hz was selected as the center frequency of the band-pass filter and the tone decoder.

To align the project, apply a 0.5-volt rms, 1200-Hz signal to the receiver input jack. Connect an ac voltmeter or oscilloscope to the output of the bandpass filter (*TP1*) and adjust trimmer potentiometer *R9* for maximum output. Next, adjust *R20* until a tone is heard in the speaker and the CODE LED lights. Reduce the input signal to as low a level as possible and repeat the procedure. If a 1200-Hz signal is not available and you have a cassette tape recorder, a cassette tape available from the kit supplier has the necessary tone recorded on it. The tape also includes recordings of sample Morse code messages and selections which can be used for code practice.

The only other adjustment is the setting of trimmer potentiometer *R14*, which determines the loudness of the speaker output. A low volume setting is

TABLE I
TRUTH TABLE FOR 1702A PROM IC14

Character	Input A7	A6	A5	A4	A3	A2	A1	A0	Output D8	D7	D6	D5	D4	D3	D2	D1
A	0	1	1	0	1	0	1	1	1	1	0	0	1	0	0	1
	0	0	1	0	1	0	1	1	0	1	0	0	1	0	0	1
B	0	1	1	1	1	1	0	0	1	0	0	1	0	0	0	0
	0	0	1	1	1	1	0	0	1	1	0	1	1	0	0	1
C	0	1	1	1	0	1	0	0	1	1	0	0	0	0	0	1
	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0	0
D	0	1	1	1	1	0	0	1	1	0	0	1	0	0	0	0
	0	0	1	1	1	0	0	1	1	1	0	1	0	0	0	1
E	0	1	1	1	0	1	1	1	1	1	0	0	1	0	0	1
	0	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0
F	0	1	1	1	0	1	1	0	1	1	0	0	1	0	0	1
	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0
G	0	1	1	1	0	0	0	1	1	1	0	0	0	0	0	1
	0	0	1	1	0	0	0	1	1	0	0	0	1	0	0	1
H	0	1	1	1	1	1	1	0	0	1	0	0	1	0	0	1
	0	0	1	1	1	1	1	0	0	1	0	0	1	0	0	1
I	0	1	1	1	1	0	1	1	1	0	0	1	0	0	0	0
	0	0	1	1	1	0	1	1	1	0	0	1	0	0	0	0
J	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1
	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0	1
K	0	1	1	0	1	0	0	1	0	1	0	0	1	0	0	1
	0	0	1	0	1	0	0	1	0	0	1	0	0	1	0	0
L	0	1	1	1	1	0	1	0	0	1	0	0	0	0	0	1
	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0
M	0	1	1	0	0	0	1	1	0	1	1	0	0	0	0	1
	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	1
N	0	1	1	1	0	0	1	1	0	1	1	0	0	0	0	1
	0	0	1	1	0	0	1	1	0	1	0	0	0	1	0	1
O	0	1	1	0	0	0	0	1	1	1	0	0	0	0	0	1
	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	1
P	0	1	1	1	0	0	1	0	1	1	0	0	1	0	0	1
	0	0	1	1	0	0	1	0	0	1	0	0	1	0	0	0
Q	0	1	1	0	1	0	0	0	1	1	0	0	0	0	0	1
	0	0	1	0	1	0	0	0	1	1	0	0	0	1	0	1
R	0	1	1	1	0	1	0	1	1	1	0	0	1	0	0	1
	0	0	1	1	0	1	0	1	0	1	0	0	1	1	0	0
S	0	1	1	1	1	1	0	1	1	0	1	0	0	0	0	1
	0	0	1	1	1	1	0	1	1	1	0	0	0	1	0	0
T	0	1	1	0	0	1	1	1	1	0	0	1	0	0	0	0
	0	0	1	0	0	1	1	1	0	0	0	1	0	0	0	0
U	0	1	1	0	1	1	0	1	0	1	0	0	0	0	0	1
	0	0	1	0	1	1	0	1	1	1	0	0	0	0	0	1

recommended to avoid confusion when listening to both the receiver and the Morse-A-Word simultaneously.

Use. The Morse-A-Word is easy to operate. The setting of the front-panel SPEED control (*R28*) is the only adjustment that must be made, and only a rough setting is required. Keep in mind that the Morse-A-Word has a sensitive input stage, so don't set the receiver audio gain control higher than is necessary. When the receiver is tuned to the center of the filter passband (1200 Hz), you should hear audio from the project's internal speaker and the code LED should flicker in time with the incoming code. The passband is only about 120 Hz wide, so some care is required when tuning in a signal.

With the signal properly tuned in, adjust the SPEED control so the DAH LED glows only when dahs are sent, and not dits. The alphanumeric readout LED will now display the incoming characters. If word spaces are desired, make sure the WORD SPACE switch is closed. Only a few amateur stations actually send word spaces, so don't expect perfectly spaced copy unless you are tuned to a station such as W1AW which sends machine-perfect code. Invalid Morse characters will be displayed as blanks.

For code practice sessions, connect your telegraph key to the KEY jack and adjust the SPEED control for the approximate sending speed. You can calibrate your SPEED control using the formula: Speed (WPM) = 0.15*f*. That is, the code speed in words per minute equals fifteen hundredths of the clock frequency as set by the SPEED control.

An excellent source of code material is amateur station W1AW, operated by the American Radio Relay League. The station transmits several code practice sessions each day, as well as ham news bulletins, propagation forecasts and OSCAR bulletins, all in Morse code, on 3.58, 7.08, 14.08, 21.08 and 28.08 MHz, as well as vhf frequencies. For a complete W1AW operating schedule, send an SASE to ARRL, 225 Main St., Newington, CT 06111.

Commercial CW stations that transmit ship-maritime, press, and weather messages are also valuable sources of code practice. Table II is a list of eight shortwave stations that you'll want to tune in if you have a general-coverage receiver. Whether you plan to confine your listening to the ham bands or branch out into the other shortwave frequencies, remember that a good antenna and a sensitive, stable communications receiver play key roles in good CW reception.

One final note—international radio regulations prohibit the disclosure to others of *any* information gleaned from press or commercial transmissions. Accordingly, it is illegal to pass information so obtained (except that learned from amateur radio or broadcast transmissions) to a third party. ◇

TABLE II
SOME COMMERCIAL CW STATIONS

Station	Frequency (MHz)	Traffic
NSS	8.090	Weather Bulletins
WSL	8.516	Commercial Press
WAX	8.527	Messages
WCC	8.587	Messages
WCC	8.590	Messages
NBA	8.617	Telegrams
NAM	12.134	Weather Bulletins
NMN	12.720	High Speed CW
NAWS	12.725	Weather Bulletins
WCC	12.926	Messages
WSL	13.026	Messages
NAWS	15.921	Messages
WCC	16.935	Messages

V	0	1	1	0	1	1	1	0	0	1	0	0	0	1	0	1
	0	0	1	0	1	1	1	0	0	0	1	0	0	0	0	0
W	0	1	1	0	0	1	0	1	0	1	0	0	0	1	0	1
	0	0	1	0	0	1	0	1	0	1	0	0	0	1	0	1
X	0	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0
	0	0	1	0	1	1	0	0	0	0	1	0	0	1	0	0
Y	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0
	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0
Z	0	1	1	1	1	0	0	0	1	0	0	0	0	1	0	0
	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0
0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	1
	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1
1	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0
	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
2	0	1	0	0	0	0	1	1	1	0	0	0	1	0	0	1
	0	0	0	0	0	0	1	1	1	1	0	0	1	0	0	0
3	0	1	0	0	0	1	1	1	1	0	0	0	1	0	0	0
	0	0	0	0	0	1	1	1	1	1	0	0	1	0	0	1
4	0	1	0	0	1	1	1	1	0	1	0	0	1	0	0	0
	0	0	0	0	1	1	1	1	0	1	0	0	1	0	0	1
5	0	1	0	1	1	1	1	1	1	1	0	0	1	0	0	0
	0	0	0	1	1	1	1	1	1	0	0	0	1	0	0	1
6	0	1	0	1	1	1	1	0	1	1	0	0	1	0	0	1
	0	0	0	1	1	1	1	0	1	0	0	0	1	0	0	1
7	0	1	0	1	1	1	0	0	1	0	0	0	0	0	0	0
	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	1
8	0	1	0	1	1	0	0	0	1	1	0	0	1	0	0	1
	0	0	0	1	1	0	0	0	1	1	0	0	1	0	0	1
9	0	1	0	1	0	0	0	0	1	1	0	0	1	0	0	0
	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1
.	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0
,	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0
	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
?	0	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0
	0	0	0	1	1	0	0	1	0	1	0	1	1	0	0	0
/	0	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0
	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0
–	0	1	0	0	1	1	1	0	0	0	0	0	1	0	0	0
	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0
Space	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0
	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
$\overline{AR}$	0	1	0	1	0	1	0	1	1	1	0	1	1	0	0	1
	0	0	0	1	0	1	0	1	0	1	0	1	1	1	0	0
$\overline{SK}$	0	1	0	0	1	0	1	1	1	1	0	1	1	0	0	0
	0	0	0	0	1	0	1	1	1	0	1	1	0	1	0	0
$\overline{KN}$	0	1	0	1	0	0	1	0	0	1	0	0	1	0	0	1
	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	1
$\overline{AS}$	0	1	0	1	1	1	0	1	1	0	1	1	0	1	0	0
	0	0	0	1	1	1	0	1	1	0	1	1	0	1	0	0