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 $150. 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

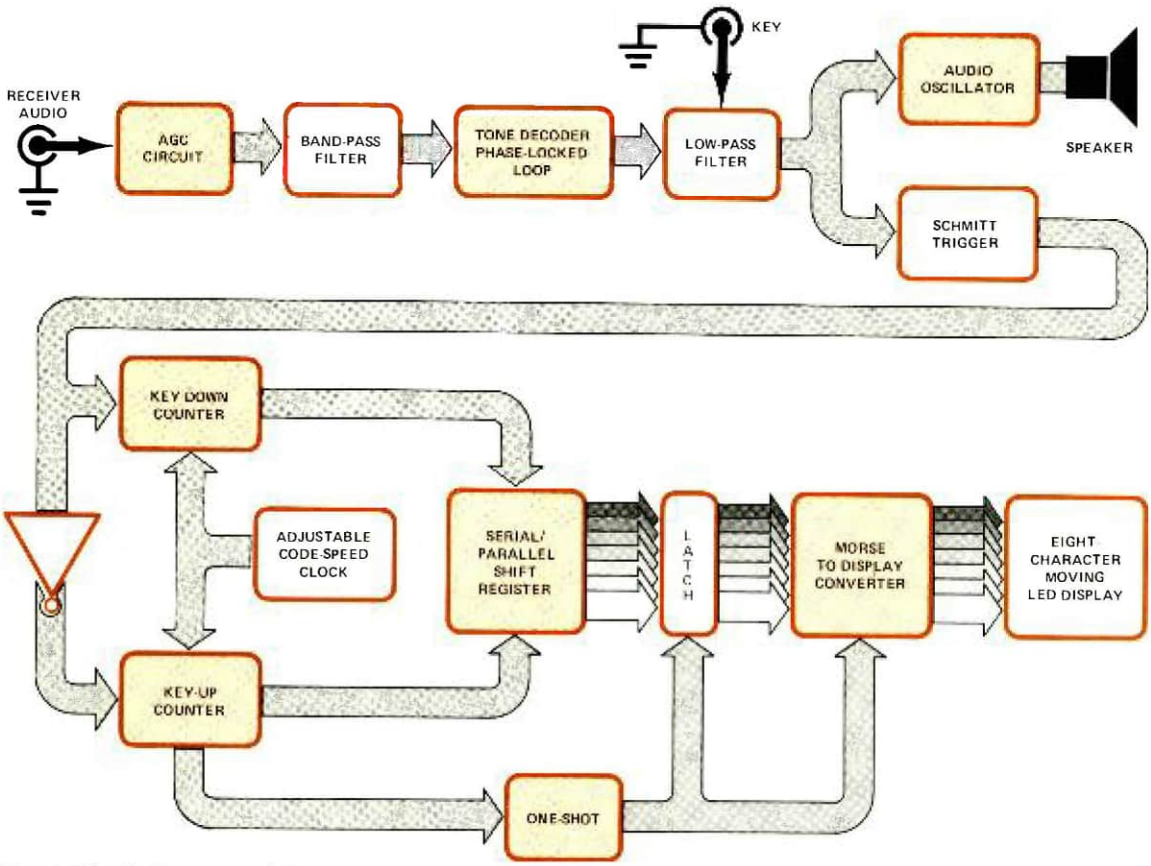

Fig. 1. Block diagram of the Morse-A-Word system shows how the incoming signal in code is processed for alphanumeric display.

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.

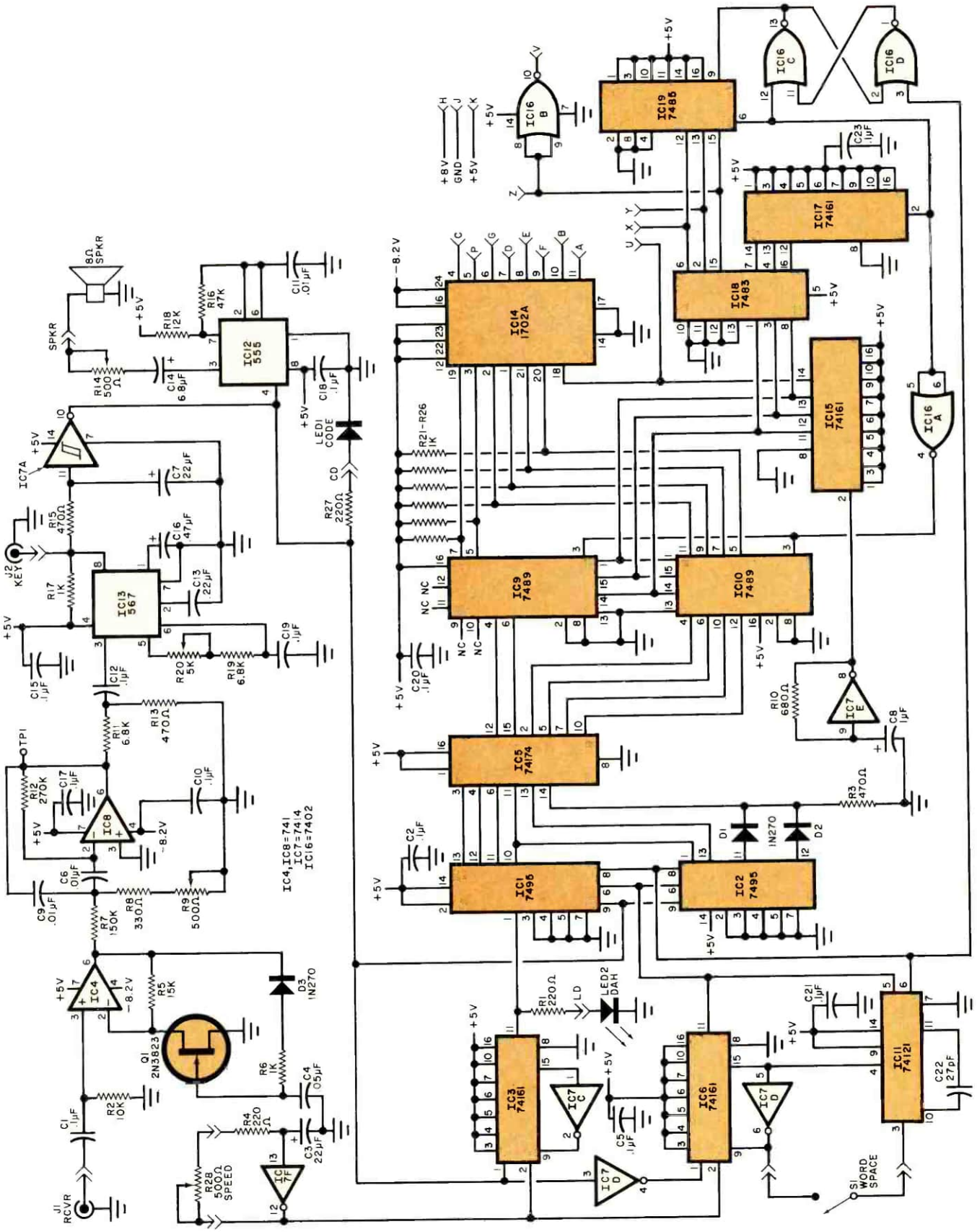

Fig. 2. Schematic diagram of the main decoder circuit. If the audio output of a radio receiver is used, it is applied to J1. An input from a telegraph key is applied to J2. Parts list is on facing page.

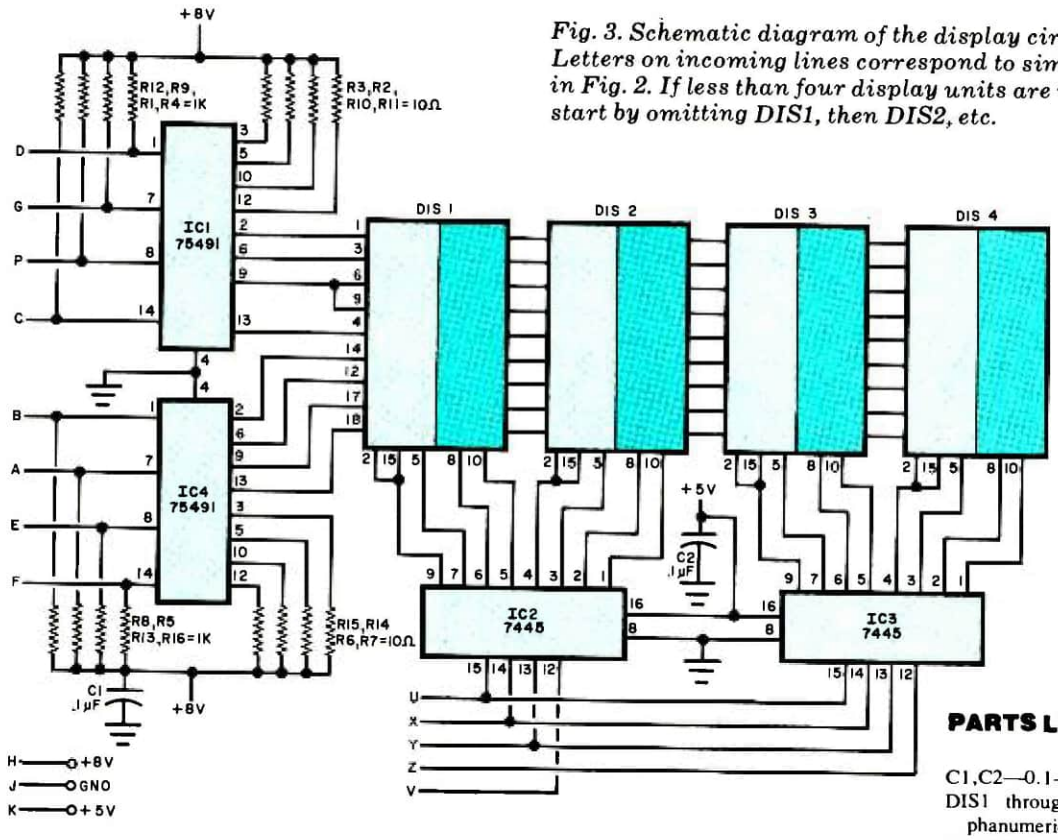

Fig. 3. Schematic diagram of the display circuit. Letters on incoming lines correspond to similar points in Fig. 2. If less than four display units are used, start by omitting DIS1, then DIS2, etc.

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-

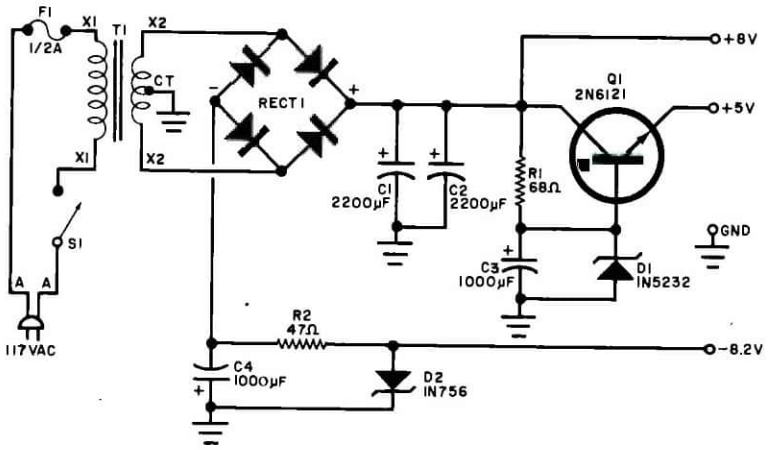

Fig. 4. Schematic diagram of power supply circuit. The main decoder requires 750 mA at 5 volts and 20 mA at −8.2 volts. Display is best with 8-volt supply.

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, $149.95. (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-1. 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.

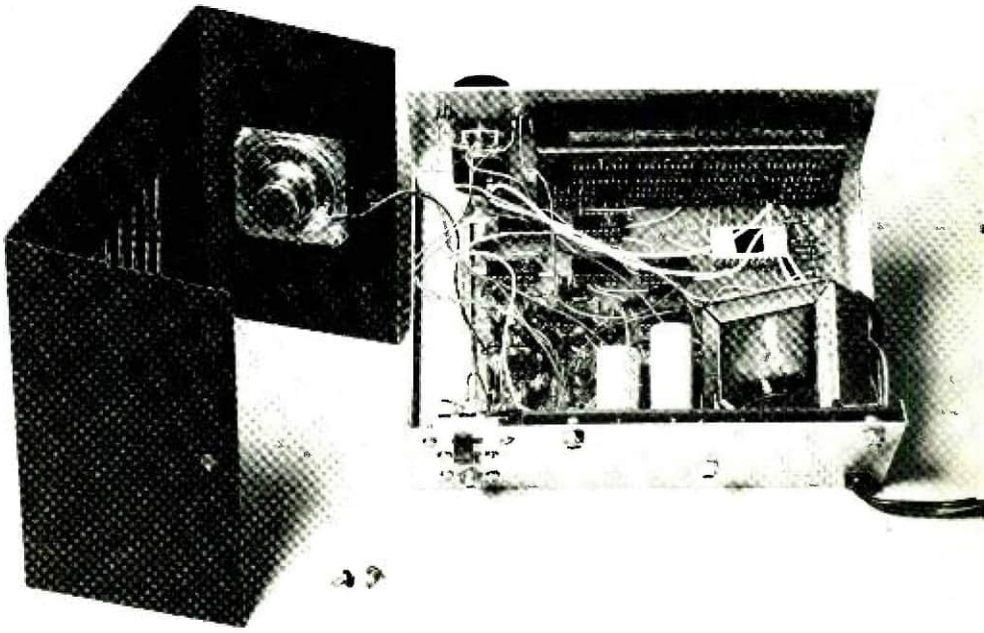

Photo shows internal assembly of the author's prototype. Display board is on front panel, power supply on back.