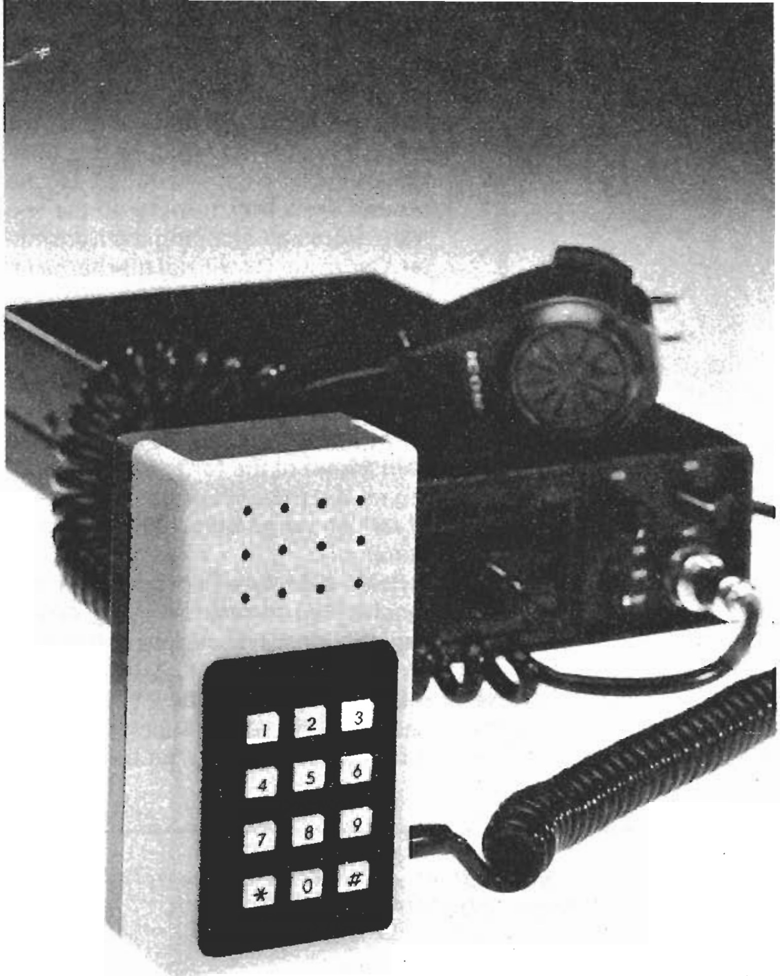


TIE INTO HAM REPEATERS WITH THIS LOW-COST AUTOPATCH

Crystal-controlled Touch-Tone® pad for initiating telephone calls from vehicles.

BY JOE JARRETT

AN INCREASINGLY important part of amateur radio operation these days is the vhf/uhf repeater (automatic relay station) and its common accessory, the autopatch. A repeater is usually located on top of a high building, a tower, or a mountain and in many cases it is able to increase the usual 3-to-10-mile range of low-power equipment to more than 100 miles.

An autopatch is an automatic telephone patch that enables repeater users to initiate and dial telephone numbers from a vehicle or hand-held transceiver without assistance from a phone operator or other amateur stations. An autopatch is legal as long as it is not used to avoid toll charges and approved interface equipment connects the repeater to the phone line.

Most repeaters operate under remote control (not legal for CB radio use) and many of them have autopatch provisions. There must be a way of remotely turning these systems on and off in case of equipment malfunction or illegal use. Also, the users of autopatch must have a way of connecting or disconnecting the telephone line to the repeater phone patch and dialing the desired number. One of the easiest ways to accomplish these jobs is by using the Touch Tone® approach.

The Touch Tone system uses eight different audio tones at frequencies carefully selected not to be harmonically related. The keyboard is arranged in rows (horizontal) and columns (vertical) so that, when a particular key is depressed, two tones are generated—one for the row and the other for the column. These tones are then transmitted to the remote decoding equipment that "recognizes" the tones being transmitted as one of ten digits or six special codes (*, #, A, B, C, D). The four letters are extra keys and are not the same as those on conventional number keys. They are used in military systems and some computers.

Recently, the Mostek Corp. announced two dual-tone, multi-frequency (DTMF) generators, MK5085 and MK5086, that can be used to build a low-cost (under $25) Touch-Tone encoder. The only difference between the two IC's is in the method of keyboard entry. In the MK5086 (used in this project), the row and column keys are switched to the positive supply when a key is operated. The MK5085 uses a calculator-type scanning technique that allows the use of single-pole switches on the keyboard.

Circuit Operation. The complete circuit is shown in Fig. 1. The reference frequency is determined by a conventional 3.579 MHz color-TV crystal, with *R5* used as the bias resistor. Operating one of the pushbuttons on the keyboard starts the oscillator. (See box for details of IC operation.)

The TONE output of *IC1* (pin 16) is coupled to modulation level potentiometer R3, whose rotor is connected through *R4* and *C3* to the transmitter microphone input. The circuit consisting of *IC2*, an audio power amplifier, is used to drive an internal loudspeaker for monitoring the tones, while *R2* determines the speaker volume.

Operational amplifier *IC3* is used as a 0-4-second timer for the transmit hold-on delay. The MUTE output (pin 10) of *IC1* is held to ground when no key is depressed. Thus capacitor *C4* is discharged through *R6* to cause the non-inverting (+) input of *IC3* to be at ground. The inverting input (−) is at a voltage level determined by the setting of hold-on time potentiometer *R7*

Since the voltage at pin 5 is lower than the voltage at pin 4, the output of *IC3* (pin 10) is at ground so both *Q1* and *Q2* are turned off. These two transistors are connected in a Darlington configuration and are used to key the push-to-talk (PTT) line of the transmitter when they are turned on.

When a key is depressed, the MUTE output of *IC1* is pulled up to the positive supply. Diode *D1* becomes forward biased and *C4* is charged (within several milliseconds) to the positive supply less the diode drop of *D1*. The (+) input of *IC3* is now at a higher voltage than the (−) input so the output of *IC3* switches to the positive supply. Resistors *R8* and *R9* reduce the drive to the transistors. When *Q1* turns on, so does *Q2* and the PTT line is pulled down to the ground level. This causes the transmitter to key and transmit the tone signal.

When the key is released, the MUTE

View of the inside of the author's prototype.

output drops, *D1* becomes reverse biased, and *C4* begins to discharge through *R6*. As this happens, the voltage on the (+) input of *IC3* decreases until it is no longer greater than the voltage on the (−) input. At this time, the output of *IC3* switches to the ground level, thus turning off the two transistors and stopping the transmitter. Capacitor *C4* will not discharge far enough for this to happen however as long as the keys are operated reasonably fast. Complete discharge will occur after the last key entry and depends on the setting of *R7*.

The value of resistor *R4* is the coarse adjustment of the tone level. Depending on the transmitter used, the value of *R4* can range from 1000 to 100,000 ohms.

Some older types of equipment may require high current for keying, or may key the positive supply instead of ground. In this case, a low-current relay can be used in the PTT line (connected to the 12-volt supply), with the relay contacts keying the transmitter.

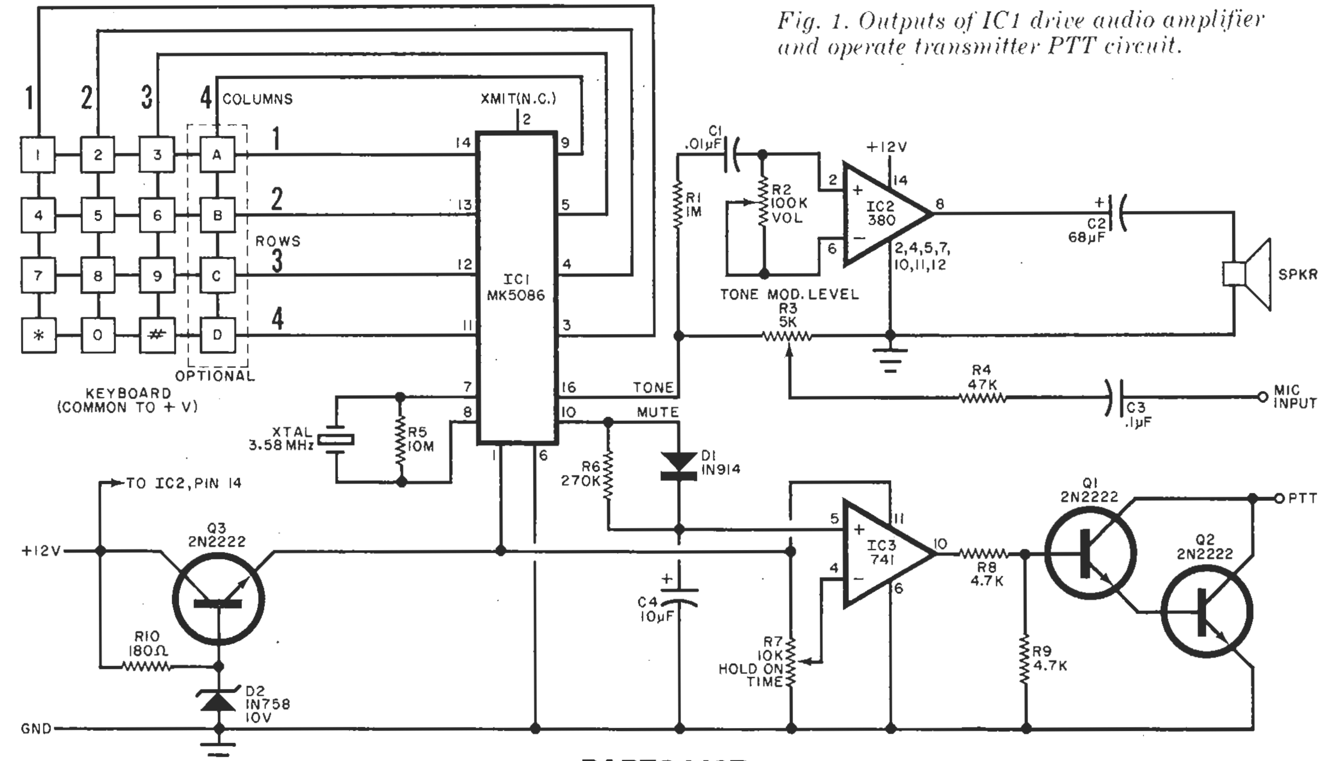


Fig. 1. Outputs of IC1 drive audio amplifier and operate transmitter PTT circuit.

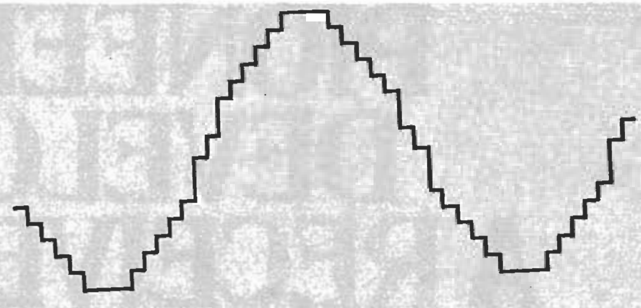
PARTS LIST

C1—0.01µF, 50-V disc capacitor.
C2—68-µF, 25-V electrolytic capacitor
C3—0.1-µF, 50-V disc capacitor
C4—10-µF, 25-V electrolytic capacitor
D1—1N914 diode
D2—1N758, 10-V zener diode
IC1—MK5086, DTMF generator (Mostek)
IC2—LM380 audio power amplifier (National)
IC3—741 op amp
KEYBOARD—Digitran Corp. KL54 (12 keys); KL0049 (16 keys)
Q1, Q2, Q3—2N2222 transistor (or similar)
R1—1-megohm resistor
R2—100,000-ohm pc potentiometer (see text)
R3—5000-ohm pc potentiometer
R4—47,000-ohm resistor (see text)
R5—10-megohm resistor
R6—270,000-ohm resistor
R7—10,000-ohm pc potentiometer
R8, R9—4700-ohm resistor
R10—180-ohm resistor
SPKR—8-ohm, small diameter loudspeaker
XTAL—3.57 9545 MHz color-TV crystal
MISC.—Suitable chassis 4¾" × 2½" × 1½" (Vero Co. #90-20-087), 4-lead flexible cable, mounting hardware, etc.
Note: The following is avaiable from S. D. Sales, Box 28810, Dallas, TX 75228: kit of all parts except chassis, speaker, and interconnecting cable at $22.50 plus $0.75 for postage.

IC OPERATION

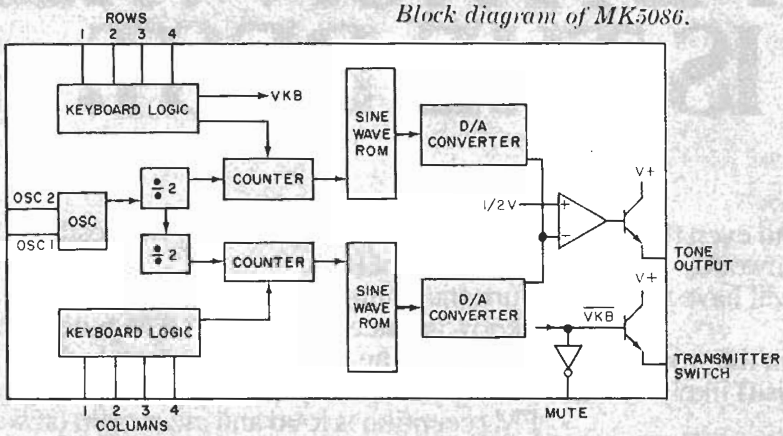
As shown in the block diagram of the MK5086, the row and column select keys are switched to the positive supply in the standard 2-of-8 format. (One key operates both the selected row and column.

The output of the crystal oscillator is divided by two counters—one for the rows and the other for the columns—and the amount of frequency division is determined by the keyboard entry switching.



Output of D/A converter.

Block diagram of MK5086.



Each sine-wave synthesizer is formed by a 5-bit, 32-state counter, decode ROM, and R-2R ladder network D/A converter. The output of each D/A converter is the 26-step sine wave shown in the waveform diagram. Six steps are missing out of the possible 32 to give the best-fit, least-distortion sine wave.

The two waveforms (row and column) are mixed in an op amp (on chip) to produce a true dual-tone signal. This is fed to a bipolar transistor (on chip) that supplies enough current to drive a 1000-ohm load to a typical 450 mV for the row tones and 640 mV for the column tones. (Telephone specifications require that the column tones be 2½ dB greater in amplitude than the row tones.)

Besides the TONE output, the MK5086 has outputs called XMIT (pin 2) and MUTE (pin 10). The XMIT output is an npn bipolar transistor that is turned on and pulls to the positive supply when no keys are operated. It is an open circuit when any key is depressed. The MUTE output is a standard CMOS circuit that is at the negative supply (when used) and switches to the positive supply when a key is depressed.

Construction. The entire circuit can be assembled on a small pc board. An etching and drilling guide and component placement are shown in Fig. 2. Observe the polarities of diodes and polarized capacitors. Sockets for the IC's are optional. Note that *IC1* is a CMOS device and must be handled with the usual precautions. The IC comes in a shorting carrier and should be kept in the carrier until time for installation. Handle it only by the edges of the plastic package. In soldering the CMOS IC, use a clip lead between the soldering iron tip and the positive foil pattern on the board. Note also that volume control *R2* is mounted on the control board. If remote control is needed, use an outboard potentiometer and run the connecting leads to the *R2* pads on the board.

After all components are installed, connect the leads for the keyboard and accessory cable. The latter should have four leads (PTT, microphone, ground, +12 V) and should be as long as necessary for the installation. The physical size of the keyboard will determine the finished size of the project and the case used to hold it. The 9-pin connector shown in the photograph was used to connect the project to an IC-230 transceiver.

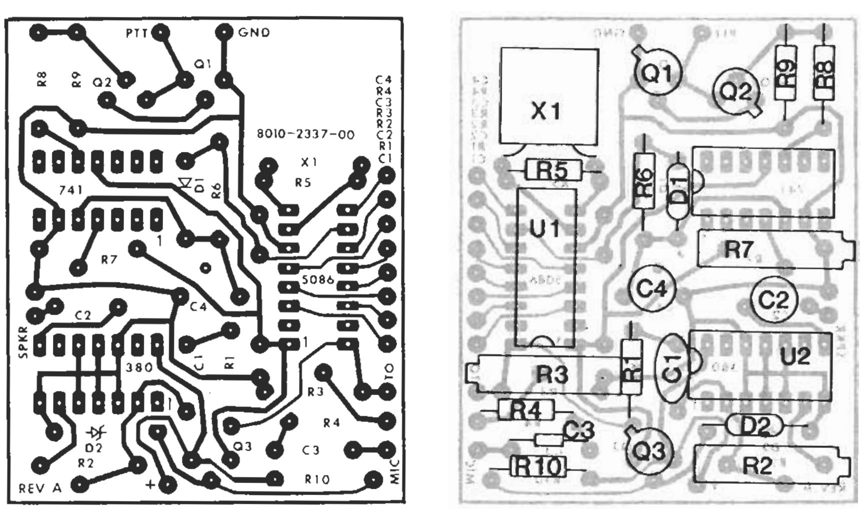


Fig. 2. Etching and drilling guide (left) and component placement.

Operation. After assembly, power up the system and determine the correct value for the combination of *R3* and *R4* to produce the required modulation level.

The dialer enables hands-off operation without annoying carrier drop between each dialed digit. The amount of hold-on time can be set by adjusting *R7*. The speaker volume is adjusted by *R2*.

The dialer should produce no r-f interference. A 5-watt rig has been keyed with its antenna resting on the dialer box with no discernable effect.

Because each section of the country has different rules regarding how to use repeaters, you must check your local repeater group for details before using the dialer.

BY GEORGE R. STEBER, WB9LVI
AND STEVEN E. REYER, WA9VNJ

Popular Electronics®
JANUARY 1977

PE TESTED

"READ" DIT'S AND DAH'S WITH THE MORSE-A-LETTER

Automatically decodes Morse transmissions and displays them alphanumerically, for amateur radio, shortwave, and code training purposes.

NOW YOU can read a message in Morse even if you don't know the code. The "Morse-A-Letter" project presented here automatically converts dahs and dits to alphanumeric characters. With this converter, SWL's can eavesdrop on code exchanges, and prospective and seasoned radio amateurs can have a valuable audio-visual Morse code training and operating aid.

What's more, the Morse-A-Letter features a sophisticated electronic design that ensures accurate and reliable performance. It accepts input signals from a receiver's headphone jack (or from across the speaker leads) and decodes them. The text characters—letters, numerals, and punctuation marks—are then shown sequentially on a LED matrix alphanumeric display. Standard TTL and linear IC's are employed, as well as two ROM's, a MOS character generator, and discrete components. Other features include a built-in monitor loudspeaker, a highly selective active filter, an agc circuit, ASCII output, and simplified, one-control operation. Total project cost is about $120.

Morse Code Theory. Before examining the Morse-A Letter circuit, let's review the basics of Morse code. International Morse code is a method of encoding Roman letters, Arabic numerals, and punctuation marks so that messages comprising them can be transmitted by radio or wire. Each character is uniquely represented as a group of *elements* taking the form of audio tones or silences (spaces) of prescribed length.

The tone elements are called dits and dahs, and the spaces consist of element spaces, character spaces, and word spaces. The dits and dahs within a character are separated by element spaces. (For example, the letter *s* is represented by the sequence: dit, element space, dit, element space, dit.) Whole characters and words are separated by character and word spaces, respectively. The normalized, ideal element lengths are shown in Fig. 1. For English text, the common method for determining the rate of transmission is expressed by the formula: code speed (in words per minute) equals dits per minute divided by 25.

Those familiar with Baudot or ASCII codes will consider Morse rather primitive. Each element is of variable length, and there is no provision for parity checking or error correction. Nevertheless, Morse is widely used by commercial press and ship-to-shore stations, the military, and amateur radio operators. This is partly due to the simplicity of the equipment required. Virtually any transmitter with provision for keying the r-f carrier on and off can be used for CW (continuous wave, or Morse code) work.

Other factors favoring Morse include its inherent efficiency. Just as much information is contained in the spaces as in the dits and dahs. Therefore, the amount of energy required to transmit a message is reduced by about 50 percent. Additional efficiency results from characters of variable length, from one to eleven elements. The most common letters in English text are assigned the shortest code.

The factors which make Morse efficient also make it difficult to decode. Atmospheric or man-made noise can occur, particularly during spaces (when no signal is present). This can introduce spurious elements. The fact that characters are not uniform in length means that character length is difficult to predict. However, the things that affect decoding most are the physical and psychological factors that influence manual sending quality. Fatigue, inattentiveness, and forgetfulness on the part of the sender cause randomness, unpredictability, and inaccuracy in element length.

The foregoing makes it clear that a Morse decoder must function with a high degree of accuracy for it to be effective. The Morse-A-Letter has been designed to meet this need by utilizing narrow filters for noise rejection, agc for fading compensation, and circuitry that allows for sending-speed variations.

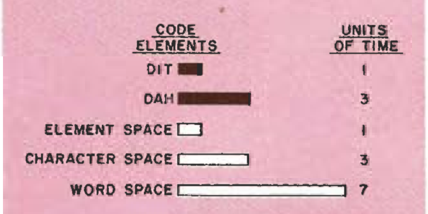


Fig. 1. Code element lengths normalized to length of a dit.

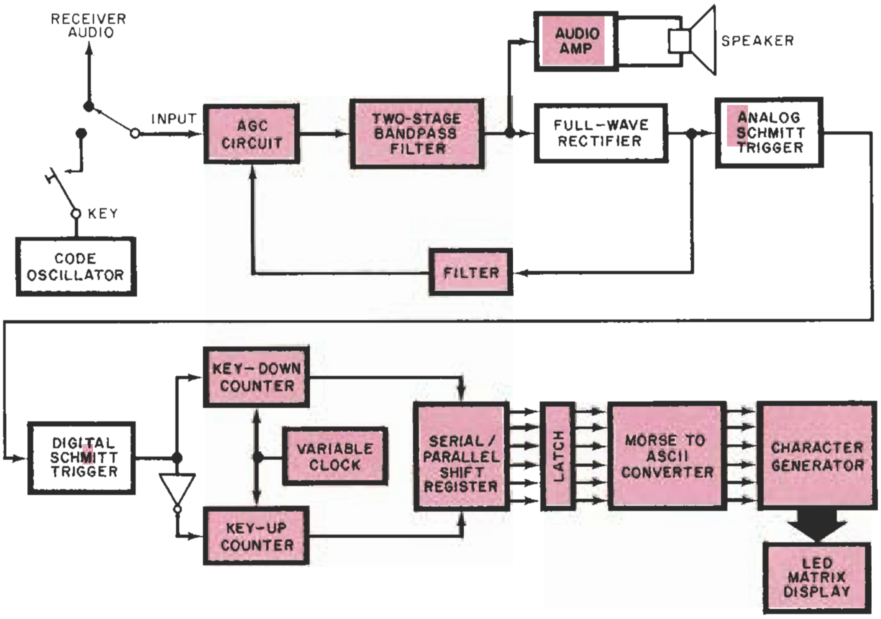


Fig. 2. Block diagram of the Morse-A-Letter shows how incoming code is converted to visual display.

System Analysis. A block diagram of the Morse-A-Letter is shown in Fig. 2, with the complete schematic in Fig. 3. A selector switch at the system's input allows selection of either the internal 1100-Hz oscillator for code practice or an external audio signal from a radio receiver. The signal applied to the input is conditioned by an agc stage whose gain is determined by a voltage fed back from a succeeding stage. The ouput of the agc circuit feeds a two-stage narrow bandpass filter whose response is centered at 1100 Hz. An op amp and a speaker are connected to the filter output for monitoring purposes.

The filter output also drives a full-wave rectifier which demodulates the audio tones so that only low voltages or high voltages are generated. The demodulated signal is applied to two stages simultaneously. It is smoothed and filtered into the control signal of the agc loop, and is also "squared up" by a two-stage Schmitt trigger. At the output of the Schmitt trigger, a logic one corresponds to a key down condition, and a logic zero to a key up condition. Clean, constant-level Morse signals are thus available for processing by the decoding circuitry.

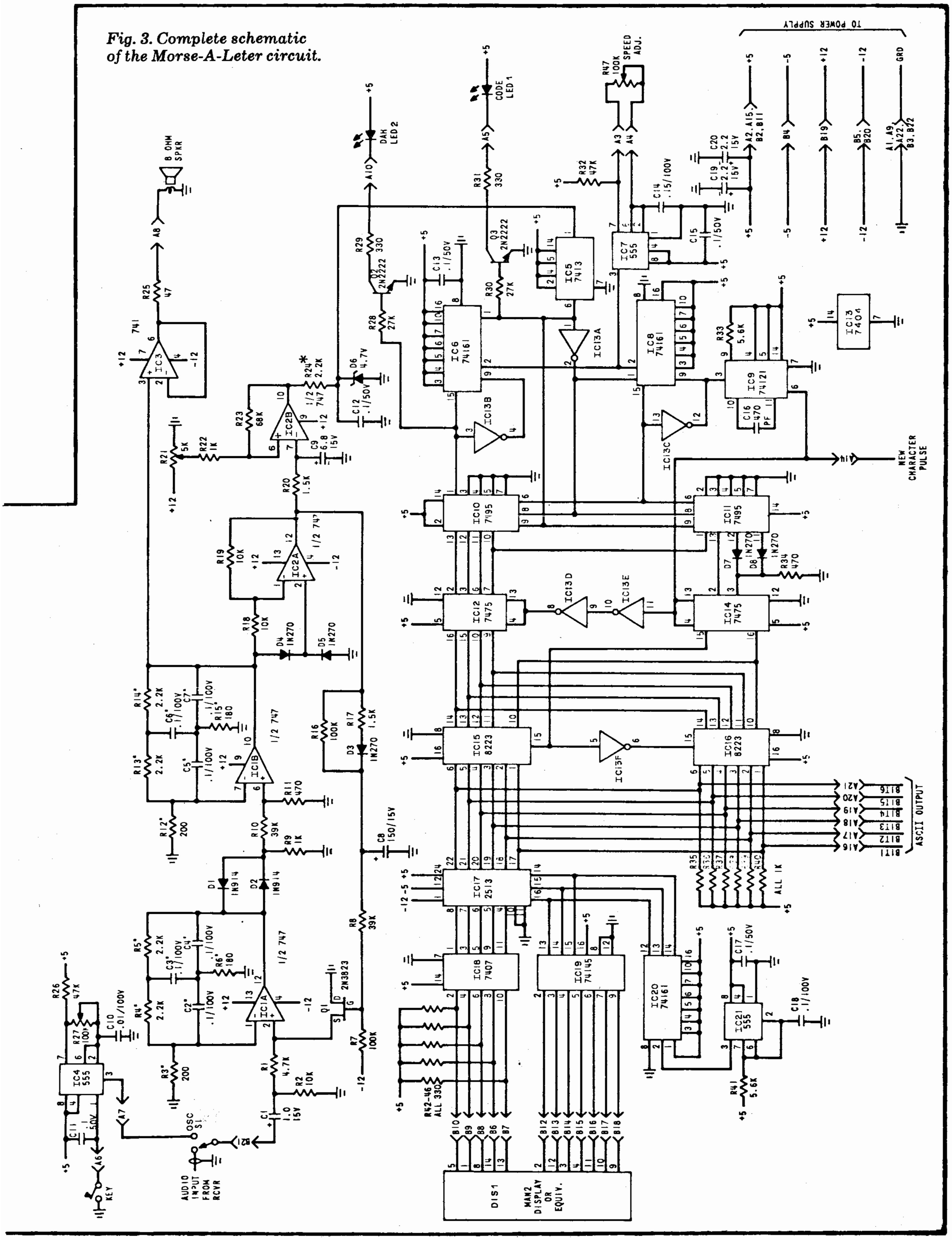
The processed Morse is then applied to two counters, called the key-up and key-down counters. One counter, but not both, will count, depending on whether the key is up or down. These key-condition counters operate at a rate dependent on the frequency of an internal, adjustable clock which must match the input code speed. However, the clock rate can be off by as much as ±50% and still provide solid copy.

Each time the key-up counter detects

PARTS LIST

C1—1-μF, 15-volt tantalum capacitor
C2 through C7, C18—0.1-μF, ±10% Mylar capacitor
C8—150-μF, 15-volt upright electrolytic capacitor
C9—6.8-μF, 15-volt tantalum capacitor
C10—0.01-μF Mylar capacitor
C11, C12,C13,C15,C17—0.1-μF disc ceramic capacitor
C14—0.15-μF Mylar capacitor
C16—470-pF silver mica capacitor
C19, C20—2.2-μF, 15-volt tantalum capacitor
D1, D2—1N914 diode
D3, D4,D5,D7,D8—1N270 diode
D6—4.7-volt, 1-watt zener diode (1N4732A or equivalent)
DIS1—MAN-2 5 × 7 LED matrix display
IC1, IC2—747A dual operational amplifier IC
IC3—741 operational amplifier IC (8-pin mini-DIP)
IC4, IC7,IC21—555 timer IC
IC5—7413 dual NAND Schmitt trigger IC
IC6, IC8,IC20—74161 synchronous four-bit counter IC
IC9—74121 monostable multivibrator IC
IC10, IC11—7495 four-bit right-shift/left-shift register IC
IC12, IC14—7475 quadruple bistable latch IC
IC13—7404 hex inverter IC
IC15, IC16—8223 256-bit bipolar programmable Read-Only Memory IC
IC17—2513 MOS character generator IC
IC18—7407 hex buffer/driver IC
IC19—74145 decoder/driver IC
LED1, LED2—20-mA miniature LED
Q1—2N3823 n-channel JFET
Q2, Q3—2N2222 npn switching transistor
The following fixed resistors are ¼-watt, 10% tolerance unless otherwise specified.
R1—4700 ohms
R2, R18, R19—10,000 ohms
R3, R12—200 ohms, 5% tolerance
R4, R5, R13, R14, R24—2200 ohms, 5% tolerance
R6, R15—180 ohms, 5% tolerance
R7, R16—100,000 ohms
R8, R10—39,000 ohms
R9, R22, R35 through R40—1000 ohms
R11, R34—470 ohms
R17, R20—1500 ohms
R23—68,000 ohms
R25—47 ohms
R26, R32—47,000 ohms
R28, R30—27,000 ohms
R29, R31, R42 through R46—330 ohms
R33, R41—5600 ohms
R21—5000-ohm printed circuit trimmer potentiometer
R27—100,000-ohm printed circuit trimmer potentiometer
R47—100,000-ohm linear taper potentiometer
S1—Spdt toggle switch
Misc.—Printed circuit board, 22-pin edge connectors (2, optional), suitable enclosure, plastic bezel, IC sockets or Molex Soldercons, small 8-ohm dynamic speaker, suitable jacks, standoff spacers, rubber grommets, brackets, machine hardware, hookup wire, shielded cable, etc.
Note—The following items are available from Select Circuits, 1411 Lonsdale Road, Columbus, OH 43227: Complete kit of parts including etched and drilled G-10 glass epoxy printed circuit board, power supply components and all parts except chassis and enclosure (MAL-1 PCK), $109.95; Etched and drilled G-10 printed circuit board (MAL-1), $17.95; Preprogrammed Letter ROM (LET-15), $6.00; Preprogrammed Numeral ROM (NUM-16) $6.00. Prices of ROM's include shipping charges if ordered with pc board MAL-1. If ordered separately, add $0.50 each for shipping charges. MAL-1 and MAL-1 PCK prices include shipping charges within the continental U.S. Ohio residents add 4% sales tax.

Fig. 3. Complete schematic of the Morse-A-Leter circuit.



an element space (a condition which occurs whenever the key-up counter detects less than 15 clock pulses), it serially transfers a logic 0 or 1 to the next stage, an eight-bit serial/parallel shift register. This shift register is always initialized to the binary word 00000001 so that the beginning of each Morse character will be uniquely decodable. The transfer of a logic 0 or 1 to the shift register is determined by the condition of the key-down counter. This counter differentiates between dits and dahs. If the key-down counter counts more than 15 clock pulses, the tone element is a dah. Otherwise, it is a dit. This simple detection scheme has been found to be very efficient and reliable in actual use.

This procedure continues until the key-up counter detects a space longer than an element space. At this point, it is known that a complete character has been sent, and the unique binary code present in the serial/parallel shift register is parallel-transferred to a latch for storage and ASCII encoding. The key-condition counters and shift register are then re-initialized and ready for the next Morse character.

Read-only memories (ROM's) are used to convert the binary code in the latch into ASCII. One ROM encodes letters, and another handles numerals and special characters. Conventional character-generating techniques are then employed for the display of the appropriate alphanumeric symbol.

A power supply circuit for the project is shown in Fig. 4. Current demand on the +5-volt supply is about 600 mA; while the −5-volt demand is only about 10 mA. Each 12-volt supply provides about 40 mA.

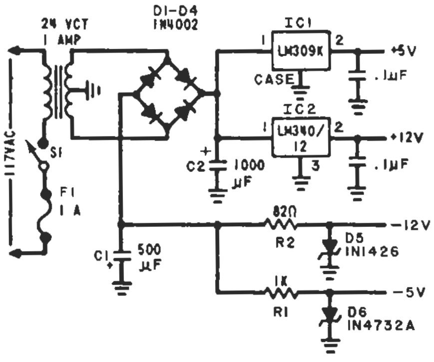


Fig. 4. Schematic of power supply.

POWER SUPPLY PARTS LIST

C1—500-µF, 35-volt electrolytic capacitor
C2—1000-µF, 35-volt electrolytic capacitor
C3, C4—0.1-µF disc ceramic capacitor
D1 through D4—1N4002 rectifier diode
D5—12-volt, 1-watt zener diode (1N1426 or equivalent)
D6—4.7-volt, 1-watt zener diode (1N4732A or equivalent)
F1—1-ampere fuse
IC1—LM309K 5-volt regulator IC
IC2—LM340/12 12-volt regulator IC
R1—1000-ohm, 10%, ¼-watt resistor
R2—82-ohm, 10%, 1-watt resistor
S1—Spst switch
T1—24-volt center tapped, 1-ampere transformer.
Misc.—Terminal strips, silicone grease, line cord and strain relief, fuseholder, hookup wire, solder, machine hardware, etc.

Construction. The Morse-A-Letter is most easily constructed on a printed-circuit board. The etching and drilling and parts placement guides for a board are shown in Fig. 5. Be sure to use a small-tipped, low-wattage soldering iron and Molex Soldercons or IC sockets. Start by inserting the smallest components first, gradually working up to the larger items. For example, install all the jumpers, then the ¼-watt resistors, followed by the diodes, etc. Naturally, you should follow good soldering practices.

Note that *DIS1, S1, S2, LED1, LED2,* the monitor speaker, jacks and sockets, and the power supply are not mounted on the pc board. Rather, provisions are made for using 22-pin edge connectors for interfacing. (See Table 1 for connector terminal number assignments.) Off-board components should be mounted in a convenient manner on a suitable project enclosure.

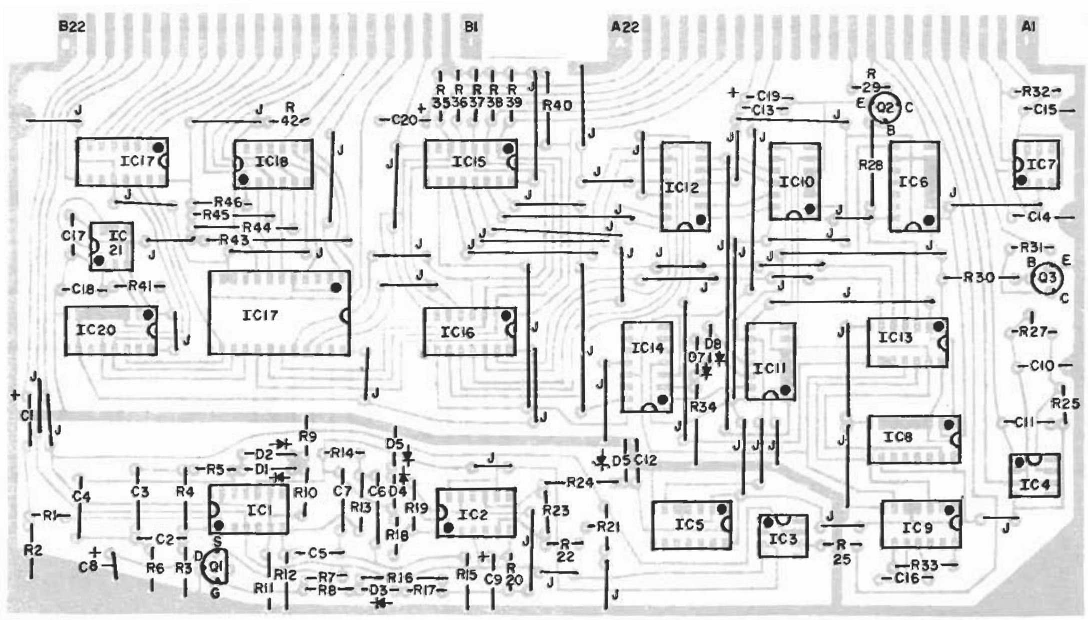
The ROM's (*IC15* and *IC16*) must be properly programmed. The truth tables are given in Tables 2 and 3. In POPULAR ELECTRONICS, July 1975, there's an article entitled "How to Program Read-Only Memories" that describes the required procedure. However, some parts sources will program the 8223's if you include the truth tables with your order. The kit supplier (see Parts List) also offers pre-programmed ROM's.

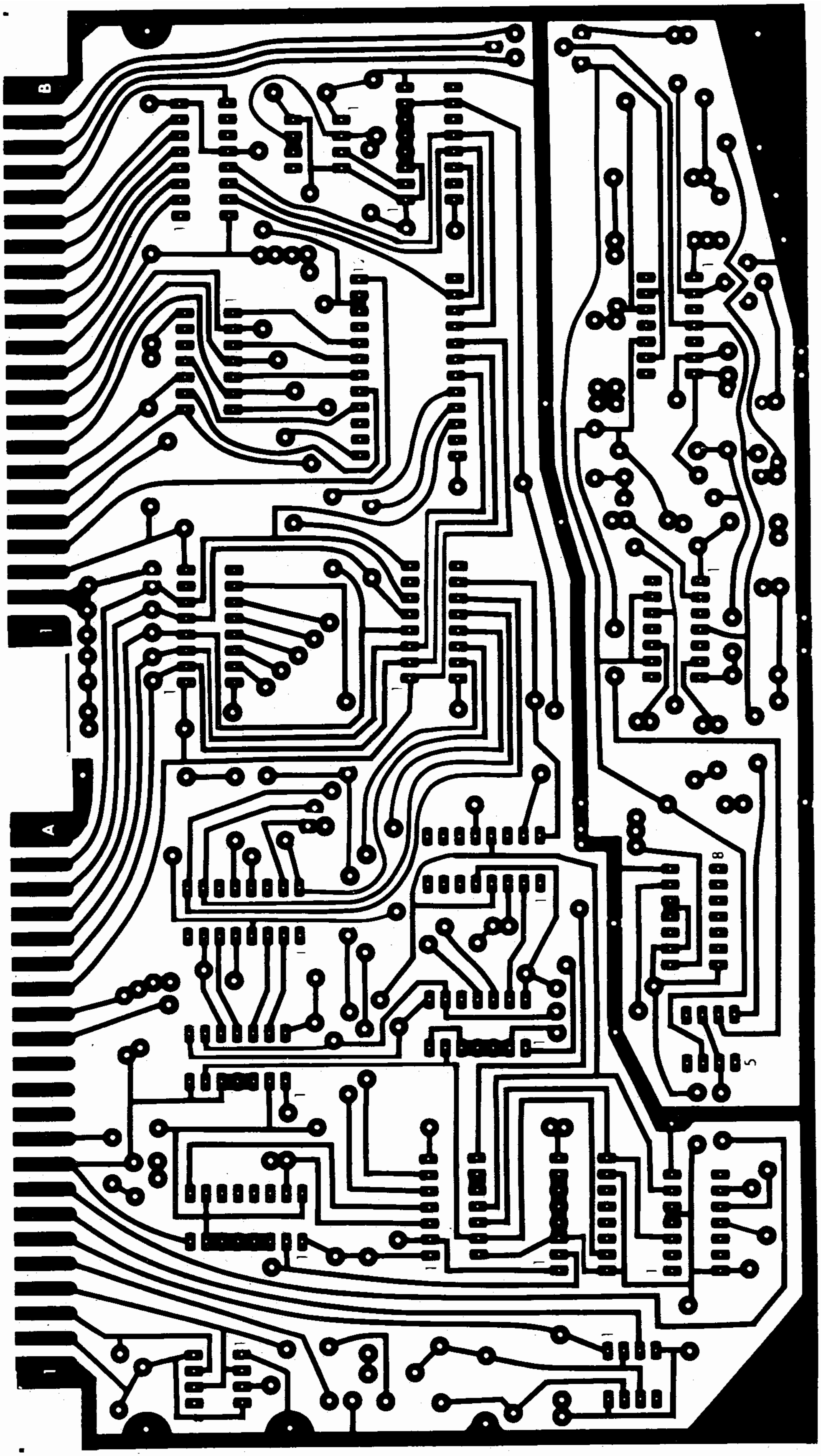
Install the IC's in their sockets, taking the usual precautions when handling MOS devices such as *IC17*. Apply power to the project.

Internal Adjustments. Two potentiometer adjustments must be made. The first determines the pitch of the code practice oscillator. Plug a telegraph key into the key jack and put *S1* in the osc position. Depress the key and adjust *R27* for the loudest output from the speaker. An aural adjustment is adequate. The pitch of the oscillator output will be approximately 1100 Hz (the center frequency of the active filter).

The second adjustment sets the threshold of analog Schmitt trigger

Fig. 5. Component placement guide is at right. Etching and drilling guide for pc board opposite.





IC2B. Connect the audio output of a shortwave receiver equipped with a BFO to the audio input jack of the Morse-A-Letter. You can take the audio signal from across the speaker leads or from the headphone jack. Use shielded cable for the interconnection.

The best way to make the adjustment is with a dc-coupled oscilloscope. Connect the receiver to the Morse-A-Letter audio input, and put S1 in the RCVR mode. Carefully tune in a signal so that its pitch is in the center of the filter passband. When it is properly tuned in, the CODE LED (LED1) will glow. The signal will also be heard through the small monitor speaker. Note that the Morse-A-Letter's input stage is very sensitive and, therefore, does *not* require a large audio signal. Back down on the audio gain if you have trouble getting a signal properly tuned in. Connect a probe from the oscilloscope's vertical amplifier to pin 7 of IC2. The signal at this point should follow the code, with zero voltage when the key is up (spaces) and about four volts when the key is down (tone elements). The waveform will appear rounded or low-pass filtered.

Decide where you would like IC2B's threshold to be, based on your observations of the waveform and its response to QRM (interference from other stations), QRN (interference from static), etc. Then place the scope probe on pin 6 of IC2 and adjust R21 so that the voltage at this point is the same magnitude as the chosen signal threshold. You'll observe that this voltage will not remain at exactly the same level, but will shift a small amount as the Schmitt trigger follows the code.

If a scope is not available, you can still make an approximate adjustment. Tune in a suitable signal as described earlier. Measure the key-up and key-down voltages at pin 7 of IC2 with a high-impedance (20,000 ohm/volt or more) voltmeter. The key-up voltage should be zero and the key-down voltage about four volts. Then measure the voltage at pin 6 of IC2. Adjust R21 so that this voltage is about 40% of the key-down voltage at pin 7. This technique should produce satisfactory results. There is nothing "magical" about the 40% figure. Experiment with the setting of R21.

If the Morse-A-Letter is to be used solely as a code practice device, the adjustment of R21 should be made by either of the methods described, using the internal code practice oscillator as the signal source. Of course, the oscillator output frequency must first be set at the center of the active filter's passband.

CIRCUIT DETAILS

As shown in Fig. 3, a selective bandpass filter comprises IC1A and IC1B and the associated components. It provides a bandwidth of about 100 Hz and a degree of threshold limiting due to D1 and D2. The filter forms the forward portion of the agc loop which automatically provides variable gain for operation during periods of signal fading. The agc loop is completed by full-wave detection of the audio output of IC1B by IC2A, D4, D5 and the associated resistors. The resulting dc voltage controls the bias of Q1, a FET acting as a variable resistor. Capacitor C8, diode D3, and resistors R16 and R17 provide independent attack and decay times for the agc circuit.

Op amp IC2B is an analog Schmitt trigger which squares up the output of IC2A. The trigger's threshold is fixed after initial adjustment of R21 because the agc loop maintains almost constant signal levels at this point even under extreme variations in input levels. The output level of IC2B is made TTL-compatible by zener diode D6. Op amp IC3 is the remaining analog stage. It is a voltage follower that passes the band-pass filter output to a small speaker, providing adequate volume for monitoring purposes. A 555 free-running timer, IC4, is used as a code practice oscillator. Its output is fed to the band-pass filter when switch S1 is in the OSC position.

The input to the "digital" section of the Morse-A-Letter (IC5) is a 7413 Schmitt trigger IC. It provides additional noise immunity and sharp rise and fall times for the succeeding stages. The output of IC5 is used to enable or disable IC6 and IC8, the 4-bit binary key-up and key-down counters, respectively. Both counters are wired to count to 15 and then latch up.

Assume that the key has been up for a few seconds. Key-down counter IC6 is being held clear by the input signal. Key-up counter IC8 has counted to 15 and latched. Thus, pin 15 (the carry output) of the key-up counter is at logic one, putting shift register IC10IC11 in the parallel mode. (These two four-bit shift registers are wired together to act as one eight-bit register.)

Now assume the key is depressed. The word 00000001 is parallel-loaded into IC10IC11 and IC8 is cleared, putting the shift register in the serial mode. If SPEED control R47—which governs the clock rate of IC7—is set properly, IC6 will count less than 15 clock pulses when a dit is sent, or latch at 15 when a dah is sent. Next, assume the key is released. The data at pin 15 of IC6 is serially entered into the shift register and key-up counter IC8 is allowed to count the length of the space. If it is short (meaning the character has not been completed), pin 15 of IC8 will remain low and the shift register will remain in the serial mode. The stages will now process the next dit or dah.

This procedure will continue until the character is completed. The data in the shift register will then be equivalent to the Morse sent, with a dit a logic 0 and a dah a logic 1. Note, however, that a leading logic 1 has been inserted to identify the start of the character in the register. This is important because Morse is a variable length code. For example, the letter A (dit dah) will appear as 00000101 while a U (dit dit dah) will appear as 00001001. The leading (left-most) logic 1 is needed to eliminate the ambiguity that would otherwise exist.

A long space occurs at the end of a character which allows IC8 to count to 15 and latch. This causes IC9, a one shot, to generate a new character pulse which will load the data from shift register IC10IC11 into latches IC12 and IC14. The data is held there and used to drive the display circuitry until the next character is completed.

If a letter is being decoded, only the first five bits are really needed. If a numeral or punctuation mark is received, six or seven bits are required. However, any punctuation mark or numeral is uniquely described by the five low-order bits in the register. If the sixth or seventh bit is a 1, the character is a numeral or punctuation mark. If the sixth and seventh bits are 0's, the character is a letter. So these bits are OR'ed together by D7, D8, and R34 before being entered into the latches. The resulting signal selects either the letter ROM (IC15) or the numeral/punctuation ROM (IC16) to decode the remaining five bits.

The output of the ROM's is standard six-bit ASCII. This ASCII is used to drive IC17, a 2513 character generator, and is also available for use with a TV typewriter. (A "new character" pulse output is provided for CRT display.) Decoders and drivers IC18-20 activate a MAN-2 LED matrix (DIS1) that provides alphanumeric display of the transmitted Morse characters. Integrated circuit IC21 provides clock pulses for the decoder and driver stages. Two discrete LED's are also used for monitoring purposes.

The CODE LED1 is driven by the Schmitt trigger output. This LED glows when the Morse signal is properly tuned in and is reaching the Schmitt trigger. The DAH LED2 is driven by the data signal at pin 15 of key-down counter IC6. This LED glows when the transmitted tone element is longer than 15 clock pulses. A simple means of determining when SPEED (clock rate) control R47 is properly set is thereby provided.

TABLE 1
CONNECTOR TERMINAL ASSIGNMENTS

A1—Ground
A2—+5 Volts
A3—To speed pot R47
A4—To speed pot R47
A5—To "CODE" LED
A6—To key
A7—Oscillator output
(to RCVR/OSC select switch)
A8—To speaker
A9—Ground
A10—To "DAH" LED
A11—No connection
A12—No connection
A13—No connection
A14—New character pulse
A15—+5 Volts
A16—ASCII output bit 1
A17—ASCII output bit 2
A18—ASCII output bit 3
A19—ASCII output bit 4
A20—ASCII output bit 5
A21—ASCII output bit 6
A22—Ground

B1—No connection
B2—+5 Volts
B3—Ground
B4—−5 Volts
B5—−12 Volts
B6—To MAN 2 (DIS1) pin 14
B7—To MAN 2 (DIS1) pin 13
B8—To MAN 2 (DIS1) pin 8
B9—To MAN 2 (DIS1) pin 1
B10—To MAN 2 (DIS1) pin 5
B11—+5 Volts
B12—To MAN 2 (DIS1) pin 2
B13—To MAN 2 (DIS1) pin 12
B14—To MAN 2 (DIS1) pin 3
B15—To MAN 2 (DIS1) pin 4
B16—To MAN 2 (DIS1) pin 11
B17—To MAN 2 (DIS1) pin 10
B18—To MAN 2 (DIS1) pin 9
B19—+12 Volts
B20— −12 Volts
B21—Audio input from receiver
B22—Ground

TABLE 2
TRUTH TABLE FOR IC15

Character	Input					Output					
	A_0	A_1	A_2	A_3	A_4	B_0	B_1	B_2	B_3	B_4	B_5
A	0	0	1	0	1	1	0	0	0	0	0
B	1	1	0	0	0	0	1	0	0	0	0
C	1	1	0	1	0	1	1	0	0	0	0
D	0	1	1	0	0	0	0	1	0	0	0
E	0	0	0	1	0	1	0	1	0	0	0
F	1	0	0	1	0	0	1	1	0	0	0
G	0	1	1	1	0	1	1	1	0	0	0
H	1	0	0	0	0	0	0	0	1	0	0
I	0	0	1	0	0	1	0	0	1	0	0
J	1	0	1	1	1	0	1	0	1	0	0
K	0	1	1	0	1	1	1	0	1	0	0
L	1	0	1	0	0	0	0	1	1	0	0
M	0	0	1	1	1	1	0	1	1	0	0
N	0	0	1	1	0	0	1	1	1	0	0
O	0	1	1	1	1	1	1	1	1	0	0
P	1	0	1	1	0	0	0	0	0	1	0
Q	1	1	1	0	1	1	0	0	0	1	0
R	0	1	0	1	0	0	1	0	0	1	0
S	0	1	0	0	0	1	1	0	0	1	0
T	0	0	0	1	1	0	0	1	0	1	0
U	0	1	0	0	1	1	0	1	0	1	0
V	1	0	0	0	1	0	1	1	0	1	0
W	0	1	0	1	1	1	1	1	0	1	0
X	1	1	0	0	1	0	0	0	1	1	0
Y	1	1	0	1	1	1	0	0	1	1	0
Z	1	1	1	0	0	0	1	0	1	1	0

TABLE 3
TRUTH TABLE FOR IC16

Character	Input					Output					
	A_0	A_1	A_2	A_3	A_4	B_0	B_1	B_2	B_3	B_4	B_5
0	1	1	1	1	1	0	0	0	0	1	1
1	0	1	1	1	1	1	0	0	0	1	1
2	0	0	1	1	1	0	1	0	0	1	1
3	0	0	0	1	1	1	1	0	0	1	1
4	0	0	0	0	1	0	0	1	0	1	1
5	0	0	0	0	0	1	0	1	0	1	1
6	1	0	0	0	0	0	1	1	0	1	1
7	1	1	0	0	0	1	1	1	0	1	1
8	1	1	1	0	0	0	0	0	1	1	1
9	1	1	1	1	0	1	0	0	1	1	1
.	1	0	1	0	1	0	1	1	1	0	1
,	1	0	0	1	1	0	0	1	1	0	1
?	0	1	1	0	0	1	1	1	1	1	1
/	1	0	0	1	0	1	1	1	1	0	1
-	1	0	0	0	1	1	0	1	1	0	1

Operation. The Morse-A-Letter is very easy to operate. The only adjustment that you must make is the setting of the SPEED control (*R47*), and only a rough setting is required. Remember that the Morse-A-Letter input is quite sensitive, so you should set the receiver's audio gain a little lower than usual. If this is done, the primary source of audio output will be the project's internal speaker, and you will quickly learn how to tune the signal in to the center of the filter passband.

Once the signal is properly tuned in, the CODE LED will blink in step with the Morse. Adjust the SPEED control so that the DAH LED glows only when dahs are sent, not when dits are. The MAN-2 display will now read out the incoming characters. Note that "illegal" Morse characters will be displayed as @. For code practice sessions, place *S1* in the OSC position and adjust the SPEED control for the approximate sending speed. You may wish to calibrate the SPEED control. If so, the following formula will help you determine the required calibration points: Speed (wpm) = 0.15 *f*. That is, the code speed in words per minute equals fifteen hundredths of the clock frequency, which is determined by the setting of SPEED control *R47*.

Some users might feel that the center frequency of the passband (and thus the pitch of the practice oscillator) is too high. Or it may not coincide with the center frequency of the crystal filter in a given receiver. If a change of the center frequency is contemplated, the values of *R4-6* and *R13-15* should be modified. Here are alternate values for two frequencies:

Resistors	800 Hz	1000 Hz
R4, R5, R13, R14	3300 ohms	2700 ohms
R6, R15	270 ohms	220 ohms.

As mentioned earlier, the passband of the filter is about 100-Hz wide. A narrow filter is very desirable when used with a stable receiver that's equipped with a smooth, slow-moving tuning dial assembly. But if the receiver has a tendency to drift or the tuning dial is compressed or has some play in it, a narrow filter should not be used. Instead, the use of wide-tolerance, randomly selected, or even deliberately mismatched components for *C2, C4, C5, C7, R4-6* and *R13-15* is recommended to broaden the filter's passband.

As a final note, you are cautioned not to relay to a third party any information garnered from press transmissions or the like. Except for ham or broadcast transmissions, it's illegal to do so. ◇

Popular Electronics
MARCH 1979

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

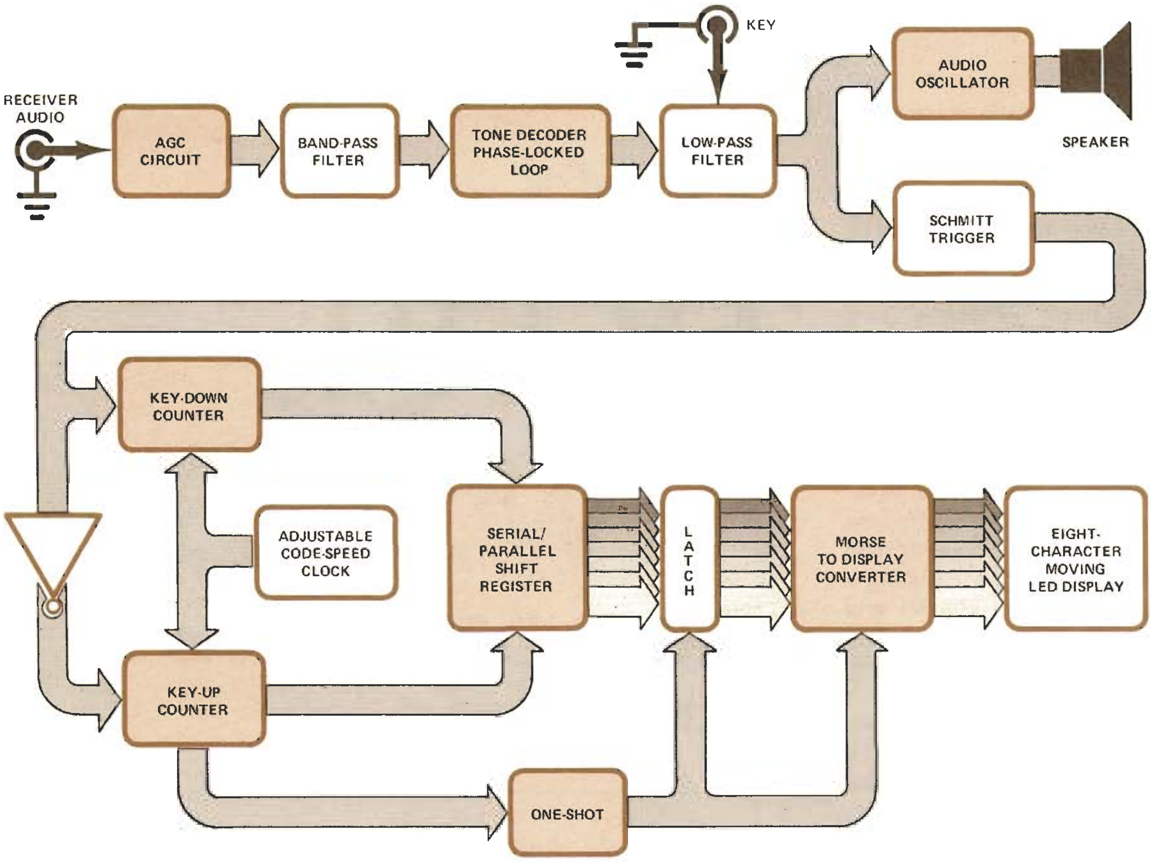


Fig. 1. Block diagram of the Morse-A-Word system shows how the incoming signal in code is processed for alphanumeric display.

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.

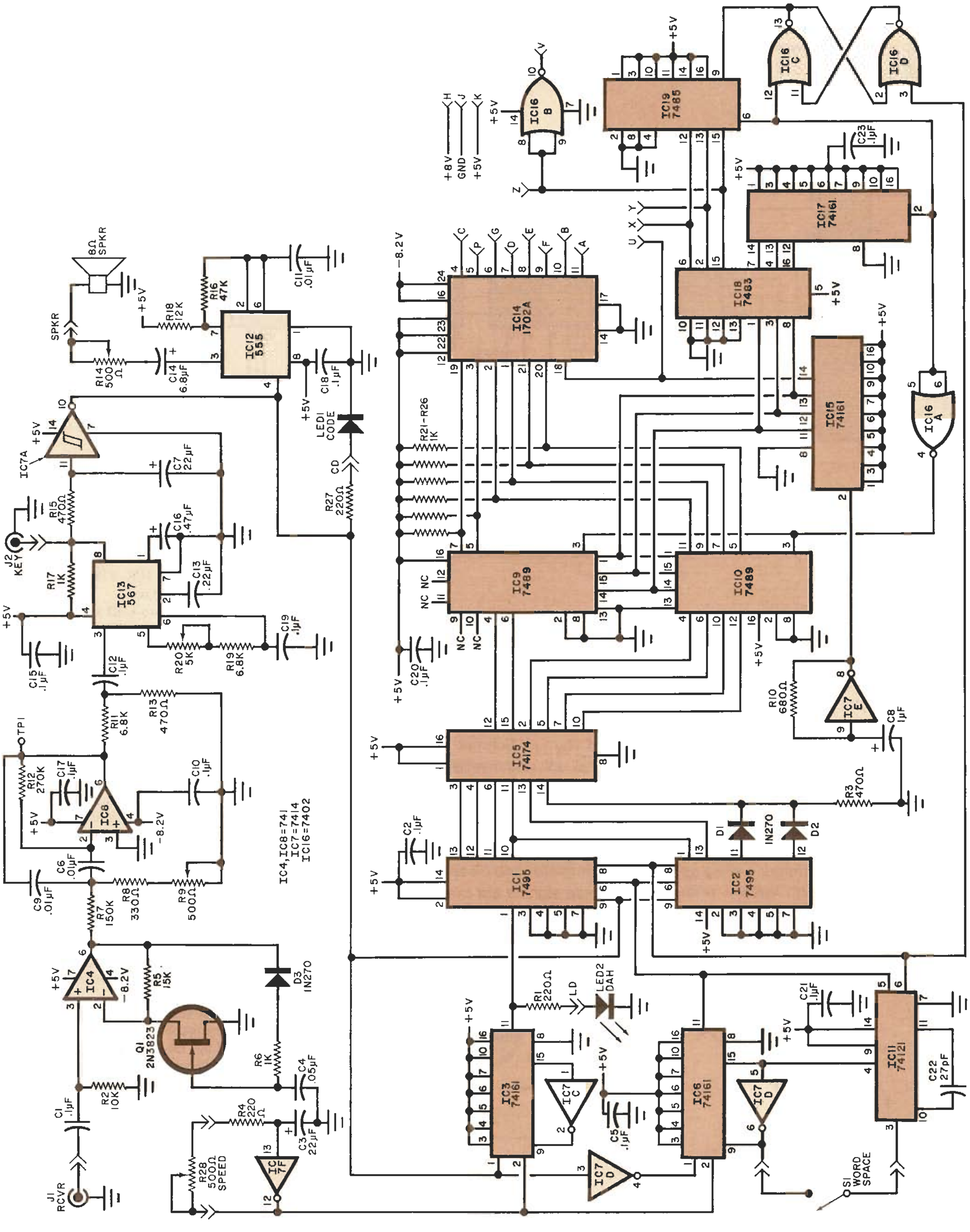


Fig. 2. Schematic diagram of the main decoder circuit. If the audio output of a radio receiver is used, it is applied to J1. An input from a telegraph key is applied to J2. Parts list is on facing page.

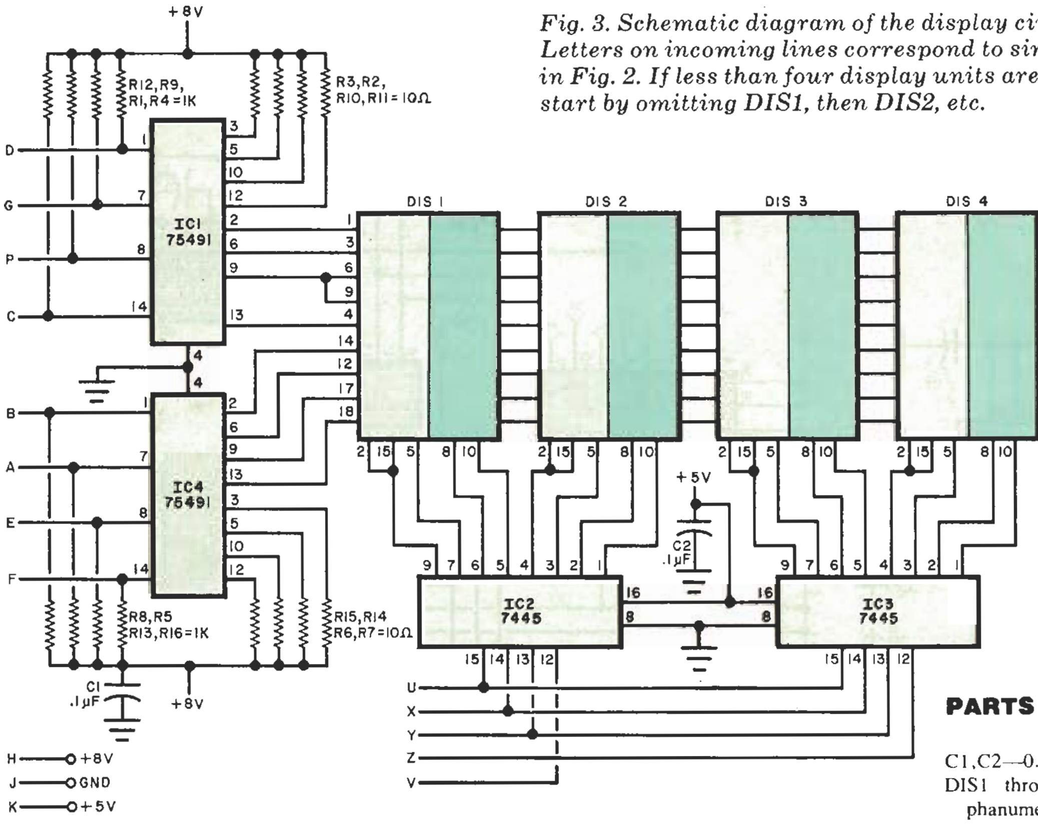


Fig. 3. Schematic diagram of the display circuit. Letters on incoming lines correspond to similar points in Fig. 2. If less than four display units are used, start by omitting DIS1, then DIS2, etc.

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.

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-

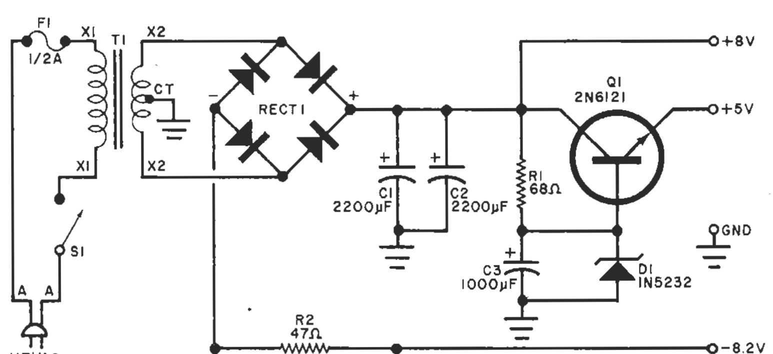


Fig. 4. Schematic diagram of power supply circuit. The main decoder requires 750 mA at 5 volts and 20 mA at −8.2 volts. Display is best with 8-volt supply.

PARTS LIST: 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.

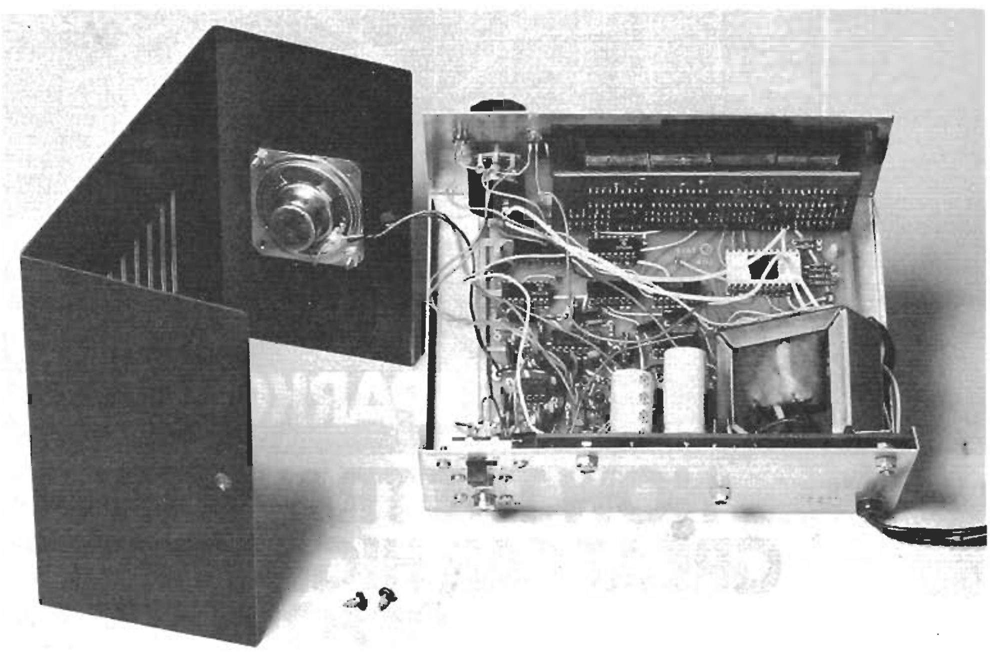


Photo shows internal assembly of the author's prototype. Display board is on front panel, power supply on back.

microvolts."

In "The Morse-A-Word, Part One: Theory and System Operation" (March 1979), in Fig. 2, there should be a pin 9 on *IC5* connected to pin 6 of *IC11*. The foil pattern for the pc board, shown as Fig. 6 in Part Two of the article in the April issue, supplies the necessary connection.

The MORSE-A-WORD

BY GEORGE STEBER

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-

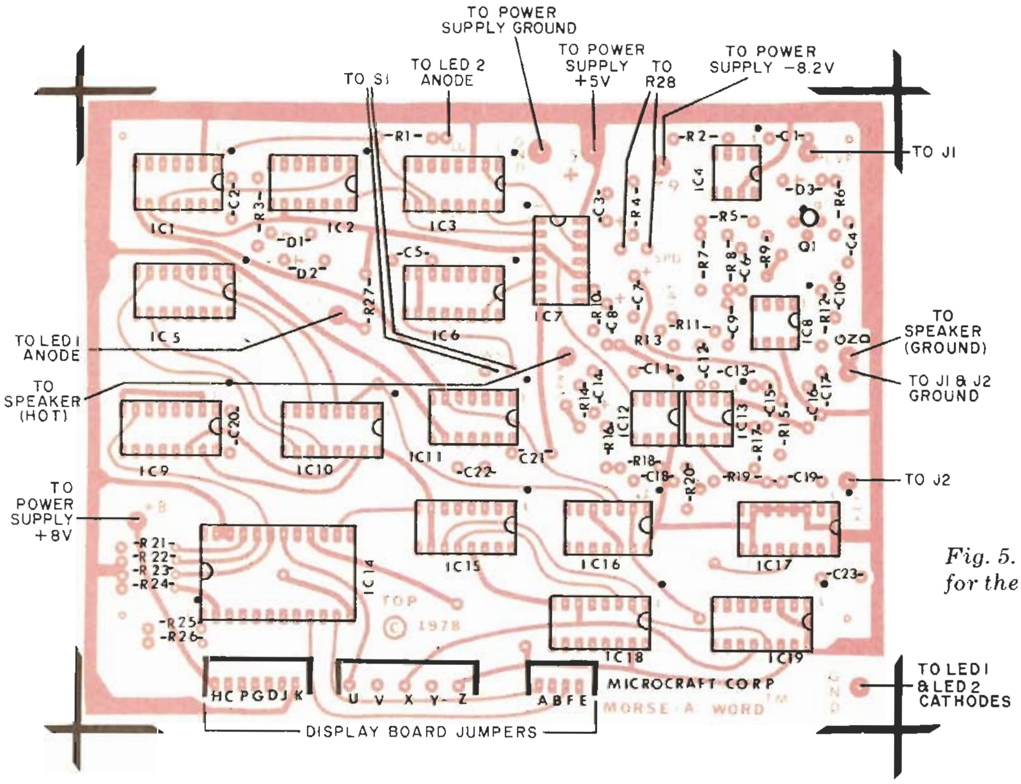
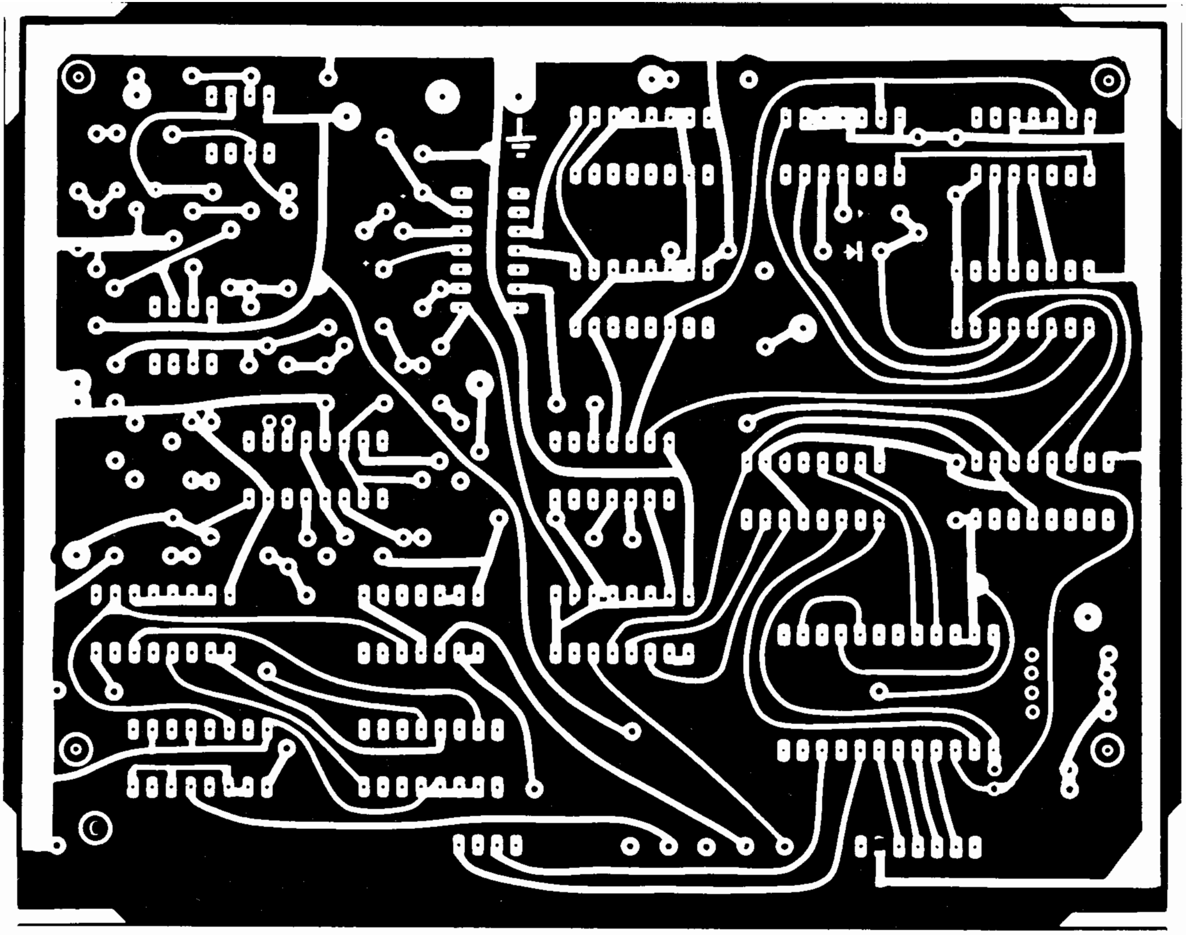


Fig. 5. Parts placement guide for the main circuit board.



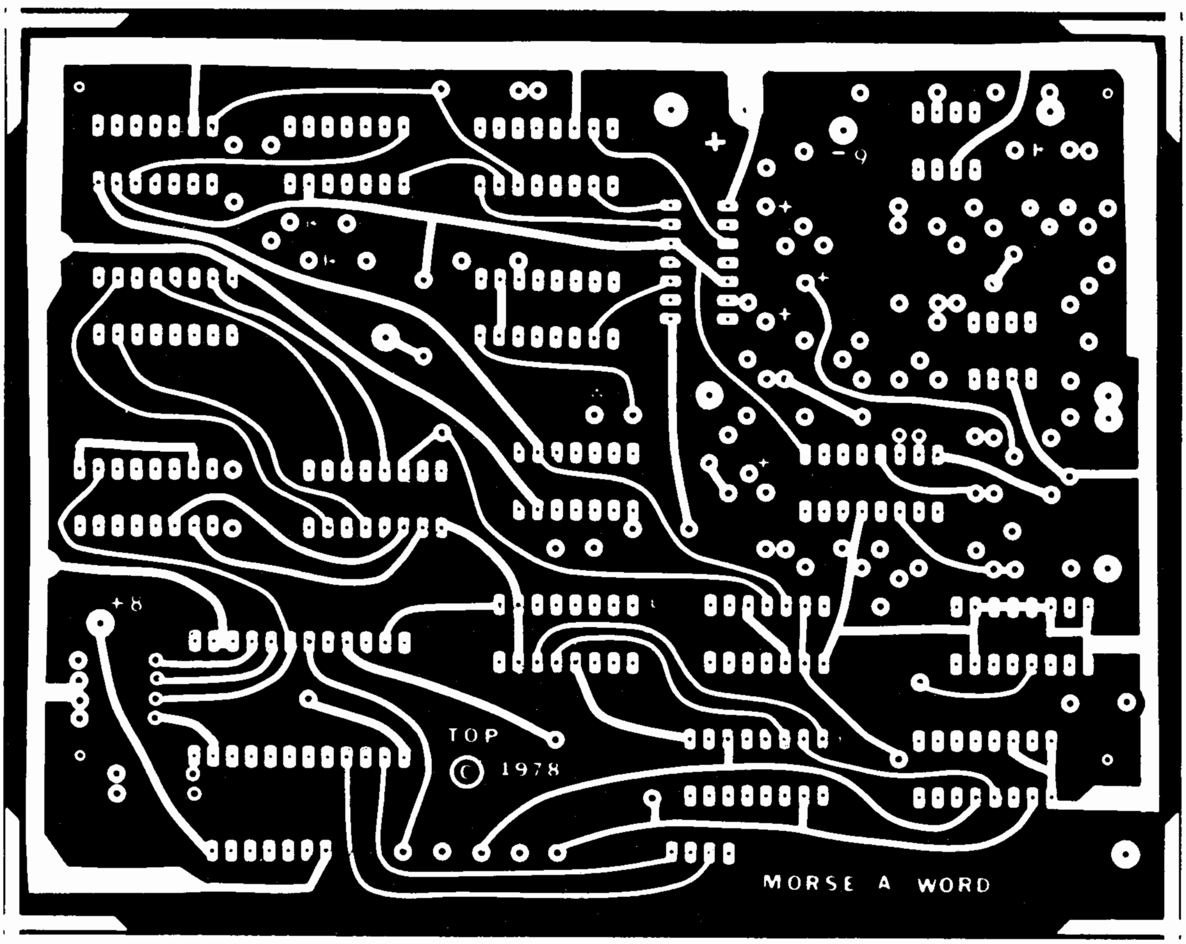
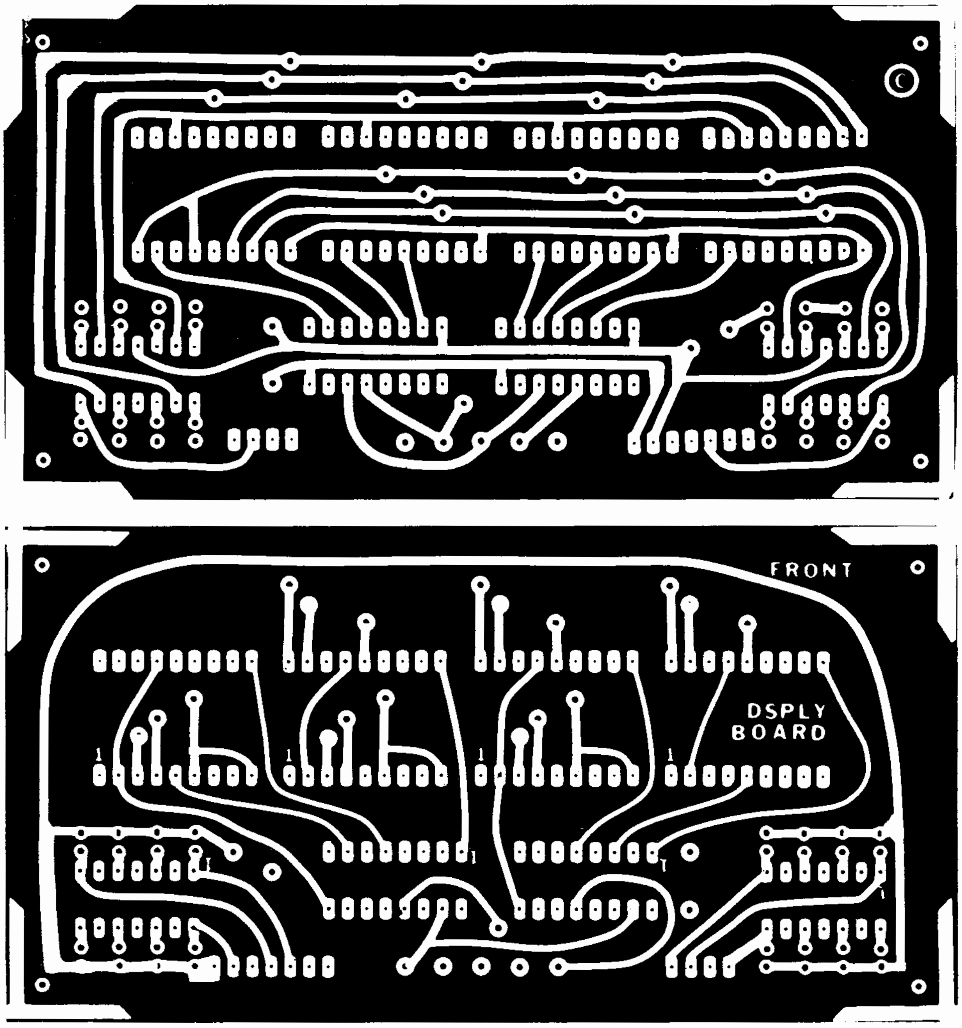


Fig. 6. Actual-size etching and drilling guides for the double-sided main printed circuit board.



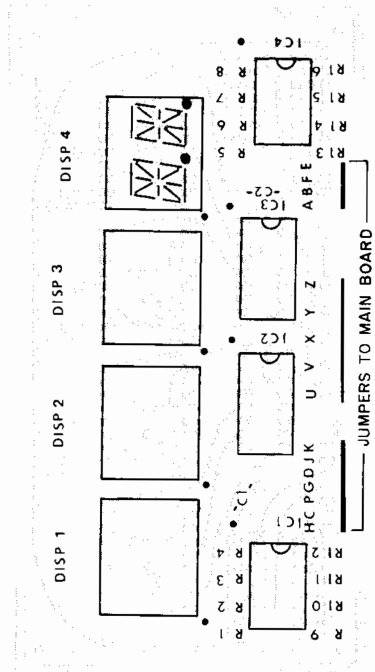


Fig. 8. Parts placement guide for front side of display board is above.

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

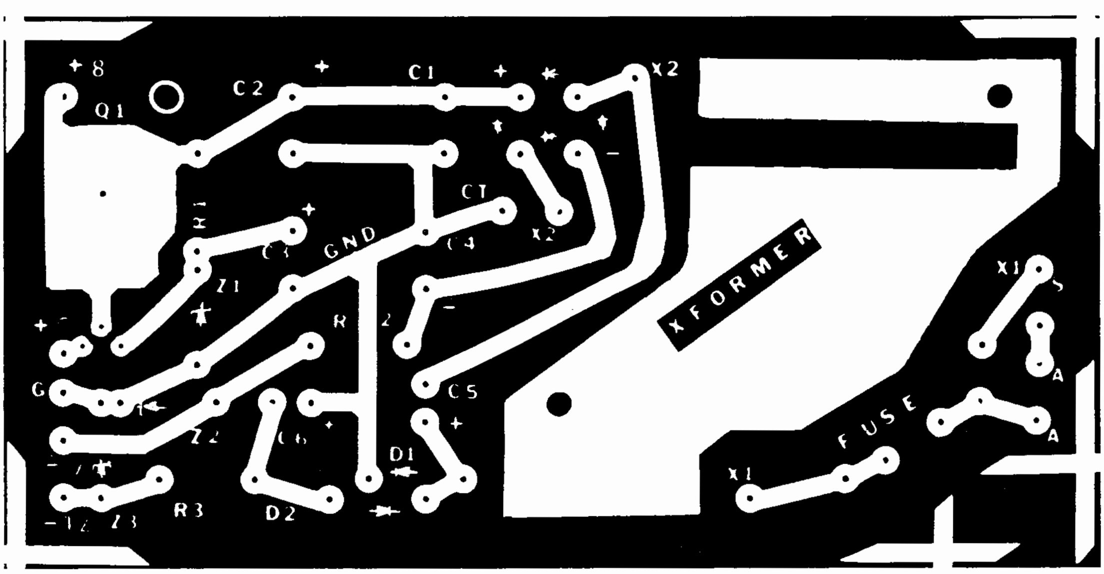


Fig. 9. Actual-size etching and drilling guide for the power supply board.

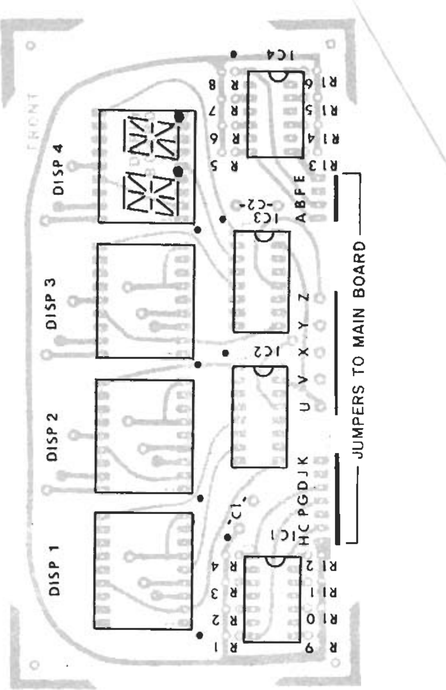


Fig. 8. Parts placement guide for front side of display board is above.

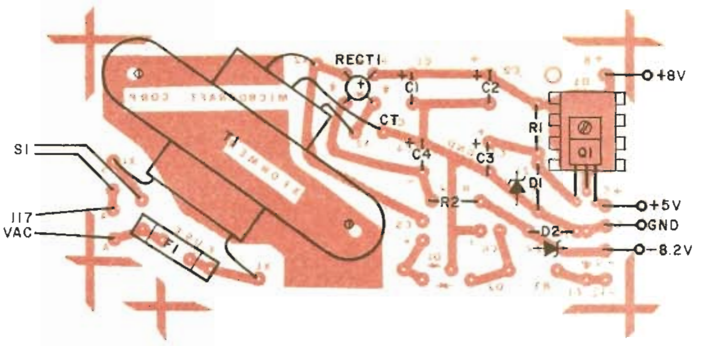


Fig. 10. Component placement for the power supply board shown above.

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

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

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

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. ◇

GREATER VISIBILITY

Many thanks for the "Morse-A-Letter" (January 1977). When I built mine, I incorporated a matrix of ¼" (6.35-mm) high-brightness discrete LED's for the seven-segment displays specified. My 5 × 7 matrix measures approximately 3" × 2" (7.6 × 5.1 cm), which is much easier to read and excellent to use in code classes. My display can be read from 20' (6.1 m) away.—*Martin J. Forrest, WA6EWC/WB6VPC, San Jose, CA.*

CAN'T PEAK WITH Q MULTIPLIER

After assembling the Q Multiplier (April 1974), I checked it out with an oscilloscope to assure myself that it was operating properly. I installed it in my Hallicrafters SX62A receiver. It operates fine on NULL, but on PEAK, I lose everything. When I pull the plug on the Q Multiplier, the receiver works properly again. In an attempt to get the multiplier working properly with my receiver, I have attempted to adjust the receiver's i-f transformers—to no avail. How can I get my Q Multiplier to work in the PEAK mode?

OWEN P. BURKLOW
Scottsdale, Ariz.

The Author replies: "It appears that your SX-62A already has a pretty good i-f. From the description of your problem, it is pretty definite that the Q of the i-f transformer is such that it is pulling the Q Multiplier out of oscillation as you tune to the center of the i-f passband.

"There are several solutions I can recommend: (1) Reduce the value of C1 to 50 to 180 pF, using the largest value that will keep the multiplier in smooth oscillation. (2) Decrease the value of C6 to 500 to 800 pF. This will increase oscillator feedback, but it will change the frequency (readjust L1 as necessary) and will result in some reduction in the height and depth of the peak and null. (3) Increase the value of R2 to 15,000 ohms, which has basically the same effect as solution 2."

WORD SPACING IS VERY COMMON

I question the statement in "Morse Code Automatic Readout On a TV Screen" (May 1977) that "word spacing is rarely sent in Morse Code." After the original "Morse-A-Letter" project appeared in the January 1977 issue of POPULAR ELECTRONICS, I made my own interface that produces perfect word spaces. I send the parallel data out to my video terminal in RS-232 via a UART. I would have submitted a photo of a full "page" of a news broadcast that shows perfect word spacing were it not illegal. Except in the case of crude or unusual keying, I find word spacing is very common, even if it does occur naturally rather than intentionally. After all, any pause longer than a character will register as a word space. —*Joseph A. Maddox, Cincinnati, OH*

Letters

USING ASCII IN HAM RADIO

In "ASCII Keyboard and Encoder" (April 1974), it was stated that the ASCII system can be used for ham radio operation. However, it appears that the keyboard characters and layout and the necessary changes in the circuit would be different from the ASCII format normally used by hams. In addition, some simple series-parallel and parallel-series conversion circuits would be needed to interface with normal ham equipment.

Do you have any specific information we hams can use to alter the basic design to bring it closer to our requirements?

ROBERT A. LUFF, W3GAC
Gaithersburg, Md.

The author replies: You refer to a five-level Baudot code, not ASCII. The former is obsolete. There are two ways the keyboard could be used with Baudot: You could redefine the key matrix using the bottom three bits of the encoder for the least-significant two bits of the Baudot code and slightly rework the upper circuitry to generate the most significant two bits. The alternative is to add a code-converting ROM to the output of the keyboard. This is preferable because stock keytops and standard layout (with little reworking) can be used. Two ROM's might be needed.

Parallel-series conversion is an easy task. The simplest arrangement would be to use a 555 timer driving a 74165 shift register. A better method for both directions at once would be to use a UART, such as Signetics' 2536, Texas Instruments' TMS-6011, or Western Digital's TR1402A.

More information on the Baudot code and the conversion process using ROM's appears in my TTL Cookbook *available from Howard W. Sams & Co.—Don Lancaster.*

IUSUAL PROBLEMS

Q. ***The tuning dial of my shortwave receiver is pretty close, but not really exact. When I set it to WWV, it stays reasonably accurate in that area but gets worse the further from WWV I get. Is there some way to keep my dial calibrated?***

A. We get many similar requests about this subject. Probably the best approach here is to build a decent crystal-controlled frequency calibrator such as that shown in the August 1969 issue. The major advantage of this particular calibrator over most others is the tone-modulation that enables locating the generator carrier in a mess of other signals.

A CB/Ham Selective Calling Project*

• CODED TONE ACTIVATES RECEIVER
• SILENT CHANNEL UNTIL WANTED

BY MARTIN MEYER

THE ever-increasing activity on the radio communication channels has created an urgent need for a device that will alert you to only those calls specifically directed at you. Ideally, the device would keep your receiver silent, turning on the audio only when a specially coded signal is received. This is exactly what the "Call Selector" described here is designed to do.

The Call Selector eliminates the need for you to monitor the constant "chatter" on the channel to which you are tuned while waiting for a call. The basic one-way Call Selector system consists of an encoder and a decoder (More elaborate arrangements are described later.) The calling party transmits a coded signal on a previously agreed upon channel. You (at the receiving end) leave your transceiver turned on at all times, but you do not hear anything until the special signal is decoded. Then you simply establish contact with no fuss or bother.

The encoded signal consists of a tone whose exact frequency and duration is keyed to the decoder at the receiving end. This tone can be transmitted over any AM, single sideband (SSB), or FM transmitter, making the system usable by CB'ers, hams, and commercial radio operators. There are about 100 combinations of time and frequency that can be selected, ensuring a minimum of false calls even in busy traffic areas. The system is also immune to extraneous noises and voices to further safeguard against false triggering.

*U.S. and foreign patents applied for.

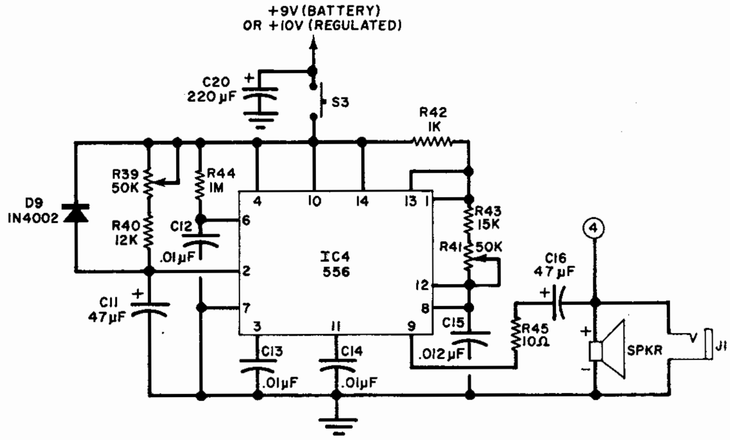


Fig. 1. The encoder uses a timer to generate a tone.

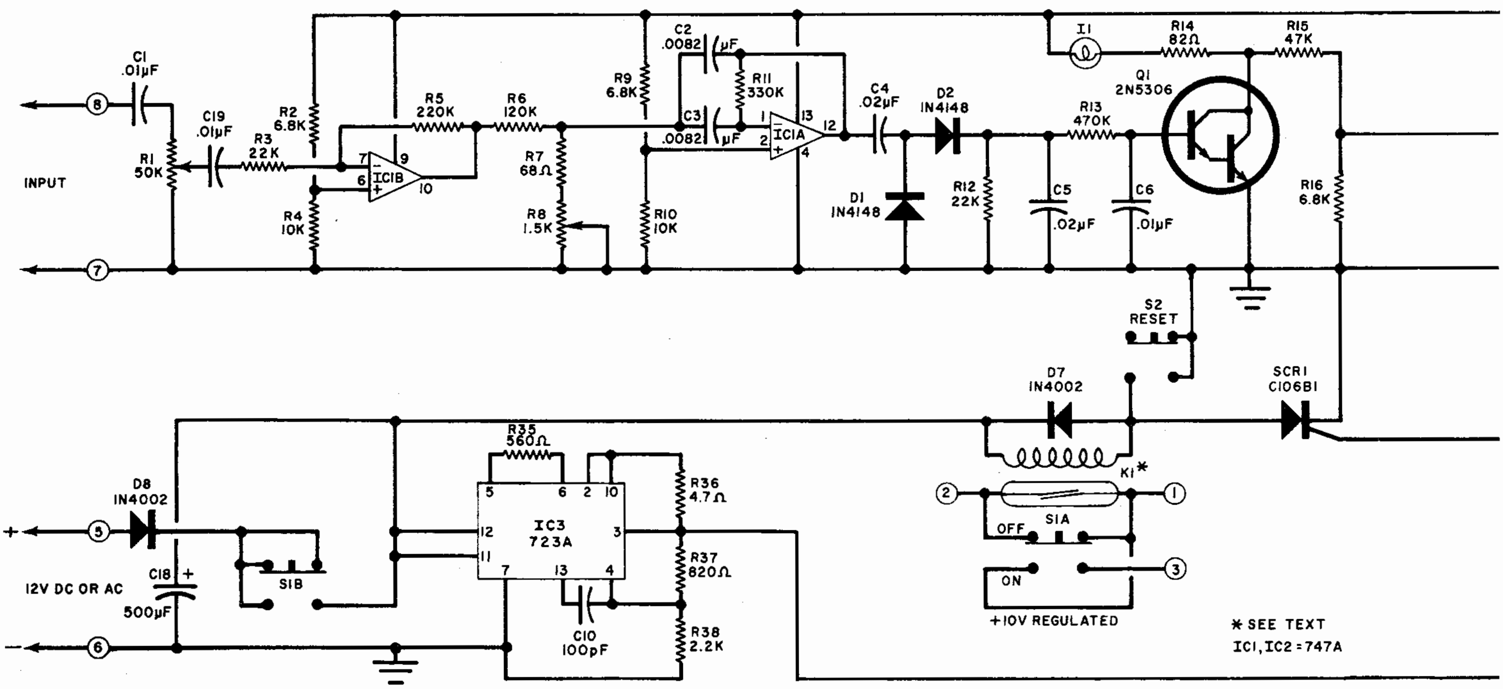
Any number of transceivers can be equipped with the system and tuned to the same frequency/time signal to communicate with each other. For example, you can equip a number of mobile transceivers with only an encoder to allow a base-station operator to listen to only those calls in which he is interested.

About the Circuit. The encoder, shown schematically in Fig. 1, consists of dual 556 timer *IC4*, a small dynamic loudspeaker, and supporting components. Half of *IC4* is used as a monostable, or "one-shot," multivibrator, which allows the other timer to free run for a given period of time when activated by closing *S3*. The output of the second timer is an audio tone with a frequency between 1000 and 4000 Hz. The actual operating frequency is determined by the setting of *R41*. The width of the monostable multivibrator's output pulse (and thus duration of the audio tone) is controlled by *R39* over a range of 1 to 4 seconds. The output of the free-running timer is coupled by *R45* and *C16* to the speaker.

The encoding tone is acoustically coupled to the microphone of the transmitter with which the Call Selector is being used. This is accomplished by pressing the microphone's housing down on *S3* and holding the mike's push-to-talk switch closed for the full duration of the tone. Because the encoder draws no current until *S3* is closed, a 9-volt transistor battery is suitable for the power source. However, if a two-way encode/decode system is desired, the encoder can be mounted on the same circuit board as the decoder and power can be drawn from a common +12 volt dc or ac supply. (If an on-board encoder is used, *C20* should be omitted.) The encoder's output will be the same with either power supply and will be stable over a wide temperature range.

The decoder is shown schematically in Fig. 2. The encoded signal from the receiver is coupled into the circuit through *C1* and sensitivity control *R1*. The signal is passed through *C19* and *R3* into the inverting (−) input of *IC1B*. This operational-amplifier stage has a voltage gain of 10 and operates from a single-ended dc power supply, as do all succeeding op-amp stages. Resistors *R2* and *R4* set the noninverting input of *IC1B* at approximately half the supply voltage.

The output of *IC1B* goes to the inverting input of *IC1A*, which is a very selective bandpass filter whose cutoff frequency can be varied between 1000 and 4000 Hz by *R8*. When the receiver's audio output contains a component at the center frequency of the filter, a signal appears at the output of *IC1A*. This signal is coupled by *C4* to *D1* and *D2*, which can detect (rectify) it, and the rectified waveform is smoothed by *R12*, *R13*, *C5*, and *C6* into a dc voltage. When this dc voltage is applied to *Q1*, the Darlington transistor conducts and cuts off *Q2*, at which point, *C9* starts charging through *R17* and the base-emitter



junction of *Q4*. The voltage across *C9* drives *Q3*, the output of which is applied to the noninverting (+) input of *IC2B* and the inverting input of *IC2A* through *R22* and *R26*, respectively.

Normally, the base of *Q6* is positive, and the transistor conducts. However, due to the comparator action of *IC2A* and *IC2B*, the voltage at the base of *Q6* will drop to zero after *C9* begins to charge and then go positive as charging continues. The exact point at which the momentary drop in voltage occurs is determined by the setting of *R20*. Also, *Q5* is always conducting except during the "window" period generated by the charging of *C9*.

Transistors *Q4* and *Q5* are normally conducting as a result of current delivered to their bases through *R29* and *R31*. Both transistors are driven into cutoff only when two conditions are simultaneously satisfied. Transistor *Q5* must be cut off by the drop in the voltage at the output of window generator *IC2*. Transistor *Q4* will be momentarily cut off when the trailing edge of the tone signal discharges *C9*. If these events occur simultaneously, the outputs at the collectors of *Q4* and *Q5* go high and trigger on *SCR1*, which, in turn, energizes reed relay *K1*, closing its contacts. The SCR conducts and the relay remains energized until RESET switch *S2* is closed.

The contacts of *K1* close only when a tone of the proper frequency and time duration is applied to the input of the decoder. Any voice or low-frequency signal that passes through the active filter will constantly discharge *C9*. This makes the system insensitive to heterodynes, voice components, and noise. For stability, the decoder circuit, except for *K1* and *SCR1*, is powered by voltage regulator *IC3*. If an encoder is mounted on a decoder's circuit board, it will also receive its power from the regulated output of *IC3*.

Construction. The encoder and decoder can be assembled on perforated board, using sockets for the IC's, or on a single or separate printed circuit boards. The actual-size etching and drilling and components placement guides for the system are shown in Fig. 3. If you plan to build the encoder and decoder on the same board, use the larger board and install the encoder components in the shaded area of the components placement guide. (Do not forget to omit *C20* in this case.) Alternatively, if you wish to have the encoder and decoder in separate boxes, use both boards, but eliminate the components in the shaded area.

Wire the board or boards as shown, starting with installation of the fixed resistors and nonpolarized capacitors. Then install the electrolytic capacitors, diodes, transistors, and IC's, paying careful attention to polarization, basing, and orientation. Finally, mount the potentiometers, reed relay, and switches. In the author's prototype, *S3* was formed from No. 4 machine hardware and a 1⅜" × ½" (3.5 × 1.3 cm) piece of springy brass shim stock. The brass shim was formed to take advantage of its natural resilience to keep it from touching the machine screw contact. A short length of wood dowel or plastic rod can be used as the pushbutton for the switch. If you prefer, you can use a standard normally open pushbutton switch, connecting it to the pc board via short lengths of hookup wire

Mount *J1, I1, I2, SPKR,* and the dowel or plastic rod for *S3* (or *S3* itself) on the top of the box in which you house the encoder/decoder. If you are housing the encoder and decoder in separate boxes, install the 9-volt transistor battery for the encoder off the board where it will not interfere with the board, speaker, or *S3*. In either case, mount the activating button of *S3* close to the speaker.

The numbers of the contacts on terminal strip *TS1* on the encoder/decoder components placement guide refer to the same numbered points in Fig. 1 and Fig. 2. This terminal strip provides a convenient means of connecting the system to its power supply, an external speaker, and any other warning device you might want to use, such as a Sonalert, LED, etc., when a properly coded signal is received. The decoder board will also accommodate a Sigma No. 77RE2 dpdt relay in the event the spst reed relay will not provide a sufficient number of contacts.

Aligning the System. To get the Call Selector system to operate properly, the decoder must be made to respond

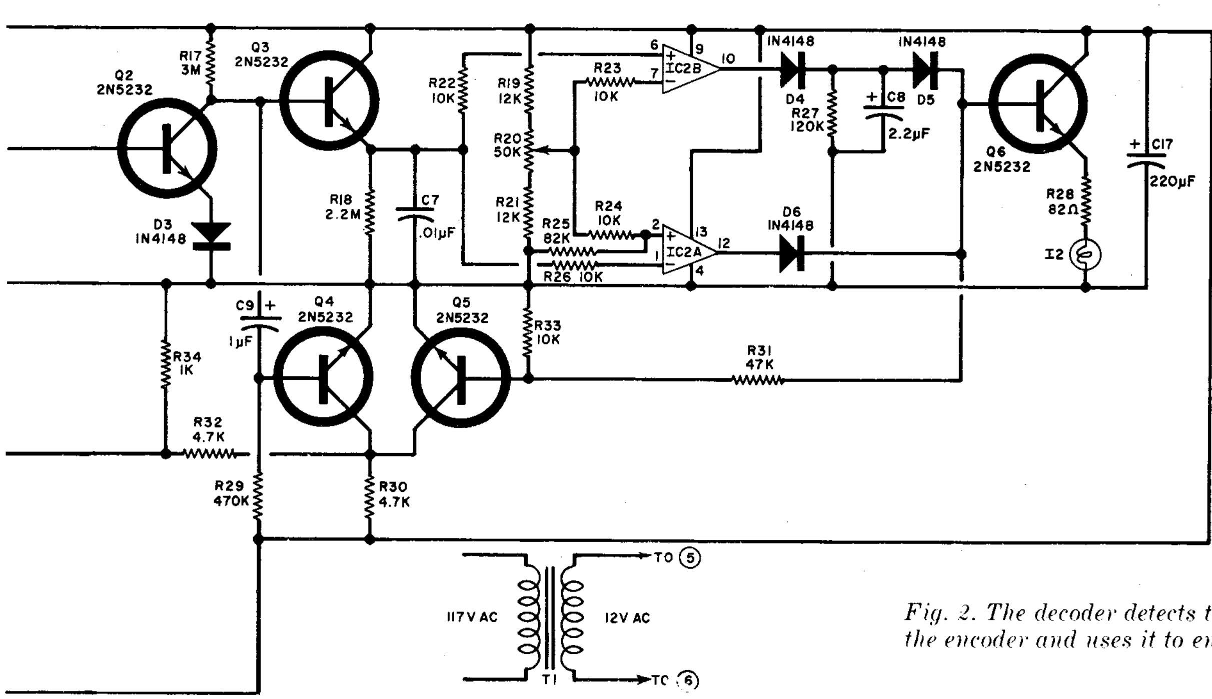
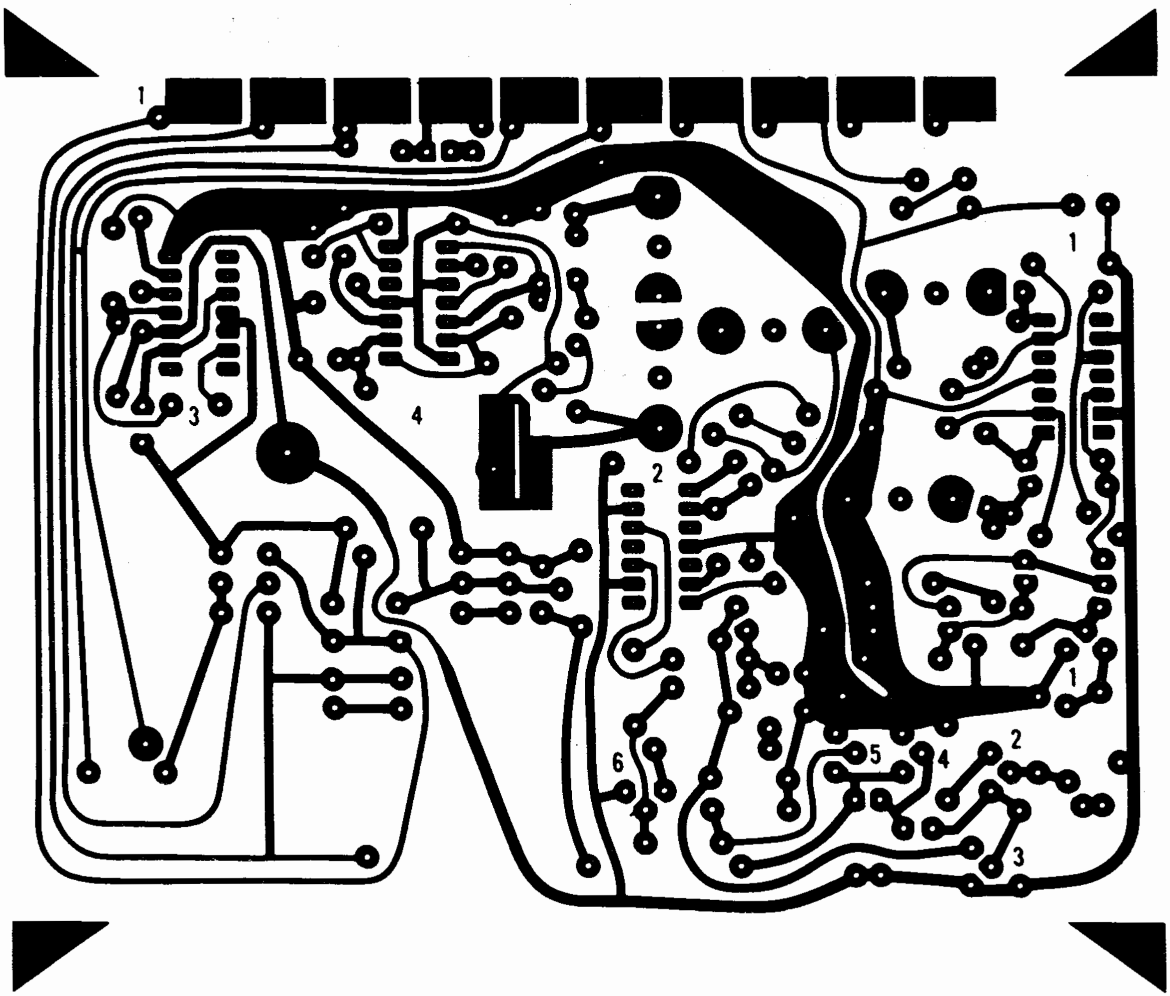


Fig. 2. The decoder detects the audio tone from the encoder and uses it to energize a reed relay.



to the selected frequency/duration characteristics of the encoder's output signal. To align a system consisting of separate encoder and decoder, you will need a shielded cable terminated at one end in a plug that mates with jack *J1* in the project. Connect the "hot" lead of the cable terminal 8 and the shield to terminal 7 of *TS1*. For a system in which the encoder and decoder are on the same board, simply connect a jumper between terminals 4 and 8. This allows the system to be calibrated by direct interconnection, rather than by transmitting test tones on the air.

Connect power to the system. Set *R1* in the decoder and *R39* in the encoder to maximum clockwise and *R8*, *R20*, and *R41* for center of rotation. Depress *S3* and hold it down for the full duration of the test tone while adjusting *R41* until *I1* glows. This sets the encoder for the maximum 4-second tone duration. It may be necessary to repeat this procedure several times before *R41* is properly set.

DECODER PARTS LIST

C1,C6,C7,C19—0.01-µF disc capacitor
C2,C3—0.0082-µF, 10% Mylar capacitor
C4,C5—0.02-µF disc capacitor
C8—2.2-µF, 25-volt electrolytic capacitor
C9—1-µF, 25-volt, 5% tantalum capacitor
C10—100-pF disc capacitor
C17—220-µF, 25-volt electrolytic capacitor
C18—500-µF, 25-volt electrolytic capacitor
D1 through D6—1N4148 diode
D7,D8—1N4002 rectifier diode
I1, I2—6-volt, 100-mA lamp and assembly (Radio Shack No. 272-1535 or similar)
IC1, IC2—747A dual operational amplifier IC
IC3—723A voltage regulator IC
K1—12-volt spst reed relay (or Sigma No. 77RE2 dpdt relay—see text)
Q1—2N5306 npn Darlington transistor
Q2 through Q6—2N5232 npn silicon transistor
R1,R20—50,000-ohm trimmer potentiometer
R8—1500-ohm trimmer potentiometer
Following resistors are ¼ watt, 5% tolerance:
R2,R9,R16—6800 ohms
R3,R12—22,000 ohms
R4,R10,R22,R23,R24,R26,R33—10,000 ohms
R5—220,000 ohms
R6,R27—120,000 ohms
R7—68 ohms
R11—330,000 ohms
R13,R29—470,000 ohms
R14,R28—82 ohms
R15,R31—47,000 ohms
R17—3 megohms
R18—2.2 megohms
R19,R21—12,000 ohms
R25—82,000 ohms
R30,R32—4700 ohms
R34—1000 ohms
R35—560 ohms
R36—4.7 ohms
R37—820 ohms
R38—2200 ohms
S1—Dpdt pushbutton switch
S2—Spdt pushbutton switch
SCR1—C106B1 silicon controlled rectifier
T1—12-volt, 500-mA transformer
TS1—8-contact screw-type terminal strip
Misc.—Perforated or printed circuit board; suitable chassis box; hookup wire; machine hardware; solder; etc.

Note: The following items are available from Netronics Research & Development, Rte. 6, Bethel, CT 06801. Complete kit of parts with instructions for one-way system which includes separate encoder and decoder, wood case for decoder, and plastic case with visor clip for encoder (Kit N5000), $44.95 + $1.50 postage; Separate encoder kit with plastic case, visor clip and instructions (Kit N6000), $14.95 + $1 postage and handling; Combination encoder/decoder for two way system which includes all parts, instructions, a wood case and built-in heavy-duty speaker (Kit N7000), $49.95 each + $1.50 postage and handling. Also available separately: decoder pc board, $5.25; encoder pc board, $3.95; reed relay, $2.60, 12-volt transformer, $2.75; S3 encoder switch and plunger, $1.30. Add $1 postage and handling for separate parts orders.

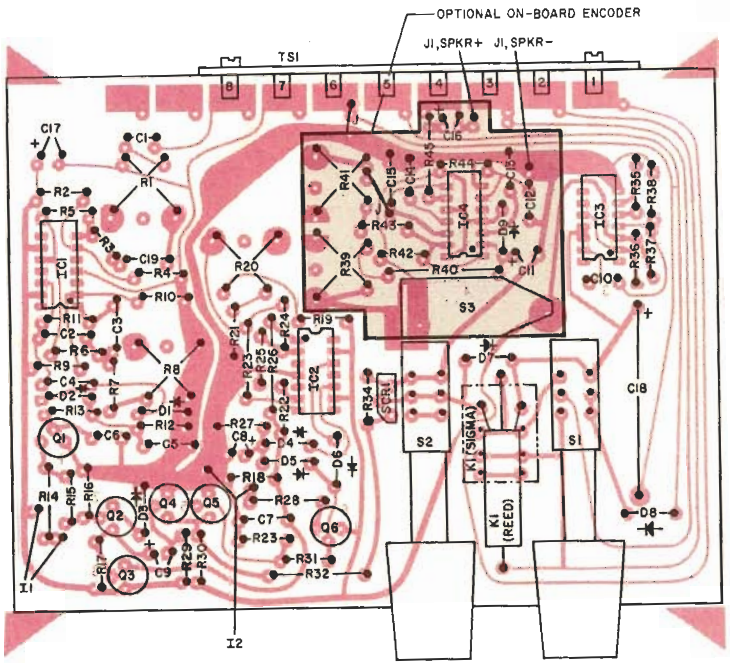


Fig. 3. If you want encoder and decoder together, use board on opposite page and install all components as above. For separate units, leave off components in shaded area above and build separate encoder board shown below.

Once *I1* comes on while *S3* is depressed, *I2* should blink about half way through the tone burst. Adjust *R39* so that *I1* turns off just after *I2* blinks. Once this adjustment has been made, depress RESET switch *S2*.

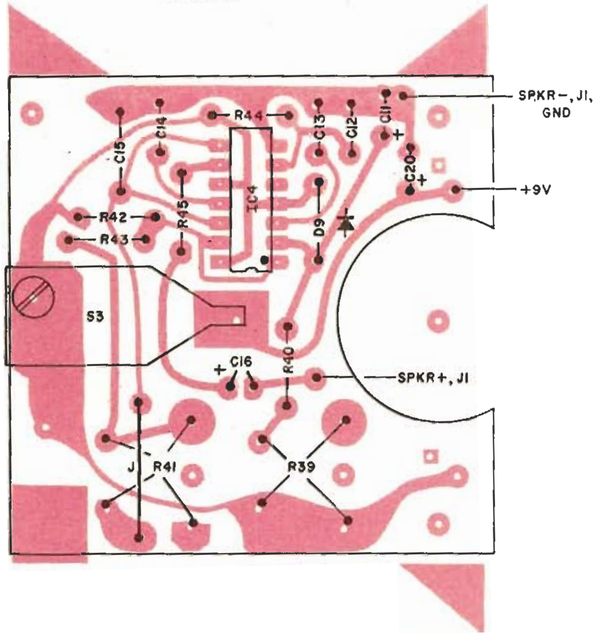
Connect an ohmmeter between terminals 2 and 3 on *TS1*. The meter should indicate an open circuit. With power switch *S1* off, the ohmmeter should indicate short circuit (zero ohms) with *S1* on. Depress *S3* for the full duration of the tone burst; *I1* should turn off immediately after *I2* blinks and the meter should indicate a short circuit. Depress *S2*; the relay's contacts will open and the meter should indicate an open circuit. If you do not obtain the proper results, repeat the alignment procedure until you do.

In Use. You can recalibrate the Call Selector system for any frequency between 1000 and 4000 Hz and for any tone duration between 1 and 4 seconds. Sensitivity control *R1* can be set for any desired signal level threshold. In practice, you use the microphone to

ENCODER PARTS LIST

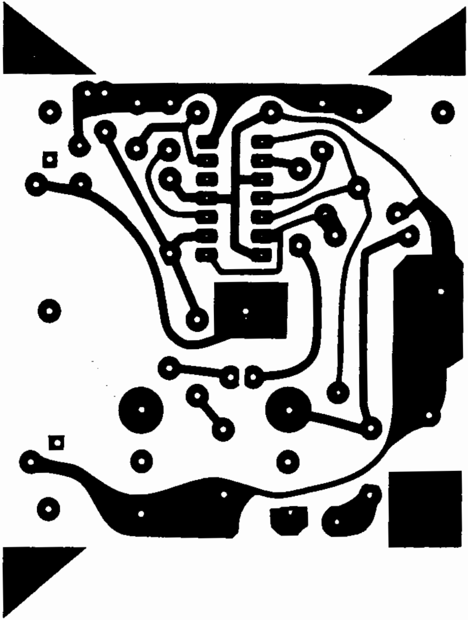
C11—47-μF tantalum electrolytic capacitor
C12,C13,C14—0.01-μF disc capacitor
C15—0.012-μF, 10% Mylar capacitor
C16—47-μF, 25-volt electrolytic capacitor
C20—220-μF, 25-volt electrolytic capacitor (see text)
D9—1N4002 rectifier diode
IC4—556 dual timer IC
J1—Miniature phone jack
R39,R41—50,000-ohm trimmer potentiometer

Following resistors are ¼ watt, 5% tolerance:
R40—12,000 ohms
R42—1000 ohms
R43—15,000 ohms
R44—1 megohm
R45—10 ohms
S3—Spst switch (see text)
SPKR—8-ohm, 2¼"-diameter dynamic speaker
Misc.—Perforated or pc board; suitable chassis box (if assembled separately); machine hardware; hookup wire; solder; etc.



der; etc.

,Jl,



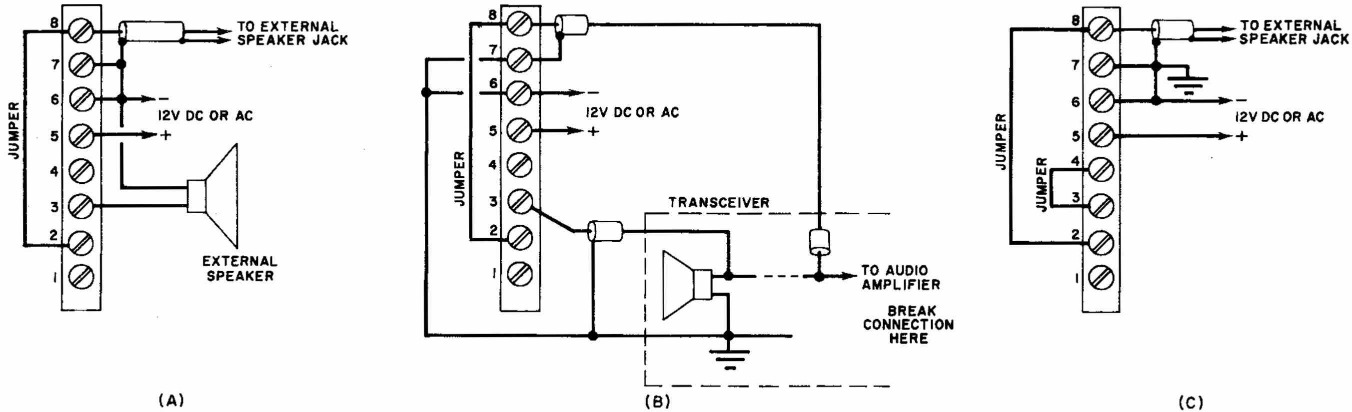


Fig. 4. Ways to use the system: with external speaker (A); with transceiver's speaker (B); and with the combination encoder/decoder's internal speaker (C).

depress *S3*, holding the mike's pickup element directly over the Call Selector's speaker for the entire duration of the tone burst. This keeps the activating signal modulating the carrier at a constant level because the mike will be stationary with respect to the speaker.

There are several different ways to connect the system to your transceiver, three of which are illustrated in Fig. 4. If you plan to use the decoder with an external speaker and do not want to touch the "insides" of the transceiver, follow the wiring scheme detailed in Fig. 4A. Use a length of shielded cable to transfer the audio signal from the receiver's external-speaker jack to the decoder's terminal strip. Terminate the cable with a plug that mates with the transceiver's jack.

You can wire the system to the transceiver's internal speaker as shown in Fig. 4B. This connection requires a slight rewiring of the transceiver's circuit. Break the connection between the audio output stage and the speaker. Rewire the circuit as shown, using shielded cable. When the relay contacts close, the audio path to the internal speaker will be completed.

The diagram shown in Fig. 4C is for systems in which the encoder and decoder are assembled on the same board. This wiring scheme allows you to use the decoder/encoder's built-in speaker as an encoder transducer and as the transceiver's external speaker.

For all three interconnections detailed in Fig. 4, the decoder can be bypassed by placing *S1* in the OFF position. The receiver's audio signal will then be applied directly to the internal or external speaker. ◈

ADRIAN WEISS, K8EEG

QRP

The art of very low power operating

The Old Tube-Hound Goes Solid State

Back in the spring of '71 or thereabouts, at the time that my efforts with *The Milliwatt* and QRPp began to bear some fruits, I had a surprise visit from a fellow that I heretofore had known only from his delightful manner of writing about mundane electronics subjects for the magazine. In fact, I'd invited C.F. Rockey, W9SCH, to join the staff as a contributing editor with no responsibility other than a continual flow of informative technical articles written from a perspective that had been vitalized through some four decades of hamming and teaching electronics to snot-nosed high school kids. Rockey knew his stuff and could get it across, 'cause he'd turn out a couple First Class Commercials each year from his electronics program at New Trier High School. That's a high school, by the way. He was especially pleased when one of his kids, "Schlitzy" Schillereff, WB9CXN, first broke into print in *The Milliwatt* and then in *ham radio*. Pretty good teaching job for an old fogey like Rockey (that's what I always call him, as I never have managed to find out what the "C.F." stands for!). Rockey is one of those guys who doesn't like the limelight and prefers to pass on his electronics wizardry on an individual basis.

Well, as I was saying, he popped up one morning in the wilds of South Dakota and we had a very pleasant visit with him and his charming wife Fran, who is also a teacher. Delightful, cultured couple, to say the least. Amateur radio will always be healthy as long as there are guys like Rockey around to instill the old idealism into the younger generation of hams. But I keep getting off the subject. We BS'd about general matters and quickly set the world straight (those were the Nixon days) and without missing a stride we tidied up the world of Amateur radio. We philosophical types are blessed with the knack of cutting through all the balderdash and getting to the essence of matters expeditiously. With serious concerns out of the way, I showed Rockey some of the "pride 'n' joy" products of my creative electronics genius—all of which were p.c. board solid-state types. That kind of flustered the Rock and got 'im ranting about the virtues of tubes and the evils of solid-state. Now, don't get the wrong picture. Not that he didn't know anything about solid-state. Why, back in '55, or was it '57, I don't remember which, he cajoled his boss into using some leverage to acquire a couple of those new-fangled "transeestors" from a friend at Bell Labs, and Rockey had his fun with 'em. Even got one to oscillate up around 1300 KHz. His boss wasn't impressed. Told him that nothing would ever come of those little gadgets, clinching his case by proclaiming that vacuum tube state-of-art had reached such a height of sophistication that vacuum tubes would never be replaced, nor was there any need to try. Well, there's no need to identify his boss in print, not now, at any rate.

To get back to my story, I reminded the Rock of that episode in his life, and he ended up admitting for all his earlier bluster, that transistors are wonderful little gimmicks and he'd really like to tinker with 'em, but by garsh, they were just too danged little for his clumsy paws to work with. Well, I forget all that I said to motivate him into trying solid-state anyway, but I do recall telling him that he could do point-to-point wiring rather p.c. board stuff as long as he didn't show it to anyone, and other stuff like that about maintaining the

The tidy QRPp station of Art Pahlke, K9KXE, (4207 N. Monitor, Chicago, Ill. 60634). Art is a member of the QRP fraternity, having decided to give it a try after reading some back issues of The Milliwatt. The antenna system is a trap vertical, ground mounted, with no radials, and surrounded by bushes and buildings, a very poor situation. Nonetheless, he's had the thrill of working CA on 40 c.w. as well as other areas of the country. He re-entered amateur radio via QRPp after a long layoff, and says he thinks he'll stay now! Great!

*83 Suburban Estates, Vermillion, SD 57069

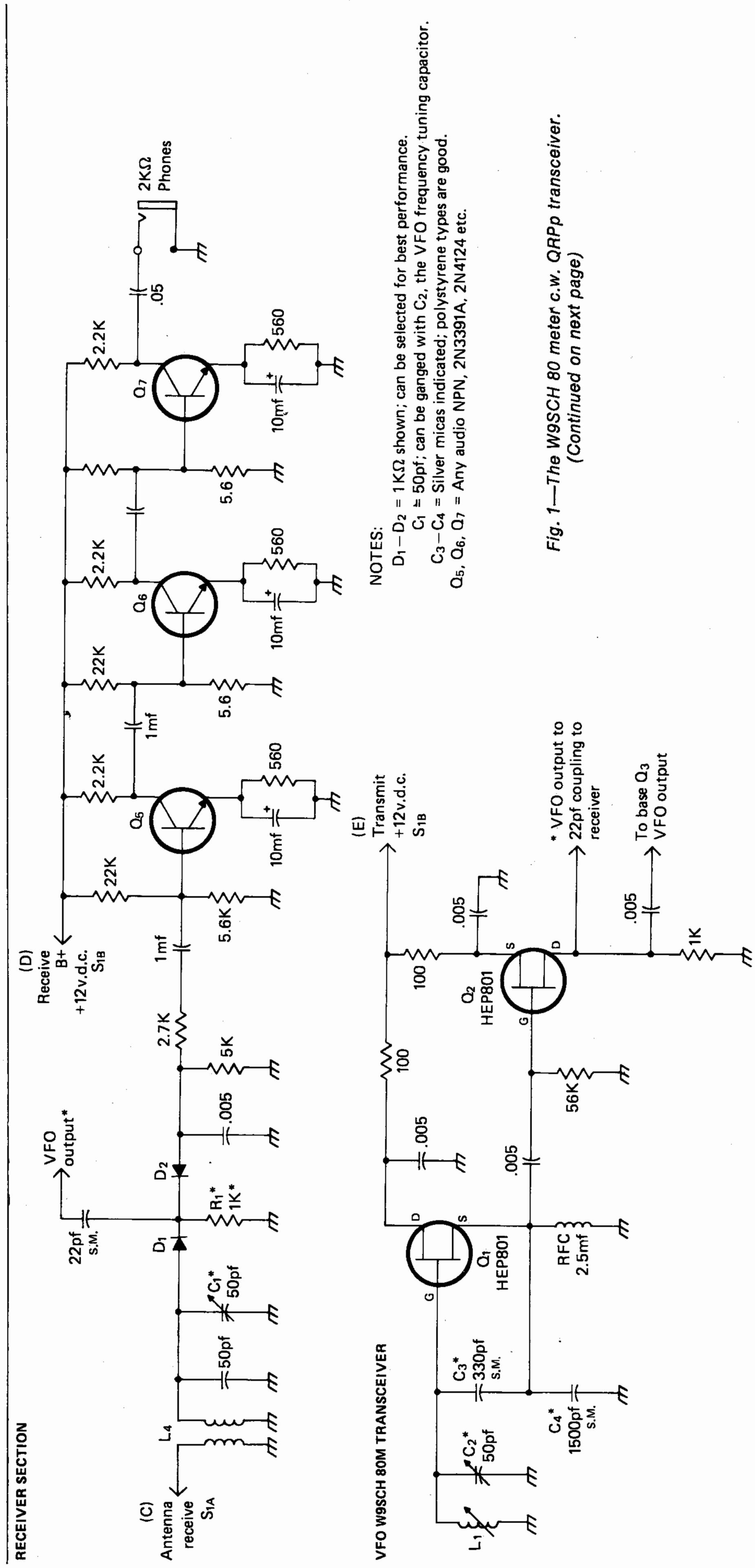


Fig. 1—The W9SCH 80 meter c.w. QRPp transceiver.
(Continued on next page)

image of QRPp'ers as being right at the front of the modern wave of developments in all respects. While, this whole incident took place quite a while back and several W9SCH "tube" designs ago, but the Rock finally could no longer resist. He went solid-state. Yep. And without any prompting on my part, he sent me the following testimonal with the appropriate moral in its conclusion. Without further ceremony, I pass it on for the reader's edification and emulation.

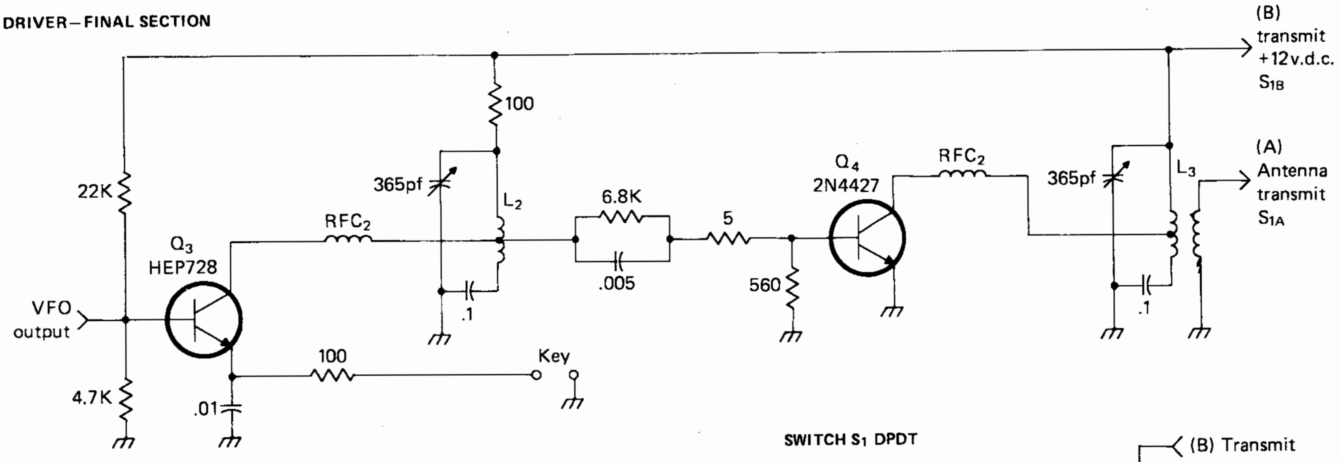
W9SCH 80M Solid-State Transceiver

After 37 years of using, and misusing the good old fire-bottle, I have finally gotten up the nerve to try an all-solid-state job. This wasn't easy, after absorbing the gloom and doom that fills the literature in this field. One *ham radio* article recently was filled with Faustian foreboding, almost. It's enough to scare a poor boy half to death, it is. But, after all, Ten-Tec has been building these things on quite a scale now, and they're not necromancers—or are they?

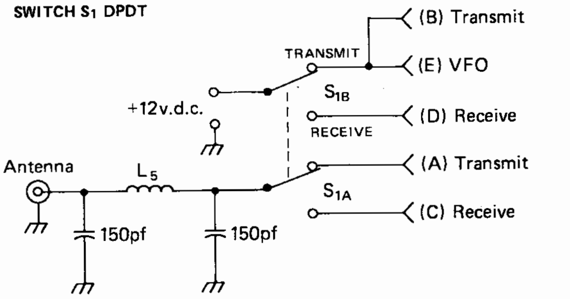
Upon reviewing the junkbox stock, the meager cash supply, and my few viable brain cells, I decided to tackle a little 80 meter c.w. transceiver in the TenTec-esque manner. Fig. 1 shows the resulting circuit. It took a while to get it into that form. To paraphrase an old U.S. Navy proverb: "Transistors, like the sea, are not inherently troublesome, but they are horribly unforgiving of human error." That's about the sum and substance of my experience in this project. You can slap a vacuum tube in the face, time and time again, and it will come back for more of the same. Not so a transistor; one little boo-boo will kill an expensive transistor in a millisecond or so. With transistors, there is no second chance to err. . . . So, being the inherently sloppy type, my first adventure with h.f. solid-state power was something of a *lachrymae rerum.*

Low-level, low frequency transistor circuitry is no problem, really. In fact, it seems less fuss and bother than the analogous tube layout. For instance, our FET v.f.o. and source-follower worked just deliciously, right off the bat. In fact, this is probably the cleanest, most stable, and least fussy v.f.o. that I've ever built. Gone are the microphonics and those esoteric little hums that plague the tube v.f.o. The audio amplifier for the receiver also amazed me by its lack of fussiness. A tube amplifier with four stages and this degree of gain would probably "motorboat" its fool head off, unless it were carefully de-

DRIVER—FINAL SECTION



SWITCH S1 DPDT



NOTES:

RFC_2 = 5t, ¼" dia close space.

Coil data: Bell wire (No. 20), 1.25" dia form

Coil	Primary	Link	Tap
L_2	25t		8t from ground end
L_3	25t	6t	5t from ground end
L_4	51t (40μH)	5–8t	
L_1	8μH slug tuned (Miller 21A68RBI		

coupled etc. The transistors are as well-behaved as they can be, with no special precautions taken whatever. Indeed, everything went so well with the receiver that I began to think that I had this solid-state stuff "made in the shade with lemonade," as they say. But ah, *hubris!* Little did I know the agony ahead. . .

So, I went blithely on to the final amplifier. It completed, I coupled up a 15V "series" type Christmas-tree bulb (my favorite r.f. indicator) to the tank circuit. Flipping on the battery, I fully expected to warm my soul in the effulgent glow of the bulb. But, alas, not so. What did I get? *Gar nichts,* as we say in German—plenty of good ol' nothing!

For gawsh sakes, how could a simple thing like this fail to work? But, there it was—the 2N4427 was as dead as a week-old baloney sandwich, shot right through the collector junction. Another, more-thorough check of the wiring with a v.o.m. exposed no faults. So, I put in another transistor . . . foolish, foolish old man, this one, too, bit the dust quicker 'n a hoss-opera Indian. This was too cotton-pickin' much. I decided to quit and think things over a bit. Two Excedrin headaches and another transistor later, I decided to try it with only six instead of twelve volts. Now we were gettin' somewhere, as plenty of "soup" was lighting up the r.f. bulb. But, behold, the thing was oscillating like a drunken cowpoke in a hoedown contest! Apparently, what was happening seemed to be that the transistor threw itself into oscillation with twelve volts and the excessive current perforated the junction. With six volts, however, there was not enough energy present to wreak such havoc.

I finally shunted the thing down with a 27 ohm resistor in the base lead. That cooled things off sufficiently to risk another twelve volt run. This time the transistor survived. Now that I was getting a goodly gob of "soup" into the r.f. bulb, about a watt with two watts input, I decided to try the thing with a live antenna. Yes, it put the stuff into the antenna all right, but on all kinds of frequencies where it shouldn't have.

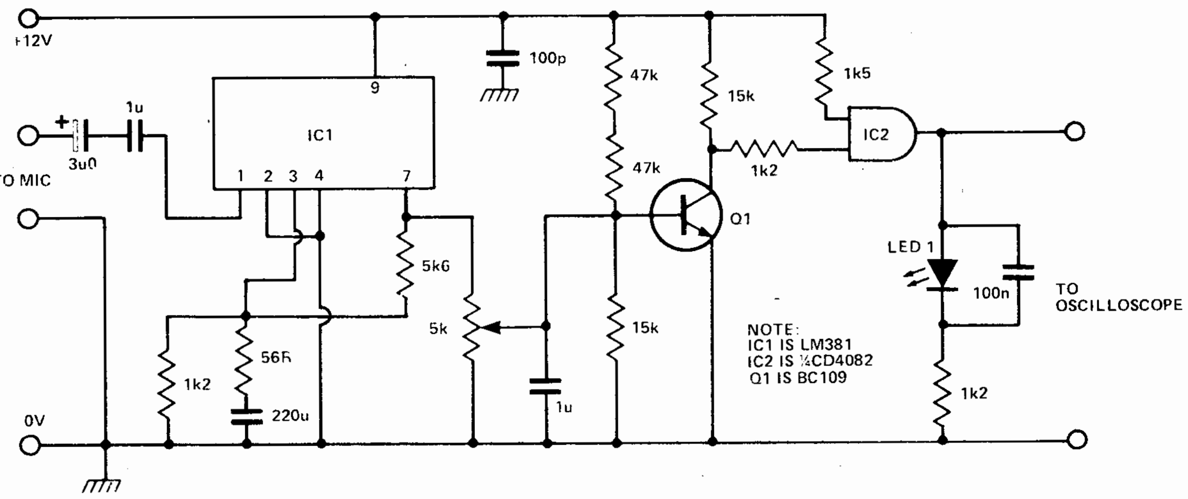
More diddling followed. I found out that when the books say that the output impedance of a power transistor is low, they mean low! This amounts to one-half of the d.c. collector resistance. In my case this is, ballpark, about 80 ohms. Assuming a minimum loaded Q of 10 for the tank, a bit of stick-slipping (Ed. Note: the slide-rule, which consisted of a fixed set of scales, and a sliding stick with another set of scales, was formerly used as a mathematical calculator before the time of minicalculators) revealed that the collector should be tapped about one-fifth of the coil turns up from the cold end. And mine presently was tapped about two-thirds of the way up. Any loaded Q the tank exhibited under such conditions was purely coincidental! Moving the tap down to where it belonged cleaned up the signal immensely.

Of course, I was favored with parasitics, the whole doggone collection, including TVI, and that sick-sounding hiss that sounds just like an old quenched-spark signal as received on an oscillating detector, and is spread out all over the band. A little five-turn, ¼ inch diameter "choke" in each collector lead of the driver and final, and a five ohm resistor in series with the final base, seemed to lick these parasitics fairly well. When the ferrite-beads that I ordered from California come, I expect them to do the job even better.

Now the output and efficiency were reasonable—about one watt output for 1.5 watts input. The tank circuit tuned as a tank circuit should, and there was no detectable spurious signals lurking about that I have been able to find. There was a smirch of cross-hatching on Channel 2 on a rabbit-eared boob tube ten feet away, but all other channels were clear. After a week of operating, I had no complaints from the neighbors. The receiver works satisfyingly well despite its simplicity; it compares favorably with that in my PM-3 (allowing for band differences) and there's not much I can hear on my faithful old HRO that I can't hear with this job. The phones are full of workable signals every night, and I'm sure there's little I could work with two watts that I can't hear with

(Continued on page 73)

tech tips



Morse Code On The Oscilloscope

S. J. Stamps

This circuit enables morse code to be displayed as dots and dashes on an oscilloscope screen. By speaking into a microphone, saying 'dit' and 'dah' as appropriate, short and long pulses appear on the screen in a format similar to that of written morse.

One half of an LM381 and a BC109 are used to amplify the signal from the microphone, which is then clipped into digital form by the AND gate. The output from the circuitry is fed to an oscilloscope set to 2V/cm and 5ms/cm, set to trigger on the start of a 'dit'.

Input to the circuit can be from a microphone, or tape recorder. If words are recorded onto the tape with the microphone and then played back via the circuit, practice at reading morse is possible.

TELETYPEWRITER INFO

The article, "Teletypewriter Fundamentals for Hams, SWL'ers, and Computer Hobbyists," in the October issue, was excellent in its coverage of baud rates, frequency shift and audio frequency shift keying, but neglected to mention that the majority of teletypewriter systems in hobby or ham use are Teletype Corp. model 28 or 33 series units. The model 28 differs greatly in the methods of signal generation and printing. The keyboard uses a lever system, which drives a contact arm, similar to automobile distributor points, back and forth to interrupt the dc loop. The printer relies on a signal which can be in one of several forms, depending on the type and wiring. It may be driven with a neutral 0.060 A or 0.020 A signal or several types of polar signals, such as +6 volts. Printing is accomplished by the positioning of a typebox in front of a single print hammer, all controlled by the selector magnets. Typebox styles may vary in surplus equipment, so it would be wise to examine, if possible, the typebox to be sure that it is a "communication" arrangement, rather than weather, etc., which may be full of unintelligible symbols. The 33 series is a self-contained setup, which works in a similar manner, but uses a rotating type wheel rather than a typebox. My firm will be glad to accept operation and theory inquiries and answer them in detail, provided a SASE business-size envelope is included. We also have schematics, wiring diagrams, parts lists, exploded views, and theory and operation manuals and courses at nominal costs.—*Karl M. Wahala, P.O. Box 19154, Honolulu HI 96817.*