THE MINI-MISER'S DREAM RECEIVER

From: The Radio Amateur's handbook, 197 , ARRL

A receiver that featured good performance with a modest outlay of building time and components appeared in the Forty-Fifth Edition of *The Radio Amateur's Handbook*. The original design was that of Byron Goodman, W1DX, and incorporated vacuum tubes in the construction.

This updated version by Doug DeMaw, W1CER, utilizes the same principle of going directly into a mixer in the front end which is followed by a simple crystal filter. Solid-state construction is used throughout the design and audio output is sufficient to drive a small speaker. This receiver should fill the need for a simple, compact unit where low current drain is also a requirement.

Circuit Description

There are some departures from the W1DX design, mainly to minimize cost and package size.

The major compromise was the elimination of agc and multiband coverage. There is ample room inside the cabinet of this receiver to accommodate one or two small converters for reception of bands other than 40 meters. This main frame is designed for 7- to 7.175-MHz coverage.

Fig. 1 shows an IC being used as the receiver front end – a CA3028A which is configured as a balanced mixer. The input tuned circuit, T1, is designed to match a 50-ohm antenna to the 2000-ohm base-to-base impedance of the mixer IC. The transformer is broadbanded in nature (300 kHz at the 3-dB points), and has a loaded *Q* of 23. This eliminates the need for a front-panel peaking control – a cost-cutting aid to simplicity.

The output tuned circuit, L1, is a bifilar-wound toroid which is tuned approximately to resonance by means of a mica trimmer, C2. The actual setting of C2 will depend upon the degree of i-f selectivity desired, and typically the point of resonance will not be exactly at 3300.5, the i-f center frequency.

Goodman used a half-lattice filter (two crystals) in his design, but this requires two crystals which are related properly in addition to a BFO crystal. For this reason, an older circuit was employed – a single crystal filter with a phasing capacitor, C3. The latter approach provides reasonably good single-signal reception (at least 30 dB rejection of the unwanted response), and assures much better erformance than is possible with simpler direct-conversion receivers.

A single i-f amplifier, U2, is used to provide up to 40 dB of gain. R1 serves as a manual i-f gain control, and will completely cut off the signal output when set for minimum i-f gain. No audio gain control is used. T2 is designed to transform the 8000-ohm collector-to-collector impedance of U2 down to 500 ohms, and has a bandwidth of 100 kHz. The loaded *Q* is 33.

A two-diode product detector converts the i-f energy to audio. BFO injection voltage is obtained by means of a crystal-controlled oscillator, Q2. RFC2 and the 1-μF bypass capacitor filter the rf, keeping it out of the audio line to U3.

Audio-output IC U3 contains a preamplifier and power-output system. It will deliver approximately 300 mW of af energy into an 8-ohm load. RFC5 is used to prevent rf oscillations from occurring and being radiated to the front end and i-f system of the receiver. The 0.1-μF bypass at RFC5 also helps prevent oscillations.

A three-terminal voltage regulator, VR1, supplies the required operating voltage to U3. It also provides regulated voltage for the VFO and buffer stages of the local oscillator (Q2 and Q3). The latter consists of a stable series-tuned Clapp VFO and an emitter-follower buffer stage. A single-section pi network is placed between the emitter of Q3 and the injection terminal of U1. It has a loaded *Q* of 1, and serves as a filter for the VFO output energy. It is designed for a bilateral impedance of approximately 500 ohms. The recommended injection-voltage level for a CA3028A mixer is 1.5 rms. Good performance will result with as little as 0.5 volt rms. A 1-volt level is available with the circuit shown in Fig. 1.

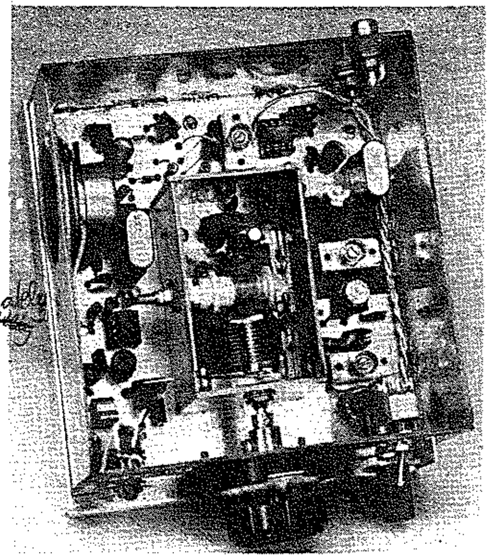
A red LED is used at DS1 as an on-off indicator. Since it serves mainly as "window dressing," it need not be included in the circuit.

Construction Notes

Front panel, rear panel, side brackets, and chassis are made from double-sided circuit-board material. The chassis is an etched circuit board, the pattern for which is given in Fig. 2. There is no reason why the top and bottom covers for the receiver can not be made of the same material by soldering six pieces of pc board together to form two U-shaped covers.

The local oscillator is housed in a compartment made from pc-board sections. It measures (HWD) 1-3/8 x 1-5/8 x 2-3/4 inches. A 1/4-inch high pc-board fence of the same width and depth is soldered to the bottom side of the pc board (opposite the top partition) to attenuate rf energy from entering or leaving the local oscillator section of the receiver. Employment of the top and bottom shields stiffens the main pc board, and that helps prevent mechanical instability of the oscillator, which can result from stress on the main assembly.

Silver plating has been applied to the main pc board, and to the front and rear panels. This was done to enhance the appearance and discourage tarnishing of the copper. It is not a necessary step in building the receiver. The front panel has been sprayed with green paint, then baked for 30 minutes by means of a heat lamp. A coarse grade of sandpaper was used to abrade the front panel before application of the paint. The technique will



Interior view of the receiver. The front end is at the lower right. The leads of U1 are bent to align with an 8-pin dual-in-line IC socket. The rim of the speaker is tack-soldered to the pc-board side wall at two points. The 20-meter converter mounts on the rear wall inside the receiver (upper left corner).

prevent the paint from coming off easily when the panel is bumped or scratched. Green Dymo tape labels are used to identify the panel controls.

There is ample room inside the cabinet, along the rear inner panel surface, to install a small crystal-controlled converter for some other hf band. A switch, S1, is located on the front panel to accommodate a planned 20-meter converter. A suitable circuit is given in Fig. 3.

All of the toroidal inductors are coated several times with *Q* dope after they are installed in the circuit. The VFO coil is treated in a like manner. The polystyrene VFO capacitors should be cemented to the pc board after a circuit is tested. This will help prevent mechanical instability. Hobby cement or epoxy glue is OK for the job. Use only a drop or two of cement at each capacitor – just enough to affix it to the pc board.

Alignment and Operation

The VFO should be aligned first. This can be done by attaching a frequency counter to pin 2 of U1. Coverage should be from 3699.5 to 3874.5 kHz for reception from 7.0 to 7.175 MHz. Actual coverage may be more or less than the spread indicated, depending on the absolute values of the VFO capacitors and stray circuit inductance and capacitance. Greater coverage can be had by using a larger capacitance value at C5, the main tuning control. Those individuals interested only in phone-band coverage can align the VFO accordingly and change Y2 to 3400.8 kHz.

Final tweaking is effected by attaching an antenna and peaking C1, C2 and C4 for maximum signal response at 7085 kHz. To obtain the selectivity characteristics desired (within the ca-

Fig. 1 — Schematic diagram of the 40-meter receiver. Fixed-value capacitors are chip or disk ceramic unless noted otherwise. Capacitors with polarity marked are electrolytic. S.M. indicates silver mica, and P is for polystyrene. Fixed-value resistors are 1/4- or 1/2-W composition.

C1, C2, C4 — 170- to 600-pF mica trimmer (Arco 4213).

C3 — 10-pF subminiature trimmer. Ceramic or pc-mount air variable suitable.

C5 — Miniature air variable, 30 pF maximum (Millen 25030E or similar).

CR1-CR3, incl. — High-speed silicon switching diode.

J1, J3 — Single-hole-mount phono jack.

J2 — Closed-circuit phone jack.

L1 — Toroidal bifilar-wound inductor. L = 5.8 μH. 8 turns No. 28 enam., bifilar wound on Amidon FT-37-61 ferrite core. Note polarity marks.

L2 — Slug-tuned inductor (see text), 11 μH nominal. J. W. Miller 42A105CBI or equiv. Q_u = 125.

L3 — Toroidal inductor, 17 μH, 19 turns No. 26 enam. wire on Amidon FT-50-61 ferrite core.

R1 — 10,000-ohm miniature composition control, linear taper.

RFC1, RFC2 — Miniature 1-mH rf choke (Millen J302-1000 or equiv.).

RFC3, RFC4 — Miniature 330-μH rf choke (Millen J302-330 or equiv.).

RFC5 — Miniature rf choke, 33 μH (Millen J302-33 or equiv.).

S1 — Miniature dpdt toggle.

T1 — Toroidal transformer. Primary has 2 turns No. 24 enam. wire. Secondary has 14 turns No. 24 enam. wire on Amidon T-50-2 core.

T2 — Toroidal transformer. Primary has 9 tu[rns N]o. 26 enam. wire on Amidon FT-37-61 core. Secondary has 3 turns No. 26 enam. wire. Primary winding has center tap.

U1 — RCA IC. Bend pins to fit 8-pin dual-in-line IC socket.

U2, U3 — Motorola IC.

VR1 — Three-terminal 8-volt regulator IC (National Semiconductor).

Y1, Y2 — Surplus crystal in HC-6/U case or International Crystal Co. type GP with 32-pF load capacitance.

Fig 1

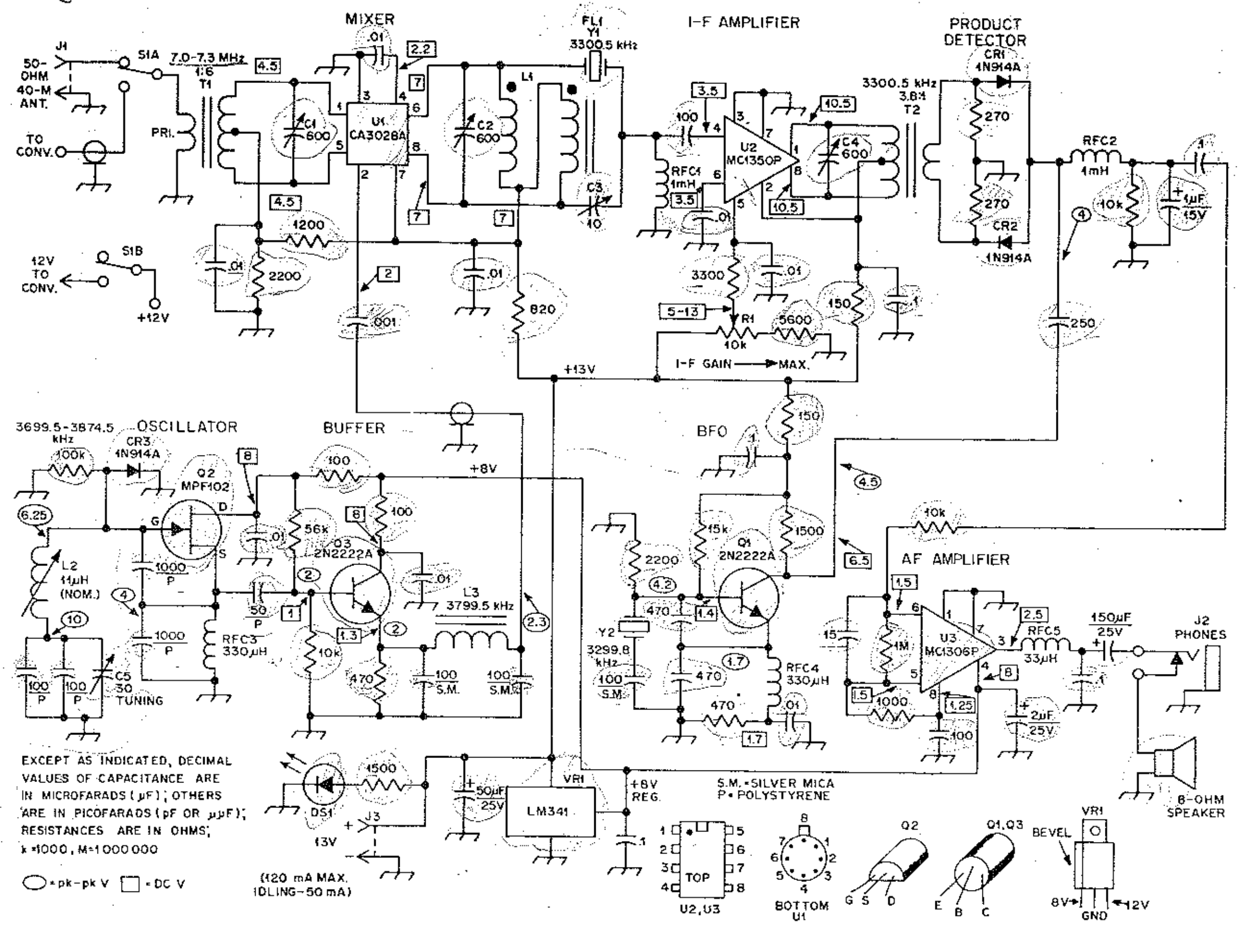


Fig 3

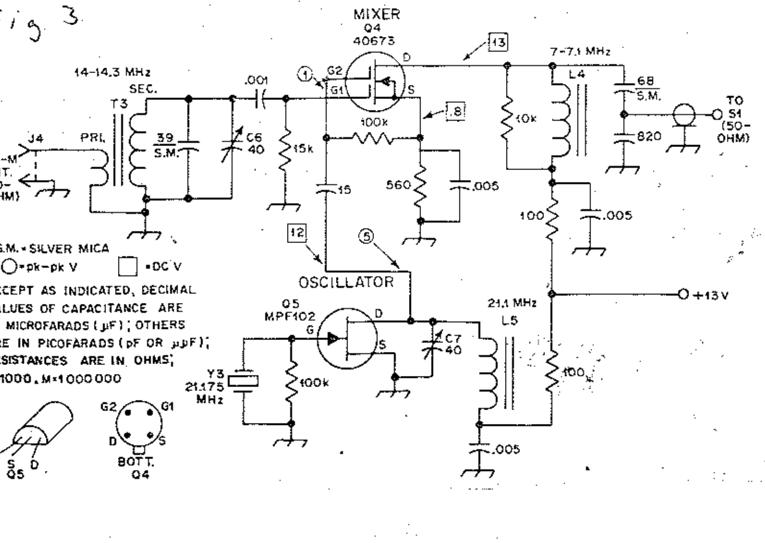


Fig. 3 — Schematic diagram of the 20-meter converter. Fixed-value capacitors are disk ceramic unless noted otherwise. Resistors are 1/4- or 1/2-W composition. Rough pc template and layout available for 25¢ and an s.a.s.e.

C6, C7 — 40-pF subminiature ceramic trimmer.

J4 — Single-hole-mount phono jack on rear panel of main receiver.

L4 — Toroidal inductor, 12 turns No. 26 enam. wire on Amidon FT-37-61 core. L = 8 μH.

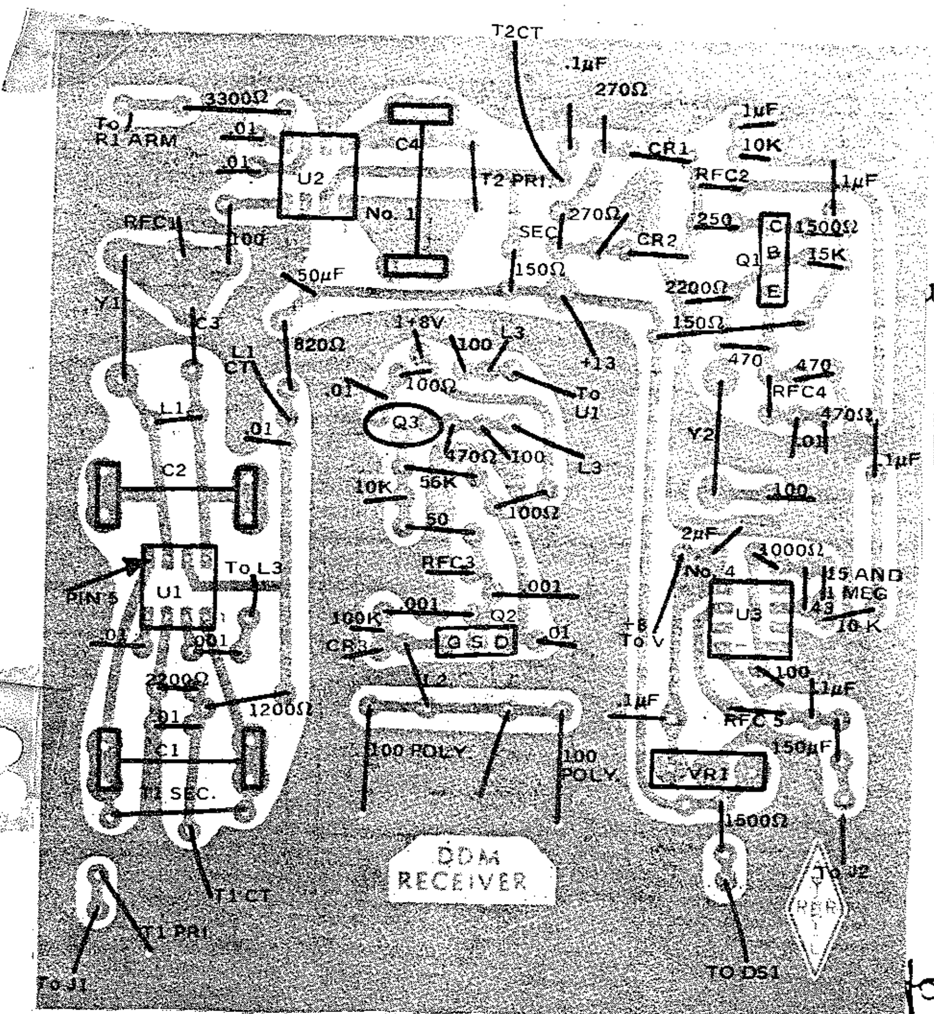
L5 — Toroidal inductor, 24 turns No. 26 enam. wire on Amidon T-50-6 core. L = 2.4 μH.

Q4 — RCA transistor.

Q5 — Motorola transistor, MPF102, 2N4416, or HEP 802.

T3 — Toroidal transformer, 10:1 turns ratio. L ≈ 1.85 μH. Pri. has 2 turns No. 26 enam. wire. Sec. contains 21 turns No. 26 enam. wire on Amidon T-50-6 core.

Y3 — 21.175-MHz fundamental crystal in HC-18/U case (International Crystal Co. type GP with 32-pF load capacitance).



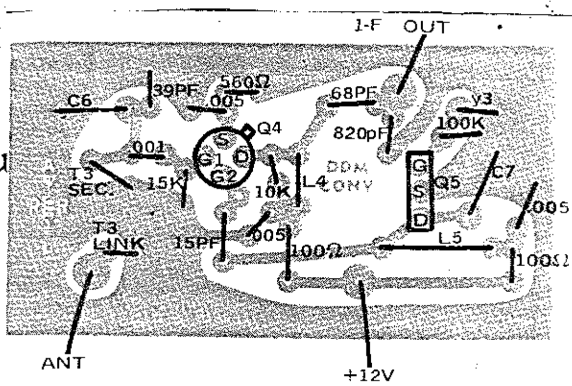


Fig. 2 – Foil-side scale pattern of the pc board. Circuit board is double-sided glass-epoxy material. Ground-plane copper should be removed directly opposite Q2 and related components (oscillator) for an area of 1-1/2 X 1-1/2 inches. Remove coppe in similar manner on ground-plane side of board opposite L1, C3 and Y1 (1 X 1-1/4 inch area). Removal of foil will prevent unwanted capacitive effects in those critical parts of the circuit. Ground-plane side of board should be electrically common to the ground foils on opposite side of board at several points.

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pability of the circuit), adjust C2 and C3 experimentally. C2 will provide the major effect. C3 should be set for minimum response on the unwanted side of zero beat. A fairly strong signal will be needed to hear the unwanted response.

For reception of lower sideband, it will be necessary to use a different BFO frequency – 3400.5 kHz. The crystal indicated in Fig. 1 was used because it was the only one available at the time of construction. Those wishing to shift the BFO frequency a few hundred Hz can place a trimmer in series with Y2 rather than use the 100-pF capacitor shown.

Because there is no agc in this receiver, the i-f gain should be set low, for comfortable listening. Too much gain will cause the audio circuit to be overdriven, and distortion will result. To prevent ear-splitting signal levels, one can install a pair of 1N34A diodes (back to back) across the output jack, J2.

Bits and Pieces

The photograph shows some fancy looking components on the circuit board. Tantalum capacitors are seen where electrolytics are indicated on the diagram. Either type will work nicely. Tantalums were found at a flea market for 10 cents each, so they were used. Similarly, the 0.1-μF capacitors used are the high-class kind (Aerovox CK05BX), which sell for roughly 70 cents each. Mylar or disk ceramic 0.1-μF units will be fine as substitutes.

The polystyrene capacitors were obtained from Radio Shack in an assortment pack. New units are made by Centralab, and they sell for less than 20 cents each in single lots. Since they are more stable than silver micas, they are recommended for the VFO circuit.

All of the toroid cores were purchased by mail from Amidon Associates. A J. W. Miller 42-series coil is used in the VFO, but any slug-tuned ceramic form can be used if it has good high-frequency core material. The unloaded *Q* of the inductor should be at least 150 at 3.5 MHz. L2 in this design has 3/8-inch diameter body. The winding area is 5/8 inch long.

The metal cases of both crystals should be connected to ground by means of short lengths of wire. This will prevent unwanted radiation from the BFO crystal, and will help keep the filter crystal from picking up stray energy. A metal cover should be placed on the VFO compartment for reasons of isolation.

James Millen encapsulated rf chokes are used in the receiver. Any subminiature choke of the approximate inductance indicated will be suitable and it need not be encapsulated. The VFO tuning capacitor is also a Millen part. Ample room exists between the VFO box and the front panel to allow making the box longer. That will permit use of a larger variable capacitor. A double-bearing capacitor is recommended for best mechanical stability of the VFO.

The i-f system and BFO can be tailored to frequencies other than those indicated. The VFO, mixer, and i-f amplifier tuned circuits will have to be altered accordingly, if crystals of other frequencies in the 2- to 3-MHz range are chosen.

Performance of this receiver is quite good. A 0.1-μV signal from a generator is plainly audible. No hum or distortion is heard in the output of the receiver at normal listening levels. VFO drift is 45 Hz from a cold start to stabilization, and strong signals do not pull the oscillator.

Extremely strong local signals (1000 μV or greater) will cause desensitization of the receiver when they appear off frequency from where the operator is listening. Under ordinary conditions this will not be a problem. At some sacrifice in noise figure and sensitivity, those living in areas where other amateurs are nearby can modify T1 to aid the situation. C1 should remain across all of the T1 secondary, and a 2200-ohm resistor should be connected across C1. Pins 1 and 5 of U1 should be connected to two turns each side of the center tap of the secondary. This will require cutting the pc board elements to divorce pins 1 and 5 from C1. This design trade-off is quite acceptable at 40 meters, as the atmospheric noise level will mask the reduction in receiver noise performance. With the circuit change there was no desensing evident below approximately 8000 μV.

Agc could be used in this receiver by applying the audio-derived "hang" type used by Goodman in his *Handbook* design. If the feature was adopted, agc voltage would be applied to pin 5 of U2 and the manual gain control would be eliminated. In such a case, it would be necessary to add an af gain control between the product detector and U3. It should be remembered that minimum gain results when 13 volts are applied to pin 5 of U2. The lower the voltage at that point, the greater the gain.

This Mini Miser's Dream may be just what you've been wanting for that next camping trip. Since it measures only 2-5/8 X 4-3/4 X 5 inches, it should fit easily into a rucksack, along with a battery pack (maximum current is 120 mA). Or maybe you're trying to get that code speed peaked for a higher license class. If so, this little fella might be the right size for the night stand by the bed – assuming the XYL doesn't object!

he center frequency was found to be ap-
roximately 400 Hz.

This filter will provide a worthwhile im-
rovement in cw selectivity. For better per-
ormance, two filters can be cascaded.

With the indicated values, the voltage gain is
, the Q is 20 and the passband center frequen-
y is 400 Hz. Power for the unit is provided by
wo 9-V transistor-radio batteries. — *Howard
Veinberg, WA6JCH, Montebello, California*

SK WITH VOX CIRCUITS

For several years I had operated a cw sta-
on with full break-in capabilities. When I
noved up to a "state-of-the-art" transceiver I
ever felt comfortable using the VOX circuit
or cw. The VOX delay had to be set long
nough to keep the transmitter from dropping
ut between words, but this caused me to miss
he beginning of the next transmission.

I decided to short the R-C network capacitor
the V ircuit at the end of my transmis-
ion. Th apacitor can be found by tracing
he wiring from the VOX delay control. The
ontrol is wired across the R-C capacitor. I us-
d a "spare" jack on the rear panel of my
ransceiver, connecting the R-C capacitor
cross the jack. I connected 0.01-μF disc
apacitors across the lines to bypass stray rf to
round. Then I cemented a Micro Switch to my
eyer paddle, connecting it to the jack with a
iece of RG-58/U coaxial cable.

When I become impatient with the VOX
elay, I simply depress the Micro Switch, put-
ing my transceiver into the receive mode im-
nediately. — *John Werner III, WB8IPG,
Warren, Michigan*

TRANSMITTER-KEYING INTERFACE

Radio amateurs have an interesting and en-
oyable variety of ways to generate Morse
ode. Keyboards and computers share air time
with straight keys and bugs. But interfacing the
newest ment with a transmitter may not
be an ask. Many of these new code
generators are not specifically designed for
ransmitter keying.

The circuit shown in Fig. 7 can be used be-
ween any code generator that produces an
udio signal and virtually all transmitters. New
arts will cost about $10. This unit was
riginally built for the N4DR 10-MHz beacon,
nd it interfaces a tape-recorded cw message
with the beacon transmitter.

U1A is a conditioning amplifier, which sets
he level of the incoming signal. C1, C2, R4
nd R5 allow the interface to operate from a
ingle-polarity power supply. D1, D2, C3 and
R6 form a rectifier circuit that changes the ac
oltage into a dc voltage that varies with the
nvelope of the incoming ac voltage. U1B is
wired as a Schmitt trigger. Voltage from the
ectifier will cause the trigger output to go from
ow to high, lighting the LED and closing the
eed relay.

Construction is straightforward. Use the
naximum level setting that will allow the LED
o flicker with the cw signal. It should be
lecreas nly if the background noise level
alsely rs the interface.

An additional use of the interface is to key a
ransmitter that does not have a sidetone.
Simply use a code-practice oscillator to drive
he interface circuit. — *Tom Cook, N3AXN,
Pittsburgh, Pennsylvania*

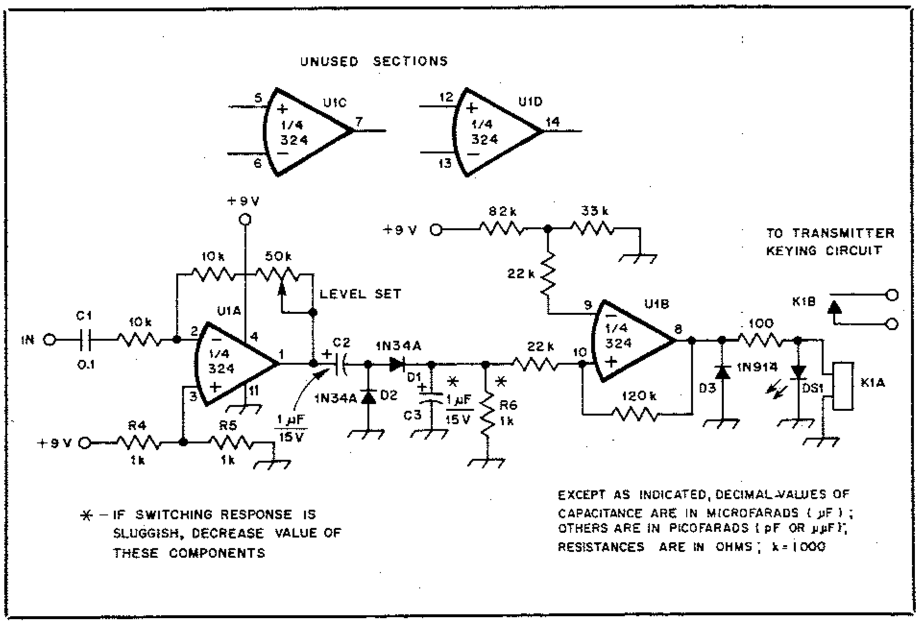
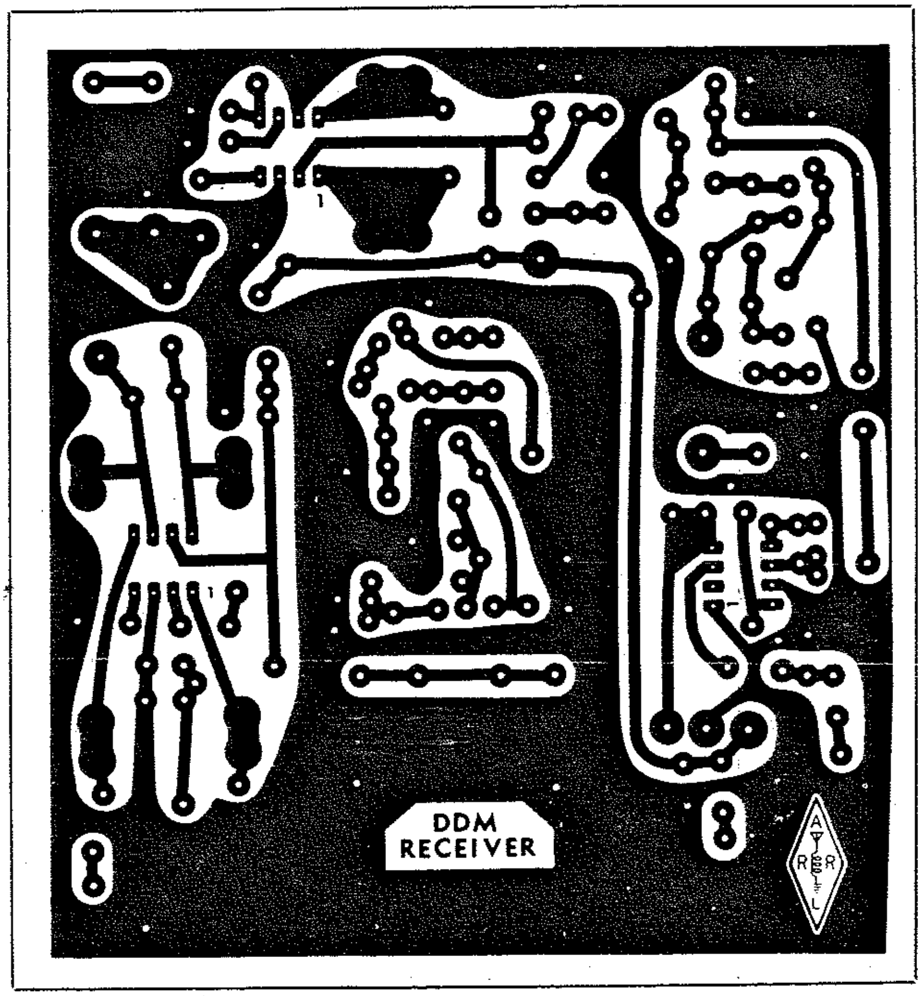


Fig. 7 — The schematic diagram of a simple transmitter-keying interface.
K1 — Reed relay (RS 275-229). U1 — 324 quad op-amp.



Etching pattern for the 10-MHz Mini-Miser's Dream. The black areas represent unetched copper viewed from the foil side of the board. Parts-placement guide appears on page 34.