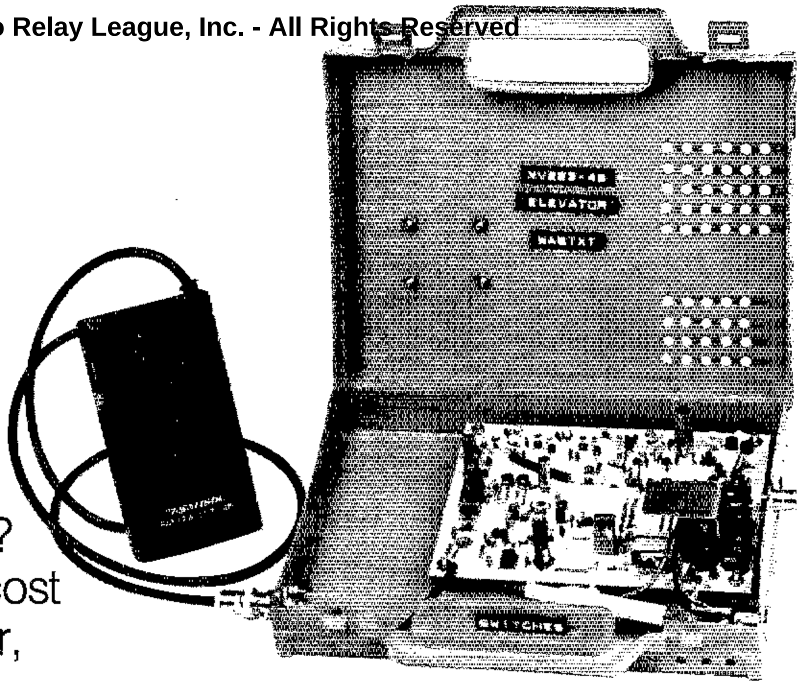
The Elevator: A Simple 220-MHz FM Transverter



Going up. . .to 220-MHz FM? Try the Elevator! Add a low-cost 49-MHz hand-held transceiver, antenna, and you're there!

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I've always been thrilled by the opportunity to try out a new band or mode of operation! Some time ago, I became interested in getting on 220-MHz FM. Novices have voice privileges on that band—and I'm a Novice at heart. The cost of commercially made gear for 220 MHz initially dampened my enthusiasm, but not for long. An avid experimenter, I considered the home-brew alternative.

I wanted a 223-MHz FM transceiver that would allow me to make solid local contacts. The radio had to be reliable, easy to reproduce and tune up. It also had to comply with current FCC specifications for spectral purity and cost less than $100. The Elevator, an intermediate-level construction project, meets these design goals. Several Elevators have been in operation locally for over a year providing dependable communications.

Overview

Hand-held transceivers—such as the 49-MHz TRC-501 available from Radio Shack® —have become very popular for short-range, unlicensed communication. These inexpensive, crystal-controlled FM radios are stable; they also have a superhet receiver and use a modulation level that is compatible with existing amateur VHF FM standards. But how do you get the '501 to work on 223 MHz? Easy—you build a transverter!

A transverter is a combined transmit and receive converter. Transverters allow you to use a transceiver (or separate transmitter/receiver combination) on a band other than that—with some additional circuitry (in this case, the Elevator)—the 49-MHz TRC-501 can be used on 223 MHz. Connected to the Elevator, the '501 acts like a 223-MHz transceiver with a speaker/mike.

One version of the Elevator—connected to the '501—is shown in the title photo. An oblique view of another Elevator is shown in Fig 1 and an inside view in Fig 2. Inexpensive plastic pencil boxes are used as enclosures for both units. Ventilation holes are drilled in the top and bottom covers on the right-hand side. A small **U**-shaped metal bracket is attached to the back of the top cover at the left (Fig 1). The TRC-501 can be clipped to this bracket when carrying the unit.

The Elevator in Fig 1 is designed for dual-channel operation and has a small slide switch mounted on the bottom lip of the

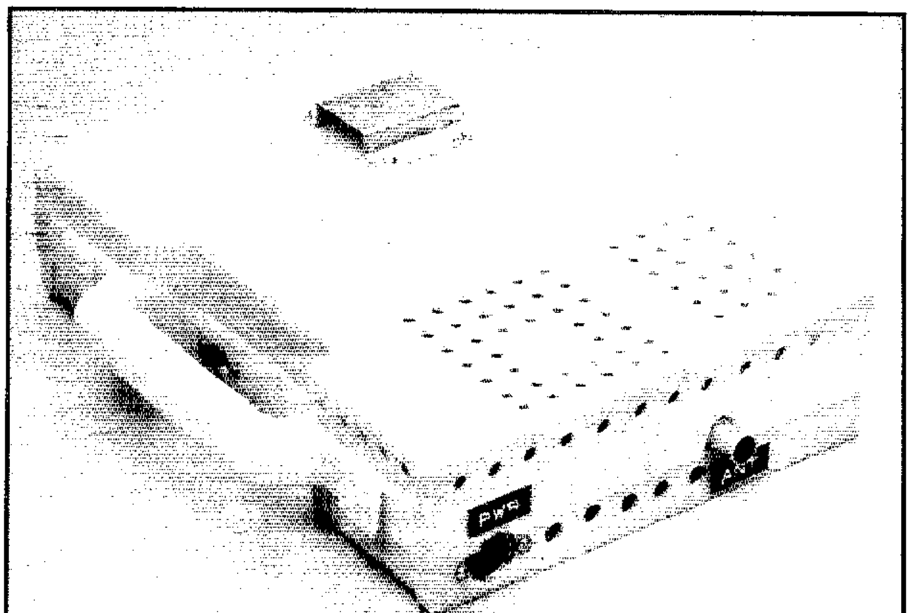


Fig 1—An oblique view of a two-channel version of the Elevator. At the top rear of the case is a **U**-shaped clip to which the TRC-501 transceiver can be attached. Beneath the handle at the left is a frequency-selection switch for two-channel operation. Ventilation holes are drilled in the top and side of the case. The DIN **PWR** and BNC **ANT** jack are mounted on the bottom lip of the box; a notch in the upper lip allows it to fit around the **ANT** jack.

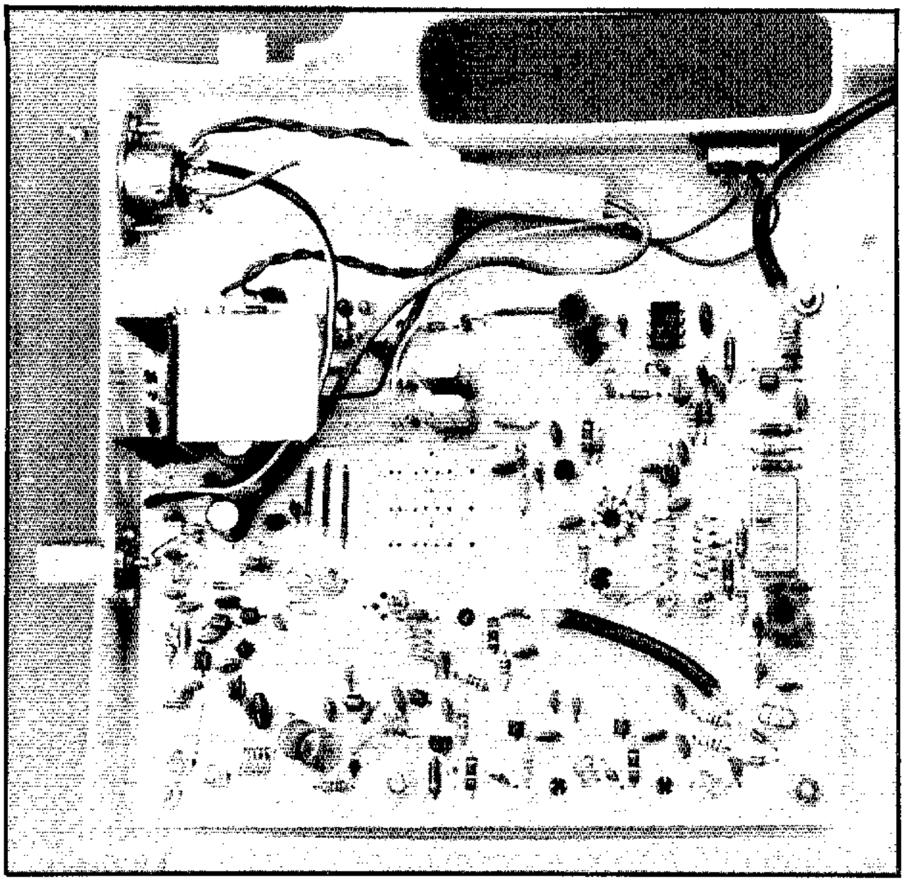


Fig 2—An inside view of an Elevator built for two-channel use (note the two crystals at the top middle of the board). The crystal-selection switch is mounted in the handle section of the plastic case. (This unit contains an experimental GaAsFET receiver preamplifier on the foil side of the board. Therefore, some components are not visible in the area of Q8. Refer to the parts overlay [Fig 7] for component placement.) At the upper left, the DIN **PWR** connector can be seen; an in-line fuse holder (for F1) is immediately to the right of the connector. The cable at the top right of the board (near the crystal-selection switch) leads to the **XCVR** jack (J1) on the other side of the case. Voltage regulator U3 and its finned heat sink are below the DIN connector. An aluminum extension is attached to U3's heat sink; beneath this extension are C17 and C18. Cylindrical heat sinks made from aluminum tubing fit tightly over Q2 (above the coaxial-cable jumper) and Q7 (left, foreground). L9 is the vertically mounted coil near Q7. The **ANT** connector (J2) is at the left just below U3.

Opportunities for Experimentation

There are several opportunities to advance the work presented here. All are subject to the possibility of elation (or disappointment) that comes from trying something new.

During development, three TRC-501 transceivers were used; all provided similar results. Similar units on the market may also work with the Elevator, but none have been tried.

This transverter was initially developed on the 2-meter band. The proximity of the transceiver's second harmonic to the 2-meter transverter's 96-MHz LO produced close-in spurs of significant amplitude. Therefore, a high-Q band-pass filter in the feed line is required for satisfactory performance. Other bands show good promise—in particular, the 1270-MHz Novice allocation. With recent strides in "no-tune" MMIC technology, it seems likely that a low-power (100 mW) microwave version of the Elevator could be produced for less than $100.

Inspection of the TRC-501 schematic indicates ample opportunity for packet-modem interfacing. Is there a need for a low-cost, limited-channel packet transceiver? Would a cheap, stand-alone microwave system help expand our beachhead on 1270 MHz? Think about it.—*Mike Agsten, WA8TXT*

plastic housing beneath the carrying handle. Because the unit in the title photo is designed for single-channel use, no switch is used, but a convenient location for this optional switch is identified by the label **SWITCHES**.

With the exception of the power transformer, power connectors and optional channel-selection switch, the Elevator is contained on a single PC board. For operation from the home station, power for the Elevator can be supplied from a 9-V ac wall transformer. For portable, mobile or home-station operation, a 12- to 14-V dc supply can also be used. The transverter delivers between 1 and 1.5 W of RF output, has adequate receive sensitivity, built-in RF-sensed TR switching and room for five crystals.[1]

Circuit Description

To give you an idea of how the transverter works, a brief circuit description is in order. Refer to the schematics in Figs 3 and 4.

Power Supply

Power for the Elevator is supplied through the DIN connector, J3. Fig 4 shows how to power the Elevator from an ac or dc power source. F1 and F2 are in-line fuse holders; F1 is installed within the Elevator's case.

For operation from the ac mains, the 9-V ac input from the wall transformer is fed to a voltage doubler/rectifier (D6 and D7). The dc output is filtered by C17 and C18 and fed to regulator U3. D8-D10 are used to raise the regulated output of U3 to approximately 13.6 V. A jumper is connected between points **A** and **D** when an ac wall transformer is used.

For operation from a dc supply, the positive output of the power supply is connected to point **D** and the jumper between **A** and **D** is not used. D20 provides reverse polarity and transient-voltage protection. Dc operating voltage is applied continuously to TR switch detector U2, local oscillator (LO) Q1 and Q2, the power-amplifier (Q6 and Q7) collector circuits and the IF transceiver (the TRC-501) at J1.

Local Oscillator

The LO operates in the 86-MHz region. For 223.5-MHz operation with a 49.830-MHz IF (standard channel A on the TRC-501), an 86.835-MHz crystal is used at Y1. The crystal frequency required is determined by subtracting the channel frequency of the TRC-501 from the desired operating frequency and dividing the result by 2:

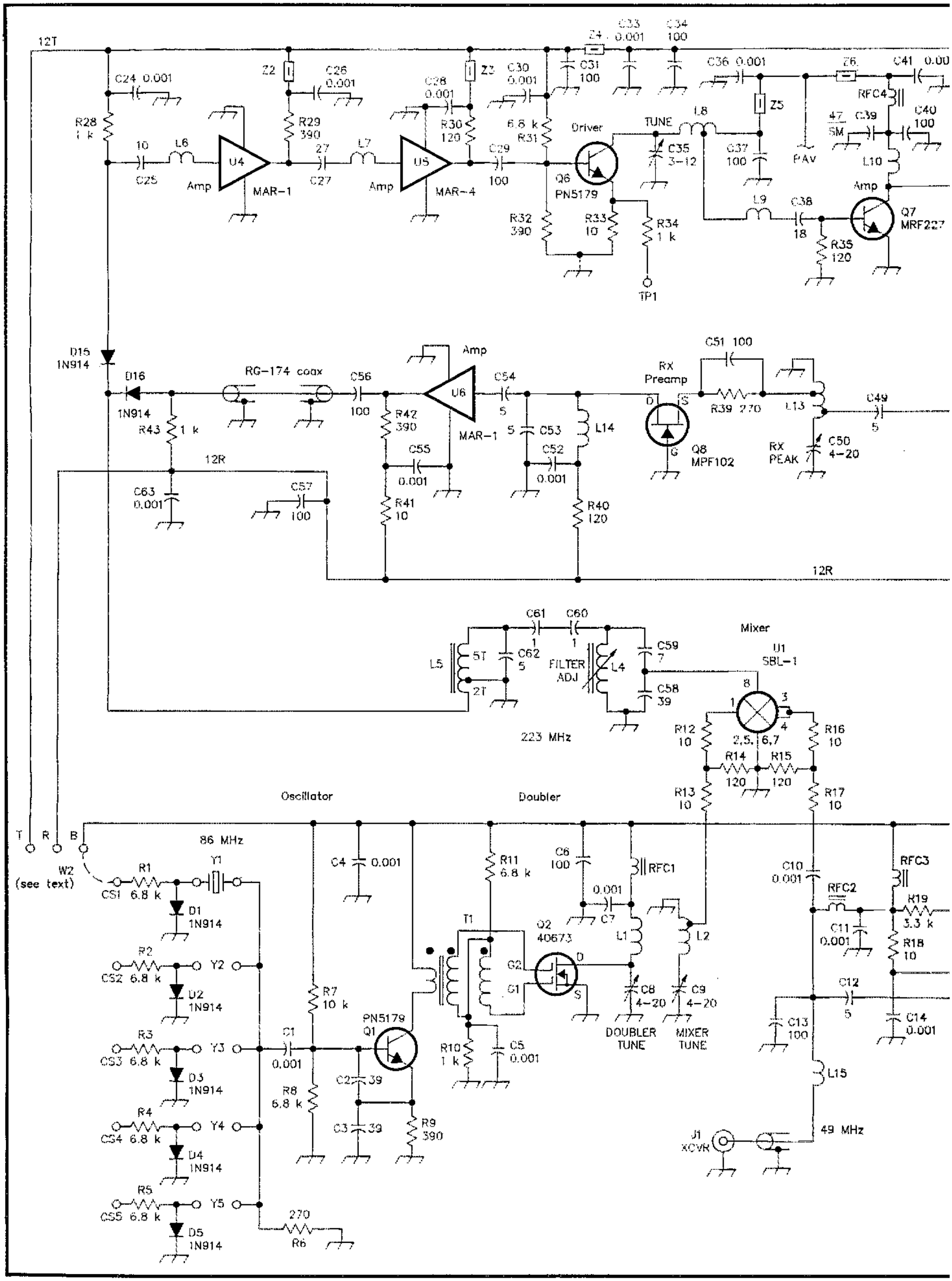
$$F_x = (F_{op} - F_{ht}) \div 2 \qquad \text{(Eq 1)}$$

Push-push doubler Q2 multiplies the oscillator output to 173.670 MHz, providing very clean LO energy to mixer U1.

Crystal Switching

Dc voltage is also available at terminal **B** for selecting diode-switched crystals with an on-board jumper (W2) or an off-board switch for simplex operation. For half-duplex operation, terminals **T** and **R** are used. Jumper **R** to the crystal-select point (CS1-CS5) corresponding to the crystal to be used for the receive frequency. Likewise, point **T** goes to the desired crystal-select point for transmit. Any switching scheme can be used, provided that only one crystal-select input is high (+12 V) at a given time.

[1]Notes appear on page 38.


12T
C24 0.001
R28
1 k
10
C25
L6
U4
Amp
MAR-1
Z2
R29
390
C26
0.001
27
C27
L7
U5
Amp
MAR-4
C28
0.001
R30
120
Z3
C30
0.001
6.8 k
R31
C29
100
Driver
Q6
PN5179
R32
390
R33
10
R34
1 k
TP1
Z4
C33
0.001
C34
100
C31
100
C36 0.001
TUNE
L8
C35
3-12
Z5
C37
100
L9
C38
18
PAV
Z6
C41 0.00
RFC4
C40
100
47
SM
C39
L10
Amp
Q7
MRF227
R35
120
D15
1N914
D16
1N914
R43
1 k
12R
C63
0.001
RG-174 coax
C56
100
C57
100
R42
390
C55
0.001
R41
10
Amp
U6
MAR-1
C54
5
5
C53
C52
0.001
L14
R40
120
RX
Preamp
D
S
G
Q8
MPF102
C51 100
R39 270
L13
C49
5
RX
PEAK
C50
4-20
12R
C61
1
C60
1
L5
5T
2T
C62
5
FILTER
ADJ
L4
C59
7
C58
39
223 MHz
Mixer
U1
SBL-1
8
1
3
4
2,5,
6,7
R12
10
R16
10
R14
120
R15
120
R13
10
R17
10
Oscillator
Doubler
T
R
B
W2
(see text)
86 MHz
Y1
R1
CS1 6.8 k
D1
1N914
R2
CS2 6.8 k
Y2
D2
1N914
R3
CS3 6.8 k
Y3
D3
1N914
R4
CS4 6.8 k
Y4
D4
1N914
R5
CS5 6.8 k
Y5
D5
1N914
270
R6
C4 0.001
R7
10 k
C1
0.001
PN5179
Q1
R8
6.8 k
C2 39
C3 39
R9
390
R11
6.8 k
T1
Q2
40673
G2
G1
D
S
R10
1 k
C5
0.001
C6
100
0.001
C7
RFC1
L1
C8
4-20
DOUBLER
TUNE
L2
C9
4-20
MIXER
TUNE
C10
0.001
RFC2
C11
0.001
RFC3
R19
3.3 k
R18
10
C12
5
C13
100
C14
0.001
L15
J1
XCVR
49 MHz

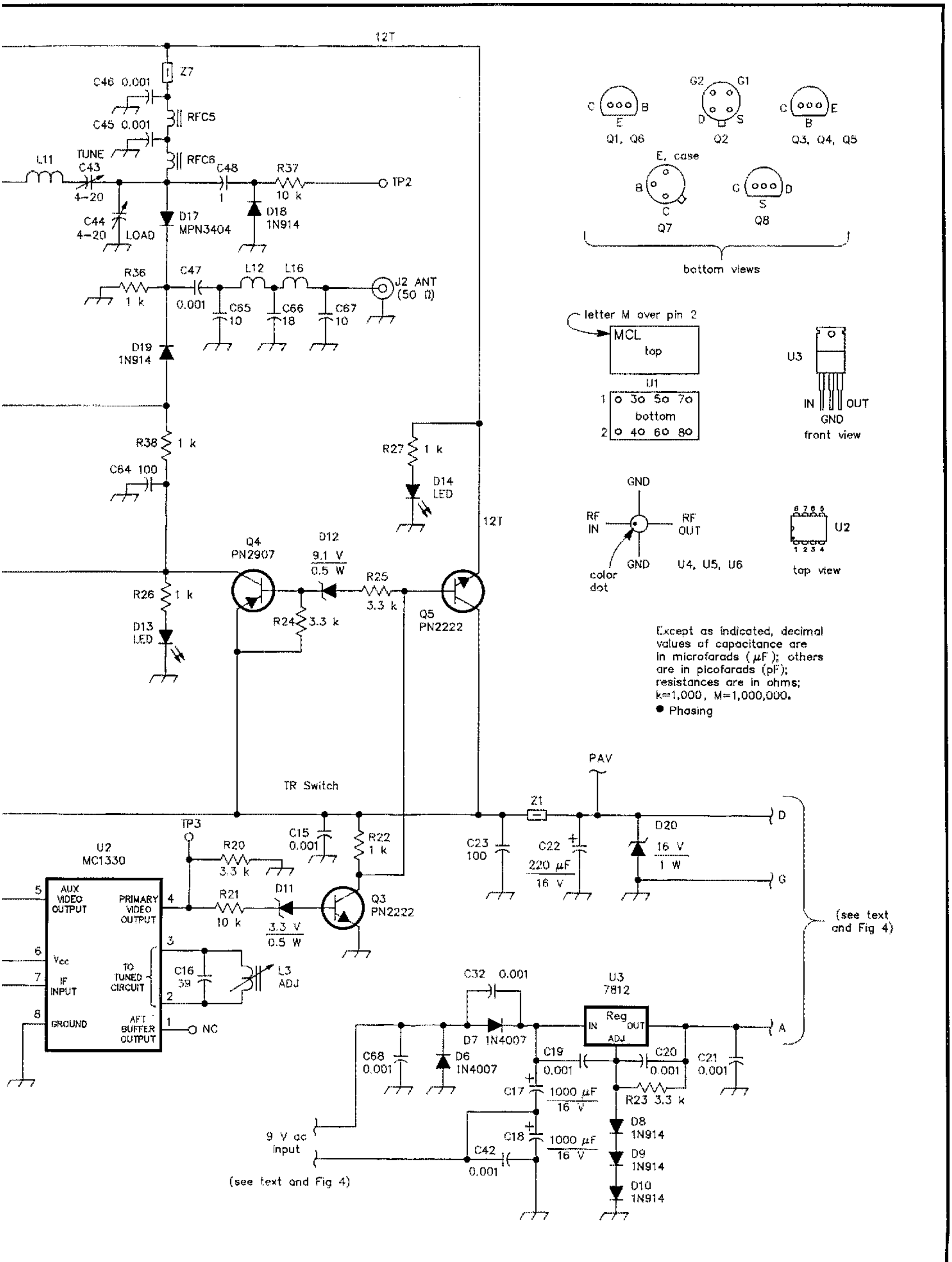

12T
Z7
C46 0.001
RFC5
C45 0.001
RFC6
L11
TUNE
C43
4-20
C48
1
R37
10 k
TP2
C44
4-20
LOAD
D17
MPN3404
D18
1N914
R36
1 k
C47
0.001
L12
L16
C65
10
C66
18
C67
10
J2 ANT
(50 Ω)
D19
1N914
R38
1 k
C64 100
R27
1 k
D14
LED
12T
Q4
PN2907
D12
9.1 V
0.5 W
R25
3.3 k
R26
1 k
R24
3.3 k
Q5
PN2222
D13
LED
TR Switch
TP3
C15
0.001
R22
1 k
U2
MC1330
R20
3.3 k
R21
10 k
D11
3.3 V
0.5 W
Q3
PN2222
AUX VIDEO OUTPUT
PRIMARY VIDEO OUTPUT
Vcc
IF INPUT
GROUND
TO TUNED CIRCUIT
AFT BUFFER OUTPUT
NC
C16
39
L3
ADJ
PAV
Z1
C23
100
C22
220 µF
16 V
D20
16 V
1 W
D
G
A
(see text and Fig 4)
C32 0.001
U3
7812
Reg
IN
OUT
ADJ
D7 1N4007
D6
1N4007
C68
0.001
C19
0.001
C20
0.001
C21
0.001
C17
1000 µF
16 V
R23 3.3 k
C18
1000 µF
16 V
D8
1N914
D9
1N914
D10
1N914
C42
0.001
9 V ac
input
(see text and Fig 4)
C B E
Q1, Q6
G2 G1
D S
Q2
C E B
Q3, Q4, Q5
E, case
B C
Q7
G D S
Q8
bottom views
letter M over pin 2
MCL
top
U1
bottom
U3
IN
OUT
GND
front view
GND
RF IN
RF OUT
color dot
U4, U5, U6
U2
top view
Except as indicated, decimal values of capacitance are in microfarads (µF); others are in picofarads (pF); resistances are in ohms; k=1,000, M=1,000,000.
● Phasing

Fig 3—Schematic of the Elevator. The **T**, **R** and **B** terminals are connected to the crystal select (**CS**) terminals as described in the text. Here, W2 is shown connected between terminal **B** and **CS1** for simplex operation. A finned heat sink is attached to U3. Q2 and Q7 have cylindrical heat sinks made of aluminum tubing. Parts suppliers are listed in Table 1.

C8, C9, C43, C44, C50—4-20 pF trimmer (Mouser 24AA022).
C35—3-12 pF trimmer (Mouser 24AA021).
D11—1N5226B, 3.3-V, 0.5-W Zener diode.
D12—1N5239B, 9.1-V, 0.5-W Zener diode.
D17—MPN3404 PIN diode (Circuit Specialists).
D20—1N4745, 16-V, 1-W Zener diode.
L1—5 turns, 5/32-in ID, ½ in long. (Note: All air-wound coils use no. 22 bare wire; the shank of a drill bit can be used as a winding jig.)
L2—5 turns, 5/32-in ID, ½ in long, tapped 2 turns from ground end.
L3—0.22-0.28 µH adjustable (Jameco CL-1).
L4—0.06-0.07 µH adjustable (Jameco CL-2).
L5—7 turns no. 24 enameled wire on a T-30-12 core; tapped two turns from D15/D16 end.
L6, L7—3½ turns, 1/8 in ID, ¼ in long.
L8—3½ turns, 5/32 in ID, 3/16 in long; tap ¼ turn from C37 end.
L9—2 turns, 5/32 in ID, 3/16 in long, mounted vertically.
L10—2½ turns, 3/16 ID, 3/32 in long.
L11—4½ turns, 3/16 in ID, 3/16 in long.
L12, L13, L16—2½ turns, 5/32 in ID, 5/32 in long. L13 is tapped 1 turn from ground end.
L14—3½ turns, 5/32 in ID, ¼ in long.
L15—4½ turns, 5/32 in ID, 3/16 in long.
Q1, Q6—PN5179 (Mouser ME333-PN5179). Note: A 2N5179 has a different pin-out than that of a PN5179.
Q7—MRF227 (RF Parts).
RFC1-RFC6—4 turns no. 28 enameled wire on an FB43-101 ferrite bead.
T1—Secondary: 8 bifilar turns no. 28 enameled wire on a T-30-12 core; primary, 3 turns no. 28 enameled wire wound over the middle of the secondary.
U1—Mini-Circuits SBL-1 mixer.
U2—MC1330 low-level video detector.
U4, U6—Mini-Circuits MAR-1 amplifier.
U5—Mini-Circuits MAR-4 amplifier.
Y1-Y5—86-MHz, 5th-overtone, series resonance, HC-25/U holder. Crystek Crystals RHF-4 or equiv. The required crystal frequency is determined by subtracting the channel frequency used in the TRC-501 from the desired operating frequency and dividing the result by 2. ($F_x = [F_{op} - F_{ht}] \div 2$.) See text.
Z1-Z7—FB43-101 ferrite bead.

A three-pole, four-position switch will handle all the crystal-switching possibilities (except for five simplex channels—an unlikely need).

Receive Circuits

During receive, the voltage present at U2, pin 4, is about 5. This positive voltage turns Q3 and Q4 on, and turns Q5 off. Q4 applies 12 V to the receive bus (12R). Incoming signals pass through D19 to Q8, a grounded-gate JFET preamplifier. Broadband amplifier U6 provides additional gain. Received-signal flow proceeds through D16 and the 223-MHz bandpass filter L4/L5, arriving at mixer U1 where the desired signal is converted to the 49-MHz region for delivery to the IF transceiver attached to J1.

Table 1
Parts Suppliers

Circuit Specialists, Inc, Box 3047, Scottsdale, AZ 85271, tel 800-528-1417.

Crystek Crystals, 2351/2371 Crystal Dr, Ft Myers, FL 33907 and PO Box 06135, Ft Myers, FL 33906-6135, tel 1-800-237-3061.

Jameco Electronics, 1355 Shoreway Rd, Belmont, CA 94002, tel 415-592-8097.

Mini-Circuits, PO Box 166, Brooklyn, NY 11235, tel 212-934-4500.

Mouser Electronics, 11433 Woodside Ave, Santee, CA 92071; tel 619-449-2222.

RF Parts, 1320 Grand Ave, San Marcos, CA 92069; parts orders only, tel 800-854-1927 or 619-744-0728 for information and technical help.

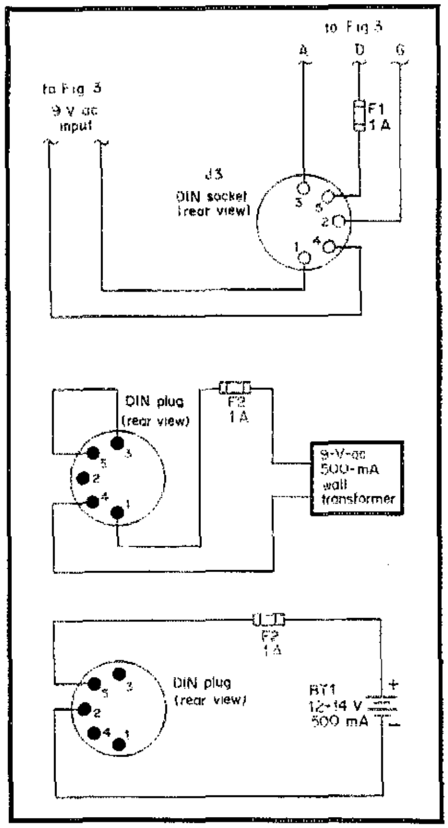


Fig 4—The Elevator can be powered from a 12- to 14-V, 500-mA source, or by an ac-operated supply delivering 9 V ac at 500 mA. All that's needed to accommodate these power sources is proper wiring of the DIN **PWR** jack (J3) as shown here. F2 is external to the Elevator; an in-line fuse works well here.

TR Detector

The RF output of the '501 transceiver is very low, so an ultra-sensitive detector (U2) is required for TR sensing. During transmit, RF applied through C12 forces pin 4 of U2 to 0 V. This turns off Q3 and Q4, disabling the receive section. Q5 turns on, applying power to the transmit bus (12T).

Transmit

When the transverter goes into transmit mode, the 49-MHz output signal from the transceiver is converted to 223 MHz in U1. Bandpass filter L4/L5 selects the desired mixer product. The 223-MHz signal is routed through D15 to broadband amplifiers U4 and U5. Interstage networks C25/L6 and C27/L7 narrow the 223-MHz response while maintaining the no-tune advantage. Additional signal amplification is provided by driver Q6 and final power amplifier Q7. PIN diode D17 passes the transmit signal to **ANT**enna connector J2 via a low-pass filter. The voltage developed across R36 by the current through D17 keeps D19 cut off, preventing transmitter RF entry into the receiver preamplifier, Q8.

Modification and Construction Information

Detailed Elevator construction and transceiver modification information is available from the author or from ARRL HQ.[2] I'll describe the more important points here.

Transceiver Modifications

To interconnect the transceiver and the Elevator, the transceiver's telescoping whip antenna is removed and replaced by a short (approximately four-foot) length of RG-58 coaxial cable. Place a grommet in the transceiver-case hole vacated by the antenna, and feed the cable through it.

Ordinarily, the TRC-501 transceiver is powered by its own internal 9-V battery. But as shown in Figs 3 and 5, J1 of the Elevator can carry both RF and dc to the transceiver. The supply used to power the Elevator can also power the transceiver through the interconnecting coax. The voltage fed to the transceiver is regulated at about 9 V by the circuit shown in Fig 5. This regulator can be built on a piece of perf board about the size of a 9-V battery. Make sure that you connect the wires to the battery clip correctly to ensure proper supply polarity for the transceiver.

The center conductor of the interconnecting coaxial cable ties to the transceiver antenna lead that originally connected to the base of the whip antenna. The 0.001-µF disk capacitor connected to the coaxial cable center conductor prevents dc voltage from being applied to the transceiver's antenna-input circuit. The coax shield is tied to the transceiver's PC board ground foil.

Elevator Construction

Unless you're an experienced VHF-circuit builder, I recommend using the PC-board layout shown in Fig 6; it's been "road tested." Parts-placement information is provided in Fig 7.

Coil winding is easier done than said. The length of each air-wound coil is set by its PC-board mounting holes; winding lengths are provided in the parts list. The turns count starts when the wire enters the

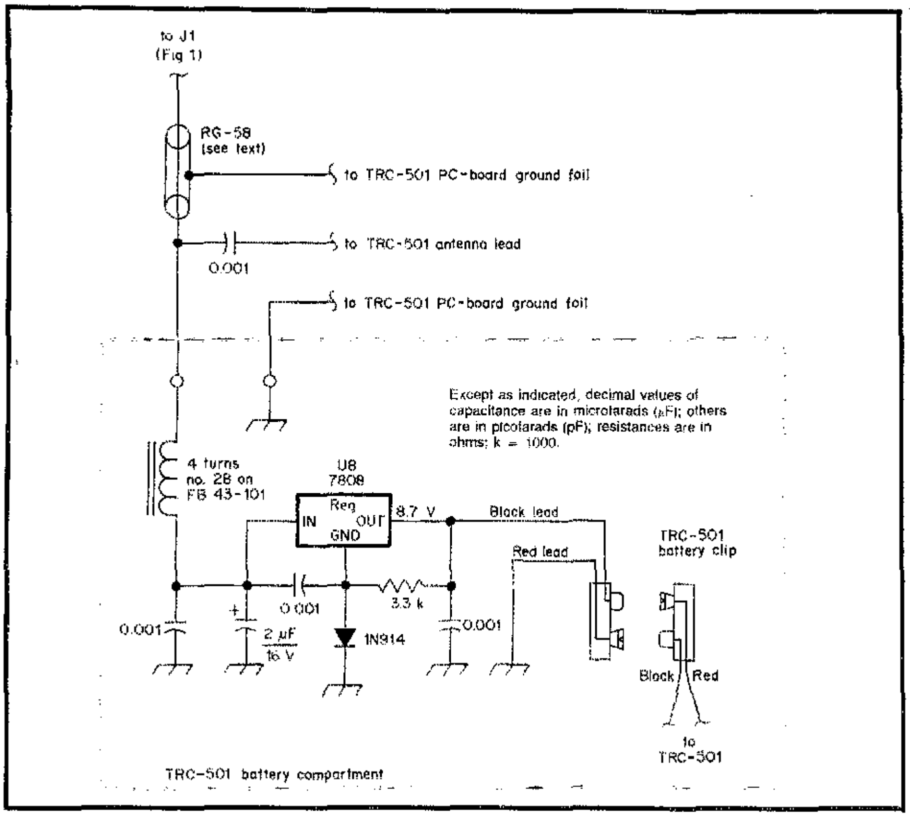


Fig 5—The supply used to power the Elevator can also power the transceiver by use of the simple regulator circuit shown here. This circuit can be built on a small piece of perf board and installed in the transceiver's battery compartment. The 0.001-µF capacitor connected to the coaxial-cable center conductor keeps dc voltage present at J1 from reaching the transceiver's antenna input circuit (see text).

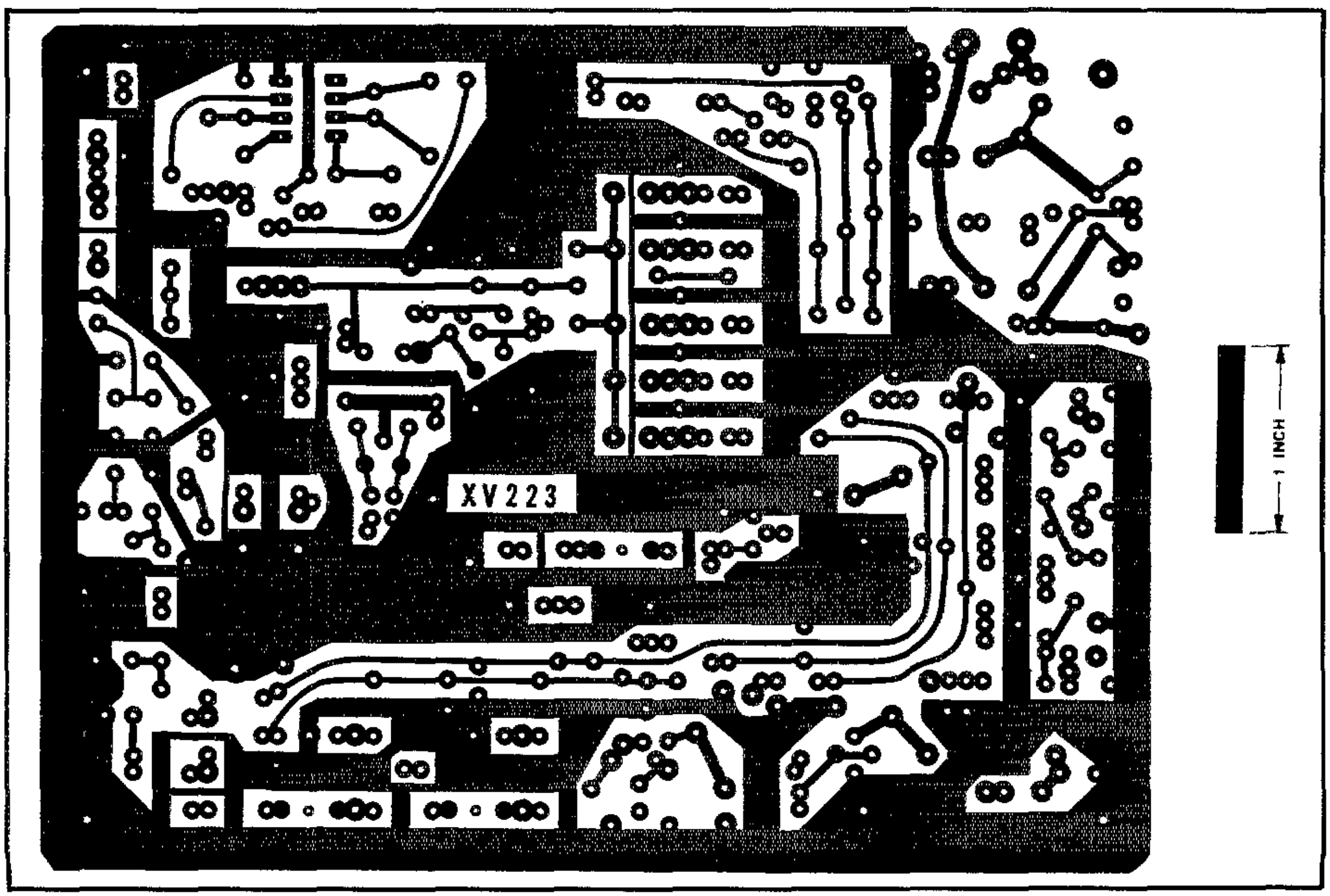
cylindrical domain of the coil and ends when it departs. For toroids and ferrite beads, one turn is counted each time the wire goes through the core hole. For L5, distribute the turns over 60 to 70% of the core. To form the bifilar secondary winding of T1, first twist together two pieces of no. 28 enameled wire (about 8 twists per inch). Wind this twisted pair to occupy 75% of the core with 8 turns of the twisted wire. Make the center tap by connecting the end of one wire to the beginning of the other, keeping the lead lengths short.

One lead of C49 connects directly to L13, as does one lead of network C51/R39. The top lead of L9 (mounted vertically) connects directly to L8 at only ¼ turn from the C37 end.

Be sure to correctly orient each transistor; make note of the position of the flat side or tab. Q7 (in a special emitter-to-case package) mounts flush with the PC board. Q2 and Q7 require heat sinks; I made mine from short lengths of aluminum tubing. Q2's heat sink is about ¾ inch long and Q7's heat sink is 1 inch long. U3 requires a finned heat sink and an additional 1-square inch radiator made from scrap aluminum sheet (see photos).

Monolithic amplifiers U4, U5 and U6 are installed on the *foil* side of the PC board;

Fig 6—Circuit-board etching pattern for the Elevator. The pattern is shown full-size from the foil side of the board. Black areas represent unetched copper foil.



the color dot on each device denotes its input lead. The leads of each of these devices must be trimmed somewhat. Before installing U4-U6, it's helpful to pre-tin four target solder areas for each device's leads.

A coaxial-cable jumper is required between D16 and C56. Use RG-174 or RG-58 for this purpose.

The **ANT** jack (J2) mounts directly on the PC board. Solder lugs on the flange of J2 permit easy soldering to the perimeter ground foil. The center pin of J2 connects to the PC board at the junction of L16 and C67. J1 (**XCVR**) is mounted on the case wall opposite J2 (see photos).

How you house the transverter PC board is up to you. I chose to use a nifty plastic pencil case available at a local drug store.[3] The case costs less than the shipping charge for a metal cabinet, and it works great.

Tune-Up

Connect the TRC-501 to J1 and attach a VHF wattmeter and dummy load to J2. (A dummy load can be fabricated by paralleling three 150-Ω, ½-W carbon resistors.) Relative RF output can be read by monitoring the dc voltage at TP2.

Preset the slug in L3 to a depth of about 7/16 inch from the top of the form; set L4's slug at 5/16 inch from the top of the coil form. Set all the variable capacitors at midrange. Attach a voltmeter set to read 5 V dc between TP3 (U2, pin 4) and ground.

Turn on the power supply; D13, the green LED, should light. Turn on the TRC-501 and press the PTT switch. The red LED (D14) should illuminate. Adjust L3 to obtain 0 V at TP3. Release the PTT switch.

Verify the transverter's crystal oscillator operation by probing with a frequency counter near T1, or by using an FM broadcast-band receiver to tune in the oscillator's signal below the FM broadcast band. If necessary, experiment with the turns spacing on T1 and/or the value of C3 to achieve oscillation.

Use a wavemeter near L2, a public-service-band radio equipped with an S meter, or a spectrum analyzer to monitor the doubler signal (near 173 MHz). Adjust C8 and C9 for a maximum signal indication at twice the crystal-oscillator frequency. With a voltmeter connected between TP1 and ground, key the transceiver and adjust L4, then C8 and C9 for a maximum indication; typically 0.15 V dc.

With the exception of the adjustment of L3, the foregoing preliminary tune-up steps can be made using a received signal. Adjust C8, C9, L4 and C50 for maximum quieting of the received signal. If this is done, be sure to reconnect the dummy load to the Elevator for the next step: power-amplifier tune-up.

Connect a voltmeter between TP2 and ground, key the transceiver and adjust C35, C43 and C44 for a maximum voltage indication at TP2 (typically, 3 to 4 V dc). The adjustments of C43 and C44 interact, so you should make the adjustments a few times to ensure you've achieved a maximum indication. Allow some time between tune-up periods to allow Q7 and the dummy load to cool off. Experiment by compressing and expanding the turns of L9 to achieve maximum RF output. Lacking a receive signal to peak on, C50 can be adjusted during transmit for a very small dip in the output indicated at TP2. If you have access to a spectrum analyzer, you can check for spectral purity.[4]

Operation

Connect the antenna feed line in place of the dummy load used during testing. If you're using a wattmeter, leave it in the line. (Alternatively, you can monitor the dc-voltage amplitude at TP2 for a relative-output indication.) Turn on the power supply, press the transceiver PTT switch and touch up C43 and C44 for maximum output. If a weak-signal source is available, peak C50 for best reception. That done, you're on the air! I recommend close-talking the mike for full modulation. RV1 in the TRC-501 transceiver provides some control of the deviation.

Activity on 220-MHz FM is mainly on repeaters, and simplex activity varies greatly around the country. Here in north-central Ohio, 223.5 MHz (the national simplex channel) is very quiet. I've mainly been working Elevator-equipped locals, such as N8AHK and WB8TCZ, for reliability testing. Late one evening, dozing in the shack, I was startled as the speaker came to life: "N8EDV listening." After a short QSO with Dave, I checked the map. Wow! 82 miles...and I wasn't even wearing Elevator shoes!

Mike Agsten was first licensed in 1966 and got his Extra Class ticket in 1969. He served six years in the US Navy as a Radar/Electronic Navigation Aids Technician and eight years in the US Merchant Marine as a ship's Radio Officer. Mike is currently self-employed in the marine-electronics field. Two of Mike's four brothers are hams: Dave, KK4QY, and Jim, NZ8B. Jim was an operator at KX6DC of 160-m fame.

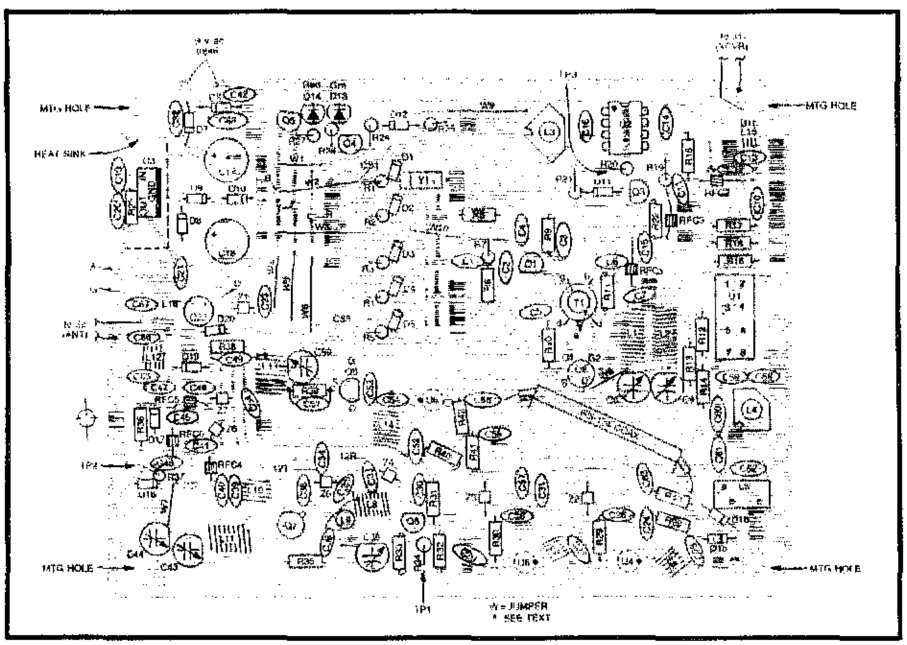


Fig 7—Parts-placement guide for the Elevator. Except for U4, U5 and U6, parts are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern. U4, U5 and U6 are soldered to the foil side of the board. The dots near U4, U5 and U6 identify the input lead of each device. Although only one crystal is shown installed on this board, five crystals can be accommodated (see text). (For the purpose of being consistent with existing author-supplied materials, a departure from *QST* style is made in the identification of D13 and D14; normally, LEDs are identified with DS designators. Also, ferrite beads—here identified as Z1-Z7—usually have FB designators.)

Notes

[1]The Elevator is available in kit form from LECTROKIT, 401 W Bogart Rd, Sandusky, OH 44870 (a telephone number is not available). PC board only and detailed manual, $15; XV223-49 Elevator transverter kit, $89. All prices are postpaid in the US; Ohio residents add 6%. The kit includes a drilled PC board, parts, case, connectors, TRC-501 modification kit, detailed assembly manual and 9-V wall transformer (unused surplus or new). TRC-501 transceiver, crystal(s) and antenna are not supplied. A 223.5-MHz crystal for the TRC-501 channel A (49.830 MHz) XTAL-A is $9. To determine the crystal frequency required for other channels, refer to the text and the parts list of Fig 3. Send a business-size SASE for latest information. The ARRL and *QST* in no way warrant this offer.

[2]To order from the ARRL, please send your request to the Technical Department Secretary, 225 Main St, Newington, 06111 and ask for the Elevator Template Package. Include $5 to cover photocopying and postage costs.

[3]The Deluxe School Cases are sold by W. T. Rogers Co, 2514 Fish Hatchery Rd, PO Box 4327, Madison, WI 53711; tel 608-257-2227. Case part numbers are 54907 (blue); 54908 (red) and 54912 (yellow). (These cases can be purchased in single-lot quantities from the manufacturer.—*Ed.*)

[4]Two Elevators checked in the ARRL Lab met FCC requirements for spectral purity. After the initial measurements were made, one unit was detuned to the starting points specified in the tune-up instructions and retuned according to the supplied procedure. Upon completion of the tune-up, all data were nominally the same as measured initially.