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A TRANSISTORIZED QSO-GETTER

For 40-Meter QRP CW Operation

by E. M. Washburn, W2RG*

Many radio amateurs have expressed a keen interest in the amazing possibilities of low-power transistorized transmitters. This expressed interest has prompted the following description, so that others may join the growing ranks of QRP operators working hundreds—or even thousands—of miles on a fraction of one watt input.

The transistorized QRP transmitter illustrated and described in this article is essentially a 40-meter cw rig, using one RCA-2N140 transistor in the crystal oscillator and another in the amplifier. The transmitter is adequately powered by two 6-volt, heavy-duty dry batteries, connected in series, which are provided with a switch to permit tuning up at 6 volts. When the transmitter is operating at full load, the crystal oscillator operates at 12 volts with a collector current of 15 milliamperes, while the amplifier operates at 12 volts, 18 milliamperes. Admittedly, these inputs are *in excess* of the manufacturer's ratings and some transistors may not operate satisfactorily under these overload conditions. An RCA-VSO69 1.5-volt dry cell is used in the oscillator emitter circuit as shown in the schematic diagram.

During the Spring and Fall of 1956, the author worked 18 states, Ontario, Quebec, Puerto Rico, Windward Islands and Transvaal, S. Afr.—all on 40 meters—with an antenna consisting of a single, 106-foot wire. The wire used with the author's transmitter is strung 28 feet across the basement rafters, then leaves the confines of the shack and slopes upwards for a distance of 42 feet to a flat top which is 36 feet long and 28 feet above the ground. The antenna can be voltage-fed from the amplifier or it can be fed from the antenna tuner.

Over a long period of operations, the signal reports received by the author have varied from RST-339 to 589, depending upon band conditions, distance and the type of receiver used by the receiving station. The QSO with Transvaal, S. Afr., (ZS6TR) appears to be a world record for a 40-meter low power/transistor transmitter and the contact was made without any form of prearrangement and without any previous communications using a higher-power rig. At 216 milliwatts and covering a distance of 8,000 miles, this performance is comparable to 37,000 miles per watt at a frequency of 7002 Kc.

Several contacts have been made on the 80-meter band, but the most gratifying and successful results have been accomplished in the 40-meter band. To the present, no attempt has been made to put the QRP transmitter on the 20-meter or the higher frequency bands; however, this band could be worked by using the amplifier as a doubler stage and substituting an RCA-2N247 transistor for the RCA-2N140.

*Manager, Frequency Control Engineering, RCA, Camden, N. J.

Complete transistor rig. Maximum input to the final amplifier: 216 Mw.

CONSTRUCTION

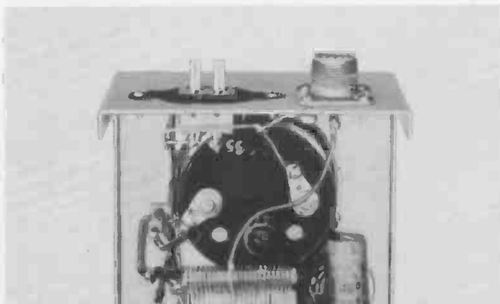
The complete transistor transmitter station comprises five units as shown in the photograph. The wave meter would normally be placed several feet away with its pickup coil about 2 inches from the antenna wire. Since this absorption wave meter is entirely conventional and the battery box is merely a housing for the two 6-volt dry batteries and the 1.5 volt dry cell, the circuit description will be limited to the crystal oscillator unit, amplifier and antenna tuner. Each of these three units is housed in a minibox which measures 5 inches by 4 inches by 3 inches. Interior construction details are shown in the photographs of each.

Although VFO circuits have been tried, the only successful operation has been with crystal control, and in this particular design the crystal unit is in the emitter circuit. The key is by-passed by a low-voltage 2 μf capacitor to improve keying characteristics, particularly when a "bug" is used. The most critical adjustment is the location of the output tap on the base inductor to achieve stable performance, free from "birdies."

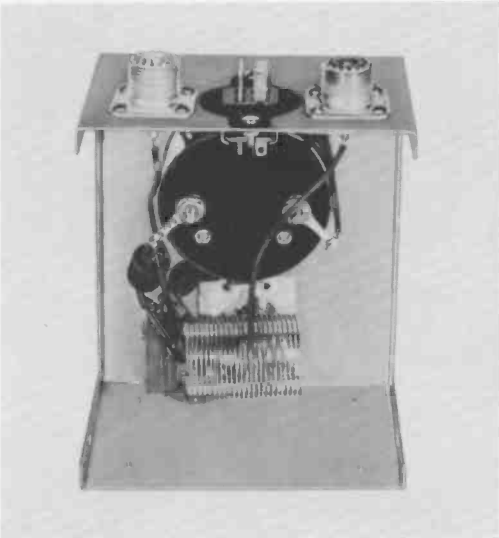
Whether or not an amplifier is used, the output tap on the tuned circuit inductor should be just far enough from the ground end for a stable signal, free from multivibrator type birdies when the key is first closed. In the unit described, the tap is almost at midpoint, 10½ turns from the ground end with a total of 23 turns in the coil. The optimum location for this tap must be obtained by "cut and try" method, keeping the collector voltage low and backing down on the emitter potentiometer to avoid exceeding 15 ma collector current.

The transistorized crystal oscillator is shown with the 2N140 transistor just above the crystal unit. The lower central knob adjusts the variable tuning capacitor, while the left-hand knob is used to set the "bias" potentiometer at optimum for clean keying at full output. The switch at the lower right is the main battery on-off switch, while the jack at the lower left is for the key. On top of the unit, the coax connector is for the rf output and the four-prong male connector is for the 12-volt and 1.5-volt supplies from the battery box. The inside components of the oscillator are shown in the photograph.

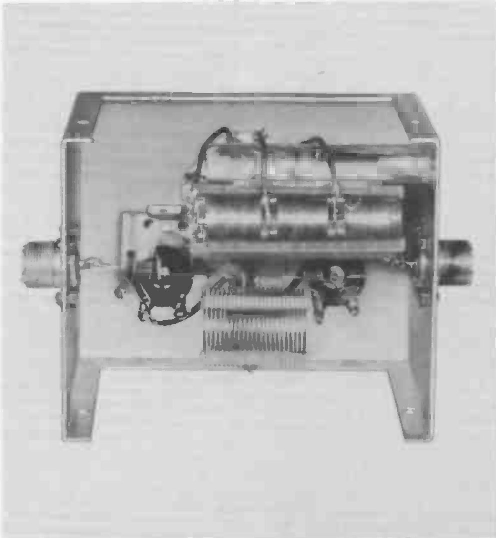
In the amplifier circuit, the only critical adjustment is the location of the tap on the



Rear view of crystal oscillator. Best dx on 40 meters was ZS6TR, 8,000 miles, Transvaal, S. Afr., without prearranged contact.

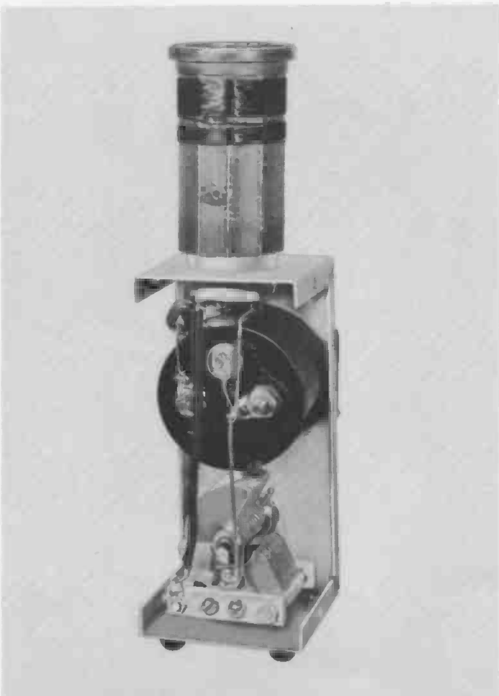


Rear view of transistor amplifier.



Interior view of antenna tuner.

collector tank coil. The optimum position must be found by trial, but should be near the midpoint or slightly towards the ground end. Because one set of batteries is used as the 12-volt supply for both the oscillator and amplifier, the on-off switch may be omitted since the common ground is made through the coax cable.



Construction details of absorption wave meter used to indicate maximum radiation from antenna.

The use of an antenna tuner was found helpful, although not essential. The absorption wave meter, however, is considered an absolute necessity, since it gives a sensitive indication of the radiated energy. During tuning operations, this meter pickup coil may be located close enough to the antenna wire (about 6 feet from the tuner or transmitter) to give a meter reading at about half-scale, assuming that full scale is about 200 μa. Then it should be removed completely or decoupled until the needle movement is just visible. Although the tuner circuit contains more components than absolutely required, it does permit precision tuning for optimum radiated power at minimum collector current, and in low power work of this particular type every individual milliwatt must be utilized to produce maximum power for maximum contacts.

As in conventional transmitter tuning, increasing the load will also increase the collector (plate) current, but instead of tuning the tank circuit for a dip in collector current, the more positive indication of proper loading is maximum wave meter current at minimum collector current. Maximum radiation normally will not be at maximum current in the collector circuit. Adjustment of the emitter potentiometer in the oscillator is quite critical for optimum setting.

In all tuning operations it is advisable to listen to the signal in the station receiver. As the voltage on the oscillator emitter is gradually increased and oscillation starts, the signal will sound very strong, even before there is any indication of collector current in the amplifier. As the emitter potentiometer is advanced slowly, the oscillator collector current will increase and the keyed signal will become clean, with a slight ringing which is characteristic of crystal oscillator keying. Unfortunately, if there is any indication of radiated power under this setting of the potentiometer, it will be very small, and the emitter voltage should be further increased. At about 10 ma collector current, there should be a definite amplifier collector current and a wave meter indication of radiated power, and all tuning controls must be adjusted carefully until peak radiation is reached. During this final tuning, birdies are very liable to be heard in the receiver all over the dial, and tuning must be readjusted until the only signal heard is at the crystal frequency. If tuning alone is not effective in eliminating these spurious oscillations with a "cold" transistor, the emitter voltage in the oscillator must be reduced or the tap on its base coil moved further from the ground end.

When the keyed signal is clean and free from birdies, with collector current between 12 and 15 ma in the oscillator and 15 to 18 ma in the amplifier, and with a good indication of radiation in the absorption wave meter, that meter should be removed or coupled very loosely. The rig is then all set for normal use.

In at least one respect, however, operation will not be normal, and that is in establishing contacts. The only successful method experienced by the writer has been in answering general calls and rarely by calling CQ, CQ-TR, CQ-QRP, or any other form inviting a QSO. Experience teaches that it is well to listen for a few seconds before answering a CQ, to see if others are answering the same call. If so, it is almost a waste of time to answer, even assuming your crystal frequency is close enough to be hopeful of establishing contact. The writer has had best success by having a fair selection of crystals, choosing one which is in the least occupied portion of the band, tuning for optimum radiation at minimum power input, and waiting for someone to call CQ on that frequency. On 40 meters you don't have to wait long under normal conditions.

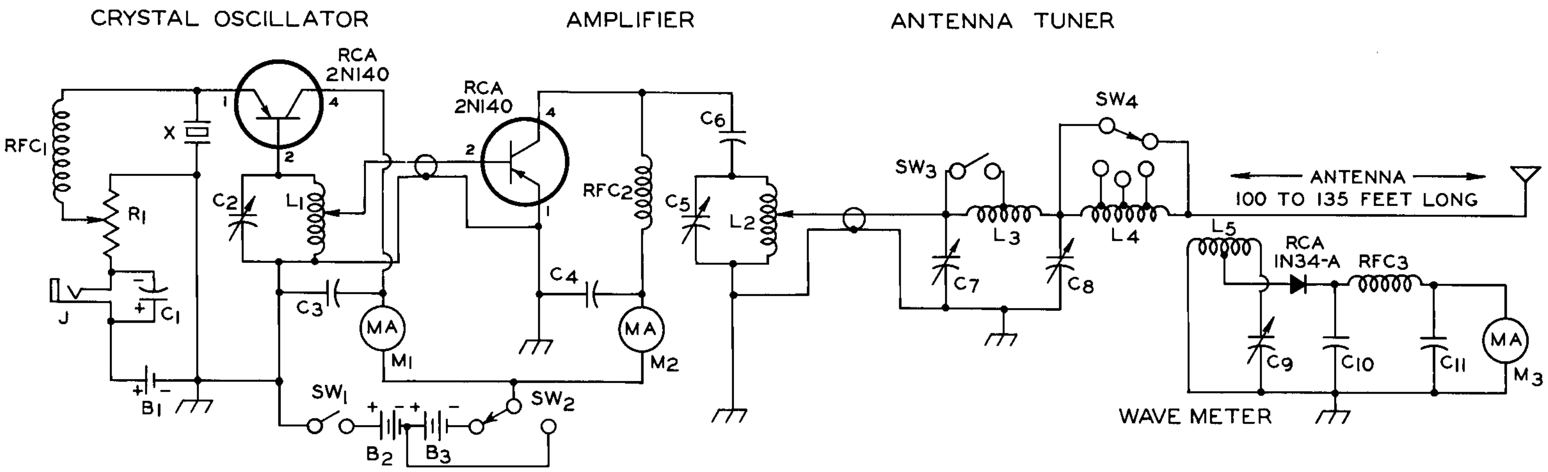
On 80 meters, a 2N139 may be used in place of the 2N140 and is slightly lower in price. Cutoff frequency of the 2N139 is approximately 5 Mc. The 2N140 should be used for 7 Mc operation, with its higher cutoff frequency at about 8 Mc. Future QRP rigs hold many possibilities of higher-frequency operation, voice modulation, and increased efficiency.

Your author wishes to emphasize the importance of selecting the proper location for the tap on the oscillator coil and also on the amplifier coil. Both are extremely critical *for optimum performance.* The antenna tuner described will load almost any kind of wire, but obviously the better antenna system employed, the better the results will be.

Your author has never used any form of beam and all contacts, nearly 200 at this writing, have been without previous arrangement and without previous contact with higher power equipment. In the author's opinion, such "piggy-back" contacts void the attraction of the adventure in transistorized QRP amateur communications.

PARTS LIST

B_1—Battery, 1.5-volt (RCA-VS069, or equivalent)
B_2—Battery, 6-volt (RCA-VS009, or equivalent)
B_3—Battery, 6-volt (RCA-VS009, or equivalent)
C_1—2μf, electrolytic
C_2—0-100 $\mu\mu$f, variable
C_3—0.01 μf
C_4—0.01 μf
C_5—0-100 $\mu\mu$f, variable
C_6—0.001 μf
C_7—0-100 $\mu\mu$f, variable
C_8—0-100 $\mu\mu$f, variable
C_9—0-50 $\mu\mu$f, variable
C_{10}—0.001 μf
C_{11}—0.001 μf
L_1—23 turns B & W Miniductor #3015, tapped near center
L_2—23 turns B & W Miniductor #3015, tapped near center
L_3—23 turns B & W Miniductor #3015, tapped near center
L_4—2¾" length B & W Miniductor #3016, 3 equal taps
L_5—Any size 40-meter pickup coil center-tapped, which tunes through band, with C_9
M_1—0-20 dc milliameter
M_2—0-20 dc milliameter
M_3—0-100 microammeter
R_1—100,000 ohms
RFC_1—RF choke, 1 mh
RFC_2—RF choke, 1 mh
RFC_3—RF choke, 1 mh
SW_1—SPST switch
SW_2—SPDT switch
SW_3—SPST switch
SW_4—Switch, 4-position
X—Crystal, 3.5 or 7.0 Mc
RCA-2N140 Transistor (oscillator)
RCA-2N140 Transistor (amplifier)
RCA-1N34-A Semiconductor Diode (wave meter)



Grounds shown are to individual metal cases; no earth ground is used. Maximum collector input is 216 milliwatts to oscillator and also to amplifier. Batteries used should be heavy-duty dry cells.

40/80 METER TRANSISTOR TRANSMITTER

From your local RCA distributor, headquarters for RCA receiving and power tubes.

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Harvey Slovik, Editor
Robert Leedy, W2PMP
Technical Editor

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