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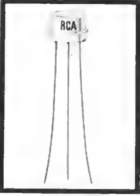

A TRANSISTORIZED KEYER

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RCA Electronic Components and Devices

The subject of semi- and fully-automatic keying has long held considerable fascination for the author, who has traced its development since introduction of the electronic semi-automatic key, or "bug," in the middle thirties. Various developments since then have resulted in numerous and sundry systems, all employing either relays or combinations of electron tubes and relays to perform the keying function. To the author, it seemed that the next logical step in the evolution of keying systems should be the design and construction of a practical transistorized electronic keyer. The compact unit described in this article represents his efforts in that direction.

The transistorized keyer may be operated either as a semi-automatic key (automatic dots) or as a fully automatic key (automatic dots and dashes). The keying function is performed by a high-speed relay, which is located at the output of the unit so that the keyer will be electrically isolated from the circuits being keyed. A double-pole relay is employed so that one set of relay contacts may be used to mute the receiver during the key-down condition. Keying speed is controlled by a voltage source in order to permit the use of a single potentiometer instead of the ganged dual potentiometer usually required for this purpose. Another feature of the keyer is the built-in tone oscillator which allows the operator to monitor his keying at all times.

W2YM's transistorized keyer can be operated either as a semi-automatic "bug" key or fully automatic key. Instrument is shown here with a Vibroplex "Vibro-Keyer" connected to it. Standard hand key can be connected to two binding posts at left.

Circuit Details

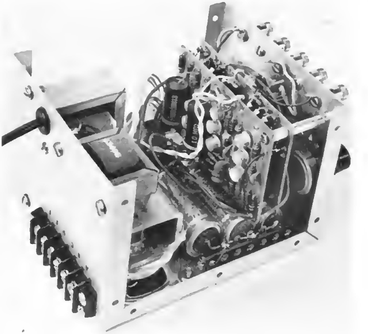
The schematic and parts list of the transistorized keyer appear in Figure 1. The actual keying circuits consist of a free-running multivibrator, a flip-flop multivibrator, an OR gate, and a transistor-controlled relay circuit. A half-wave rectifier provides the DC voltage to control the keying speed, and a voltage doubler from the 6.3-volt winding of the power transformer provides the DC supply voltage for the unit. A tone oscillator provides an audible indication of the keying.

The dot multivibrator, as its name implies, controls the formation of the dots, and the repetition rate of this multivibrator determines the rate at which the dots are produced and hence the speed of the keying. When the "Vibro-Keyer," S_1, is in the open position, the multivibrator is held inoperative (transistor Q_2 is not conducting) by the biasing action

*Commercial Receiving Tube and Semiconductor Division, Somerville, New Jersey of clamp-transistor Q_3. When the paddle of S_1 is moved to the dot position, the clamp-transistor becomes inoperative, and the dot multivibrator becomes a free-running circuit. The square-wave signal developed at the emitter of multivibrator transistor Q_2 is then applied to the base of transistor Q_7 in the OR gate. During the positive alternation of this signal, the OR gate will permit current to flow through the relay-control transistor, Q_9, and through the keying relay, K_1, in series with this transistor.

Once a dot is initiated by moving the paddle of S_1 to the dot position, the action will continue—regardless of the position of the paddle—until both the dot and the space that follows it are formed. This feature is provided by the feedback circuit from the base of clamp transistor Q_3 to the collector of multivibrator transistor Q_1, which assures that clamp transistor Q_3 will be held inoperative, and that the operation of the multivibrator—once begun—will continue until a full cycle is completed.

The ratio of the "on time" to the "off time" of the dot multivibrator is controlled by the setting of potentiometer R_5. This ratio is usually referred to as "weight." Thus, R_5 is called the "weight control." In most cases, an operator will want this weight control in the center, or neutral, position, but occasionally it may be desirable to change the ratio of the dot time to space (i.e., under conditions of



Bottom view of keyer shows location of speaker, transformers, and filter capacitors. Terminals "A" through "F" (left) are connected to the double-pole, double-throw relay contacts.

slow sending, when the change can be readily made).

The rate at which the dots are produced is controlled by the voltage applied to the combination of C_1 and R_4 and combination of C_3 and R_6. The more negative this voltage on the movable arm of R_5, the faster the timing capacitors will charge to the conducting potential of the multivibrator transistor not conducting at that instant. In other words, the greater the multivibrator-repetition rate, the more rapid the keying speed. In the author's model, the maximum charging potential was set at 60 volts. This corresponds to a keying speed of about 40 words per minute.

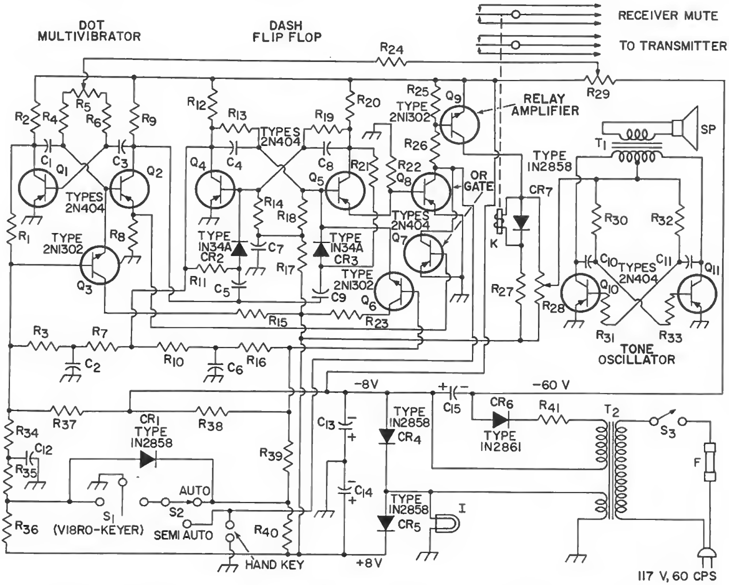
A keyer of higher speed can be obtained by reducing the value of R_{41} to produce a corresponding rise in the speed-control voltage and keying speed.

The value of R_{41} should not be reduced below 1,000 ohms because the voltage across filter capacitor C_{13} would then exceed its working-voltage rating. If desired, the minimum speed of the keyer (approximately five words per minute) can be decreased by increasing the values of the timing capacitors, C_1 and C_3. To insure good stability, it is important that these timing capacitors be of the paper or plastic type. Electrolytic capacitors are not stable enough for this application.

The discussion of circuit details thus far covered the production of "dots." When a "dash" is to be generated, the paddle of S_1 is pushed to the dash position. The clamp transistors, Q_3 and Q_6, which hold the dot multivibrator and the dash flip-flop inoperative during the "key-open" condition, will not conduct due to the application of increased bias. Consequently, the multivibrator and the flip-flop are allowed to operate simultaneously—a required condition for the formation of a dash.

The output from the emitter of multivibrator transistor Q_2 and that from the emitter of flip-flop transistor Q_5 are applied to the OR-gate transistors, Q_7 and Q_8, respectively. The keying relay is energized during the positive alternation of these signals, whether applied separately or simultaneously. The dashes that are produced are three times as long as the dots—a relationship achieved through timing functions explained in the paragraphs that immediately follow.

Probably the best way to explain the keying function is through a graphical presentation such as Figure 2. Assume, for the purpose of this discussion, that there is no voltage drop across the transistors of the multivibrator and



C_1, C_3—1.0 μf paper (or plastic), 200 volts
C_2—0.47 μf, ceramic, 25 volts
C_4, C_8—560 pf, ceramic, 600 volts
C_5, C_9—330 pf, ceramic, 600 volts
C_6, C_7—0.01 μf, ceramic, 50 volts
C_{10}, C_{11}—0.02 μf, ceramic, 50 volts
C_{12}—0.1 μf, ceramic, 50 volts
C_{13}, C_{14}—2,000 μf, electrolytic, 15 volts
C_{15}—16 μf, electrolytic, 150 volts
F—Fuse, 1 ampere
I—Indicator lamp No. 47
K—DC relay; coil resistance—2,500 ohms; operating current—4 ma; Potter-Brumfield ML11D or equiv.
R_1—39,000 ohms, 0.5 watt
R_2, R_9, R_{12}, R_{20}—3,900 ohms, 0.5 watt
R_3, R_{16}—18,000 ohms, 0.5 watt
R_4, R_6—51,000 ohms, 0.5 watt
R_5, R_{29}—Potentiometer, 10,000 ohms
R_7, R_{10}—22,000 ohms, 0.5 watt
R_8, R_{22}, R_{25}—68 ohms, 0.5 watt
R_{11}, R_{21}—15,000 ohms, 0.5 watt
R_{13}, R_{19}—33,000 ohms, 0.5 watt
R_{14}, R_{18}, R_{30}, R_{32}—27,000 ohms, 0.5 watt
R_{15}, R_{23}—270 ohms, 0.5 watt
R_{17}—68,000 ohms, 0.5 watt
R_{24}—100,000 ohms, 0.5 watt
R_{26}—560 ohms, 0.5 watt
R_{27}—1,200 ohms, 0.5 watt
R_{28}—Volume-control potentiometer, 50,000 ohms
R_{31}, R_{33}—10,000 ohms, 0.5 watt
R_{34}—6,800 ohms, 0.5 watt
R_{35}—8,200 ohms, 0.5 watt
R_{36}, R_{39}, R_{40}—15,000 ohms, 0.5 watt
R_{37}, R_{38}—47,000 ohms, 0.5 watt
R_{41}—10,000 ohms, 1 watt
S_1—Vibroplex keyer or equiv.
S_2—Toggle switch; double-pole, double-throw
S_3—Toggleswitch;single-pole,single-throw
SP—Replacement speaker; 3½-inch, 3.2-ohm voice coil, QUAM 3A05 or equiv.
T_1—Push-pull output transformer (14,000 ohms to V.C.), Stancor A3496 or equiv.
T_2—Power transformer, Stancor PS8415, PA8421 or equiv:
Secondary One—125 v at 15 ma or more;
Secondary Two—6.3 v at 0.6 ampere or more

Figure 1: Schematic diagram and parts list of W2YM's transistorized keyer.

of the flip-flop when they are conducting. Assume also that the switching time for these transistors is zero (i.e., the transistors can be switched from "off" to "on" or from "on" to "off" instantaneously). As mentioned previously, the keying relay will be energized whenever the positive alternation of the signal from either multivibrator transistor Q_2 or flip-flop transistor Q_5—or both—is applied to the OR gate.

When a dot is being produced, only the dot multivibrator supplies the keying signal to the OR gate. For this condition, OR-gate transistor, Q_7, controls the operation of the relay circuit. The relationship between the current through this transistor and that through the relay are shown by the dot-formation waveforms in Figure 2.

When the paddle of S_1 is positioned to connect the dash contact to ground, the dot contact is also connected to ground through steering diode CR_1—resulting in simultaneous operation of the dot multivibrator and the dash flip-flop. Signals will now be applied to both OR-gate transistors, and the relay will be energized for an interval three times as long as that used to produce a dot. The dash-formation waveforms in Figure 2 illustrate this relationship.

The voltage drop across the keying relay and resistor and R_{27} is the DC supply voltage for transistors Q_{10} and Q_{11} in the tone oscillator. For current to flow through these components, the relay-amplifier transistor, Q_9, must receive a keying signal from the OR gate. The tone oscillator, therefore, operates only when dots or dashes are being produced. Its output is then applied to the speaker to provide an audible indication of the keying. Potentiometer R_{28} controls the volume of this output.

The transistorized keyer may also be operated as a semi-automatic or manual key. In the semi-automatic mode, switch S_2 (see Figure 1) is placed in the SEMI-AUTO position. Although the dots are still produced automatically, the automatic-keying circuits are bypassed when the paddle of S_1 is moved to the

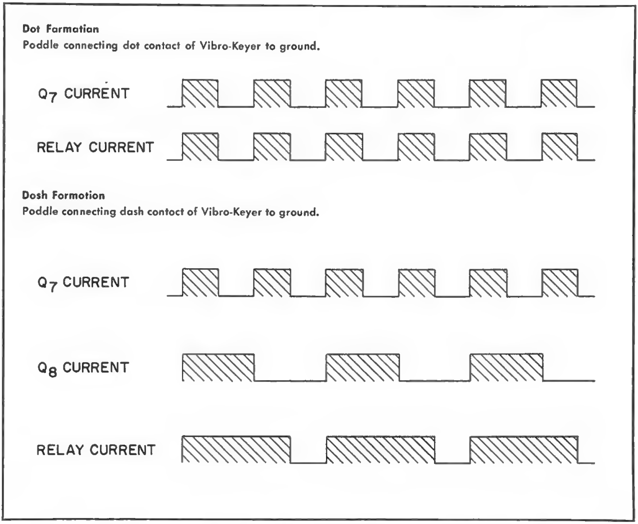
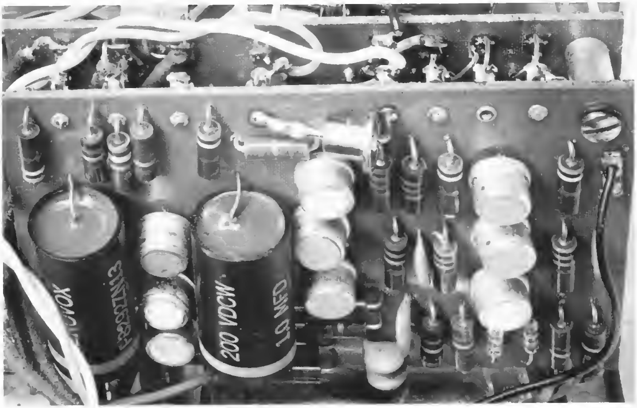


Figure 2: Graphical representation of keying function showing waveforms for Q_7, Q_8, and relay currents.



Close-up of transistorized keyer's circuit board showing dot-multivibrator circuit (left) and dash flip-flop circuit (right). Shown in center are three transistors comprising the OR gate and relay control. Board immediately in back includes circuitry for the instrument's side-tone oscillator and biasing network.

dash position, and the dashes must then be produced manually. If desired, a hand key may be connected to the unit (across the terminals marked HAND KEY in Figure 1) so that the automatic-keying circuits can be by-passed when producing both dots and dashes.

Construction

The complete keyer is housed in a miniature aluminum case which is only 4 inches high, 5 inches wide, and 6 inches deep. Internal mounting details for the unit are shown in the photographs on pages 2 and 5.

The major circuitry is mounted on two phenolic boards. One board contains the multivibrator and its clamp transistor, the flip-flop and its clamp transistor, and the OR gate. The other board contains the tone oscillator and voltage bridge for the dot and dash clamp circuits. [*Author's Note:* The voltage bridge and clamp circuits are similar to those used by James C. MacFarlane, W3OPO, in the December, 1962, issue of "QST" magazine.]

The power supply, relay, speaker, output transformer, switches, and potentiometers are all mounted directly to the case. The cone of the speaker is protected from damage by covering it with a small piece of perforated aluminum. In the model constructed by the author, binding posts were used to connect the Vibro-Keyer, S_1, to the automatic keyer, but any method of connection that suits the fancy of the builder would be equally satisfactory.

All relay contacts are brought out to the rear of the keyer and the connections to them are made through a six-terminal Jones strip. This arrangement permits two circuits to be keyed simultaneously. It also allows the relay to provide either normally closed action or normally open action, whichever is preferred. In the unit described here, the second set of contacts are used to mute the receiver during the key-down condition. This feature required that the relay be normally closed. [*Author's Note:* Some relays do not have non-metallic strikers on either the pole pieces or the armature and, consequently, may be sluggish. This condition can be corrected by drilling and tapping the armature and installing a No. 2-56 brass screw. The screw should be adjusted so that about 2 to 6 mils protrudes from the armature. A lock nut should be used to prevent any shift in the position of the screw.]

The transistorized keyer constructed by the author has been in constant use for more than a year. Once an operator becomes familiar with the instrument, he will find it extremely easy to send perfect copy.

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