

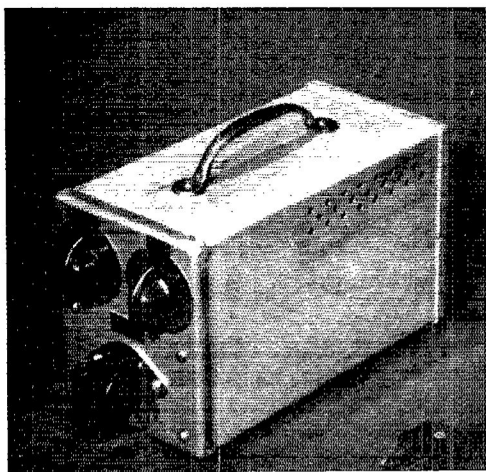
Further Advances in Electronic-Keyer Design

Some New Ideas in Automatic Keys

BY F. A. BARTLETT,* W6OWP

A CASUAL LISTEN ON any c.w. band leaves no doubt that the fully-automatic sending key — and particularly the so-called “electronic bug” — has come into its own. And with it, the readability “quotient” of amateur sending has started a steady improvement. Heretofore, with one or two exceptions, the most important consideration in electronic-keyer design has been automatic dots and dashes. Several circuits effectively achieve this result. But as more and more operators try their fists with keyers of this type, the need for features other than the basic automatic dot-dash principle has become increasingly evident.

A common difficulty is the intraletter timing where a change from dashes to dots is made. Un-



The completed electronic keyer occupies little more table space than a conventional bug.

less the last dash is timed correctly, clipping results and our machine-like fist does a disappearing act. On dots, there is a fifty-fifty chance of hitting timing correctly, but on dashes the chance for error is multiplied by the increased mark-to-space ratio. This critical timing is eliminated when dots and dashes are self-completing, and the key lever serves only to start each dot or dash.¹

In this same category can be included a dif-

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¹ Beecher, “A Better Electronic Keyer,” *QST*, Aug., 1945.

• Self-completing dots and dashes, single-control speed adjustment and a simple keying lever — all without undue circuit complication — add up to an electronic-key design easier to master. For the c.w. man who is looking toward perfection, this automatic key looks like one of the closest approaches we’ve yet had.

ficulty with which we all are familiar. This is a tendency to develop one or two speeds at which the operator’s sense of timing is highly developed and he puts out code of a quality above reproach. But when asked to QRS or to speed up, he finds himself in trouble. Often he will blame his bug or “late hours the night before.” By eliminating critical timing, the self-completing feature tends to break up this “self-resonance” in code sending. An operator using a keyer with self-completing action finds that he has a maximum speed which is perhaps influenced by “state of mind,” but for sending below his maximum, one speed is as good as another, and changing pace on a moment’s notice causes no difficulty.

Another frequent complaint — especially among amateurs who build their own gear — is the complicated adjustment of dots, dashes and spaces each time a change in speed is made. The dot-dash-space relationship is fixed regardless of sending speed. Thus the need for individual adjustment of each is superfluous. Simplification here to permit instant variation in sending speed is in order.

Although perhaps not as basic as the above considerations but deserving of mention is need for a less complicated key lever. The principle of dots on one side, dashes on the other, seems to dictate single-pole double-throw. The familiar “feel” of the traditional bug would thus be retained and adjustment difficulties reduced to a minimum.

In the following paragraphs, the writer describes a new automatic-keyer circuit in which the above desirable features are inherent in the design.

Circuit Operation

Essentially, this keyer circuit, shown in its basic form in Fig. 1, consists of a stable, mechan-

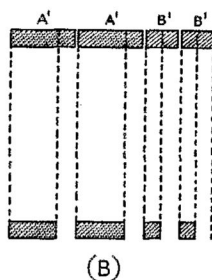
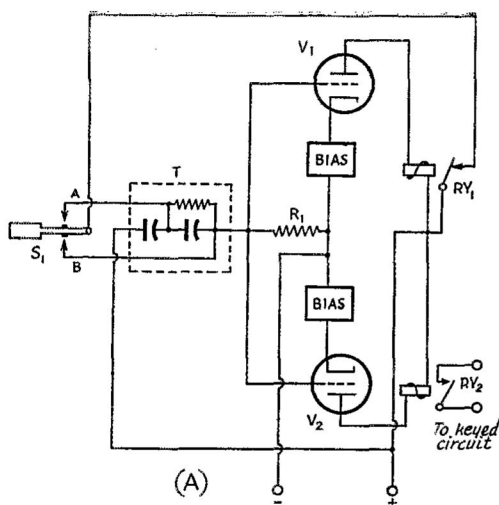


Fig. 1 — A — Basic keyer circuit. B — Graphic illustration shows operation of basic pulsing circuit and shaping-keying circuit in terms of operational cycle of respective plate-circuit relays. Full explanation is contained in the text.

ically-triggered pulse generator working into a clipping circuit which shapes the operating cycle of the keying relay in conformity with standard concepts of the telegraph code. The manner in which the circuit functions is quite simple. Referring to Fig. 1, two tubes and associated plate-circuit relays are connected with their grids in parallel, but with independent bias supplies which hold the idling grid voltage beyond plate-current cut-off. To the grid circuit is connected timing network *T* which provides one of two time constants as selected by key lever *S*₁. The opposite side of this network connects to the positive B supply. *S*₁, through the back contacts of *R*_{Y1}, is likewise connected to B+ with the circuit idling.

Now, consider only *V*₁ for a moment. If *S*₁ is moved to position A, three things take place simultaneously: (1) the effective capacitance of *T* is discharged; (2) positive potential is placed on the grid of *V*₁; and (3) plate current begins to flow through *R*_{Y1}. This closes the relay armature, opening the back contact connected from B+ to *S*₁. The short-circuit across *T* thus is removed and the network begins to charge through resistor *R*₁ reducing the positive potential on the grid of *V*₁ until the applied bias takes over, plate current ceases and *R*_{Y1} opens. If *S*₁ is held to position A, a continuous pulsation of *R*_{Y1} occurs. The duty cycle of these pulsations is shown graphically as A' in Fig. 1. If *S*₁ is held to position B a different time constant becomes effective and the pulsations are shorter, as at B' in the illustration.

The over-all speed of operation is dependent upon the value of *R*₁ which controls the rate-of-charge of the timing network. Opening *S*₁ or moving the lever to the opposite contact at any time during the progress of a cycle has no effect upon completion of that cycle, since *S*₁ will not be

connected into the circuit until *R*_{Y1} opens. *S*₁ thus is seen to serve only to initiate the start of each pulse, at either of two rates as selected at A or B. For all speeds used in manual telegraph work, this basic pulsing circuit can be made very stable and capable of an almost unlimited number of operational cycles.

It will be recalled that in standard telegraph practice, a dot is considered of unit length, a dash three unit lengths and the character space, i.e., space between consecutive dots or dashes within a letter, one unit length. Referring again to Fig. 1, the pulsation of *R*_{Y1} can be considered the equal of the mark-to-space keying characteristic of this relay, were it connected into a keyed circuit. It is at once apparent that spacing between pulses is almost totally lacking. Insertion of the character space then is the function of *V*₂, and *R*_{Y2} becomes the keying relay for operating an external transmitter or other telegraph instrument.

The manner in which this is accomplished is as follows: Constants for the timing network *T* are chosen such that A' is four units in length and B' is two units.² Now the grid of *V*₂ is subject to the same input voltage during pulsing cycles as is the grid of *V*₁. Accordingly, similar plate current variations would be expected to pass through relay *R*_{Y2}. However, by means of the independent bias supply, the grid of *V*₂ is biased to a value higher than the grid of *V*₁. This results in the cutting off of plate current to *V*₂ during pulsing cycles a fixed interval ahead of cut-off in *V*₁. The additional bias voltage for *V*₂ is selected to cause *R*_{Y2} to open one unit length ahead of *R*_{Y1}. The action, in terms of the operating cycle of *R*_{Y2} compared to *R*_{Y1}, is shown graphically in Fig. 1.

With *S*₁ in position A, dashes of three units

² For purposes of explanation, round numbers are used and the slight spacing of pulses at *R*_{Y1} is neglected.

length, each followed by a space characteristic of one unit length, will be produced. In position *B* dots of unit length with unit character space are formed. Note that Ry_2 always starts simultaneously with Ry_1 .

Since the rate of all operations is a function of the timing network *T*, then variation of *R* will change the speed of all characteristics in proper relationship. A variable bias voltage for V_2 , provided by R_{10} (Fig. 2), can act as control for the weight of the keying.

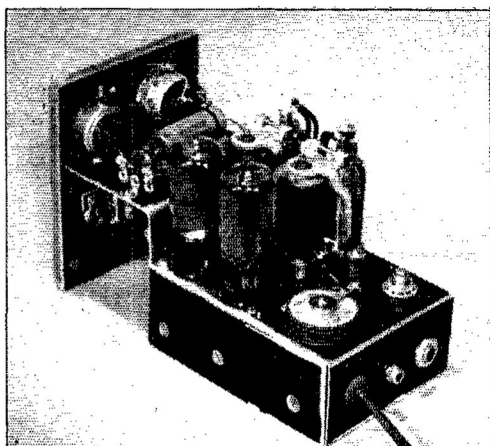
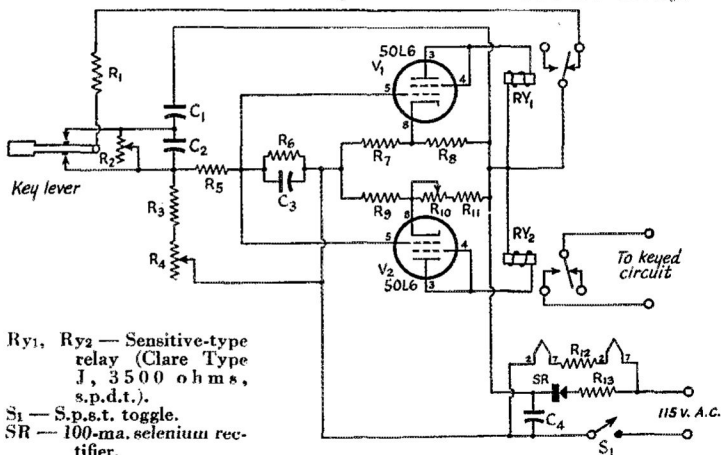
Practical Keyer Circuit

The foregoing material has dealt in general terms with the basic principle of operation. To equip the circuit for practical usage, suitable means of obtaining bias and insuring stability of the grid-input circuit must be introduced. In Fig. 2 is shown a complete circuit diagram of a keyer built around the principles just discussed and using standard parts. Exact circuit values are given to enable duplication.

Operating grid bias is obtained by means of the two divider networks made up of R_7R_8 and $R_9R_{10}R_{11}$. R_3 and R_5 prevent excessive change in grid-input impedance with variation of the speed-control resistor, R_4 . C_3 and R_6 furnish necessary grid-input stabilization. R_3 also serves to fix the maximum operating speed by limiting the current flow through R_4 . Maximum resistance of the latter sets minimum speed. Values shown provide a range of approximately 12 to 50 words per minute. R_1 in series with the movable contact of the key lever limits the instantaneous discharge current of the timing network. This minimizes sparking both at the key lever and pulsing-relay contacts. R_{10} is used to vary the bias on V_2 by controlling the bleeder-current flow through R_9 . This allows the weight of the keying to be varied to suit the operator's wishes. In addition, it is of advantage in compensating for differing characteristics when tube replacements are made.

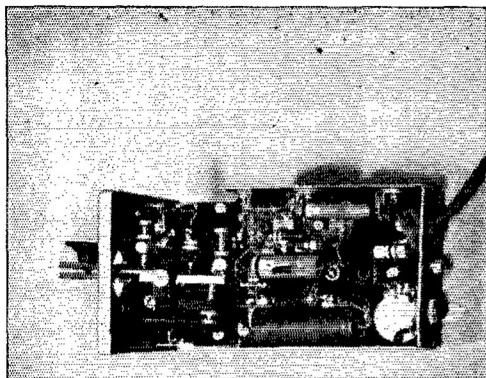
Fig. 2 — Practical keyer circuit.

- C_1 — 0.15- μ fd. 600-volt paper.
- C_2, C_3 — 0.05- μ fd. 600-volt paper.
- C_4 — 40- μ fd. 150-volt electrolytic.
- R_1 — 470 ohms, $\frac{1}{2}$ watt.
- R_2 — 0.5-megohm variable (dot-dash ratio control).
- R_3, R_5 — 0.22 megohm, 1 watt.
- R_4 — 2-megohm variable (speed control).
- R_6 — 2.7 megohms, $\frac{1}{2}$ watt.
- R_7, R_8 — 2200 ohms, 1 watt.
- R_9 — 6800 ohms, 1 watt.
- R_{10} — 5000-ohm variable (shaping control).
- R_{11} — 10,000 ohms, 2 watts.
- R_{12} — 150 ohms, 5 watts.
- R_{13} — 39 ohms, 1 watt.



Interior view showing the mounting of tubes, relays and other major parts.

High-quality condensers should be used at C_1 , C_2 and C_3 . Standard-make 600-volt tubulars were used in the keyer illustrated. C_1 consists of 0.05- and 0.1- μ fd. units in parallel to give the required 0.15- μ fd. capacitance. No particular comment need be made on the power supply which uses a standard 100-ma. selenium rectifier. The 150-ohm resistor in the filament circuit drops the voltage to a safe operating value for the 50L6s. The two relays constitute the most-critical components in this circuit. These should be identical and of fixed-adjustment wiping-contact design. Coil resistance, of course, must be suitable for vacuum-tube operation. So-called "sensitive plate-circuit" relays of the type having numerous adjustments should be avoided. In the experimental keyer shown in the photographs, the author used 3500-ohm Clare relays. However, any good telephone-type relay with proper contact and coil specifications should be satisfactory.



This bottom view of the electronic keyer shows a compact but orderly arrangement of the minor components.

If duplication of the circuit of Fig. 2 is planned, it is important that relay-contact spacing be set at 0.010 inch, as measured between the movable contact and the "make" contact. To set this spacing, use a feeler gauge and carefully bend the "make" contact arm. The overtravel of the armature should be sufficient to give moderate wiping action on both the forward and back contacts.

Timing-Circuit Adjustment

The setting of R_2 in the timing circuit for the correct dot-dash ratio must be made by monitoring a circuit keyed by Ry_2 . First, set R_2 at minimum resistance and with the key lever held to the dash position, set the speed control R_4 at about one-quarter scale beyond the point where the keying relay picks up. The speed control should be set at about two-thirds scale. Now, advance R_2 and at the same time swing the key lever alternately from the dot position to the dash position. To the average operator's ear, the point where the dot-dash ratio is about right is readily determined. Once set, the timing circuit needs no further attention. The dot-dash ratio will remain true at all sending speeds.

Mechanical Layout

The photographs show an electronic keyer using the circuit of Fig. 2 and built to occupy a minimum of space at the operating position. The construction is compact but not overcrowded. A semiautomatic-key assembly was altered to serve as the control lever. Aside from the portability angle, the author favors a design wherein the keyer is built as a unit separate from the key lever. This makes for a more orderly operating position — since one advantage of a keyer of this type is the simple lever required. Lead length is not critical and the keyer unit can be incorporated right in the exciter unit or transmitter proper. A semiautomatic key can be converted to single-pole double-throw action in a

matter of minutes. The shorting connection between the stationary dot and dash contacts is removed and the vibrating arm is locked by strapping it to its backstop with a rubber band. Contacts are then adjusted to give the desired s.p.d.t. action.

Sending Technique

"Go slow" is the best advice the writer can give to the operator learning to use this new type of keyer. Each letter involves a different operational sequence and these sequences will have to become mechanical — that is, done without conscious mental assistance — before high-speed work should be attempted. A little study will show that each letter can easily be transmitted with mechanical perfection if full advantage is taken of the timing margin afforded by the keyer's self-completing action. Strive for this perfection. Once the sending rhythm of each letter is mastered, pay close attention to spacing between letters and words. This is the road to manual sending that compares favorably with the precision and accuracy of tape transmission.

In closing, the writer wishes to acknowledge valuable suggestions contributed by A. R. Burns of Highland Park, Calif., in the development of certain portions of the circuit described.

Silent Keys

IT is with deep regret that we record the passing of these amateurs:

W1NFF, Fred A. Latimer, Lenox, Mass.
W2AFU, Elmer Theibault, Lakewood, N. J.
W2GHIQ, Joseph T. Bell, Short Hills, N. J.
W2IGY, Arthur D. Gonyea, Hudson Falls, N. Y.

W2QGT, Mrs. Katherine L. Wood, Syracuse, N. Y.

W2SAK (ex-W2ABS), Peter S. Case, Somerville, N. J.

W2SXR, Albert L. Wahl, Mt. Vision, N. Y.

W5JMK, S/Sgt. Nunzio DiPaola, USAF, Winnsboro, La.

W6MGC, SCM John R. Kinney, Sacramento Valley Section, Sacramento, Calif.

W8AHU, John T. Stillwell, Grafton, W. Va.

Alvina G. Zachary (second op at W8DEN), Detroit, Mich.

W8HDW, Frank Rogowin, Lorain, Ohio

W9COI, Charles J. Lemieux, Fort Wayne, Ind.

VE3MT, Art Potts, Toronto

GM5UT, Eldrick Fowler, Aboyne, Aberdeenshire

HB9CD, Enzo Sala, Zurich

PK6XA, Lt. Bert Krygsmann