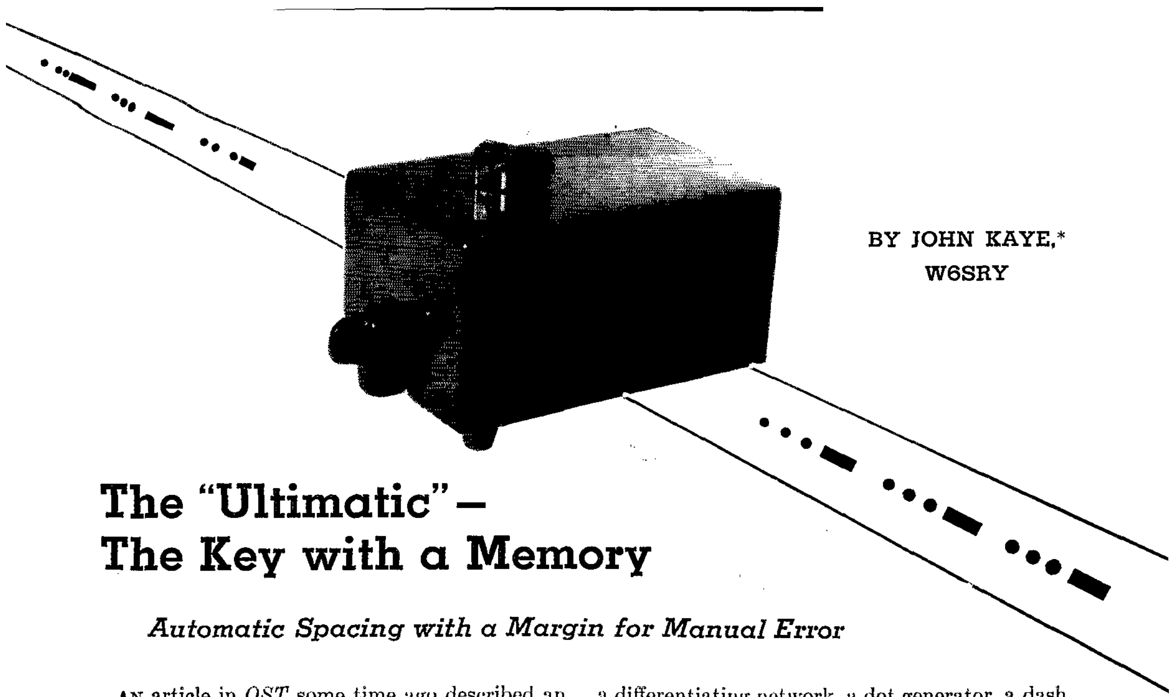

BY JOHN KAYE,* W6SRY

The "Ultimatic" – The Key with a Memory

Automatic Spacing with a Margin for Manual Error

An article in *QST* some time ago described an electronic key [1] that sent automatic spaces as well as automatic dots and dashes. The author described it as an "infernal, maddening machine" because it required that the operator "stay with it" all of the time. The continuously-running time base resulted in an uncontrollable "beast" that would wait for no one. If the key were not closed at the instant of a marking pulse the character was lost. However, using the basic idea of a continuously-running time base and adding "memory" to the key transforms the "beast" into a "beauty." Once the key has been closed to select a character, that character is stored and properly transmitted when the "mark" pulse arrives, even if the key is open, or closed on the opposite side. And adding "sequencing" allows the storage of a dot-dash (or dash-dot) series, even if both are stored before the appearance of the first character at the output. Stated simply, with the key set for 10 w.p.m., you can hit a 40-w.p.m. "N" and walk away while the key produces a slow "daah-dit."

In general, the "Ultimatic" key[2] considers interletter and interword spacings as specific code characters, just as much as the dot and dash. These all-spacing characters are delivered in exact one- and two-cycle durations, just as start-stop autokeys deliver exact one- and two-cycle marking characters. The memories provide tremendous timing leeway at the key for selection of a succeeding character, in some cases as much as three full cycles. The astounding ease of operation due to this leeway cannot be fully appreciated without some knowledge of how the circuits work. The key combines a free-running time base, a differentiating network, a dot generator, a dash generator that starts the dash for completion by the dot generator, a dot memory, a dash memory, a sequencing circuit, a regulated power supply, a heavy iron base and the front half of an old bug. Shoehorn it all into a 3 × 4 × 6-inch box and you have the Ultimatic, a key that gives Klein output with Lake Erie input. It does everything for the operator but spell and punctuate.

The sketch in Fig. 1 illustrates to some extent the potentialities of the key. The top line shows some possible key-lever positions in sending the word "MICE," and the second line shows the perfect copy that comes from the key. The third line shows the positive and negative pulses of the time base — it can be seen how they line up with the code characters in the output and thus account for its perfection. Note, however, that the

• Here is something that comes as close to being an electronic brain as you are likely to encounter in amateur radio. A big step forward in the automatic-key field, it has the ability to hold a dot or a dash and send it at the proper time, thus eliminating much of the need for perfect rhythm on the part of the operator. As the inventor says, "It gives Kleinschmidt output with Lake Erie input."

The history of the key's development is a story in itself, and one that we have followed with the author for about a year and a half. During that time several versions have been submitted to *QST*, and uncounted more have been devised and tested by the author. The present key is, therefore, a simplification of the original concept and a key that anyone can build and put to use.

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[1] Herbstreit, "Automatic Spacing of Letters and Words for the Electronic Key," *QST*, April, 1951.

[2] Pat. pending.

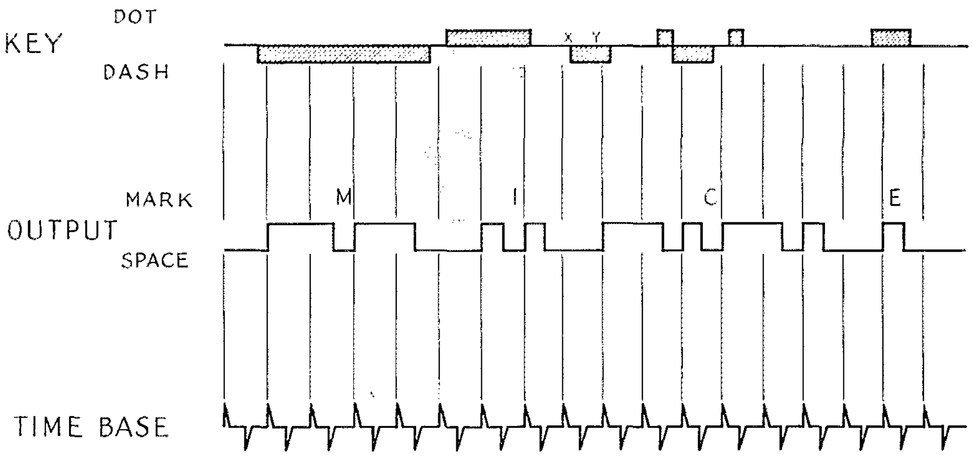


Fig. 1 — Some possible key-lever positions during the sending of the word "MICE" illustrate how the "Ultimatic" key corrects for operator timing errors.

key takes over from the operator and corrects his timing errors. For example, his poor spacing of the "M" and "I" would normally show up as a poorly-sent "Z," but here the too-short space allowed after the completion of the "M" is corrected to a full letter space by the Ultimatic. Farther along, the first dash of the "C" is made too soon after the "I," but the key corrects for it, as well as for the sloppy spacing within the "C." The "C" also illustrates the memory principle to its fullest capability — notice that the last dot of the "C" is hit while the last dash is just starting, but it shows up correctly in the output.

This particular model was selected for description because it proved to be the simplest to build and the easiest to adjust. Motor-driven cams, capacity-delayed buzzers, squared sinewave and sawtooth oscillators, etc., have been used successfully for the time base. Directly-operated relay integrators, flip-flop triggers, gas triodes, blocked oscillators, transistors — all work equally well as marking generators, memory and sequence circuits. With three more inches on the box, secondary memories fit in, permitting advance storage of a full letter C or umlaut A (· - - -).

General Circuit Data

A hazard was introduced in minimizing this model's bulk and, for safety's sake, the line rectifier and heater string should be operated from an external isolation transformer. Unregulated 140 volts is fed to the relays, while the cathode-coupled multivibrator is run from 108 volts regulated and decoupled to prevent reaction from relay and line surges.

All relays are open in the idle circuit condition, as shown in the schematic in Fig. 2. The back contacts are shown above the relay arms and will be called "*B*" in the discussion. The contacts made when the relays are closed are drawn below the arms and will be called "*C*." The figure "*6C*" would therefore refer to the contact closed when relay K_6 is energized. A constant holding current of 1.5 ma. flows in all relays via series tubes or resistances. This does not cause operation of the relays, but holds them closed after pull-in by a pulse.

To separate the functions of the various components in the circuit, a tabulation is given below:

Component Summary

Power: CR_1, R_6, R_{27}, R_{28}, C_1, C_9, V_7.
Time Base: V_1, V_2, C_2, C_3, R_2, R_3 (speed range limiter), R_4 (speed control), R_5 (mark-to-space control).
Differentiator: C_4, R_{12}, R_{10}, R_{11} (load isolation).
Dot Generator: V_4, V_5, R_9, R_{16}, R_{19}, K_1 (dot output), K_2 (dot memory clearance).
Dash Generator: V_3, V_6, R_7, R_8, R_{14}, R_{15}, R_{17}, R_{18}, C_5R_{13} (release delay), K_3 (dash output), K_4 (dash memory clearance).
Dot Memory: K_7, C_8, R_{25}, R_{26}.
Dash Memory: K_6, C_7, R_{22}, R_{23}.
Memory Clearance: C_6, R_{24}.
Sequence: K_5, R_{20}, R_{21}.

Time Base

The time-base generator is a cathode-coupled multivibrator, which generates rectangular-shaped waves. The on-off ratio can be adjusted by the setting of R_5 — the sketch in Fig. 1 is plotted for a true square-wave ratio. The frequency is set by the adjustment of R_4. When the square wave output from V_2 is passed through the differentiator circuit C_4R_{12}, only the spikes shown in the third line of Fig. 1 get through, corresponding to the rise and fall of the square wave.

Dot Generation

These alternate positive and negative pulses are applied to the grids of V_4, V_5 and V_6. When the key is idle, the cathode of V_5 is heavily biased and the pulses have no effect. Ground on the dot bus from the key or dot memory applies 13 volts cut-off bias to the cathode of V_5 from $R_{16}R_{19}$. The first positive pulse at the grid of V_5 then produces a 4-ma. peak pulse through K_1, K_2 and closes them. The marking output starts at closed *1C*. The 1.5 ma. through R_9 and V_4 holds K_1 and K_2 closed until the following negative pulse cuts off V_4 and releases them. A second dot marking baud cannot be generated until the arrival of the next positive pulse, one baud later. This provides the spacing baud to complete the dot.

Dash Generation

Similarly, V_6 closes K_3K_4 on a positive pulse when the dash bus is grounded at the key or dash memory. Dash output begins at *3C*. K_3 and K_4 hold in via R_{14} and *1B*. The opening of *3B* lifts ground from the grid of V_3. When the following negative pulse cuts off V_4 and V_5, the grid of V_3 is raised to its plate potential via R_8 and R_9 during the pulse. K_1 and K_2 close on the resultant 4-ma. pulse through V_3 to continue the marking output at *1C*. The K_3K_4 holding current is now interrupted at open *1B*. These relays release after C_5 charges. This delay guarantees that *1C* closes before *3C* opens. The following positive pulse does nothing except momentarily pulse K_3 and K_4 if the dash bus is grounded. The second negative pulse releases K_1 and K_2, as in dots.

Dot Memory

While the memory is idle, C_8 discharges across R_{25}. Grounding the key dot contact charges C_8 through K_7. The 8-ma. peak pulse closes the relay, which then holds in on the 1.5 ma. through R_{25}, R_{26} and *7C*. Ground is maintained on the dot bus at *7C* independently of the key. When K_2 closes later on for this stored dot, discharged C_6 is applied to the top of K_7 via *2C*, releasing the relay to clear the memory. Steady ground at the key generates successive dots. The resistor R_{24} is more than a spark suppressor — it also prevents reverse-current hang-up of the relay because of the large capacity of C_6.

Dash Memory

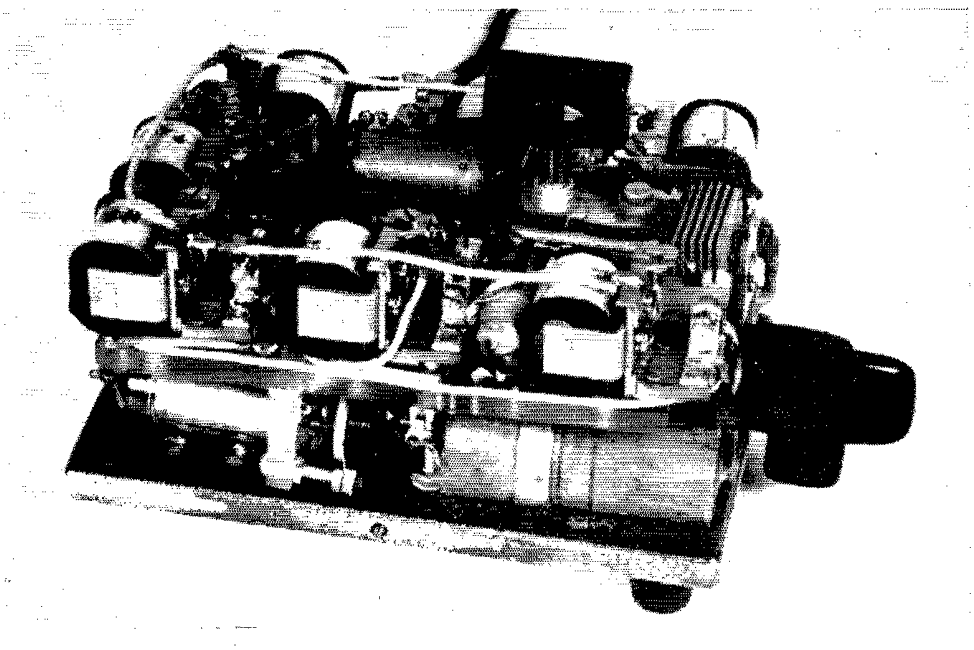
Similarly, ground at the key dash contact closes K_6 by charging C_7. Independent ground is maintained on the dash bus at *6C*. The memory is cleared by C_6 via *4C* and *2B* when K_4 closes at the start of the stored dash. Contact *2B* is never open when *4C* initially closes on a dash. When *2C* does close after *4C* has already closed, C_6 has charged up enough so that it does not affect K_7. Therefore, the action of *2C* clears only the dot memory, and *4C* only the dash memory. Steady ground at the key generates successive dashes.

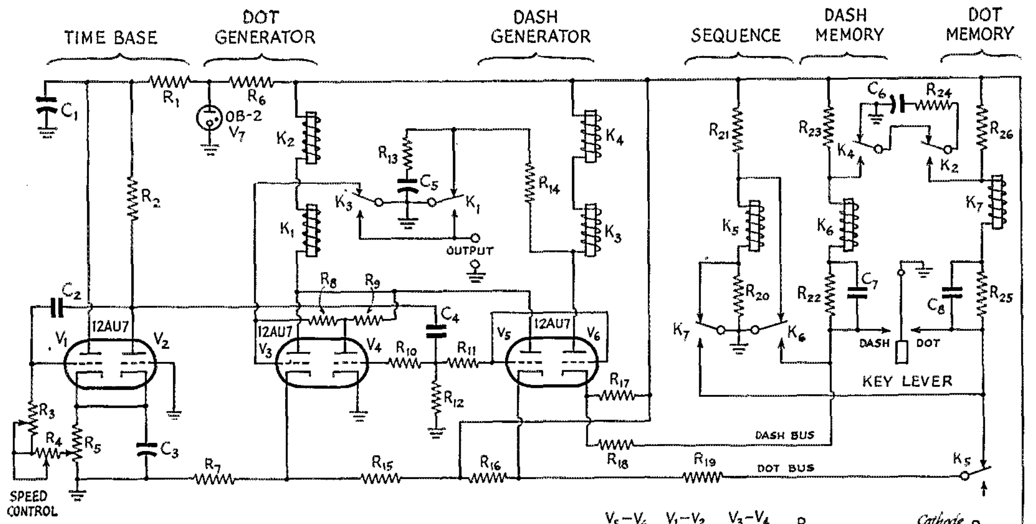
Spacing Characters

A one-cycle interletter spacing is obtained if the new letter is started at the key any time between the two successive positive pulses following the preceding letter's last spacing baud. The key need be merely bumped, not held until the second pulse. The memories hold the character until that second pulse. Interword spacing of two cycles is obtained by starting the new word at the key any time between the second and third positive pulses following the preceding word's last spacing baud. In Fig. 1, the key may be bumped, or held solidly, any time between "x" and "y" to start the "C."

The first two characters of a letter may be stored during the last cycle of the spacing character. The time base thus corrects underspacing at the key, and the memory eliminates the necessity for the manual delay used to get adequate spacing, which usually results in overspacing.

The "Ultimatic" key is built on two sides of a sheet of plastic, and the whole is mounted on an iron plate.





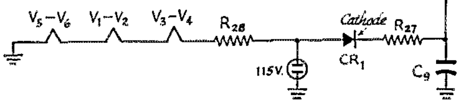


Fig. 2 — Circuit diagram of the "Ultimatic" key.

C_1 — 40-μfd. 150-volt electrolytic. See C_9.
C_2 — 0.03-μfd. 200-volt paper.
C_3, C_6 — 0.25-μfd. 200-volt paper.
C_4 — 0.01-μfd. 200-volt paper.
C_5 — .1-μfd. 200-volt paper.
C_7, C_8 — 0.05-μfd. 200-volt paper.
C_9 — 120-μfd. 150-volt electrolytic. (Three 40-μfd. in parallel. C_1 and C_9 made from two dual 40-μfd. electrolytics. Sprague 18F178).
R_1 — 1000 ohms.
R_2 — 56,000 ohms.
R_3 — 0.5-megohm volume control.
R_4 — 4-megohm volume control.
R_5 — 3000-ohm volume control.
R_6 — 1800 ohms, 1 watt.
R_7 — 15,000 ohms.
R_8 — 3.3 megohms.
R_9 — 62,000 ohms.
R_{10}, R_{11} — 2.2 megohms.
R_{12} — 0.15 megohm.
R_{13}, R_{18}, R_{19}, R_{24} — 2700 ohms.
R_{14}, R_{22}, R_{25} — 82,000 ohms.
R_{15}, R_{16}, R_{17} — 27,000 ohms.
R_{20} — 75,000 ohms.
R_{21} — 18,000 ohms, 2 watts.
R_{23}, R_{26} — 8200 ohms.
R_{27} — 25 ohms, 1 watt.
R_{28} — 530 ohms. 330- and 200-ohm line cords in series.
All resistors ½-watt unless specified otherwise.
CR_1 — 75-ma. selenium rectifier.
K_1 through K_7 — 8000-ohm s.p.d.t. relay (Sigma 4F). See text for adjustment.
NOTE: The 12AU7 is the only dual triode that is rated to stand the 140 volts heater-to-cathode when the busses are open.

Accurate overspacing in three- and four-cycle units is available for feeble signal work.

Sequencing

A dot and a dash often are so rapidly stored, in that order, that both busses are grounded before the dot is started by a positive pulse. Subsequent closure of *2C* by the dot generator clears the dot memory, but the simultaneous brief closure of *4C* by the dash generator does not clear the dash memory because of open *2B*. The dash remains in storage until the dot is completed and then appears after the dot's spacing baud. Contact *4C* clears the dash memory this time, as *2B* is closed.

A problem arises when a dash-dot combination is similarly stored. Ground on both busses would permit operation of the dot generator first, converting the stored dash into a dot to be followed by a dash in reverse order. However, when K_6 stores the dash the opening of *6B* provides 6 ma. to pull in K_5 via still-closed *7B*. When *7B* opens as the dot goes into storage, the current through K_5 drops to 1.5 ma. for holding. Open *5B* removes the memory ground (and key) from the dot bus until the dash has been started first, and the dash memory cleared. Contact *6B* then reshorts K_5, and the stored dot reappears as ground on the dot bus via *5B*. The dot follows the dash in the order keyed.

Returning to the combination dot-dash: *7B* opens first (on the dot), so the current through K_5 is only 1.5 ma. when *6B* opens (on the dash), and the relay does not close. Ground on the dot bus therefore appears through *5B*. As the dot starts and the dot memory clears, *7B* closes. K_5 pulls in since *6B* is still open on the stored dash. After this instant another dot to follow the dash may be stored for an "R." The "Sequence" would then be holding a dash-dot series.

Timing Leeway at the Key

It is to be noted that once a character has been stored in the memory it appears at the output in the order of selection, independently of the position of the key. A dot can be coming out while the key is being held to dashes, or while the operator is applying a match to his pipe. A stored dash can be transmitted while the operator waits over on the dot side or just relaxes. For the amazement of visiting speed merchants, one can crank the speed down low and demonstrate the maximum full three-cycle interval during which a dot may be struck off when it follows a dash in a letter. In ordinary sending not much more than one or two bauds of leeway is actually used or needed within a letter, but by taking advantage of three or more bauds of leeway, continuously perfect letter and word spacings come up with no attention whatsoever paid to the spacing.

If Fig. 1 were transmitted as is, it would read ZTR E, and very poorly at that; yet it comes out MICE *a la* Klein, with proper letter and word spacing. Any character can be keyed as late as the positive pulse that would start the character, or as early as right after the pulse that starts a foregoing spacing cycle or like marking character. When it is the second character in a letter, it can be stored as early as right after the pulse that starts the last spacing cycle prior to the letter (after storage of the first character, of course).

Construction

The Ultimatic key works equally well spread all over the work bench or jammed into the same volume occupied by an ordinary bug. The photographs show some of the details. The relays and associated *RC* components are assembled on top of the notched ¼-inch lucite deck. The four sockets are fastened to the lucite bracket glued to the deck, with most of the time-base and generator components tied to the socket terminals. The power supply components and speed control are mounted on and about the bug frame. R_3 and R_5 are mounted under the frame with shafts projecting through counterbored holes in the 4 × 6 × ⅜-inch iron base. The deck is then attached to the base on four long pillar bolts and the few interconnecting wires tied down. No tie-point strips are used. Resistor and condenser leads pass through small holes drilled in the plastic and are secured with solder blobs on the far side. Wires are tied to these leads on both sides of the lucite. The entire circuitry could just as well be spread out in the station rack with only the key and speed control leads brought out to the desk.

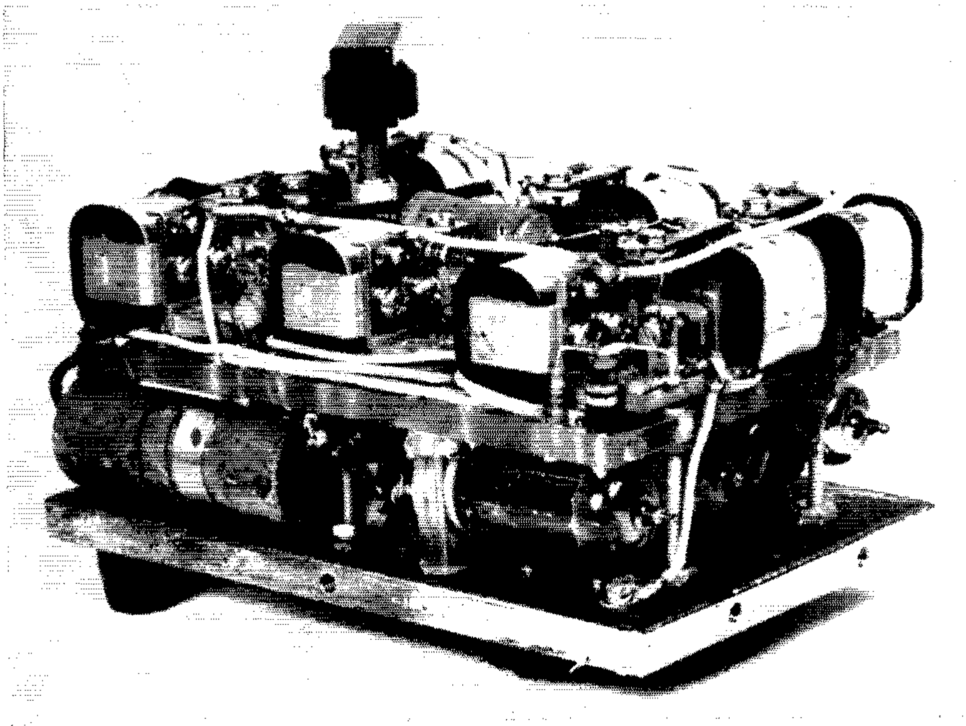
The cover is ¼- and ⅛-inch plastic sheet cemented together and painted with black auto lacquer. The base and rear of the cover are riddled with ¼- and ⅛-inch ventilation holes. That weird knob accommodates the radically different reaches and techniques of the author and wife while it plugs up the unavoidable slot in the cover.

Adjustment

The relays are all initially adjusted to close on 2.0 ± 0.1 ma. and to open on 1.0 ± 0.1 ma. These figures are readily met with 0.008-inch armature travel and 20 to 23 grams spring tension when the operated contact is turned in just far enough for reliable contact. With two relays in series in the generators there is a tendency for one relay only to close on the exceedingly short pulse. A slight variation of the armature travel at the back contact on one relay of the string equalizes the relays for simultaneous operation. Use of d.p.d.t. relays such as the 10,000-ohm Potter Brumfield type

(Continued on page 120)

Another view of the key shows the four tubes mounted between the iron and plastic plates.



A.R.R.L. ACTIVITIES CALENDAR

Feb. 6th-8th: DX Competition ('phone)
Feb. 8th: CP Qualifying Run — W6OWP
Feb. 11th: Frequency Measuring Test
Feb. 17th: CP Qualifying Run — W1AW
Feb. 20th-22nd: DX Competition ('phone)
Mar. 6th-8th: DX Competition (c.w.)
Mar. 13th: CP Qualifying Run — W6OWP
Mar. 18th: CP Qualifying Run — W1AW
Mar. 20th-22nd: DX Competition (c.w.)
Apr. 3rd: CP Qualifying Run — W6OWP
Apr. 11th-12th: CD QSO Party (c.w.)
Apr. 16th: CP Qualifying Run — W1AW
Apr. 18th-19th: CD QSO Party ('phone)
May 9th: CP Qualifying Run — W6OWP
May 15th: CP Qualifying Run — W1AW
June 6th-7th: V.H.F. Contest
June 7th: CP Qualifying Run — W6OWP
June 15th: CP Qualifying Run — W1AW

The "Ultimatic"

(Continued from page 15)

LM11 would eliminate this adjustment which, incidentally, is the only one required other than setting up the mark-space ratio and the top speed.

With an ohmmeter connected to the output, R_5 is twisted for midscale reading on dots. It will read ¼ scale on dashes. The mark-space ratio holds within 2 per cent from 1 to 75 w.p.m. With 0.004-inch armature travel, the variation is 0.5 per cent, but with such small travel the relay current range is reduced from 1 to 0.25 ma., resulting in unstable operation if the line voltage varies more than ± 10 per cent. With 0.008-inch travel, the circuit is stable from 90 to 140 volts.

A value of 0.27 megohm at R_3 gives a speed range of 4 to 75 w.p.m. when R_5 is set for 50–50 mark-space. R_5 affects the top speed considerably. When a distorted mark-space ratio is set up to compensate for distortion in connected equipment, R_3 must be readjusted for the desired top speed.

Operating the Keyer

A detailed study of Fig. 1, with contemplation of what occurs when the key is closed at times other than those shown in the first line, will greatly help in getting the hang of the Ultimatic. At first, the speed should be set at minimum (or lowered to a fraction of a w.p.m. by shunting C_2 with 0.25 μfd.) and games played on the knob. Rip off a 50-w.p.m. "A" before the dot shows up in the output, or an "N" before the dash appears, and listen to the stuff drag out while you fumble for smokes with the sending hand. Make a "K" by holding the dash side until the output starts, and then add the rest with the quickest flips possible. Convert it to a "C" as soon as you hear the dot, or anytime during the second dash. Make a "Y" by flipping dash-dot and immediately lay on the dashes (all before the first dash starts). The entire letter comes out while the key

(Continued on page 122)

is held to dashes. Reverse this for an "L." These initial practices will check operation of all the circuits.

Then, with the speed set at 10 to 15 w.p.m., key at various (and varying) speeds. It will be found that the hand can move, on the average, somewhat slower than the output or a great deal faster. As the speed control is slowly advanced there will appear an abrupt point at which the output goes completely to pot. At this speed, determine whether the hand is *averaging* too slow or too fast. A few hours of operation, always just below the break-up speed, will acquaint the fist with the memory leeway effect, and the speed of easy perfect sending will climb and climb. In the meantime, what would ordinarily be drudgery is pure pleasure listening to the beautiful stuff coming out. Practice preferably from written copy.

Thirty-w.p.m. top-speeders have made it to 50 in a couple of weeks,[3] with far less concentration than originally. The quality won't be indifferent or just good — it will be perfect. Now we can all sound like WCX.

[3] But not without being able to *copy* 50 in the first place! — Ed.

Clapp Oscillator

(Continued from page 81)

have been a result of the increased current brought about by the by-passing effect of the coaxial cables. In his final circuit arrangement, the majority of the circulating current has been confined to the remote control box by placing the lumped capacitance of the feed-back condensers in that position, so that any losses in the coaxial cables should have been reduced.

In closing, here's hoping I'll be seeing you on 7023 kc. some time. Yes, I'm "rock bound," but not for long (I hope) now that I know where to look for some of the bugs that are going to arise when I build that new Clapp VFO oscillator!

Appendix

Suppose that an r.f. current, i_1, is flowing around the circuit in the direction shown. The voltage developed across the terminals *1–1*, is equal to $i_1 z_1$, that is,

$$e_1 = i_1\left[R + j\left((\omega L_1 - \frac{1}{\omega C_1}\right)\right]$$

Consider now the voltage developed across the feed-back condensers across the terminals *2–2*. Let the plate current be $i_2 = g_m e_g = g_m(i_1 j X_2)$. The voltage developed across the feed-back condensers will be the sum of the voltages produced by the two currents which are flowing.

$$\begin{aligned}\text{That is, } e_2 &= i_1(jX_2 + jX_3) + i_2 jX_3 \\ &= i_1 j(X_2 + X_3) - (g_m i_1 X_2)X_3 \\ &= i_1\left[-g_m X_2 X_3 + j(X_2 + X_3)\right]\end{aligned}$$

If the two voltages we have found above are

(Continued on page 124)