The Accu-Memory

BY JAMES M. GARRETT,* WB4VVF AND
D. A. CONTINI,** W4YUU

THE RESPONSE to the Accu-Keyer[1] has really been enthusiastic. There have been over 4000 ready-made keyer boards shipped, and no way of telling how many additional boards have been made from published etching patterns, so someone must still be interested in cw. Many enthusiasts have requested an add-on memory system. The system described below permits storage of up to 200 letters of text[2] organized in one, two, three, or four messages. A digital display provides an indication of the message being sent or loaded (No. 1, 2, 3, or 4) and the message bit being addressed (0 to 512). Any number of pauses may be programmed into a message to allow manual insertion of changeable text (such as RST or contest serial number). After manual insertion a touch of the RUN button allows the remainder of the programmed message to continue. The message being sent may be aborted by pressing the STOP button (the "I didn't mean to press the button!" button). Unlike some programmable keyers, the use of a free-running (asynchronous) clock in the load mode has been avoided, greatly simplifying the loading process. All features of the original Accu-Keyer have been retained. The dot and dash memories of the Accu-Keyer and its automatic character-space feature are used to good advantage in the Accu-Memory along with an added feature, a tone oscillator and speaker.

In addition to the Accu-Keyer board, three printed circuit boards make up the Accu-Memory: a memory board, a display board, and a display-driver board. A heftier power supply than used in the Accu-Keyer provides 5 volts at 0.8 ampere to power all the circuitry.

The circuitry has been arranged so that those not wishing to tackle the entire project may omit the bit-display feature (two pc boards including the tone oscillator). The memory board may be constructed with but one memory IC (1024 bits of memory) and the second memory IC added at a later date. Since the message indicator display is located on the memory board, the message display feature can be retained even if the bit display is not included. At a minimum, an existing Accu-Keyer can be upgraded to an Accu-Memory by the construction of one additional pc board (13 ICs) and a huskier power supply.

The Accu-Memory has been "battle tested" in three contests and has been found to be very effective in reducing operator fatigue. It is of use whenever there is a requirement for repeatedly sending the same cw sequences such as in contests, DX pileups, and net-control operations. Experience has shown that the digital displays are far more useful than originally anticipated.

Operation of the Random-Access Memory IC

The storage capability of the Accu-Memory is provided by use of a static random-access memory (RAM). Two type 2102 or 2602 MOS ICs, each a 1024-word by one-bit device, are employed to provide 2048 total bits of storage capacity. The 2602 ICs are available from quite a few manufacturers including Intel, Mostek, TI (TMS 4035 NL), and Signetics. Initial prices were about $25 each but they are now starting to appear in the "discount" ads at about $15 and the price trend is downward. Dynamic RAMs cannot be used in the Accu-Memory. A static type of RAM will store data for as long as power is applied and does not need to be "refreshed," as is the case with a dynamic RAM. The main advantage that a RAM offers over a shift register is the instant access to any memory location that the RAM allows.

[1] **For this and all subsequent references, see the listing at the end of this article.**

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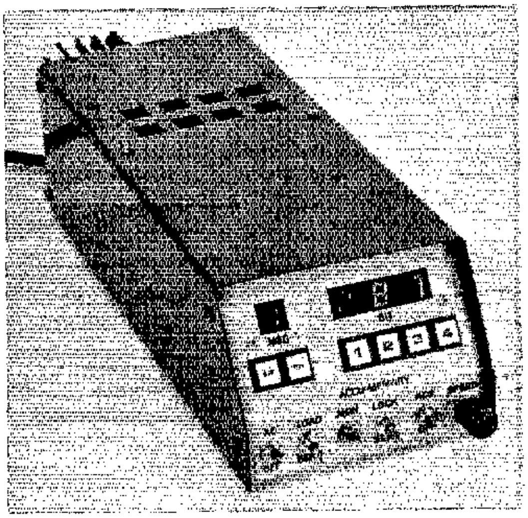
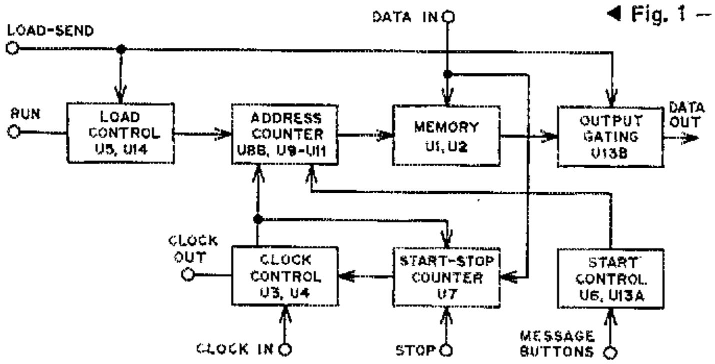


The front view of the Accu-Memory



◀ Fig. 1 – Block diagram of the Accu-Memory.

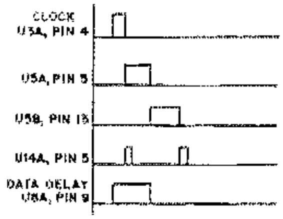


Fig. 2 – Timing diagram.

Ten of the 16 pins of the 2602 are "address" inputs (pins) 1, 2, 4, 5, 6, 7, 8, 14, 15, 16). The possible different binary combinations of these ten inputs total 1024. The first memory location is addressed by applying 0000000000 to these lines, the second by 0000000001, and the 1024th by 1111111111. The RAM has two modes of operation, read and write, as selected by the read/write input (pin 3). When pin 3 is low (write), the data (high or low) being applied to the data input (pin 11) are loaded into the memory position selected by the address inputs. When pin 3 is high the stored data in the memory locations cannot be changed. In the read mode (pin 3 high) the "data out" line (pin 12) presents the data stored in the locations being addressed. In the Accu-Memory the output lines of a binary counter are connected to the address inputs of the RAM. The counter input is connected to the keyer clock. In operation, the clock is started and the counter "counts" the keyer clock pulses and the counter outputs sequentially step the RAM through all its addresses. In the LOAD mode the cw characters from the Accu-Keyer are written into the memory positions as ones and zeros. In the SEND mode the stored ones and zeros forming those cw characters are read from the memory and fed into the output stage of the keyer. As the counter counts the clock pulses and steps the memory through its addresses, cw characters are produced at the keyer at the speed to which the keyer is set.

Pin 3 is normally held high and in the write mode is pulsed low after the address inputs have reached the intended binary number and the data input is stable. If pin 3 were held low continuously in the write mode rather than pulsed, the data would be "smeared" – written into more than one location is memory.

An important function is provided by the chip-select (pin 13) input. Unless $\overline{CE}$ is low, no data is produced at the data output pin and no data can be loaded into the input pin. Thus several memory ICs can be combined into a larger memory by connecting all corresponding leads of the ICs in parallel and addressing the desired IC through the use of the chip-select pin. In the Accu-Memory two 1024-bit RAMs are connected to act like a single 2048-bit RAM in which the chip-select input behaves like an eleventh address input.

A word is in order about the organization of RAMs. The 2602 is organized as a 1024 × 1 RAM. This means that there are 1024 bits of memory addressable, one bit at a time. A 512 × 2 RAM has the same total bits, 1024, but they are addressable only in pairs. Likewise, a 256 × 4 would have 1024 bits addressable four at a time. In these RAMs, two or four input and output lines are provided instead of one.

Theory of Operation

A detailed circuit description would be lengthy and difficult to follow, so a functional description will be given that will enable interested readers to trace through the logic. Fig. 1 is a block diagram of the memory and reference will be made to the functional names in this description.

The RAMs, U1 and U2, are described in the previous section. In both SEND and LOAD modes they are addressed by a binary counter consisting of U9, U10, U11 and U8B. The initial start count for the address is determined by presets, generated by U6 and U13, and controlled by the push buttons for message selection. Jumpers are used to vary the preset depending on whether one or two memories are installed.

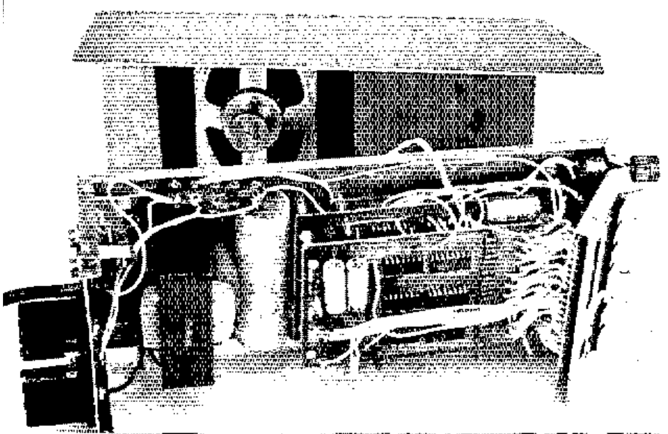


Fig. 3 – A look at the inside of the Accu-Memory. The power supply components may be seen at the left, and the three "stacked" circuit boards to their right. The fourth circuit board, containing the readout, is mounted behind the sloping portion of the front panel. The board at the bottom of the "stack" is that of the original Accu-Keyer (see reference 1).

In the SEND mode, the output of the memories is connected to the Accu-Keyer manual key input and the memory addressed sequentially by the keyer clock. U7 is used as a start-stop counter. It will gate off the clock and thus prevent the memory from advancing if nine sequential zero bits are detected in the output data. These nine zeros are placed at the end of each message in the LOAD mode as a stop signal.

In the LOAD mode U5 and U14 are used to generate load commands to the memories. To load them correctly, it is necessary for the proper sequence of commands to occur. One-shot multivibrators U5 and U14 generate this sequence.

TABLE I – INTERCONNECTIONS

WIRE NUMBER	FUNCTION	
Keyer-to-memory interconnections.		
1	Clock – connect to R6	
2	Anode CR1	
3	Cathode CR1 (Remove CR1 in keyer and connect as shown.)	
4	Data in (Connect to U7B in keyer and tone oscillator on driver board.)	
5	Data out (Connect to manual key input, U7B pin 5 in keyer.)	
Memory-to-control switches		
6	Send 1	Dpdt switch
7	Send 2	
8	Load 1	
9	Load 2	
10	Common 1	
11	Common 2	
Memory to readout		
12	Insert	Push buttons
13	Insert return	
14	Reset 1	
15	Reset 2	
16	Reset 3	
17	Reset 4	
18	Reset common	
19	Stop	
a, b, c, d, e, f, g	Quadrant readout	
Memory to driver		
20	Readout count	
21	Readout reset	
22	Readout quadrant reset (use with one 2601)	
23	Readout quadrant reset (use with two 2602s)	
24	NOR 1	
25	NOR 2	
26	NOR out	
Driver to readout		
27-33 (a-g, LSB)	Least-significant digit	
34-40 (a-g, CSB)	Center-significant digit	
41-47 (a-g, MSB)	Most-significant digit	
48-49	Pitch control (short if no control desired)	
50	Speaker	

Memory interconnections

For one memory IC connect:	A to H, B to G, C to I, D to F, J to ground, K to + 5 V, L to N, and M to O.
For two memory ICs connect:	A to J, B to I, C to K, D to H, E to F, G to + 5 V, L to O, and M to P.

Connect DP (decimal point) on readout board to wire 13.

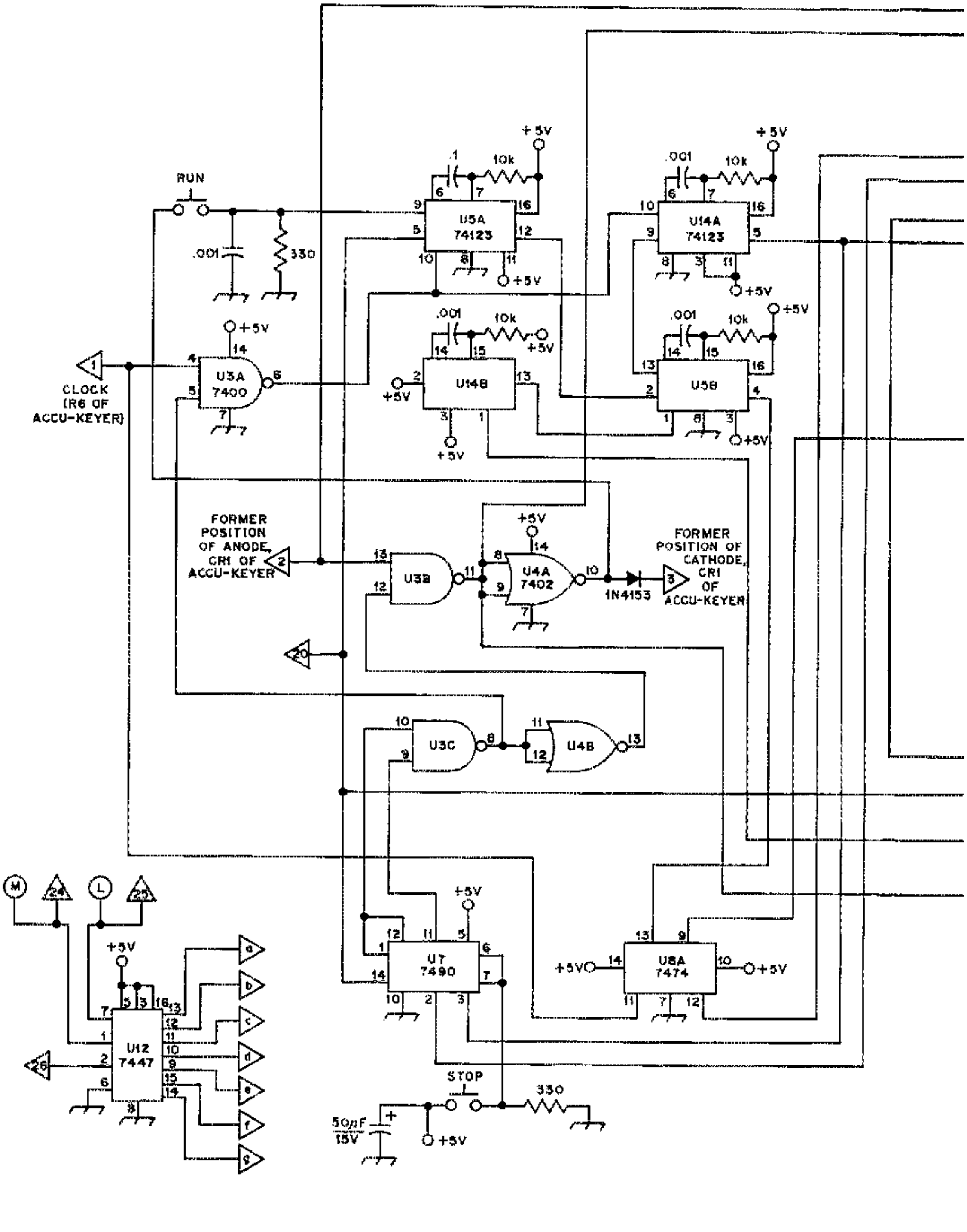
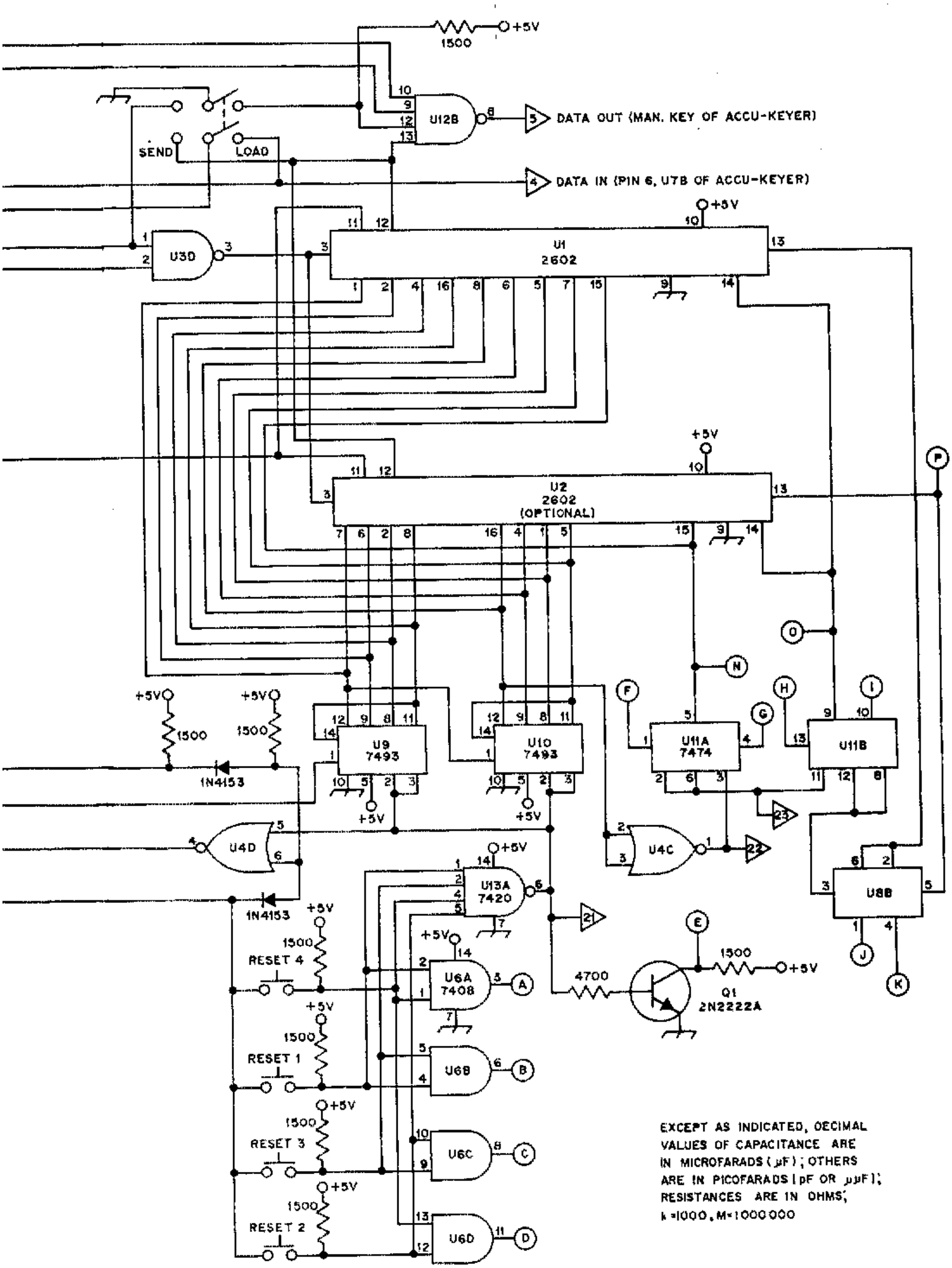


Fig. 4 — Diagram of memory circuitry of the Accu-Memory. See Table II for list of parts. Numbers and letters in triangles identify inter-connections to other parts of the Accu-Memory, as listed in Table I. Letters in circles indicate terminals for jumpers to be wired for either one or two RAM ICs. This wiring information is also listed in Table I.


+5V
1500
SEND
LOAD
U12B
DATA OUT (MAN. KEY OF ACCU-KEYER)
DATA IN (PIN 6, U7B OF ACCU-KEYER)
U3D
U1
2602
U2
2602
(OPTIONAL)
U9
7493
U10
7493
U11A
7474
U11B
U8B
1N4153
U4D
U4C
U13A
7420
U6A
7408
U6B
U6C
U6D
RESET 4
RESET 1
RESET 3
RESET 2
4700
Q1
2N2222A
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF); OTHERS ARE IN PICOFARADS (pF OR μμF); RESISTANCES ARE IN OHMS; k=1000, M=1000 000

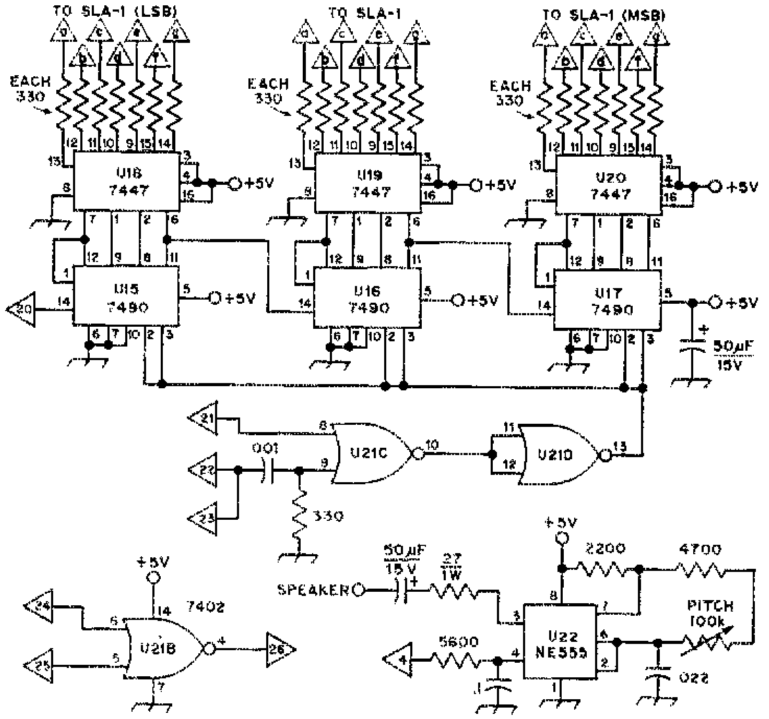


Fig. 5 — Diagram of driver and display. See Table II for list of parts. Numbers inside triangles identify interconnections to other parts of the Accu-Memory, as listed in Table I.

When a message button is depressed in the LOAD mode, the memory is preset to the correct message start point and the address counter to zero. U7, a decade counter, will allow the keyer clock to run unless it is at a count of nine. Inside U7 an AND function takes place from inputs on pins 2 and 3, and results in U7 being reset to zero if data are present from the keyer and a clock pulse occurs (as it will when the paddle is closed). U3B and C and U4A and B are used to keep the clock in the keyer running until the stop signal (nine sequential zeros) occurs. Operation of U7 is identical in the SEND mode except the data output of the memory is AND gated with the clock pulse.

Each clock pulse generated by the keyer initiates the series of pulses shown in the timing diagram, Fig. 2. The data (1 or 0) from the keyer output are stored in flip-flop U8A on the leading edge of the clock pulse. The output of U8A is the input to the memories. From Fig. 2 it can be seen that a load command is sent to the memory twice from U14A. In between these commands the memory address is changed by U5A pin 5, and U8A is reset by U5B pin 4. This results in loading the input data in one location, incrementing the address by one, and then loading a zero in the next address. This zero is changed by the next clock pulse except in the case where U7A stops the clock. In this case the zero is not cleared and nine consecutive zeros are written into the memory. At the end of each word of message, therefore, a series of nine zeros is put in. The ninth zero will be changed to a one by the next word, except at the end of the message. In the SEND mode, this will cause U7 to stop the clock.

U3A is used to block the clock to the one-shots except when U7 is reset. The keyer can therefore be used manually without advancing the memory address when U7 times out or is stopped with the STOP button. U3D blocks load commands to the memory in the SEND mode.

As a manual input, the STOP button will force U7 to a nine count, stopping the memory. The RUN button, in the LOAD mode, manually triggers one-shot U5A which causes U7A to count from 9 to 0, and thus causes the clock to run until U7 again reaches a count of nine. This action loads eight additional zeros into the memory at the end of the nine already there at the end of the previous word. A second part of the message is then loaded. In the SEND mode, the message will stop at the end of the first nine spaces, allowing manual insertion. If the RUN button is then depressed, U7 will reset and attempt to count to nine, but on the count of nine new data will appear, reset U7, and keep the memory running.

A seven-segment decoder, U12, decodes the memory message location and drives a message readout. It is connected to count from one to four (a zero count on pins 1 and 7 is changed to a four count by a NOR gate, U21, on the driver board).

The bit readout is driven by a three-stage BCD counter/decoder consisting of U15-U20. The reset line and count line from the memory address counter are used to start the bit count at zero and advance it in step with the memory advance. Also, each time the message number changes during SEND or LOAD the bit count is reset.

The tone oscillator is quite conventional and uses an NE555 timer. It is contained on the readout driver board.

Construction

As shown in Fig. 3, the Accu-Memory is constructed in an aluminum box made by cutting and bending sheet aluminum. The front-panel dimensions are deliberately made small because depth in most ham shacks is more abundant than frontal-area space. This method also gives a neat, streamlined appearance. The overall outside dimensions are 4-1/4 × 3-1/4 × 10-1/2 with the length dimension measured across the bottom plate, less knobs and heat sink. The heat sink for the LM309 is attached to the rear panel,[3] along with the key jack, the output jack, and a fuse holder (Safety First!). Power supply components are located on the bottom plate near the rear. Two terminal strips are used to mount the power supply diodes and filter capacitor. All the other electronic parts are mounted on four printed-circuit cards.

Three of these cards are "stacked" on top of each other while one, the readout board, is attached to the front panel. The bottom board is the basic Accu-Keyer board, followed by the memory board, and the driver board on top. These boards are mounted using No. 4 screws with spacers for separation. The interconnecting wiring was routed around the front of the boards so that, with screws removed, they could be lifted easily for service (not required as yet). The readout board is attached to the back of the front panel after the panel has been drilled. All the rectangular holes can be made with a 1/2-inch square chassis punch. The miniature switches and speed control are mounted along the bottom edge of the panel.

A small speaker is mounted in the box lid, using 1/2-inch square holes and a piece of cloth fabric for grille cloth. Holes drilled along the edges of the box lid are used to attach it by means of sheet-metal screws to flanges bent along the box edges. Rubber feet pressed into the bottom holes keep the unit in place.

The push buttons are sold by Solid State Systems (see reference 3). One word of caution: do not increase the value of the filter capacitor in the power supply. It has been chosen for minimum dissipation by the LM309 regulator.

Fig. 4 is a schematic diagram of the circuitry on the memory board and Fig. 5 shows the circuitry on the driver and display board. Figs. 6, 7, and 8 show the pc-board layout and parts placement for the three boards. Wires that interconnect the boards are shown as numbers or lower case letters in triangles on the figures. Selectable jumpers allow the use of one or two RAM ICs. The jumper points are shown as capital letters in circles in Figs. 4 and 6. Table I is a list of interconnecting wires. Table II gives a parts list for each board. Fig. 9 is a diagram of the power supply.

Operation

The memory is designed so that the basic Accu-Keyer retains all its features when the memory function is not in use. Operation of the memory is divided into two modes, the LOAD mode and the SEND mode.

To load a message, place the LOAD/SEND switch in the LOAD position, press the button for the number of the message that it is desired to load, and key in the message. For proper loading, the message should be keyed one word at a time with the automatic character space on. After each word is inserted, the memory counter will automatically provide an eight-bit pause for a word-space interval, and then stop.

To send, place the LOAD/SEND switch in the SEND position and press the proper message button. The STOP button will halt sending, but the message can be continued from the halted point if the RUN button is depressed.

If it is desired to use the insert feature, load the first part of the message as described above. Then after the memory stops advancing, press the RUN button once, wait until the count stops, and then

TABLE II – Accu-Memory Parts List

	Memory Board	
2	7474 ICs	U8, U11
2	7493 ICs	U9, U10
1	7408 IC	U6
2	74123 ICs	U5, U14
1	7400 IC	U3
1	7490 IC	U7
1	7402 IC	U4
1	7420 IC	U13
1	7447 IC	U12 (optional)
2	2102 or 2602 ICs	U1, U2 (U2 optional)
1	2N2222A transistor	
3	1N4148 silicon diodes or equivalent	
8	1500-Ω ¼-W resistors	
4	10-kΩ ¼-W resistors	
2	330-Ω resistors	
1	4700-Ω resistor	
4	.001-µF disk ceramic capacitors	
4	.1-µF disk ceramic capacitors	
1	50-µF 15-V electrolytic capacitor	
	Driver Board	
3	7490 ICs	
3	7447 ICs	
1	7402 IC	
1	NE555 IC	
22	330-Ω resistors	
1	5600-Ω resistors	
1	2200-Ω resistor	
1	4700-Ω resistor (33kΩ with no pitch control)	
1	27-Ω resistor	
1	.001-µF disk ceramic capacitor	
1	.022-µF disk ceramic capacitor	
2	.1 µF disk ceramic capacitors	
2	50-µF 15-V electrolytic capacitors	
	Readout Board	
4	SL A-1 readouts	
6	Push buttons (see text)	
8	330-Ω resistors	

COMPONENT SIDE UP

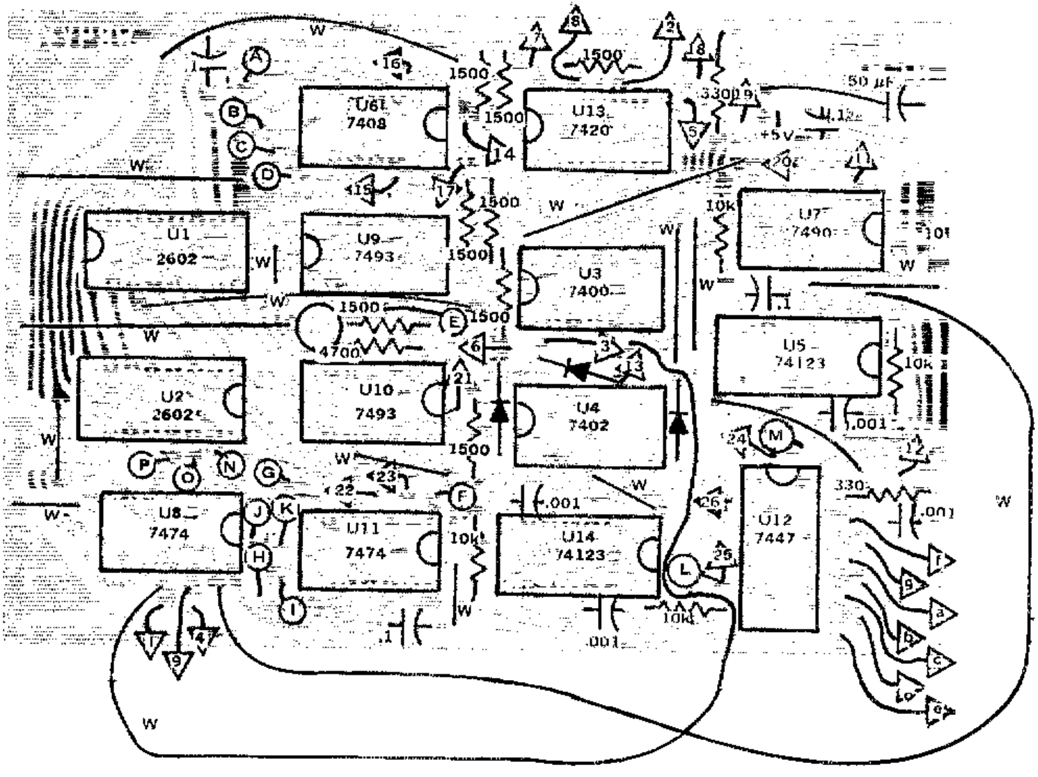


Fig. 6 — Etching pattern and component layout for memory board of the Accu-Memory as seen from component side of board. Ready-made circuit boards are available (see reference 4). Letters and numbers in circles indicate points for connection to other parts of the device, as listed in Table I. W = wire jumpers.

load the second half of the message. In the SEND mode the memory will send the first part, stop and allow insertion of manual input such as signal reports, and then, when the RUN button is depressed, continue with the second half. This procedure may be repeated as many times as necessary.

If a message is too long for one of the four message locations it will automatically continue into the next message location in line. Using this feature, messages of any desired length may be loaded, up to the full 2048-bit capacity.

The readout indicates the message number and the location within the message starting at 000 and continuing through either 256 or 512, depending on whether one or two memories are installed. A decimal point lights when the keyer is sending either manually or automatically.

Helpful Advice

Some additional information that has been gleaned from appearance of the earlier article[1] is perhaps in order. After a lot of correspondence with amateurs who built the Accu-Keyer, it is apparent that some do not know that there is a difference between a 7400, a 74H00, a 74L00, and a 74C00. These are all members of a family of quad two-input gates that are different internally and are not interchangeable (in almost all cases) with each other. Some IC distributors tend to be haphazard about which type they send.

Rf shielding is essential and quite often totally neglected. Each side of the ac line, in particular, should be bypassed to the chassis with .01-µF 1000-V capacitors.

Logic is particularly difficult to troubleshoot by mail, because in almost all cases any number of failures can cause the same problem. Substitution of ICs is the best troubleshooting procedure. Sockets or Molex pins are therefore very helpful. Besides bad ICs, two common problems are improper substitution of parts and solder bridges. Some of the boards that have been repaired looked like they were built by dripping solder on the board from a blowtorch! *A small-tipped iron is essential.* A Polaroid picture taken of the board before assembly will permit easy location of solder bridges later.

As with the Accu-Keyer, ready-made boards are available for the memory through Garrett.[4] A business-size self-addressed stamped envelope is mandatory to reduce addressing time to a minimum. Experience has shown that addressing envelopes is a real problem. Now we know what a

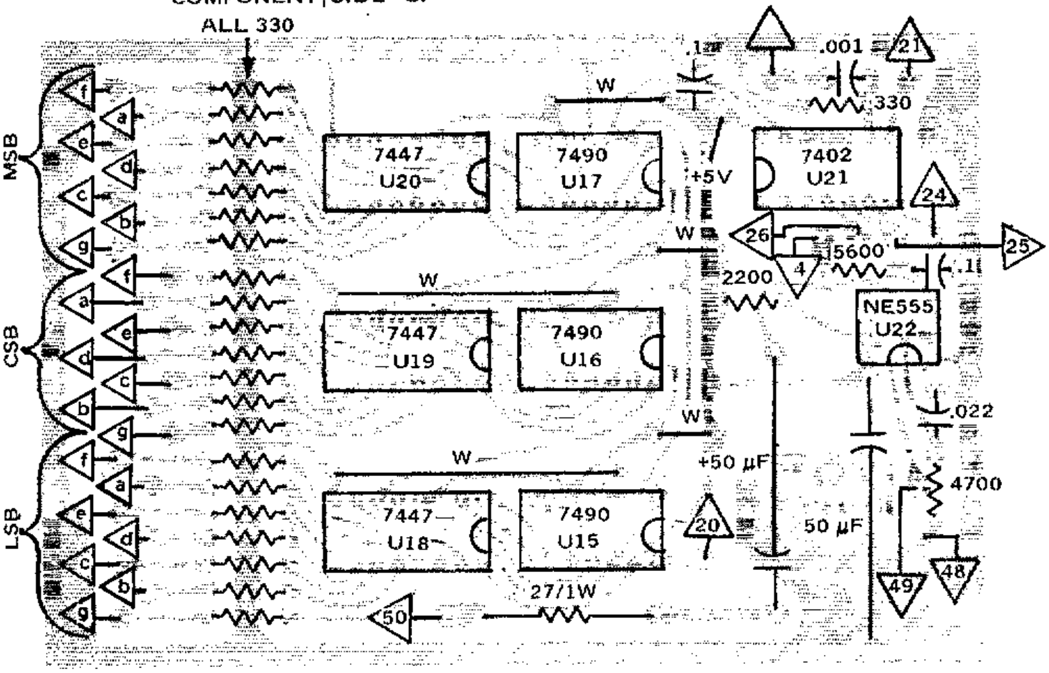


Fig. 7 – Etching pattern and component layout for driver board as seen from component side. W = wire jumpers. See Table I for wiring connections to other parts of the circuit.

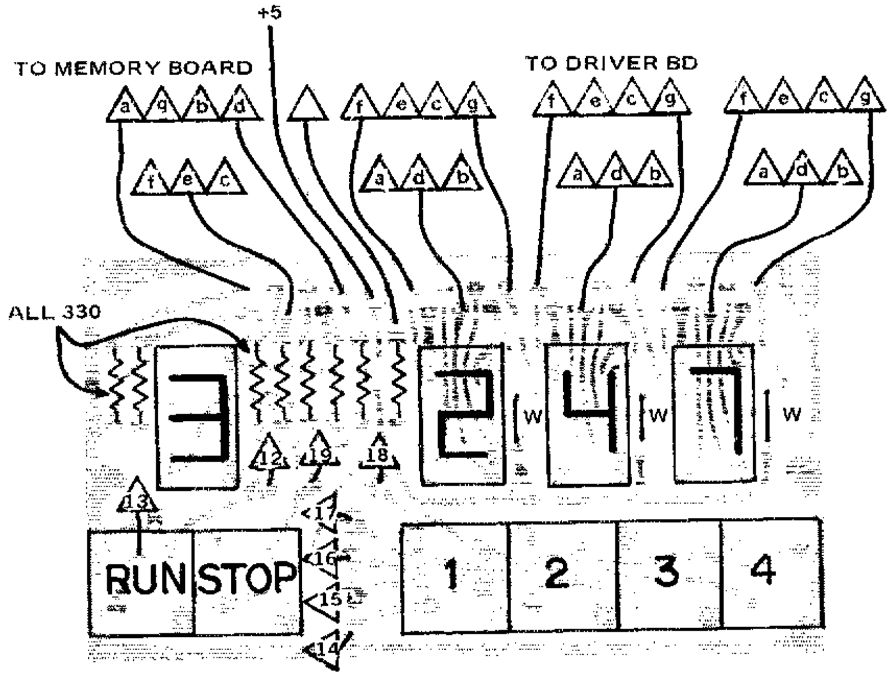


Fig. 8 – Etching pattern and component layout for readout board, shown from component side. W = wire jumpers. See Table I for wiring connections to other parts of the circuit.

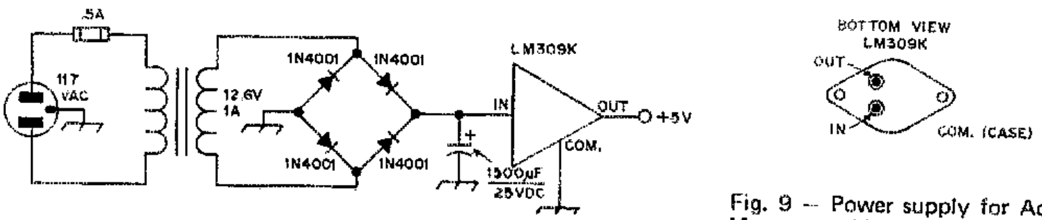


Fig. 9 — Power supply for Accu-Memory and keyer. See text.

QSL manager must go through. If any problems develop or changes occur in the circuit, a data sheet showing corrections will be included.

References

[1] Garrett, "The WB4VVF Accu-Keyer," *QST*, August, 1973. Also see Garrett, "More on the Accu-Keyer," Technical Correspondence, *QST*, May, 1974, p. 58. Information also appears in *The Radio Amateur's Handbook*, 1974, and later editions.

[2] The memory has a total of 2048 bits of storage capacity. A dot occupies one bit, a space one bit, a dash three bits, a letter space three bits, and a word space eight bits.

[3] The heat sink for the LM-309 is available from Solid State Systems, Inc., Box 773, Columbia, MO 65201.

[4] As a service to those who wish to avail themselves, ready-made circuit boards may be obtained through Garrett. All boards are glass epoxy and drilled. At the time of this printing, the Accu-Keyer board (see reference 1) is $3.50. The memory, readout, and readout-driver boards are $12 as a set. The memory board, if ordered alone, is $6.

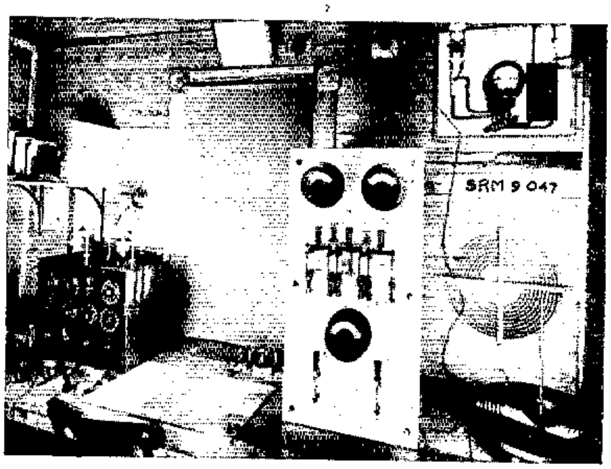
Strays

Stolen Equipment

Stolen May 12, 1975, stereo translator station (F.M.) with serial number 740516. (Station operated under F.C.C. license W-213-AA to rebroadcast signal of WFCR Public Radio in Amherst, MA) Any information concerning whereabouts or present use should be forwarded to radio station WFCR at the University of Mass., Amherst, MA, or to the F.B.I. or the F.C.C.

Stolen May 15, Clegg FM-27B, serial number 27053-1854. Please notify W4PJG or Ft. Myers FL Police Department.

Icom model IC-230 stolen May 29, serial number 1276. Contact Roy A. Cartier, K4AC, 800 National Avenue, Winchester, VA 22601.



Recent Silent Key K6KI leaves a radio legacy going back to 1915; his station, pictured above, would be termed "immaculate" even by today's standards. TNX to K6QI for the picture.

Transatlantic Sporadic-*E* Propagation

In June and July, 1974, there were several instances of transatlantic work on 28 MHz, presumably via multihop sporadic-*E* propagation. (See "World Above 50 Mc." in August and September, 1974, *QST*.) It started happening again in June, 1975, which is of special significance in view of the very low state of solar activity and absence of high-latitude *F*-layer propagation above about 20 MHz.

ARRL is interested in details of any reception or two-way work with Europe on 21, 28, or 50 MHz during summer, 1975. Several instances on 21 and 28 MHz have already been observed, and F8SH, sporadic-*E* coordinator for IARU, has unconfirmed reports of reception of American and Canadian 50-MHz stations. The undersigned heard the German beacon, DLØIGI, 28.195 MHz, around 1500 UT, June 21. No 50-MHz operation is presently authorized in Europe, but cross-band tests, 50-28, might bring results, as they did so successfully in the period of high *F*-layer muf 15 years ago. The 50-MHz region is full of video in Europe, and the familiar buzz should be a tip-off for 6-meter listeners in this hemisphere. The IARU beacon stations between 28.16 and 28.2 provide good 10-meter indicators. Most likely times are 1200 to 1500 and 2000 to 2300 UT. — *W1HDQ*

QST Congratulates

Bernard Ostrofsky, W9HTF, named a Fellow in the American Society for Nondestructive Testing. Ostrofsky is technical editor of "*Materials Evaluation*," as well as being a member of the American Chemical Society, the American Crystallographic Assoc., the Electron Probe Analysis of America, the American Society for Testing and Materials, and the ARRL.

Anthony F. Knoll, WA2TRK, who won five awards for his "Radio Emissions from Jupiter" project at the Greater Trenton Science Fair.

James F. Bartram, W1PDL, ex-president of NCRC, who was made a Fellow of the Acoustical Society of America.