

build 'dyna-micro' an BOBO ...icrocomputer

Complete with keyboard for data entry, LED readout of the address and data, breadboard socket for experimenting, SOD-bytes of PROM, SOD-bytes of RAM, expandable to 6SK and self-contained power supply

JOHN TITUS

LAST MONTH, PART-1 OF THIS ARTICLE described the operation of the Dyna-Micro and presented the schematic diagram and construction details.

This month, the foil patterns and component placement diagram are presented along with a description of how to use the Dyna-Micro.

Final check

All integrated circuits should now be in place, hopefully in sockets. Remove the 8080A IC and check for the correct voltages at its socket. You should find +5 volts at pin 20, +12 volts at pin 28 and -5 volts at pin 11. You should also check the PROM for -9 volts at pins 16 and 24. A PROM must be in one of the sockets for the -9 volts to be present.

Turn on the power with all the IC's in place and check the power supply voltages. They should be at their preset levels of +5 and ± 12 volts. If these are correct, your Dyna-Micro system should be operational.

Depress the R key. The LED displays should now indicate 003 (0000011) at the HI and 000 (00000000) at the La. The OUTPUT PORT 2 LED's may have some random data present. If this doesn't happen, remove the power and carefully check your system. Things to check for are solder bridges, cold solder-joints, unsoldered IC pins and incorrect orientation. Plated through holes don't have to be soldered unless there is a component or other lead going through them. Also check for +5 volts and ground at all the IC's.

If the LED's display the correct pattern, depress and release the s key.

Each time that this key is pressed, the LO address information should be incremented by 1. If this doesn't happen, check the keyboard encoder section and the I/O sections.

If the LED's are operating correctly, enter some data (0 through 7) from the keyboard. The binary codes for these keys will be entered in the Data-Register (OUTPUT PORT 2) display in the three least-significant bits. You will note that as new data is entered, the old data is shifted to the left where it finally disappears as more new data is entered. The actual operation of the KEX software to input and output data will be discussed later.

How to use the Dyna-Micro

The Keyboard Executive software is the "heart" of the Dyna-Micro system. It allows you to examine data or pro-

PARTS LIST

R1, R2, R4, R5, R6-1000 ohms, 1/4 W, 10%	IC13, IC17-SN74LS05 Open-collector hex inverter
R3-2200 ohms, 1/4 W, 10%	IC14-SN74LS155 Dual 2-to-4 line decoder
R7-R30-220 ohms, 1/4 W, 10%	IC15-1702A PROM memory (Intel)
C1-33 μ F/6.3V electrolytic	IC18-SN74L42 BCD to decimal converter
C2-5 μ F/50V electrolytic	IC19-SN7402 Quad 2-input NOR gate
C3, C5-C14-0.01 μ F disc ceramic	IC20, IC21-SN74L04 Hex inverter
C4-3.3 μ F/16V electrolytic	IC24-IC29-SN7475 Bistable latch
D1-D24-Small red LED (Hewlett-Packard 5082-4484, Monsanto MV5075B, or equal.)	IC31-DM8095 or SN74365 Buffer
Z1-1 N751A, 5.1V Zener	IC32, IC33-SN74148 8-to-3 line priority encoder
Z2-1 N746, 3.3V Zener	S1-S16-Keystwitches with legends
C1, IC22, IC23-SN7404 Hex inverter	XTAL-6.750 MHz crystal, HC-18/U holder
C2, IC3, IC30-SN7400 Quad 2-input NAND gate	Solderless breadboard-SK-10 IF18
IC4-SN74174-Quad type-D flip-flop	Chassis-10" x 12" x 3" (Bud type AC-413)
IC5-8224 Clock generator (Intel)	Misc.-Binding posts, IC sockets, hardware
IC6, IC7-8216 Bus driver (Intel)	Optional IC's for expanded memory
IC8-8080A CPU (Intel) (Must be "A" version)	IC11, IC12-8111-2 RAM memory
IC9, IC10-8111-2 RAM memory (Intel)	IC16-1702A PROM memory

cept MMD-1IC, MMD-1 PROM, and MMD-1 RAM come complete with construction details, experiments, and tutorial material.

#MMD-1CBK- Etched, plated-through PC board, keyboard parts and breadboarding socket. \$125 postpaid.

#MMD-1K-Complete kit of parts including 1702A PROM preprogrammed with KEX software and power supply. \$350 postpaid.

#MMD-1A-Completely assembled and tested system. \$500 postpaid

#MMD-1IC-Microprocessor IC set includes one 8080A CPU, one 8224 clock generator, two 8216 bus drivers, two 8111-2 RAM memory, one 1702A PROM preprogrammed with KEX. \$100 postpaid.

#MMD-1 PROM-Additional 256-Word PROM (1702A). \$40 postpaid.

#MMD-1 RAM-Additional 256 words of RAM (8111-2). \$15 postpaid.

Keystwitches are available from Solid State Systems, Inc., P.O. Box 617, Columbia, MO 65201. Order type LM or LFW-LT, with legends shown in Fig. 7.

Breadboarding socket is available

from Circuit Design, Inc., Box 24, Shelton, CT 06484.

The following kits are available from Circuit Design, Inc., Box 24, Shelton, CT 06484. Phone 203-735-8774. All kits, ex-

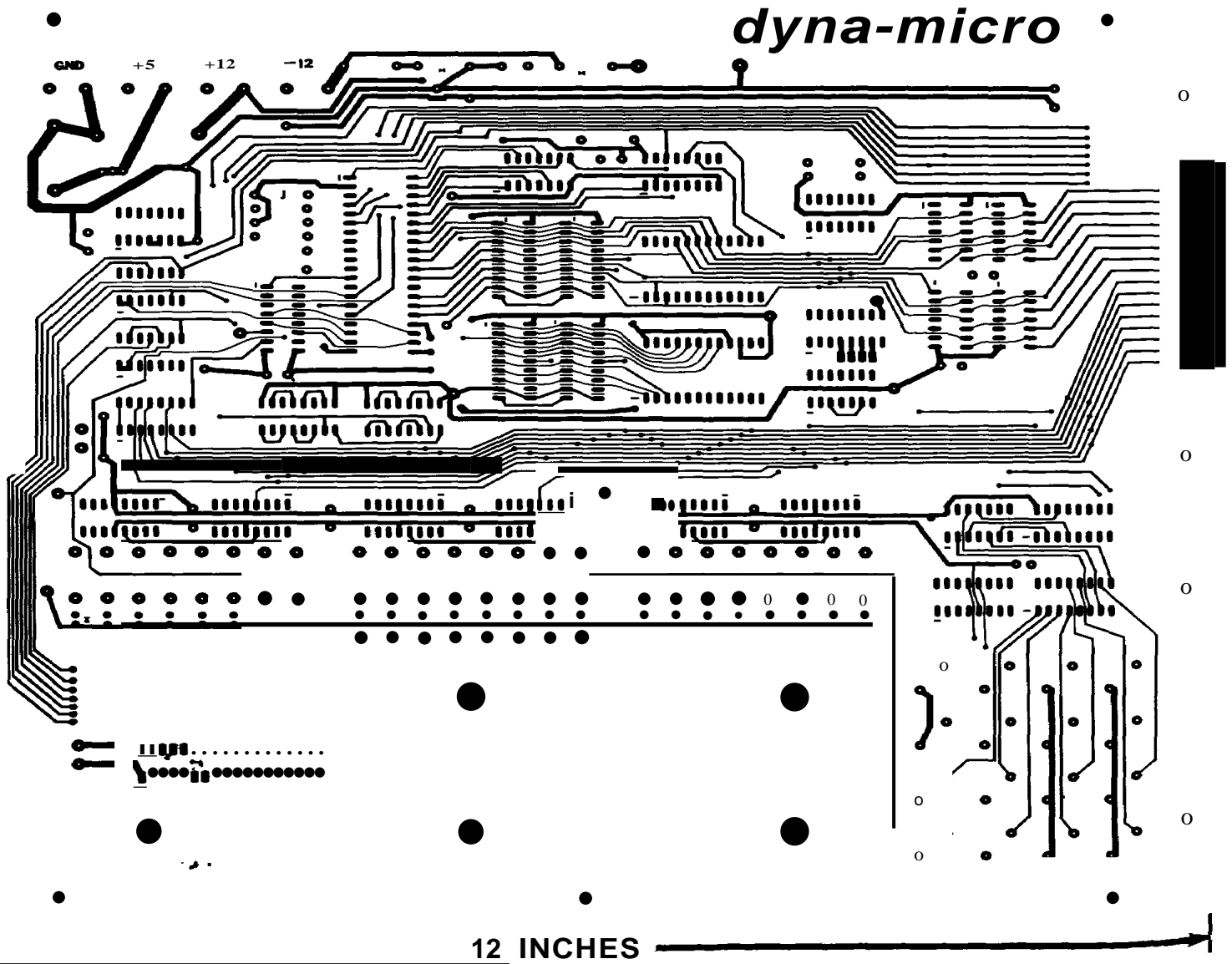


FIG. 3-FOIL PATTERN of the component-side of the double-sided board. The actual board measures 10 X 12 inches (254 X 305 mm.)

gram steps and to change data or program steps stored in the R/W (read/write) portion of the memory. We can also specify any address and start the program there.

The data keyswitches are labeled 0-7. When anyone of these keys are depressed, data is entered in the corresponding octal format. The H key designates the HI address and the L key designates the LO address. The G represents Go and S represents See and Store. Three keys are not used by the KEX-A, Band c. The R key will always reset the computer and restart the KEX program. All manual data entry is through the keyboard in the basic Dyna-Micro system.

Whenever you want to start the system, depress keyswitch R. This will reset the KEX program and address the first location in the R/W section of the memory. This is HI=003 and LO=000. If you will only be using 256 words of R/W memory to get started, it must be in the locations allocated for IC9 and IC10. The KEX will not function without R/W memory.

To enter data, whether it will be used for new data or to address a memory location, simply depress the numbered keys as you would on a calculator. Data will be entered into the three least-significant right-most LED's and it will shift to the left as more data is entered. If a mistake is made, simply re-enter the data. Mistakes are shifted out and lost. The data-register LED's will display the data just entered from the keyboard and this may be used as the HI address by depressing H, or it may be used as the LO address by depressing L. These keys will transfer the data to the proper LED display register and it will be used by the 8080A to address a new memory location.

Whenever a new HI or LO address is specified by depressing either the H or L keys, the KEX program will always display the contents of the specified memory location on the data-register LED's. To examine the contents in the next location, depress the S key. By depressing the S key again and again, we can examine the contents in sequential memory locations. It should be noted

that this S function follows increasing memory locations, *not* the sequential flow of a program.

To change the contents in a R/W memory location, simply load the address using the data input keys and the Hand L keys. The old data presently in the location will immediately appear on the data-register LED's. Enter the new data into the data register using the numeric keys and then enter it into the R/W location by depressing the S key. After S is depressed, the new data is stored and the address is automatically incremented by one to address the next memory location. The data from the next location is now displayed on the data-register LED's.

The S key has two functions, both See and Store. How can we tell the difference? If the data has changed we will store it and see the next location. If the data hasn't changed, it will be stored in the same location that it originally came from and then the contents from the next memory location will be displayed. When we store old data back to the same location, we can't really see

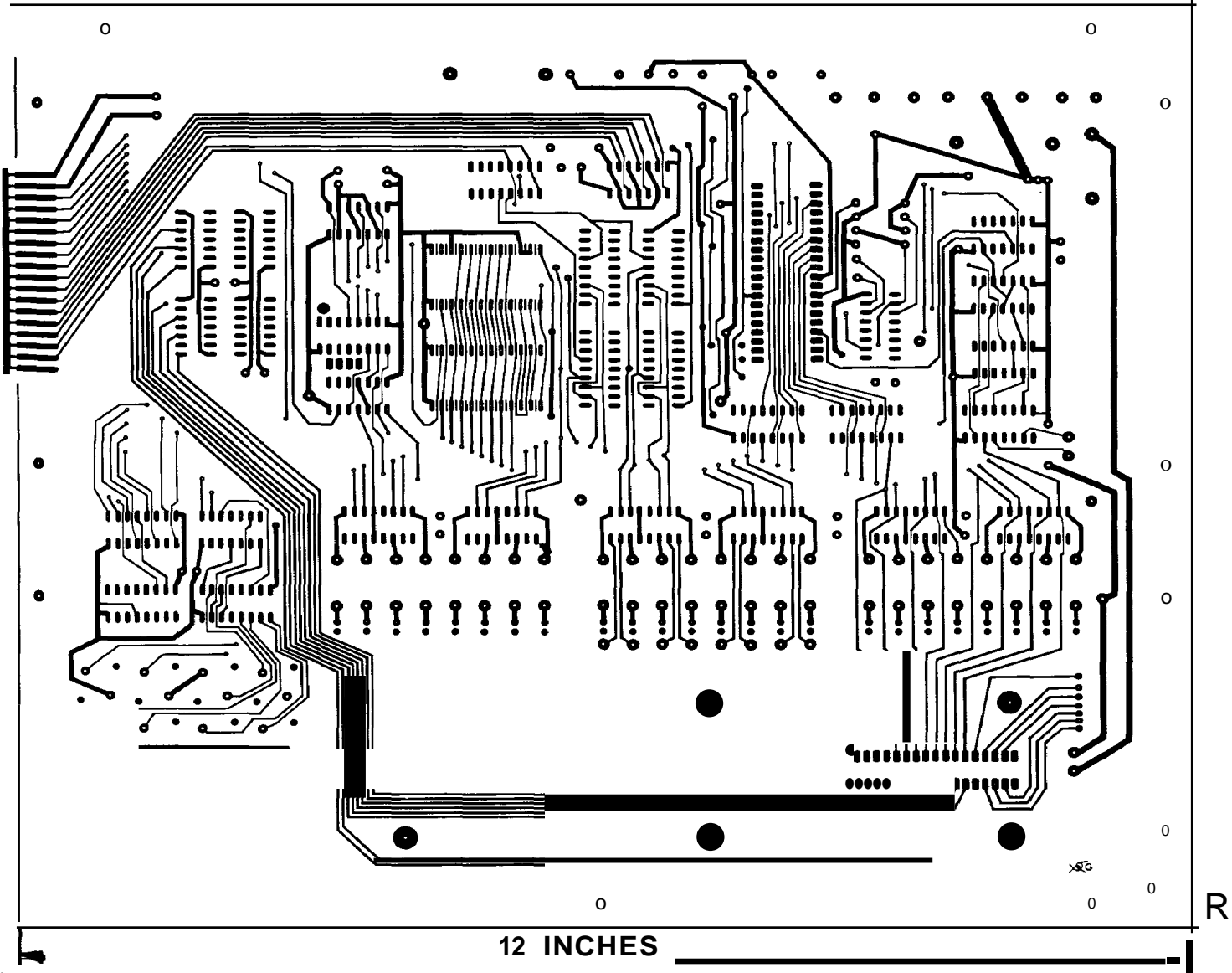


FIG. 4—FOIL PATTERN of the bonom of the double-sided board. A board with plated-through holes is recommended.

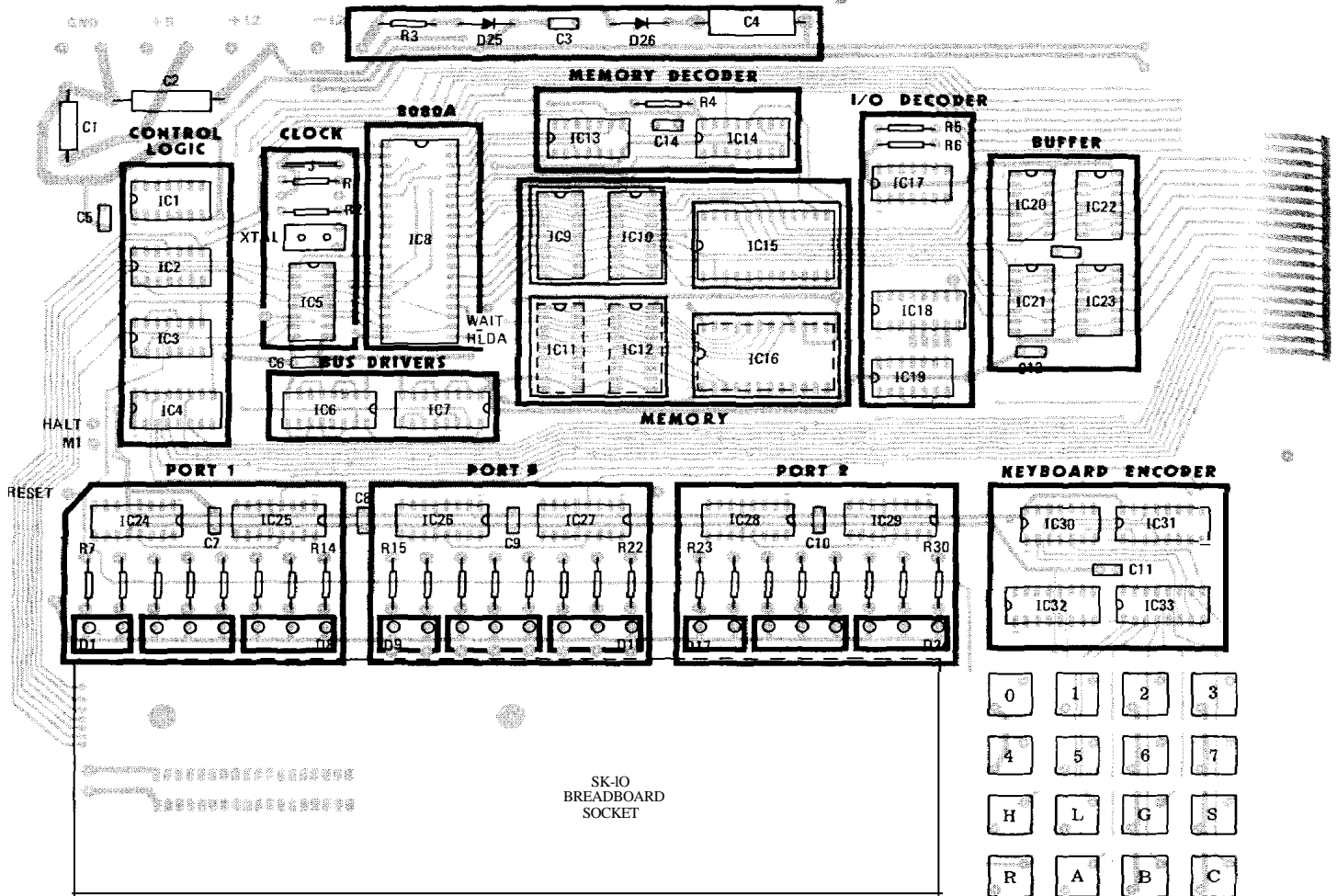


FIG. 5-COMPONENT PLACEMENT diagram. The board is shown divided into functional sections.

any change, but this is exactly what the KEX does. It displays data from a specific location, allows us to make changes and then puts it back. If no changes are made, the old data is restored to its memory location.

Once a program is entered into the computer through the keyboard, we can start it by loading our starting address and actuating the G key. This will transfer control from the KEX software to the program that we want to run. Starting addresses are loaded in the same way as previously described. Starting addresses don't have to be in R/W memory, but can just as easily be in PROM.

If your program starts at the first location in R/W memory (003000) you can simply depress R followed by G. We can do this because KEX always resets the address back to this first R/W location.

Keys labeled A, B and C are not used by the KEX program. It should be remembered that the three LED output ports and the keyboard are not hardwired for use with the KEX program only. They are available for you to use

in your programs. All fifteen keys may be used in any way you like, using software.

HI	LO	
000	000	KEY PROM
000	377	
001	000	
001	377	OPTIONAL PROM
002	000	
002	377	OPTIONAL R/W MEMORY
003	000	
003	377	R/W MEMORY
004	000	
377	377	AVAILABLE FOR USER EXPANSION

How KEX operates

The keyboard Executive software is contained in a single 1702A type PROM in the location allocated for IC13. This contains all the necessary

software to operate the keyboard and the LED displays. This is our software controlled "front panel", since the keys and LED's perform functions determined by the KEX software.

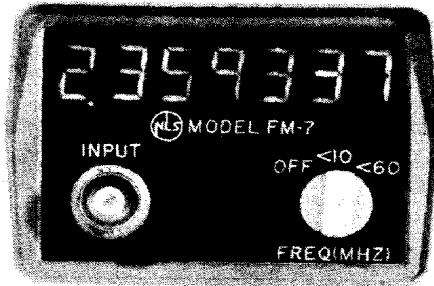
Whenever the R key is depressed, the S0SOA CPU will start to execute the program that starts at location 0. Looking at the software listing for the KEX program (Table II), you will see that immediately after starting at location 0, the software instructions cause the computer to jump to location HI=000, LO=070 (HI=000 throughout the KEX program) where we start the program by pointing to the first R/W memory address (003 000.) The address and the data in that location are displayed on the three output ports. This is done between POINTA and POINTC in the program (see Table II). The software between POINTC and POINTD will do the necessary tasks to input new data from the keyboard and shift the data onto the LED's. The shifting is done inside the S0SOA with software instructions. Doing this by hardware would require

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BUILD A COMPUTER (continued from page 44)

many more Ie's, but it takes relatively few software steps.

The software routines at POINTD, POINTE, POINTF and POINTG make up what is called a command decoder. The software decodes the key-switches into real actions. Depressing

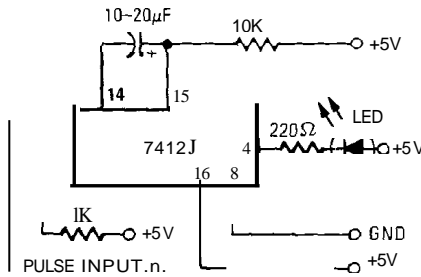


FIG. 6-MONOSTABLE-LED circuit is used for check-out of the Dyna-Micro.

0	1	2	3
4	5	6	7
H	L	G	S
R	A	B	C

FIG. 7-KEYBOARD LEGENDS are oriented as shown.

H or L causes the data temporarily stored in the 8080A as numeric key inputs to be output to either the HI or LO set of LED's. The S key causes the current or new data to be put back into the current memory location. Depressing G causes the computer to use the HI and LO address as the start/Dg Point for a new program.

The TIMOUT and KBRD software subroutines have specific tasks. The TIMOUT will count its way through various loops for about 10 milliseconds, while the KBRD subroutine will input a code from the keyboard. The KBRD subroutine has some unique features that illustrate an interesting hardware software tradeoff. The keyswitches used in the Dyna-Micro are not bounce free, so that when the switches are opened or closed, they can often re-make or re-break the contacts. This can be confusing to the computer since it can't distinguish between a real switch closure and a bounce. We don't want

A user's group has already been formed for the Dyna-Micro. Interested people should contact:

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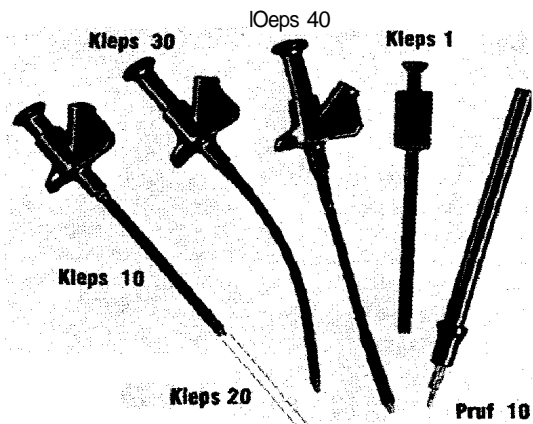
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WE GOOFED

WE SURE DID! Last month we ran the first part of this construction article on the Dyna-Micro and we erred. It seems that one or more gremlins (little green people) found their way into our editorial offices and stole-that's right, stole-74 lines of text from the article. The text was stolen between the last paragraph on page 36 and the opening paragraph on page 74. To correct this evil crime, we are reprinting the two paragraphs in italics along with the missing text. To prevent this from happening again, we have tightened security around our offices.

The clock circuit uses an Intel 8224 integrated circuit. This is a crystal clock oscillator that provides the proper MOS clock levels for the 8080 system. It also contains circuitry for a TTL level clock (Ø2), RESET and READY inputs. Construction of the clock circuit begins by inserting components R1, R2, the 6.75 MHz crystal, IC5 and the jumper. Good quality IC sockets are recommended for all the integrated circuits.

After inserting and soldering the parts, the clock section should be checked. To do this, apply power and check for voltages on the 8224 chip. You should observe +5 at pin 16, +12 at pin 9 and ground at pin 8. Clock operation can be checked at pins 10 and 11. These are the MOS level outputs that swing between +12V and ground. The signals can be observed with a good scope. The TTL output on pin 6 can also be checked with a scope or with a monostable-LED circuit. The monostable circuit can be constructed on the SK-10 socket before it is added to the system.

With the 6.75-MHz crystal, the output frequency will be 750 kHz. This is slower than the maximum 2-MHz frequency that the 8080A will operate at, but a slow frequency was chosen to allow for slow access times of the PROM's.

The output ports are constructed next by inserting and soldering all the LED's (D1 through D24). Be sure to observe the polarity as shown by the symbol near O1. Add all the 220-ohm resistors (R7 through R30) and insert the SN7475 latches. Be careful to orient the IC's in their sockets. The foil pattern has a small mark near pin 1 for all the IC's.

With the latches and parts installed and soldered, apply power to the system. All of the LED's should light. If any are not on, check the associated SN7475 latch. With power still applied, ground the input pins to the latches, one at a time. Since all the inputs are on eight common data bus-lines, only eight inputs must be grounded to check all the LED's and latches. Ground pins 2, 3, 6 and 7 on IC24 and IC25. One of the LED's in each group of eight should go out, one at a time. If this doesn't happen, again check the SN7475's.

The keyboard section consists of 16 keyswitches-15 are used to input data and one is hardwired to the 8224 chip to reset the Dyna-Micro. The key-switch closures are encoded by two SN74148 octal encoders and the encoded binary data is gated onto the bus through a three-state DM8095 or SN74365IC.

Insert and carefully solder the keyswitches to the printed-circuit board and then insert the four integrated circuits, IC30 through IC33.

The keyboard section is tested by monitoring the data on the LED's. Carefully ground pins 1 and 15 on the three-state driver, Ie31. This will cause data from the keyswitch encoders to *constantly be fed to the bus. With these two pins grounded, apply power and depress the keys, one at a time. The binary data for each keyswitch will be indicated on the LED's at all of the output-ports simultaneously. Note that the most significant bit, D7, will be on whenever one of the keys is depressed. This is often called a 'flag' since it is used to flag down the computer and tell it that one of the switches is ready with data.*

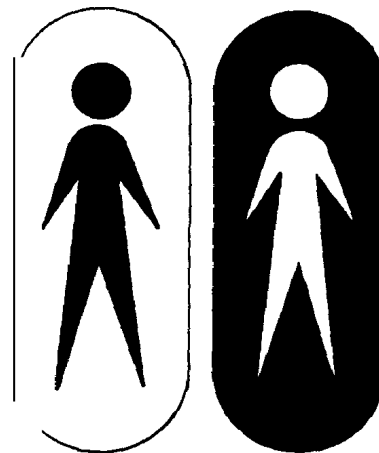
the computer to sense each bounce as a key closure so we would like some way to filter them out. Additional circuitry including latches, clocks and monostables could do this for us, but it complicates the system. We can also do the debouncing via software.

The KBRD subroutine will recognize any key closure, but it will only input the key codes after being sure that the key is closed and not bouncing. It does this by waiting after sensing a closure

and then rechecking the switch to be sure it is still closed. It also checks when we release a key to be sure that it has stopped bouncing before it tries to sense another key being depressed by the user. We have traded some additional software steps for a great deal of hardware. Since there was plenty of PROM left, it was easy to include.

The TIMOUT and KBRD software

(Table II is on page 86)
(Text continues on page 90)



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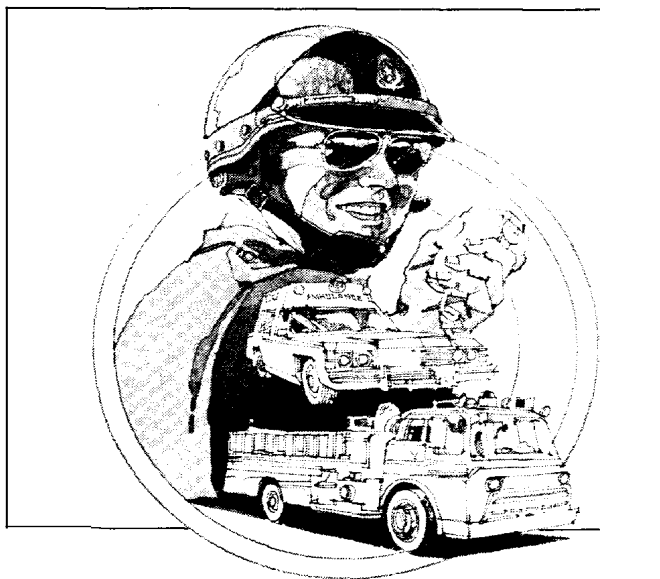
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BUILD A COMPUTER

Text continues on page 90

TABLE II-KEYBOARD EXECUTIVE (KEX) PROGRAM

000 000	303		*000 000
000 001	070		JMP
000 002	000		START
			O
			<i>j</i> JUMP UP TO RjW MEMORY TO BE USED BY RESTARTS & VECTORED INTERRUPTS
			*000 010
000 010	303		JMP
000 011	010		010
000 012	003		003
			*000 020
000 020	303		JMP
000 021	020		020
000 022	003		003
			*000 030
000 030	303		JMP
000 031	030		030
000 032	003		003
			*000 040
000 040	303		JMP
000 041	040		040
000 042	003		003
			*000 050
000 050	303		JMP
000 051	050		050
000 052	003		003
			*000 060
000 060	303		JMP
000 061	060		060
000 062	003		003
			<i>j</i> BEGINNING OF MAIN PROGRAM
			*000 070
000 070	061	START,	LXISP <i>j</i> SET STACK POINTER TO TOP OF R/W MEM.
000 071	000		000
000 072	004		004
000 073	041		LXIH /INITIAL VALUE FOR H & L
			000
000 074	000		003
000 075	003		MOVCM /LOAD MEM DATA INTO TEMP DATA BUFFER
000 076	116	POINT A,	/OUTPUT HI TO LED'S
			000
000 077	174		MOVAH
000 100	323		OUT
000 101	001		001
000 102	175		MOVAL /OUTPUT LOW TO LED'S
			OUT
000 103	323		000
000 104	000		MOVAC /OUTPUT TEMP. DATA BUFFER DATA TO LED'S
000 105	171	POINT B,	
			OUT
000 106	323		002
000 107	002		CALL <i>j</i> WAIT & INPUT NEXT KEY CLOSURE
000 110	315	POINT C,	
			KBRD
000 111	315		O
000 112	000		CPI
000 113	376		010
000 114	010		JNC /JUMP IF KEY WAS < 010
000 115	322		POINT D /O-7, OCTAL DIGIT)
			O
000 116	134		MOVBA /SAVE KEY CODE
000 117	000		MOVAC /GET OLD VALUE
000 120	107		RAL <i>j</i> ROTATE 3 TIMES
000 121	171		
000 122	027		

```

000 123 027 RAL
000 124 027 RAL
000 125 346 ANI jMASK OUT LEAST
SIG. OCTAL DIGIT

000 126 370 370
000 127 260 DRAB JOR IN NEW OCTAL
DIGIT

000 130 117 MOVCA jPUT NEW DATA
BACK INTO BUFFER

000 131 303 JMP
000 132 105 POINT B
000 133 000 O
000 134 376 POINT O, CPI
000 135 011 011 j"L" KEY
000 136 302 JNZ jJUMP IF NOT AN "L"
000 137 145 POINT E
000 140 000 O
000 141 151 MOVLC jPUT BUFFER DATA
IN L

000 142 303 JMP
000 143 076 POINT A
000 144 000 O
000 145 376 POINT E, CPI
000 146 010 010 j"H" KEY
000 147 302 JNZ jJUMP IF NOT AN "H"
000 150 156 POINT F
000 151 000 O
000 152 141 MOVHC jPUT BUFFER DATA
IN H

DOD 153 303 JMP
000 154 076 POINT A
000 155 000 O
DOD 156 376 POINT F, CPI
000 157 013 013 j"S" KEY
000 160 302 JNZ jJUMP IF NOT "S"
000 161 170 POINT G
000 162 000 O
000 163 161 MOVMC jPUT TEMP. DATA
INTO MEMORY

DOD 164 043 INHX jINCREMENT H & L
ODD 165 303 JMP
000 166 076 POINT A
DOD 167 000 O
000 170 376 POINT G, CPI
000 171 012 012 j"G" KEY
000 172 302 JNZ jJUMP IF NOT "G"
DOD 173 110 POINT C
DOD 174 000 O
000 175 351 PCHL jGO EXECUTE PGM
POINTED TO BY
H & L

ITHIS 10 MSEC DELAY
DISTURBS NO REGISTERS OR
FLAG

DOD 277 365 TIMOUT, *000 277
000 300 325 PUSHPSW jSAVE REGISTERS
PUSHD
LXID jLOAD D & E WITH
VALUE TO BE
DECREMENTED

000 301 021
000 302 046 046
000 303 001 001
000 304 033 MORE, DCXD jJUMP IN THIS
LOOP UNTIL
jD & E ARE BOTH
ZERO

000 305 172 MOVAD

000 306 263 ORAE
000 307 302 JNZ
000 310 304 MORE
000 311 000 O
000 312 321 POPD
000 313 361 POPPSW jRESTORE
REGISTERS

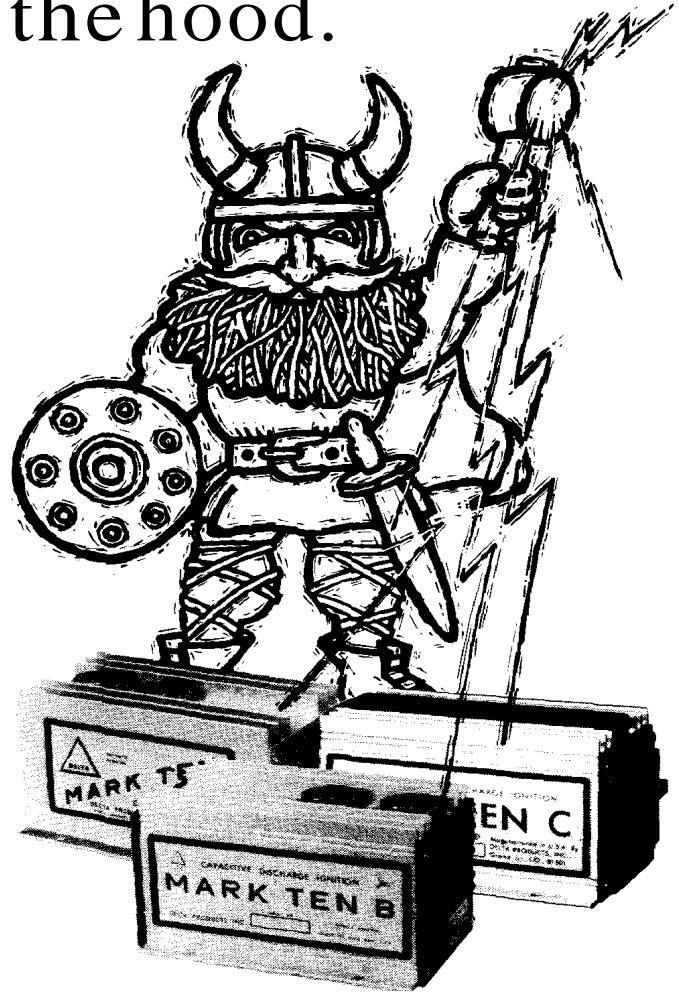
000 314 311 RET

ITHE KBRD ROUTINE
DEBOUNCES KEY CLOSURES
IAND TRANSLATES KEY CODES

```

Table II continues on page 89 (text continues on page 90)

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BUILD A COMPUTER

Table neollilliled from page 87
Text continues 011 page 90

		IFLAGS AND REG A ARE CHANGED	
		/A0-A3 = CODE; A4-A7 0000	
000 315	333 KERO,	IN	/INPUT FROM KEYBOARD ENCODERS
000 316	000	000	
000 317	267	ORAA	/SET FLAGS-
000 320	372	JM	/JUMP BACK IF LAST KEY NOT RELEASED
000 321	315	KBRD	
000 322	000	0	
000 323	315	CALL	WAIT 10 MSEC
000 324	277	TIMOUT	
000 325	000	0	
000 326	333	FLAGCK,	IN
000 327	000	000	
000 330	267	ORAA	
000 331	362	JP	/JUMP BACK TO WAIT FOR A NEW KEY TO BE PRESSED
000 332	326	FLAGCK	
000 333	000	0	
000 334	315	CALL	/WAIT 10 MSEC FOR BOUNCING
000 335	277	TIMOUT	
000 336	000	0	
000 337	333	IN	
000 340	000	000	
000 341	267	ORAA	
000 342	362	JP	/JUMP BACK IF NEW KEY NOT STILL PRESSED (FALSE ALARM)
000 343	326	FLAGCK	
000 344	000	0	
000 345	346	ANI	/MASK OUT ALL BUT KEY CODE
000 346	017	017	
000 347	345	PUSHH	/SAVE H & L
000 350	046	MVH	/ZERO H REG
000 351	000	000	
000 352	306	ADI	/ADD THE ADDRESS OF THE BEGINNING OF THE TABLE TO THE KEY CODE
000 353	360	360	
000 354	157	MOVLA	/
000 355	176	MOVAM	/FETCH NEW VALUE FROM TABLE
000 356	341	POPH	/RESTORE H & L
000 357	311	RET	
/THIS TRANSLATION TABLE CONVERTS THE CODE /GENERATED BY KEY CLOSURES TO THE CODE /USED BY THE MAIN KEY PROGRAM			
000 360	000	TABLE,	000
000 361	001		001
000 362	002		002
000 363	003		003
000 364	004		004
000 365	005		005
000 366	006		006
000 367	007		007
000 370	013		013
000 371	000		000
/S /THIS CODE CAN'T BE GENERATED			
000 372	017		017
000 373	012		012
000 374	010		010
000 375	011		011
000 376	015		015
000 377	016		016

end of Table II (text continues on page 90)

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segments have been set up as subroutines and can be used in your software and in the experiments. Each of these subroutines may be started with a CALL instruction, 315. The TIMOUT subroutine does not affect any of the registers or flags and it only serves to delay the software flow by 10 ms.

An important distinction between the 8008 and the 8080 processors is in the use of subroutines. In the 8008, return-pointer addresses were stored in the 8008 IC itself. In the 8080, these return-pointer addresses are stored in a portion of the R/W memory. This is called a "stack" area. Whenever a subroutine is used, we want to execute the subroutine and then return back to the normal program flow. These return addresses are very important to the computer since they provide the only link between the subroutine and the main program. If we are to store them in a portion of R/W memory, the computer must know where this storage area is if it is to be able to use the addresses properly. In the KEX software, this is preset to be the top of the R/W memory with instructions at locations 070, 071 and 072. The LXISP instruction

loads an internal 8080 stack-pointer register to HI= 004, LO= 000. Since the stack-pointer register is decremented to point to a new location before anything is stored, the first stack location will be HI=003, LO=377. Check your 16" bit binary numbers if this looks a little confusing.

You can use the stack as set up by the KEX (generally a good idea) or you can put your own stack anywhere you want, just by using the LXISP instruction. Remember to avoid the stack area when writing your programs. Remember, too, that you can't put the stack in an area of non-existent memory or in PROM.

You will use the stack area and you'll see how it can also be used to temporarily store data. This will be covered in

the software modules. Let's see how the TIMOUT and KBRD subroutines can be used in our own software. We will use the software stack already set up in KEX.

Let's input a keyboard character, add a constant to the binary code for that character and display the result. We would first CALL the KBRD subroutine to input a binary key-code, then add the constant and display the result. The software listed in Table HI will do this:

You can enter this with the KEX program. Depress the R key and start entering data. Enter 000 at location 003 004 so we'll first add zero to the codes. This will let us check what values are assigned to each key. Write down the codes. Go back and restart

TABLE III

HI	LO	INSTR	MNEMONIC	
003	000	315	CALL	/ Input keyboard character
003	001	315	KBRD	/Subroutine's IO address
003	002	000	a	/Subroutine's HI address
003	003	306	ADI	IAdd the following DATA to
003	004	???	DATA	/the contents of register A
003	005	323	OUT	IOutput data from register A to
003	006	000	000	/device 000 (LEOs)
003	007	303	JMP	/Jump back to program at
003	010	000	000	fIO address = 000
003	011	003	003	IHI address = 003

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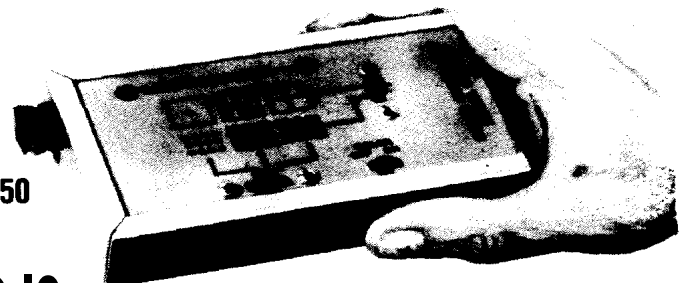
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TABLE IV

Assume HI = 003 throughout this program

LO	INSTR	MNEMONIC	
000	006	MVIB	/Load register B with the following data
001	370	370	/0data; time constant
002	315	CALL	/Call TIMOUT subroutine at
003	277	277	/LO address = 277
004	000	000	/HI address = 000
005	005	OECB	/Decrement B by 1
006	302	JNZ	/Jump if result is not zero to
007	002	002	/LO address = 002
010	003	003	/HI address = 003
011	076	MVIA	/Load register A with the following data
012	377	377	/0data; all 1's
013	323	OUT	/Output to device,
014	000	000	/device 000 (LED's)
015	166	HLT	/Stop once you reach here

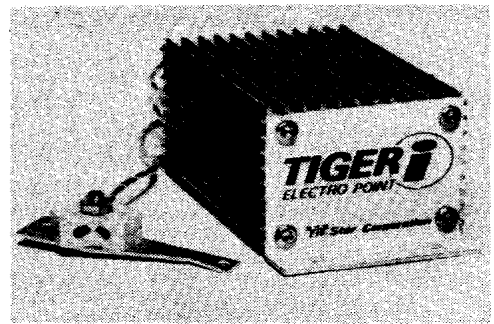
KEX and change the value in 003 004 10, say, 005. This will add 5 to each code. Restart your software and see if this is the case. Congratulations, you have just done your first software experiment! The instructions at 003 003 and 003 004 could be changed to do other things to the data. Can you suggest one?

The 10 ms delay routine, TIMOUT, can be useful when we want a software delay that is in multiples of 10 ms. The software routine listed in Table IV will delay an output of all I's on OUTPUT PORT 0 by about 2.5 seconds after the

program is started. Try it. Can you see how the time delay might be shortened? Can you see any use for programs like this?

The keyboard input subroutine, KBRD, is called at address 000 315 and the time delay subroutine, TIMOUT, is called at address 000 277.

Next month, this construction article concludes with a description of the 8080A microprocessor and how the Oyna-Micro works. This will include an explanation of how the memory is accessed and how the Oyna-Micro selects input/output devices via software. R-E



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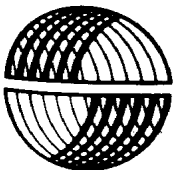
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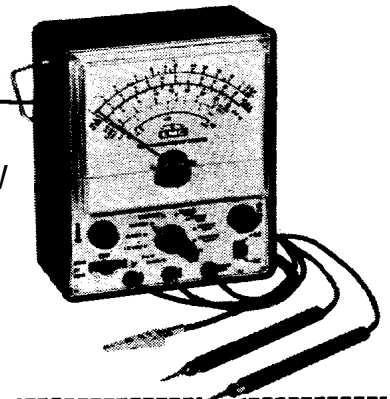
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