FIRST ISSUE OF
VOLUME THREE

A C S NEWSLETTER

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VOLUME III IS UNDERWAY

Thanks to all who mailed in checks so promptly, enough were received within only 40 days after mailing the last issue of Volume II to pay for printing and mailing eight issues of Volume III. Of course, the rise from $3 to $5 for a subscription meant that only half as many checks were needed.

A WORKING COMPUTER

Don Tarbell wrote from Alabama:

"My machine is now in working order! I have done quite a bit of programming with it in the past several months. My first piece of software was an editor, which enables me to type programs on the Teletype, into memory, and to modify them from the keyboard. The editor receives letters for commands: N for new entry, L for list the buffer, A for append, D for delete, I for insert, and P for print. The D, I and P are followed by the appropriate line number.

"The second piece of software I designed is the CALCULATOR. With it, I can add, subtract, multiply, and divide integers up to 256 digits long. It does not yet accept decimal points, but it will in the near future.

"I am still working on the third piece of software, the ASSEMBLER. It will convert symbolic programs into machine language, and will at first be a stripped-down version, later to be expanded, by using itself to create more subroutines.

"The machine is an 8-bit byte-oriented machine, all integrated circuits, with 16 8-bit file registers, and 4K bytes of core at present (soon to be expanded to 65K!). The 16 8-bit file registers are used for 5 16-bit index registers, 1 16-bit accumulator, 1 16-bit program counter, 1 8-bit terminator register, and 1 8-bit temporary register. The cycle time is at present 7 usec, but will be speeded up to 2.4 usec shortly. The 8-bit byte organization does not really slow things down, since six 8-bit transfers between registers can take place during one cycle. The byte orientation also speeds up list-processing-type subroutines, which will be used considerably in my work in artificial intelligence. Even with the 7-usec cycle time, I can multiply a 140-digit number (all nines) times itself in about 40 seconds.

"There are eight address modes: direct relative, indirect relative, direct indexed, indirect indexed, extended, literal, direct to X3, direct to X4. The last two modes use only one byte; the extended uses 3 bytes (instruction and mode, 16-bit address); and the rest use 2 bytes. There are 8 conditional jump instructions, all of which are relative addressing. There are arithmetic instructions which handle both single and double bytes: ADD, SUBTRACT, LOAD, STORE, and AND. One of the conditional jump instructions decrements an index register, then jumps if it is not equal to one. This is very effective for loop control. There is also a jump which may be in any address mode, and also a jump to subroutine.

"My present organization allows for 16 I/O devices, but this will shortly be increased to 256. The I/O devices I have working are: keyboard,

Teletype, cartridge tape write and read. The 8-track cartridge tape is useful as a paper-tape replacement. I run it about 100 characters per second. It is not yet as reliable as I would like it, but as I have error-checking write and read subroutines, it is no problem to read or write again if it is not correct. I use one track for clock and one for data, which automatically compensates for speed variations. I have a 6.5-million-bit disk, and am presently building its interface. I also have an IBM 727 tape drive, but it will have to wait for the disk. A friend and I also have a joint project: a CRT display. It is about half done.

"So I should have a big enough system in the near future to do some really meaningful work in the field of artificial intelligence. Right now, my machine has 45 active instructions, and I'll be adding about 20 more.

"One problem which set me back some was the fact that I had a 20-volt power line (for lamps) running next to an ALU control line. Well, a scope probe slipped, and zorked two of the TI SN74181N ALU chips. If anybody needs a couple of these with the 53 line non-functional, let me know. I learned one great lesson about using MSI: when using high-cost chips, be very careful to protect them against accidents such as this. Another thing I found is that interboard wiring on connectors using solder-lug-type terminals can turn out to be a mess. It's too late for me, but I advise anyone who is starting out to use wire-wrap if possible, or at least connectors with widely-spaced terminals.

"Another thing. I am using the 36-place DIP breadboards with 44-pin edge connectors. If possible, use boards with more connections, at least 56. Several times I have had to use another board only because of insufficient pin count. If you use TTL, always use plenty of .01-.1-uf capacitors on the board to bypass noise. Keep the main computer clock duty-cycle to a bare minimum. In other words, it should be a spike-type clock of, say, 100-nsec spikes. This is because many flip-flops are sensitive to what happens on their J and K inputs while the clock input is high. So if you have a control signal running to these inputs, then a spike for the clock allows the maximum time for your control signal to propagate through the logic. This was a major source of problems for me as long as I had a 50% duty-cycle clock.

"While designing your major-state generator (the counter that changes state once per memory cycle), keep in mind that it will need to be stalled in one position for halt, for I/O interrupts, and for direct-memory access. In control-unit design (about half my machine), I found it a good concept to make control lines wire-ORed or tri-state. In other words, when the machine is halted, the required position for the control lines in this state should be defined as normally high. Instructions are then implemented by "pulling down" the proper control lines in the proper sequence, with open-collector or tri-state gates (e.g., SN7401N is good). This organization allows you to build a minimum instruction set on one card which can be used to check out the memory and other parts of the system. Then instructions can be added on in logical sets. I also wire-ORed my 8 data-bus lines to allow attaching more registers."

INTEL MICRO COMPUTER SETS

Intel Corp. (3065 Bowers Avenue, Santa Clara, Calif. 95051) has two

"Micro Computer Sets," the MCS-4 and MCS-8, which are sets of LSI chips for microprogrammable general-purpose computers. The MCS-4 has a 4-bit parallel CPU with 45 instructions; the MCS-8 is 8-bit with 48 commands. The MCS-4 consists of the 4001 programmable ROM control memory (256 x 8-bit), 4002 RAM data storage (320-bit), 4003 I/O expansion (10-bit shift register), and 4004 CPU.

The last three are fairly cheap: $50, $10, and $100, respectively, for 1 to 24. The catch is the 4001; you have to order at least 25, at $25.50 each, plus mask charges of $600. If you don't know exactly how you want the 4001 ROM custom-programmed by Intel, you can do it on a cut-and-try basis with electrically programmable ROMs such as the 1601, 1602, 1701 or 1702, which are $91 to $109 each, for 1 to 24. You can have these ROMs programmed by Intel for $10 if you provide the tape, or $90 additional if Intel prepares the tape.

To program one of these ROMs yourself, you need the SIM4-01 microcomputer ($500, or you can build one from the schematics in the MCS-4 user's manual), MP7-02 programmer board ($400; schematics also available), three control-program ROMs at $101 each ($91 plus $10 for programming), and one ASR-33 Teletype.

The MCS-8 is not just an 8-bit MCS-4; for details see the 45-page brochure. An MCS-8 is made up of an 8008 CPU chip that contains circuits quite different from the 4004, and which costs $200 for 1 to 24; RAMs (such as the 1101); ROMs (such as the 1701) and TTL interface circuitry. To program a 1701 (or 1601) yourself, use the same setup as for the MCS-4, except that you use a SIM8-01 microcomputer at $900, along with the MP7-02, three control ROMs, and an ASR-33. All in all, if you want only one MCS-4 or -8, it's cheaper to buy a SIM4-01 or SIM8-01 and add ROMs and RAMs.

THE TRADING POST

RPC-4000 Parts?

Lyle Bickley (2351 Ridley Creek Rd., Media, Pa. 19063) writes:

"I recently purchased an entire RPC-4000 system which was in working order for $1000, less shipping. It consists of an RPC-4010 CPU with 8K of 32-bit drum memory and a RPC-4437 I/O control unit, Tally paper tape reader (120 cps), Tally paper tape punch (60 cps), and an 180XE console typewriter. Thrown in "free" was a Flexowriter in good working order. The entire system required a good deal of cleaning up and the I/O gear needed adjustments and preventive maintenance. I have completed all this, having easily obtained the service manuals from CDC and Tally. There is a complete set of diagnostic, assembler, compiler and problem-oriented program packages available from the CDC user organization, FOCUS (Forum of Control Data Users).

"One can purchase RPC-4000's (also LGP-30's and LGP-21's) directly from organizations upgrading to more powerful equipment. The names of these organizations are available from CDC salesmen or from ads in the FOCUS newsletter.

"I am interested in finding some parts of RPC-4000 equipment, especially a 300-cps Ferranti reader, and spare heads for the drum."

A Store in Dallas

KA Sales (1312 Slocum St., Dallas, Texas 75207) sent a flyer showing some EDP hardware, such as a "World Computer Unit" containing 58 Signet-

ics Unilogic ICs, power supply, etc.; and also used Nixie tubes, computer-grade capacitors, etc.

TTY Parts for Sale

Per Biorn writes from N.J.: "A friend of mine sells TTY equipment and ham stuff. Although a rather sharp businessman, he is a helpful fellow and has quite a few goodies in his shop. It is also possible to get TTY parts from him at reasonable prices. His address is: Van, W2DLT, 302 Passaic Ave., Stirling, N.J. 07980. He has a catalog he will be glad to send. Or call him at (201) 647-3639, at night only. Say Per sent you; it may (or may not) help."

Computer Parts for Sale

Gary Forbes (2028 W. Indian School Rd., Box 100, Phoenix, Ariz. 85015) writes:

"Your members may be interested in some computer parts I have for sale, some of which are: (1) computer-to-EIA interface boards (all ICs), (2) discrete logic which is compatible with TTL (this is a complete logic line), (3) a nice 32K x 20-bit ½-usec memory, complete except for power and computer interface, (4) a real nice core controller; this is a small IC sequencer and address and parity checker for an 18-bit word, (5) a lot of nice ICs mounted on boards, mostly TTL Sylvania SUHL II, (6) good technical assistance in getting these things operating. I have copies of many of the manuals."

Later Gary wrote to say he also has several boards out of a GE DN500 Datanet, an IC version of the DN30; "these cards would make into a nice minicomputer, I have some of the CR10 table-top card readers at $75 and an I/O interface board at $25. I have several core memories. The most complete ones are 2-usec Ampex 36-bit plus parity, 16K words. Some of the other core stacks I have are (1) 16K, 2 usec, 37 bits (2) 16K, 2 usec, 24 bits (3) 5.6 usec, 1K, 8 bits (4) 10 usec, 8K, 20 bits. Most of the memories are available with drawings and technical info to get them running. Another item is a 300-lpm 120-colum line printer. This stuff comes out of General Electric large computers. A friend and I are rebuilding a GE computer and hope to have it running soon."

A N.J. Member Has...

Wayne Ely (209 Lees Ave., Teaneck, N.J. 07666), who writes that he got a PDP-8 without core for about $1000 from Maynard, Mass., wants to sell a 728 tape drive, complete with maintenance manuals; this is the old tube model; $125, you haul. Also a switch panel, $50. And some core array from an IBM computer, 3 feet square, 16 planes with 4x4 arrays. Wayne needs PDP-8 core and an ASR-33 and PDP-8 cards for extended memory and extended arithmetic, etc.

Integrated Circuits

Steve Wiebking saw in Electronic News an ad for Intel-compatible 1101's, at $5.50; 1402, 1403, 1404 at $6.50; 2150 256-bit TTL RAMs, $28.50; for 1 to 100, $10 minimum order, from: Roni Discount Electronic Supply Co., 61 First St., Derby, Conn. 06418, (203) 735-9333.

Used DEC Computers and Modules

American Used Computer Corp. (15 School St., Boston, Mass. 02108) sells a 4K PDP-8/L or 8/I for $3000, an 8K 8/I for $6500, and a 12K 8/L for $8000. They have various DEC peripherals, from $1K to $3K, such as a TU-55 DECtape for $1200. And DEC modules (series B, G, K, M, R, S, W) and hardware such as 8/L racks, power supplies, etc., at 35% off DEC prices.

MORE ABOUT INTEL'S MCS

The MCS-4 directly drives up to 16 of the 4001's and 16 of the 4002's. Without a 4003, there are 128 I/O lines; with 4003's, I/O is unlimited. Minimum MCS-4 is one 4004 CPU and one 4001 ROM.

The MCS-8's 8008 CPU can directly address 16K x 8 bits of memory (any mix of RAM (including the 1103), ROM or shift register), and 32 different I/O ports.

HARDWARE

Dynamic Digital IC Tester

The May 1972 Radio-Electronics has a construction article, "Build R-E's Digital IC Tester," (pp 33-36, 85). Heart of the Digi-Dyna-Check is a 20x10 matrix switch that connects various inputs to any of the DIP pins; these inputs include 0, 1, a stepping pulse from a push-button, and an internal 50-kHz clock. Sixteen lamps monitor the logic levels. External input to and output from the IC is connected through binding posts. An adapter cable permits in-circuit testing of ICs.

The June R-E (pp 55-59) tells how to use the Digi-Dyna-Check, and is mainly concerned with how to set the matrix switch for the various ICs (SN7400 series, mostly) and then how to test them.

The July R-E (pp 59-61, 94) shows how to use the Digi-Dyna-Check in breadboarding circuits. A complete kit for building the DDC is $79.95 from MITS; a manual listing the pin connections for over 500 ICs is $2.75.

DEC PDP-8/F

The new PDP-8/F is exactly the same as the 8/E, except that it isn't as deep — it has room for only 20 card slots for expansion, instead of 40. So the 8/F is for the user who knows he'll stay within those 20 slots. The 8/F is $3990; the 8/E is $4990. If the 8/F user needs more than 20 slots, he can buy an expander box for — guess — $1000.

LED Edge Card Lights

Monsanto has introduced low-power edge card lights, for diagnostics and for indicating malfunctions. Typical operation is 15 mW at 5 volts, 3 mA. An internal resistor permits operation at 2.2 volts, with maximum set at 6 v DC. The lamps can be stacked 10 to the inch, and they fit in standard DIP sockets. Price for 1 to 9 is $2 each, from Monsanto — Electronic Special Products, 10131 Bubb Rd., Cupertino, Calif. 95014.

LSI for a Calculator

The Nov. 1970 Newsletter (p 3) mentioned the Electronic Arrays set of 6 MOS LSI circuits for a 16-digit calculator with 8-digit display capability; price, 1-10, $158.46, for 11-49, $144.06.

Now there are two cheaper sets from Electronic Arrays, the S-101 and S-114, for 8- and 16-digit entries. Each set consists of four chips: input, control & memory, arithmetic & register, and output. Both sets provide add, subtract, multiply, divide, stored-constant operation, keyboard setting of decimal-point location, and BCD outputs for display control. For 100 to 249, $40.

An Expensive Kit

Lockheed has developed a modular line of minis called SUE (System User Engineered), which involves a kit of parts from which you select the various ones you want: basic chassis, CPU, core, I/O controllers. One minimum configuration, with 4K

The Amateur Computer Society is open to all who are interested in building and operating a digital computer that can at least perform automatic multiplication and division, or is of a comparable complexity.

For membership in the ACS, and a subscription of at least eight issues of Vol. III of the Newsletter, send $5 (or a check) to:

Stephen B. Gray
Amateur Computer Society
260 Noroton Avenue
Darien, Conn. 06820

The Newsletter will appear every two months or so.

of core, costs $3425 each.

Minuteman Computers

Computerworld notes that "only about five of the 100 installations actually have their D17's running." These 100 are the members of the Minuteman Computer Users Group.

Computer-Generated Grey Shades

According to Computerworld, Computax Corp. uses computerized graphics in their office interior design. Variable density was achieved by using ten shades. The #0 shade is blank; #8 is superimposed O, A and X; #9 is superimposed O, A, X and V. Different fonts may require other combinations. The 10 shades:

```
 0  1  2  3  4  5  6  7  8  9
    ...'''===+++XXXOOOOOO▒▒▒▒▒▒
    ...'''===+++XXXOOOOOO▒▒▒▒▒▒
```

More on Scopes

That Heath/Schlumberger EU-70A dual-trace 15-MHz scope, mentioned in the previous newsletter as available assembled for $595, is also available as a kit, model IO-105, for $430 from a Heath store.

And as for electronic switches, the 10:1 rule does say that the highest frequency to input to an electronic switch should be no more than a tenth of the switch's switching frequency. However, in practice it has been found that ratios as low as 2:1 are often suitable, so that if the electronic switch's top rate is 100 KHz, you can input up to 50 KHz without missing too much in the chopping of the signal. Beyond these limits, you either have to examine one signal st a time, or use a dual-gun scope.

TI's Low-Priced Minicomputer

Texas Instrument's 16-bit 960A, with a 750-nsec cycle time and 4K words of semiconductor memory, is $2850, for 1 to 100. The 960A is built with standard 7400 TTL MSI! The CPU is on one 10-layer board, with a front panel also formed from a circuit board. LEDs are used in the panel display. Added MOS memory is $1500 per 4K words. Software includes Fortran, monitors, loaders, microprocessors. For OEMs.

Heathkit Peripheral Interface

A do-it-yourself peripheral interface kit for the PDP-8 family of minis (L, E, M or I), the Heath/Schlumberger "EU-801E Computer Interface ADD" costs $1250, consists of the three-module Analog-Digital Designer (see the Aug. 1968 Newsletter, p 4), an interface-buffer assembly, and a workbook.

A GENEROUS OFFER OF HELP

E. Douglas Jensen (M.S. A3340, Honeywell, Inc., 2345 Walnut St., St. Paul, Minn. 55113) writes: "Since I design computers for a living, and also have a lot of contacts in the surplus and excess inventory business, perhaps I can be of help to other members. Anyone is free to write to me on either topic."

HAL-4096

ACS NEWSLETTER

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HAL CHAMBERLIN'S COMPUTER

According to Hal (Howard) Chamberlin's Survey Form, his operating "HAL-4096" computer has 6 registers and is 3/4 made of IBM cards, 1/4 home-built cards. Core memory: IBM 1620 stack, 16-usec, 4096 16-bit words. I/O is Selectric typewriter, paper tape reader/punch, dataphone. The clock speed is 1 MHz; there are 16 instructions. Add speed: 3 µsec carry propagation, 16 µsec total.

Special features: "16 index registers in upper core, 6-level nested priority interrupt system, programmed I/O to slow devices in 2 groups and 2 independent data channels for fast devices. Trace interrupt permits control program to trace untried program on console typewriter. 4-level priority memory-access scheme." The CPU cost $500, total time was 2½ years to build, with wire-wrapped construction.

Other information: "Paper-tape reader is entirely homemade, with step-motor drive, 125 char/sec; photocell read; total cost with new step motor, $45. I/O devices available but not connected: 384K-word drum, two 7330 tape drives, two 100-cpm card readers, 180-column/sec card punch, alphanumeric keyboard, facsimile machine. A home-built line printer is 1/3 complete; 52-character chain, about 200 lpm. Current use is object machine for computer science class projects. Current programming project is a 4 remote user (by home-built dataphones) Basic-language time-sharing system."

Hal has written 20 pages of notes and schematics, "Using Complete 1620 Memory Units for Binary Addressing." Here are some of the notes:

"This set of drawings and plans represents the original work I did in adapting a complete 1620 memory unit for operation in a 16-bit homemade computer. The method used for converting to binary addressing was optimized for minimum alteration of the unit itself and simplified driving circuitry at the expense of speed. The unit that will be described has been built and operating for about 6 months. Reliability has been perfect. The complete 1620 memory stacks may be purchased from Mike Quinn Electronics, 727 Langley St., Oakland Airport, Calif. 94614, for $175. They include a stack of 12 planes of 10,000 bits each, divided into two sense-inhibit groups each, and X and Y-axis switch core matrices. No electronics are included.

"Statistics on the unit built are as follows: Cycle time, 16 microseconds full cycle read, write, read-modify-write, 6 microseconds access. Size: 4086 words of 16 bits each, 12-bit binary addressed. Special features: split-cycle operation; a cycle may be suspended halfway through it, the data in the memory data register may be manipulated, and the cycle restarted. The data in the memory data register will be written back into the same location. The memory data register is also an up-down counter so that the contents of a memory location may be incremented or decremented in only one cycle. Writing in a location can be all bits, the upper 8, the lower 8, or the lower 12. Where only a portion of a word is written, the rest of the word is unaltered.

"The only modifications made on the memory stack were the cutting of 4 jumper wires on the switch core matrices and bringing the free end of

the jumpers out to the wire-wrap terminal boards. Conversion from the decimal addressing to binary addressing was accomplished with 12 3-input NOR gates, 12 2-input NOR gates, 4 4-input NORs, and 12 inverters. The current drivers are simple saturating switches capable of carrying 350 ma; 40 are used. The drivers have 5-input NOR inputs; all inputs must be logical zero to have drive current. The other logic gates should be capable of dot-ORing. In this design, 4 planes in the stack were wasted. If one wants a 24-bit word, all that would be required is 8 additional sense amplifiers and inhibit drivers. No modifications to the drivers should be necessary. A slight change in address decoding logic would allow 8192 locations of 12 or fewer bits.

"The logic gates, sense amplifiers, flip-flops, and inhibit drivers are all of IBM origin. The current drivers are an original design. Circuits of all plug-in cards are given so that the entire unit could be duplicated, given a good supply of IBM parts boards."

The remainder of the 20 pages contain a page on address decoding and driving, another on the procedure for aligning the drivers and sense amplifiers, and schematics for a timing signal generator, X and Y switch core matrix decoders and drivers, memory data register, and the various NORs, inverters, amplifiers, drivers, etc. The last three pages concern memory driving with ICs, with four schematics.

Ferranti 371-12A Memory Drum

Hal next sent 13 pages of text and schematics on a Ferranti drum. Part of the text is as follows:

"This memory drum is currently being sold for $295 by Herbach & Rademan [401 E. Erie Ave., Phila, Pa. 19134] and is ideal for the advanced amateur computer builder. Although there is space for 480 tracks on the drum surface, only 384 data heads are mounted. As a result, if part of the surface is damaged (H&R do not guarantee a perfect surface, but I haven't found any bad tracks yet), the affected heads can be moved. Along with the data heads there are 6 clock tracks with heads. A read clock, write clock, and index clock along with a spare for each is provided. Actually, I use only the read and index clocks, since the write clock is simply a delayed version of the read clock. The index clock, in conjunction with the read clock, will generate a pulse each revolution at the beginning of the data tracks."

There are schematics for bit and track timing circuits, drum matrix driver, drum amplifier, peak detector, drum write driver, etc.

Plans Available

Later, Hal wrote, "I would be happy to provide copies of the 1620 memory plans to interested people for $2.00. I can reproduce and mail the Ferranti drum information for $1.50. [Hal Chamberlin, 516-B West Cabarrus St., Raleigh, N.C. 27603].

"I would emphasize that the 1620 stack is very flexible in that 8192 locations of 12 or fewer bits are possible for short-word fans, and 4096 words of 13 to 24 bits can be done also simply by rearranging circuits slightly. The cycle time of 16 µsec is unaffected by the word length chosen.

"For people who prefer faster cycle times with more costly drive circuits, I am completing a similar set of plans for a diode-matrix drive which will cycle in 4.5 µsec. The drive circuits can drive any memory of 30, 50 or 80-mil cores with half-select currents of 350 ma

or less. The 4 basic circuits (source-sink drivers, inhibit drivers, sense amp-data register, and load resistors) are laid out on 22-pin edge-connected single-sided circuit boards. I can soon offer a complete package for $5.00, on these universal memory-driver cards, including theory of operation, schematics, timing diagrams, instructions on how to adapt to nearly any kind of surplus memory stack, and a set of layout negatives along with assembly diagrams. All components are readily available on the surplus market from a number of suppliers, and all circuits generate 7400 TTL outputs and accept TTL inputs.

"Any interested person can have a copy of the principles of operation manual on my computer, and a sample program, for 50¢."

Other Surplus Available

"For the moderate-size-memory maker, two items have shown up in surplus catalogs lately. First, Star-Tronics (Box 17127, Kenton Station, Portland, Oregon 97217) is offering a 1024-word by 8-bit, 50-mil core memory stack for $20. The selection diode matrix is included and all connections terminate in a connector with mate supplied.

"A perfect complement is a PC board sold by Delta Electronics Co. (P.O. Box 1, Lynn, Mass. 01903) for $12. This board has all of the source-sink drivers, inhibit drivers, and sense amplifiers for two of the Star-Tronics memory stacks, which would provide 1024 words of 16 bits each with about 6-usec cycle time. The only items needed for a working memory are a timing generator, a handful of 3-input gates for address decoding, and 8 dual D flip-flops for a data register. Inputs and outputs are TTL compatible. Delta also has another board for $20 which appears to be the same thing except for a 4096-word by 16-bit memory."

Hal's Uses of HAL

"As to what kind of programs I run on my computer, the story goes something like this: The computer was built to control an electronic music synthesizer (analog) which I built up during high school for science fairs. In the course of building the computer it became clear that the synthesizer could be greatly improved if the analog circuits were replaced by digital circuits. So here I am with a computer and without a satisfactory music synthesizer to connect it to.

"I have two friends who are regular users and who are helping write a firm software base. So far we have written a full-function debug program which doubles as an operating system, a complete in-core assembler, and are about 75% finished with a 4-user timesharing Basic system. When the hardware catches up, access to the Basic system will be on a dial-up basis from any standard Teletype terminal. Since the compiler, interpreter, telecommunications routines, and math routines take up nearly 3K words, a 20K-word memory expansion is being put on to give a reasonable-sized user partition. My Herbach & Rademan drum should be up in 2 or 3 months, which will give users the ability to save programs and data."

Home-Grown Instruction Sets

"At this point I wish to take issue with Bob Carpenter's remark March 1972 Newsletter about "home-grown instruction sets." The HAL-4096 has a homebrew instruction set which seems to be optimized simultaneously for simplicity and effectiveness. The simplicity is borne out by the fact that the softwear mentioned above has all been written and debugged since last December [6 or 7

months ago]. The effectiveness shows when a full-function assembler fits in 1200 words, or a stripped assembler (such as PAL-III for the PDP-8) fits into about 750 words. The floating-point package is 30% smaller than the one supplied for the IBM 1130, which uses the same data format, and the 1130 has automatic multiply/divide!

"In short, I think that a big part of amateur computing is programming and discovering programming tricks that can be done with one's own instruction set. To me, copying a production machine's instruction set is like building a kit, in that you can't honestly say that the final result is all yours. Anyway, commercial machines with decent I/O provisions are way too expensive. If you exclude the 453 oscilloscope, then the computer, I/O gear, 40K words of add-on memory, and drum have all cost less than $1500.

"At any rate, I still plan to connect the machine to a digital music synthesizer (the design of the synthesizer is my Master's thesis topic), an organ keyboard, and a graphics display so I can experiment with computer-aided composition and performance of music. When the hardware is ready, I would also like to set up an amateur modem network with other members' computers which have data modems."

Hal sent a photo that shows the console keyboard set into one end of an L-shaped desk, with the CPU and its lamps and switches directly behind, in a cabinet about 6' high, 3' wide, and maybe 6' deep. At the other end of the desk is a Selectric typewriter; in between is the 453 scope for alphanumeric display. To one side is steel shelving with the tape reader and punch, facsimile machine, etc., and next to that the magnetic-tape drives. Most of it is in quiet, pastel shades of green and yellow, and blue.

WHAT OTHER MEMBERS PLAN TO DO

The latest version of the Survey Form asks "What kind of programs do you intend to run on your computer when operational?" Here are most of the responses so far:

Engineering calculations, statistical data reduction, data storage and retrieval, entertainment graphics, perhaps automatic machine-tool control (Durk Pearson, Calif.). Computer-generated music (J. Hemenway, Calif.). Games, personal income tax, bookkeeping, etc. (Steve Marum, Ind.). Data storage, number crunching with "programmable calculator," computerized music (G. Chamberlain, Fla.). Mostly educational programs (Dale Schutte, Ariz.). Interpreter, compiler, assembler, editor; real-time applications; i.e., monitoring, timing (Bob Diffely, Ore.). Accounting programs (tax, general ledger, financial, etc.)(Jim Law, Tex.). Usual games and desk-calculator-type programs, and simulation and learning programs. Would like to try multiprogramming when core and drum permit (Pete Bayly, Ontario, Canada). Number experiments, linguistics, CAD for a bigger machine, high-school student math projects, home economics (Jerry Bryson, Va.).

Fortran CAD programs (Rickey Caldwell, Okla.). Desk calculator, computer demonstrator and trainer, music synthesizer, and processor for a programmable terminal (Elmer Beachley, Pa.). The first task will be to write utility routines and an assembler. After that, I am primarily interested in exploring the development of new languages designed to allow non-programmers to utilize computers. One example might be something to permit young children to interact with a computer. Another might be a language to facilitate programming of games. Of course, I also intend to write household ac-

counting programs and things like that (Gene Witherup, Pa.). Intend to use machine as proving grounds for software systems experiments, and eventually to build a time-sharing machine (Ira Baxter, Cal.). General purpose; e.g., home "MIS," possibly service-type operation. Hope to develop commercially (Jim Melton, N.J.). Mainly for educational purposes (Michel Dreyfus, France). The machine will be used for dedicated real-time control of a robot (Chris Dewhurst, B.C., Canada). Artificial intelligence (after assembly language and operating system are written)(Ron Carlson, Calif.). Statistical analysis, computer-aided education, and language translation (George Dinsmore, Calif.).

THE TRADING POST

A Garage Full

Ron Carlson (6717 #44 La Cienega, Inglewood, Calif. 90301) has "an entire garage full of stuff that needs cleaning out," and will sell (1) a Douglas experimental digital computer in two 6-foot relay racks, without backpanel wiring; all schematics; will deliver within 75 miles, $60. (2) Two Goodyear analog computers, 24 amplifiers each, two patchboards each, one set manuals; 600 lb. each, so bring a trailer; $400 each, $600 both. (3) Teletype model 18, 4 char/sec, $100. More information on request.

IC Mounting Boards

Gary Forbes (2028 W. Indian School Rd., Box 100, Phoenix, Ariz. 85015) has "some real nice boards for mounting 14-pin ICs. They are mounted dead (pins up) and soldered to wire-wrap pins. This board will mount 200 ICs. One side of board is $+V_c$, other is ground. The mating connector will handle 6 of these boards. Boards, $3 each; connector rack, $6. I think this would solve the IC-socket problem if you're willing to solder the ICs."

PC-Board Layouts

Peter Stark (196 Forest Drive, Mt. Kisco, N.Y. 10549) has several PC-board layouts he'll send you for a self-addressed stamped envelope: (1) frequency counter (to 20 MHz), uses Fairchild ECL and 7400 TTL, Numitron or LED readout (costs $90 with all new parts), ECL scaler (about $25) extends range to 300 MHz (see 73 magazine, May, June, Sept. 1972); (2) touchtone decoder.

HELP WANTED

Bendix G-15 Computer

Charles Kiessling (P.). Box 539, Endicott, N.Y. 13760) is rebuilding an old Bendix G-15 computer, and is "interested in contacting others with G-15's either as hobby or business."

AWCIS MA-1 Computer

Alvin Marshall (412 Oakwood St., Angola, Ind. 46703) is "thinking of using the drum unit from an AWCIS MA-1 computer -- some sort of USAV Nav-Attack system -- as a file unit. Has anyone used one? What is the drum speed, what data rate - bpi - did you use, what did you use to drive the heads? Any problems with the drum coating, heads, etc.? If anyone has a drum and no data, I have prints for head-to-socket-pin data. Send a SASE and I'll send you a copy. Would be glad to hear from anyone using disk/drum for fast mass memory."

Associative Memory

Darrell Foster (8220 Research Blvd., Apt. 173C, Austin, Texas 78758) would like to know if anyone is working on a "general purpose" associative memory or processor.

The Amateur Computer Society is open to all who are interested in building and operating a digital computer that can at least perform automatic multiplication and division, or is of a comparable complexity.

For membership in the ACS, and a subscription of at least eight issues of Vol. III of the Newsletter, send $5 (or a check) to:

Stephen B. Gray
Amateur Computer Society
260 Noroton Ave.
Darien, Conn. 06820

The Newsletter will appear every two months or so.

His computer "is not going to be designed around the CPU, but around the memory (e.g., to give the memory a data-processing capability). As is indicated by various computer projects (e.g., CDC's STAR, TI ACS), the wave of the future is in high memory utilization (not high CPU utilization alone.)"

Ampex Memory Unit

Louis Taber (3520 N. Prescott Pl., Tucson, Ariz. 85715) asks for information on an Ampex memory unit, model MA6, Assy. No. 3227339-10 M, Issue No. 088.

HARDWARE

More on the NRI Computer Kit

The 16-pound desk-top 832 computer is built as part of a $500 National Radio Institute course (March 1971 Newsletter, p 3).

ACS member Louis Frenzel, who designed the 832 for NRI, and is their Director of Instruction and Product Research, has very kindly arranged to make the 832 Reference Manual 10KX available for $10, if there is enough demand. The manual contains block diagrams and full schematics, with all component values except the power-supply transformer and rectifiers.

The 832 computer will soon be offered separately from the course, in wired form, for $600-$700. There are 16 8-bit words in a read-only memory consisting of slide switches. For another $35, the student gets another 16 words of semiconductor RAM memory, plus the 11K manual on how to install the RAMs, along with 10 programming experiments including square root, floating point, and some games.

The ten PC boards will be available for about $10, without ICs or IC sockets or terminals. If you're interested in either the manuals or boards, write Louis E. Frenzel, Jr., National Radio Institute, 3939 Wisconsin Ave., Washington, D.C. 20016.

The full 832, with bipolar RAM memory, consists of 74 ICs, 7400 types. The 832 has 15 instructions.

The 10K manual contains ten programming experiments for the 832, and the assembly manual has a set of diagnostic programs for checkout.

Digital Kits

Environmental Products (Box 1014, Glenwood Springs, Colo. 81601) has a 52-page catalog that includes quite a variety of counter/display modules, with both LED and Numitron (vacuum-tube) segmented displays, and several types of counters, plus several assembled instruments, 7400-series ICs and other components. No surplus, all new from the factory. Quarterly, they publish application notes, mostly digital, for $5 a year, and they pay authors for new notes. EP invites ACS members to submit circuits.

ACS NEWSLETTER

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BOB BENJAMIN'S COMPUTER

From Texas, Bob Benjamin first sent the following:

"I read your article on building your own computer. I have built one and thought you might be interested. I'm an electronic engineer with LTV Electrosystems. Never had digital experience. Built the computer to learn. Now doing digital work as a result. Started October 1968, was operating stored programs by Feb. 1969. Have added instructions and I/O features since....

"Started with model 19 Teletype and worked I/O first. Memory: 62 words, 25 bits, dynamic shift register.

"Registers: ACC, MQ, 1 Index, I/O status, program count save for subroutine save. Arithmetic: 2's complement; add, subtract, logical And, mult, divide 2's comp, increment ACC, clear + add, clear ACC, etc. Branches: jump if minus, not zero, unconditional; decrement Index and branch if not zero.

"Five-bit byte symbol string oriented. "FIGS" used as op code prefix for digit keys causes automatic decimal to binary conversion into ACC. If op code (5 bits) needs address, next byte is address. FIGS prefix on address op codes causes displacement by index register value.

"Op codes semi-mnemonic: AX means Add contents of location X to ACC. D = divide, M = subtract, L = load ACC ⇆ Index register, X = multiply, S = store, O = output one byte off ACC to TTY and shift 5 bits, C = clear ACC, H = halt, etc.

"Word organization for programs is 5 consecutive symbols - address not in particular bit positions - reads symbols in sequence - ops that don't need address just 5 bits then next op examined.

"Binary to decimal conversion and print on TTY is software but takes only 8 words (less for positive numbers). E = external execute, takes instructions from paper tape if actuated or from keyboard if tape not actuated, such as for loading bootstrap program. Some op codes required an extra byte, use next 5 bits as modifier, such as for shifts: long, short, left, right, circular, non-circular, etc.

"Some software: wife's adding machine, desk calculator for me, random flash-card exercises for children with messages typed to user, line by line text edit.

"FIG F in program prints following message until FIG H, then proceeds to compute "F" by itself, prints next symbol such as for decimal point. Each key on Teletype is a potential address (31), "LF" changes pages of memory. Machine serial and very slow; 100-kHz clock, 400 symbols/sec execution. Following is a program example for binary-to-decimal conversion and printing result:

Program					Loc. Letter	Loc. Bin.
(#1,000,000)					E	01
F	-	N	G	SP	LF	02
J	LF	F	+	SP	A	03
L	C	FG	7	L	SPACE	04
D	E	Z	Q	Ø	S	05
I	S	F	CR	F	I	06
LF	R	SP	SP	SP	J	07

"Main program would say RGA, meaning Return Go to location A (03). R remembers program count by swapping with 5-bit register. J LF (02) means jump if ACC neg to location LF (02). F - means print a minus sign. N = negate ACC. G SP, go to location SPACE (04). L = swap ACC and index to save ACC. C FG 7 = clear ACC, loads binary 7 to ACC. L = swap index and ACC. D E = divide ACC by E, 1,000,000. Z = print digit of 4 LSB's of ACC (quotient ends up in ACC, remainder in MQ). Q = swap ACC with MQ to get remainder. Ø = mult ACC by 10. I S = decrement index, if not zero go to location S (05), otherwise continue. F CR F LF = print carriage return and line feed. R = return to main program. (Spaces are no op.)

"Branch points must be beginning of 5-symbol block. Numbers are 24 bits and sign. This machine has been functioning for 2½ years. Made for $400 with samples and surplus. Have a 4K core memory now that this computer can read and write with -- planning PDP-8 with old computer primarily as ASR33 simulator and executive control."

Bob's second letter said, in part:

"Scientific Controls Corp. in Dallas went bankrupt and had an auction. Couldn't make the auction but friend bought me a 4K x 12-bit complete Fabri-Tek memory system (new) for $25. I've added a general I/O instruction to old computer to talk to it. Can load data and retrieve data with 12-bit address and 12-bit data from ACC of old computer. Have loaded TTY pictures and played back. Also have run worst-case test patterns.

"Plan is to build PDP-8/I. Got all ICs for 1½¢ apiece, including such items as 1-out-of-16 decoders at SCC auction.

"Design of computer was at random, no previous conceptions or books, except Richards' "Arithmetic Operations in Digital Computers." Machine is serial. The 25-bit word was shortest National Semiconductor dynamic shift register. Also, machine was originally wanted for stock market, and 25 bits is approximately correct for personal finances and hopes 300,000 dollars (wishful thinking). The PDP-8 software can be bought for a nominal fee including FOCAL which would make a nice home scientific machine.

"Incidentally, I find my easy-to-program computer more useful for doing some work problems than the IBM 360, H-P 9100B, or Raytheon 703, particularly in simulating digital algorithms related to hardware."

In his third letter, Bob notes:

"I've been amazed at how useful only 62 words (two 31-word pages) of memory can be when symbol byte oriented. Memory size has not yet limited what I have wanted to do with the machine. If the problem is much larger it is done at work on the 360/50."

HISTORICAL PERSPECTIVE

Doug Jensen, who kindly offered to help ACS members with design problems (June 1972 Newsletter), writes:

"I cannot imagine better advice to an ACS newcomer than for him to read straight through from issue 1 to (the current) issue 24. The historical perspective of computer technology that can be obtained could well be one of the most important benefits he receives from his amateur computer activities. Semiconductor cost/complexity curves have changed

by orders of magnitude over the design cycle of a typical ACS computer. This will continue to be true: SSI circuits will be 10¢ and microprocessors such as the Intel 8008 will be $25 in the near future. ACS members should carefully consider their motives and goals in the light of rapidly changing technology. Even if a builder's principal objective is to acquire engineering experience, it is still frustrating to see hundreds (even thousands) of hours and dollars be replaced by a $10 IC. A member who is more concerned with having and using a computer would be wise to concentrate on the systems and software aspects of the machine rather than the detailed design of its processor. Even if it were free, the 8008 is not much of a processor — how could you build a more capable machine from several of them? Learn to program the PDP-11 and/or the Nova — the next generation of IC processors will have instruction sets which are compatible with these popular minicomputers."

In an earlier letter, Doug wrote:

"Much more sophisticated 16-bit and larger processors are now imminent from several major IC manufacturers. Some of these will be directly program and I/O compatible with today's popular PDP-11 and Nova minicomputers. Many other valuable units (such as complete 103-type modems) will also be introduced soon as LSI chips. This indicates that perhaps amateur computer builders should stop worrying about a level of design which for the most part they are ill-equipped to cope with. Vol. 1, No. 8 noted that successful members have been professional EE's. The availability of low-cost TTL ICs may have altered that situation slightly, but the emergence of LSI subsystems should allow serious hobbyists to construct their own machines. This goal will still require substantial technical knowledge, and in some cases the traditional EE will be no better prepared than the amateur. For example, LSI microprocessors like the 8008 may be inexpensive, but they are also very low performance, which raises the question of how to effectively interconnect more than one of them to increase throughput. This is a very broad and complex problem that is the subject of study at many corporations and universities.

"In the area of excess inventory, I list below several sources that I have found to be productive. Few, if any, of these advertise in national media; most do not have catalogs or mailing lists — write and tell them what you need.

Vide Corp.
1918 Ottawa
Houston, TX 77043

Teco
P.O. Box 1050
Garland, TX 75050

AC Equipment
10616 Hempstead Hwy.
Houston, Texas

KA Sales
1312 Slocum St.
Dallas, TX 75207

Acme Electronics
224 washington Ave. N.
Minneapolis, Minn. 55401

Gordon Elliott White
1502 Stonewall Ave.
Alexandria, Va. 22303

"It should also be noted that large companies everywhere frequently operate surplus stores; these almost always require personal visits. Another extremely good way to find components, subsystems, and even complete systems, is to attend electronics company bankruptcy auctions. These are usually advertised in the local papers; some auctioneers maintain mailing lists. You must attend personally and bring cash, but even travelling a consid-

erable distance can sometimes be worth the time and cost. However, not everything sold at an auction is a bargain — particularly beware of test equipment, which often goes for near new prices.

"I am afraid that I am unable to assist your readers in the design or selection of core sense amps and drivers.

"I have for sale some new, factory-sealed Lambda 5V/48A power supplies. These are 3½" rack-mounted units. The manufacturer's current price is $475 each; my price is $150 each. [Doug also has Augat 8136-PG1 high-density DIL packaging panels, new, unused, list price over $350, for $100. Also for sale: a variety of IC's, mainly SN7000N types, at "10% less than any advertised prices."]

"I do quite a bit of consulting in the area of computer organization and design; I would be happy to donate whatever assistance I can to your readers. My response time is always a function of my business commitments. I encourage that requests be sent on cassettes; a phone number where the individual can be reached during the day will allow me rapid reaction to particularly time-critical or interesting problems."

Doug is a Principal Research Engineer/Scientist, in Computer Technology. His address is: E. Douglas Jensen, M.S. A3340, Honeywell, Inc. 2345 Walnut St., St. Paul, Minn. 55113. (That's Honeywell's Government and Aeronautical Products Div.)

CALCULATING WITH BASIC?

The thin, fuzzy line between computers and calculators seems to have been erased by the Wang Laboratories 2200, which is the first calculator that operates in Basic language. The 2200 looks like a terminal, with an 8-by-10½-inch CRT display, cassette data store, and keyboard. The keyboard has a key for each Basis instruction (which is fast and also reduced errors), numeric keys, exponential and math function keys, plus 16 special-function keys to which subroutines can be assigned by the user.

The microprogram architecture involves a 6-kilobyte braided-wire read-only memory, used instead of MOS because it's cheaper. The basic 2200 has 4096 program steps, expandable to 32K steps. The CRT shows 14 lines of 64 alphanumeric characters per line.

The 2200 is modular: the CPU with 4K programming steps is $3500; additional 4K steps are $1500 each. The combined CRT and cassette unit is $2500; CRT alone, $1500. The keyboard is $700. So a minimum 2200 is $6700; without cassette storage, only $5700.

Hewlett-Packard's 9830A (Model 30) calculator was announced a few weeks later. The Model 30 looks more like a combination typewriter and calculator, with integral 32-character LED alphameric display and built-in tape cassette.

The minimum 30 has 3520 8-bit bytes (1760 words) of read/write memory, expandable to 7616 bytes. The keyboard includes all typewriter keys, a set of numeric keys, edit keys, and 10 special-function keys. The single cassette can hold up to 80,000 bytes.

Add-on ROMs provide optional features such as matrix operations, plotter control, extended I/O and string

variables.

The minimum 30 is $5975. Each add-on ROM, $485. Peripherals include plotter, paper-tape reader, page-width printer ($2975), external cassette unit, Teletype, etc.

ELECTRONIC MUSIC CLUB

The Electronotes Newsletter appears every 20 days or so (!!) and covers construction, theory and use of synthesizers, etc., as well as reviews of literature, performances and products. For further information, write: B.A. Hutchins, 60 Sheraton Dr., Ithaca, N.Y. 14850. As he puts it, "Computers have lost some favor in electronic music, people preferring the synthesizers, but recently there is a trend back, as more and more computer equipment is available to more people, and also digital generation of sound is very big." ACS member John Bottoms is cited as having "teamed up with Gary Nelson at Purdue, using a CDC 6500 computer in a modified version of "Music V" called "Music 65."" A copy of the program from the line printer is 1½ inches thick. There is also mention of DECUS (the DEC Users Society in Maynard, Mass.) having "a couple of music-type programs in its program list."

TEMPLATE FOR DRAWING PC BOARDS

The Quad-Template by Kandu provides four types of symbols: (1) for PC boards: conductors, pads, card-edge connectors; (2) for logic, gate and function-box outlines; (3) for drill jig: lead-hole patterns for transistors, ICs and components; (4) for schematics: alphabet, components, arrows, etc. Made of a rather thin plastic, the Quad-Template is $2.50 from Kandu, Inc., 6115 Miller St., Arvada, Colo. 80002.

THE TRADING POST

Used PDPs

Ken Karow writes from Chicago that Newman Computer Exchange (222 S. Seventh St., Ann Arbor, Mich. 48103) offers a PDP-8 4K for $1500. Also a 4K PDP-8/L for $2640, 4K PDP-8/I for $2900, and a TU-55 DECtape at $1150.

Readout Samples

Barry Mulligan of New York writes about the limited-time offer by Dialight Corp. (60 Stewart Ave., Brooklyn, N.Y. 11237) of a number of readout modules (both segmented and dot-matrix) at around half-price, for prototyping.

Computer Equipment Source

For 50¢, a catalog from MNH - Applied Electronics (P.O. Box 1208, Landover, Md. 20785) lists used computer equipment such as control panels, RCA memory systems ($485), address registers, arithmetic units, cabinets, etc. Also a complete communications processor that needs some logic debugging and interface wiring. Also listed: TTL ICs, electric wire-wrap guns ($87), etc.

Surplus Burroughs Computers

Dick Breidenbach of Michigan writes that "Silverstein's, a surplus store in Detroit, has about 90 Burroughs B-200 computers for sale. The CPU with 4K storage is going for $150, the 132-position line printer for $150, and the card reader for $100....Documentation is hard to come by....Unfortunately only those who live near Detroit will be able to take advantage of these machines, as they are strictly cash and carry, and the printer weighs about 1700 pounds! I bought one door of the CPU with the core, all drivers and buffers, for $35."

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The ACS Newsletter will appear every two months or so.

Logic Cards, Anyone?

Dave Digby (311 South Brown Ave., Orlando, Fla. 32801) writes:

"I have acquired a fair number of logic cards, discrete transistor type, of various brands (Milgo, Raytheon, Milgo, etc.) and would gladly part with them for little more than the cost of shipping. Not enough of any type to build a whole computer, but maybe enough to construct an I/O interface or supplement one's existing supply. Let anyone interested send me their limitations — connector type and contact spacing, number of pins, transistor types, card dimensions — whatever, and I'll let them know if and how many I have to match. And I have telephone-type relays by the pound! And some lab instruments."

Help Needed

Bob Harrington (2228 Ft. Stockton Dr., San Diego, CA 92103) writes:

"I'd be interested to know of anyone who has built a cassette drive for 3M's belt-driven cassettes. It looks like it would be easy, but may not be.

I'm having trouble trying to program the Signetics 8223 256-bit P/ROMs, They seem to be re-linking, as they do not take. Anyone else having this problem?"

Audio Heads for Drums?

Jerry Bryson (618 W. 33 St., Richmond, Va. 23225) writes, in part:

"Since I announced my intentions, I have received a lot of advice about core ("Don't try it!"). Indeed, the drum may be better, from the standpoint of expense, capacity and word size. I'm not interested in great speed. I'm wondering about audio heads for the drum. Will 20,000-cps audio heads work for 20,000 bits/sec? will they work faster? Will they work at all?

"I visited the computer exhibit at the Smithsonian. Most of the relics were built by hand and should be an inspiration to "datamaniacs." The exhibit does leave something to be desired, however. Many displays are not yet labelled and most of the stuff is from space and military applications. An Atlas control system is still alive and does demonstrations daily. There is no 1401, which should certainly be there. And the miscellany of memory stacks, etc., is just so much junk without any captions, unless you already know what you're looking at. If the Smithsonian accepts volunteer help, Washington-area ACS members could make a contribution to both history and public education with their services."

FAST FLIP-FLOPS

Motorola has a new MECL III IC, the MC1690, a master-slave D flip-flop with a toggle rate over 500 MHz, at $55 each for 1 to 24.

ACS NEWSLETTER

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February 1973

ROTHMAN WRITES AGAIN

Allyn Rothman writes from New York:

"I don't have much progress to report on the hardware side, but my logic design has undergone several revisions. My basic philosophy still remains that of implementing the machine instructions by means of a microprogram stored in some type of read-only-memory or alterable ROM. This neatly divides my work effort into two convenient sections. I can design and test the logic of my microprogram on another computer using simulation techniques, thus saving the expense and time of building complex logical functions with hardware. The hardware I require, then, becomes just the ROM plus relatively simple data busses and gates. I have redesigned the micro-logic several times, since as various ICs become cheaper on the market, it pays to take advantage of them in the overall design. Prices are dropping rapidly, so I tend to spend more time developing my "firmware," and less on the hardware. ROMs are still expensive, and with my computer depending heavily on them, the longer I wait to buy, the cheaper my machine becomes. For me, looking at the output from a successful micro-logic simulation run is just as satisfying as seeing the lights blinking on the finished machine.

"I have been lucky in one respect. My memory, which is a 10K x 12-bit unit taken from an IBM 1620, is working satisfactorily in a breadboard setup. It runs with a 10-microsecond cycle time and appears to be 100% reliable as far as errors are concerned. I see that Bob Carpenter is also making use of an IBM 1620 memory [Mar. 1972, p 3], which he obtained from the same source that I did, Herbach & Rademan. I regret not having bought additional modules, because the slow cycle time plus the core matrix switches used for drive-line selection make the unit relatively easy to operate. The 10-μsec cycle time also gives me plenty of room for micro-programming to control all the necessary functions between cycles. A 500-nsec cycle time may be right with the state of the art, but I'd sooner avoid the problems and aggravation from such high frequencies, and settle for a slower memory that works reliably. I think Bob is at a decided disadvantage using his 12-plane unit for a 12-bit word. Having a spare plane (which I would advise his somehow adding) provides a parity bit, and this is crucial to reliable operation. Not just by indicating obvious catastrophic failures, but for "tuning" the memory to operate in the middle of its error-free operatime area. I check the parity error count and I vary the select drive currents and the matrix switch bias current to develop a plot which neatly defines for me in what region my memory is most reliable.

"Steve Wiebking quotes an excellent text [Nov. 1971, p 5] on micro-programming concepts, but I submit that it is possible to implement the micro-logic to support the IBM 360 instruction set in a far more simple manner than the approach taken by IBM. IBM's micro-logic was not designed to minimize the number of separate functions needed to support its instruction set. It was designed, rather, for complete flexibility so that emulators for their older computers and a very complex I/O channel system could be included in the machine capabilities. The 360 micro-

instructions therefore control hardware gates, latches, and data channels at a much lower level in the machine hardware than is necessary to merely implement the instruction set. For the fun of it, I have partially developed microcode from which most of the 360 machine functions could be controlled, and it appears that far less than the 1408-word x 176-bit ROM which IBM presently uses is needed to actually support the instruction set. Leave out the floating-point instructions, and you are not left with an impossibly large task. As the book on micro-programming by Husson explains, Honeywell has taken the opposite approach from IBM, resulting in more compact microcode that controls the actual machine hardware at a much higher functional level. I find the designing of a microlanguage to implement machine instruction sets to be one of the most interesting aspects of computer design. To come up with optimal control microinstructions which minimize ROM requirements while maximizing control flexibility is tricky business, but far more satisfying (to me) than getting a shift register to work. I would like to know if anyone is seriously considering tackling a 360-like machine, especially with a microprogram approach.

"In the March 1972 Newsletter was a small blurb on the utility or necessity of using an oscilloscope in developing machine hardware. I find an oscilloscope indispensible; so much so that I am in the process of putting together a more adequate one than the simple one now at my disposal. A delayed sweep doesn't seem to be that essential, since you can always find some pulse in the system advanced enough to provide a trigger signal for the waveform you actually want to look at. What is a real convenience is a dual trace, because very often it is the time relationship between two pulses that is of interest. For those who want to build a kit, I recommend the Heathkit IO-105 Solid State 15-MHz Dual Trace Triggered Scope, at $429. I'm making it an even better buy by scratch-building it myself from Heath schematics and using a less expensive CRT (flat-face tubes aren't cheap). I expect to finish the job for about $100. And I started out building a computer!

"The longer I wait, the cheaper ICs become, so I feel very little pressure to rush my machine to completion. The software simulation of my micro-instructions provides me with enough of a sense of accomplishment for the time being. I would be interested in hearing from any members who have successfully used ROMs, especially the semiconductor types. Has anyone attempted a CRT I/O device? Many such units have been mentioned, but has anyone actually managed to build one? [Allyn Rothman, 19 Roberta Lane, Syosset, NY 11791]"

TWO WORKING COMPUTERS

D.A. Bowman writes from Arizona:

"I have built two computers from scrap parts in the past 4 years. Both are 12-bit, 2-μsec machines patterned after the PDP-8 instruction set. The first was built from second-generation discrete-component DTL NAND logic. The memory was of my own design. My second computer was built to get around the power dissipation problem (1.5W) of the first machine. It gets expensive to operate and refrigerate that kind of system in Arizona. The second machine is made out of 7400 series TTL and has an 8K x 12 main core memory.

"I have also designed and have operating the following extensions to my computer: high-speed reader and punch (General Electric); Calcomp 565 incremental plotter; 32K-word

x 12-bit extended core memory; ASR 33 Teletype; video display (16 lines of 64 characters, 1K refresh memory, 5x7 dot-matrix characters); X-Y D/A converter and storage scope.

"All of the PDP-8 software works on my system. This has saved considerable time, as you can well imagine. I have used the following DEC software: compilers (Focal - 8K, Basic - Poly, Fortran - 8K); assemblers (Macro 8, Pal III, Saber); maintenance programs, disk monitor systems (my 32K core memory looks like a DF32 Disk System).

"My entire system logics are mounted in a 19-inch rack and all of the packages are wire-wrapped together using 30-gage wire. I use wire-wrap boards on which you can mount 200 TTL packages. They are mounted upside down and soldered to pins that go through the board and are wire-wrapped on the other side. This allowed me to put my whole computer logic (registers plus control and timing) on one card. I have a module that holds 10 such cards, including: one for video display logic, one 32K interface logic, two core memory, one Teletype and high-speed reader/punch logic, one computer card.

"I have devoted most of my spare time for the last four years in accumulating the parts and developing my software."

THE TRADING POST & HELP WANTED

1101 RAMs

Dave Vednor (P.O. Box 1317, Tustin, Calif. 92680) writes: "I've had a mfr offer me 2700 pieces of a CMI 1101 256-bit RAM. These are new, but have been scrapped due to a product change." With at least 16, at $1.50 each, you've got a 4K x 1 memory, at $24. With at least 256, at $1.25 each, a 4K x 16 memory for $320. And with at least 512 of these, at $1.17 each, an 8K x 16 memory, for $600. "I need a total order of 500 minimum to get these prices. If I can move all 2700, prices would be about 10-15% lower. Again, these devices are new and are being offered to me by a computer mfr. However, I can offer no guarantee."

Time-Sharing Club

Frank Eperjesi (P.O. Box 221, Burbank, Calif. 91503) writes: "I would like to start a local club in either LA or Orange County. I live in Orange County but am in LA so much that I don't care which area — it depends on where I could drum up the other members. The purpose of the club would be to buy a small time-sharing system. I figure that if 20 people were to kick in $250 each to join, and possibly $250 a year thereafter, this would allow me and the other members to have a fairly powerful system at minimum expense, and expandable as extra members join. The other possibility would be for ten people to get together to purchase an Intel computer development system (about $1K) and a TI printer/dual mag-tape unit with keyboard ($2400) and misc. hardware at about $1K. This would be a fairly powerful mini-computer system at minimum expense."

727 Tape Drives

Alvin Marshall (412 Oakwood, Angola, Ind. 46703) says: "I have some 727 tape drives — with the books — $100; you haul 'em. These are tube, but worked when removed. They are stored at Pocomoke, Md., not at my place, but they can be picked up at almost any time."

727 Circuit Info?

Al Sinclair (941 Hedge Dr., Mississauga, Ont., Canada): "I acquired an IBM 727 tape drive in perfect

condition and spent the next four months tracing out all the circuits. Is there no way of getting this information? I use a 1½-HP 3-ph motor and a 240-to-208V autotransformer to generate the three-phase power to run the tape drive. I am dispensing with all parity and deskewing circuitry at this time since the relatively few errors don't matter to me anyway. The outfit sure generates a lot of noise in the house!

On a visit to Kingston, N.Y., dropped in to P&D Surplus [Mar. 1972 Newsletter] and picked up a card reader, keyboards, control panels and a host of other parts at ridiculously low prices."

Surplus Items

Gary Forbes (2028 W. Indian School, Box 100, Phoenix, Ariz. 85015) sent a list of items advertised in the Dec. 1972 Popular Electronics; he has a 2K x 1-bit core plane for $5, driver board for $3, sense amplifier for $2, IBM electric typewriter with solenoids, $50; ICs; IC mounting boards, core stack, etc. Write him for a copy of the list.

Any Readers Involved?

Dave Digby (311 S. Brown Ave., Orlando, Fla. 32801) writes:

"Over the past year or two here in Florida, I have been too busy designing computers at work to feel much like doing it also at home. Have not given up the project, however, but keep accumulating little bits and pieces. Let me list a few minor projects in various states of non-completion: (1) A one-pass assembler, hopefully tailored to very small computers. Few restrictions on features for paper tape object tape, but obviously requires an optional second pass for complete address data in listing. (2) An all digital modem -- except for line interface. (3) A display buffer and generator to display on conventional TV set.

Are any readers currently involved in accumulating orders for shift registers or other memories? Or in evaluating currently available logic lines for home computer use? Or in projecting possibilities coming up with MOS, CMOS, etc?"

KENBAK DROPS CASSETTE INPUT

Development of the cassette input for the Kenbak-1 training computer (March 1972 Newsletter, p 1) has been shelved, as it isn't needed in the educational field, toward which the Kenbak-1 is oriented. Kenbak is concentrating on the secondary and post-secondary schools, which can obtain Federal funding for such hardware.

Half a dozen of the Kenbak-1 (which is now $850) have been sold to private individuals, half of whom are programmers and EE's. As one programmer put it, "I have an IBM computer at work with half a million words of storage, but I didn't have a computer at home."

Kenbak Corp. is now at 12167 Leven Lane, Los Angeles, Calif. 90049, (213) 472-8347; John Blankenbaker, president.

A $695 COMPUTER KIT

The System One computer kit will soon be available from EPD, P.O. Box 1014, Glenwood Springs, Colo. 81601. There are 16 individual kits that make up the entire computer, with 1K of memory, and addressing for 8K. System One contains 82 ICs and has a control and display console that displays the contents of most of the major registers. Input is by pushbutton; output by lamps. There are 29 micro-instructions

and 28 combined micro-commands programmed in a diode matrix that is in the form of a read-only memory. This matrix can be altered by the user who wishes to try out his own instructions. The entire System One is $695. The plans, with all schematics and parts layout, is $25. The first ad will appear in the May Radio-Electronics.

You will need a good scope (at least 10 MHz), preferably dual-trace, for setting the core levels. System One has a data-bus terminator connector, and there are instructions for setting up I/O to anything that operates on an 8-bit binary code. Only 15 machines will be offered at this time, because EPD has only 15 IBM 1401 core memories, bought surplus, and no more are available. When the core is gone, they will switch to solid-state memory, either Intel 1106 or Signetics 2601 1024-bit types. This will add about $200 to the price; this machine will be System Two; another change will be from 8-bit with link to 16-bit with link.

System One is patterned after the PDP-8, but comes only with a list of commands. There is no user group yet -- only 11 of the original System One machines were made (plus 2 prototypes).

Also available is an 80-page Memory Core Booklet, MPB-1, for $5, on setting up a core memory, with values for the 1401 memory as used in System One, but with all the equations for adapting to any core memory.

IN PRINT

Cryptology and Computers

By coincidence, two articles on a subject quite rare in trade magazines appeared in January: "Computers and Cryptology" by Chesson in Datamation (Jan. 1973, pp 62-64, 77-81) and "How to protect data with ciphers that are really hard to break" by Geffe in Electronics (Jan. 4, 1973, pp 99-101). The first is about programs for cryptoanalysis and includes a Fortran program for simple work; the second describes enciphering methods.

ROMs in Digital Systems

"ROMs are versatile in digital systems" by Percival of National Semi-Conductor (Electronic Design, June 8, 1972, pp 66-71) goes into lookup tables, programming the ROM, arithmetic with ROMs, converting codes, and microprogramming.

LSI and Central Processors

In the Nov. 1972 IEEE Spectrum, "MOS/LSI launches the low-cost processor" (pp 33-40) is well worth reading (reprint is $1.50 from IEEE, 345 E. 47 St., NY, NY 10017; ask for article X72-112 within a year).

The devices outlined are the American Microsystems 7200, Fairchild PPS-25, Intel MCS-4 and MCS-8, National MAPS and GPC/P. The MCS-4 is noted as having an extensive software library compared with other processor families.

The article points out the slower execution times of MOS processors, the minimum applications support from the makers, and the need to buy large quantities of an IC to offset customized masking charges.

TV Set for Data Display

"TV set is display for data terminal," by Bratt of Motorola (Electronic Design, Sept. 14, 1972, pp 134-141), has an all-digital character-generation circuit; 1024 characters, each in a 5x7 dot matrix, with 16 rows of 64 columns; full set of 64 ASCII alphanumeric characters available. Six 1024-bit

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Stephen B. Gray
Amateur Computer Society
260 Noroton Ave.
Darien, Conn. 06820

The ACS Newsletter will appear every two months or so.

RAMs refresh the display; a specialized ROM (MCM1131) generates the characters; the remaining circuits require much construction, on four logic cards.

Computer Logic Book

For your son or a young friend, "Beginner's Guide to Computer Logic" is a recent one from Tab Books (Blue Ridge Summit, Pa. 17214). By Gerald Stapleton, it has 192 pages, is $7.95 hardbound, $4.95 paperbound.

The first 96 pages are on logic theory. The rest is on building logic projects. A discrete-component breadboard (DTL) is built. Then come ICs, RTL and DTL, with breadboards for each. The final IC DTL experiment is an 8-bit binary adder-subtractor.

Laboratory Manual for Integrated Computer Circuits.

The paperback with this name, by Robert F. Coughlin (Prentice-Hall, 152 pages, $5.95) has a somewhat misleading title. The manual starts off with facts and principles about RS flip-flops, and then asks the student to design several of these with various parameters. It discusses and gives some applications of some ICs: NOR gates, Schmitt triggers, JK flip-flops, and counters, and describes some lab experiments for each. Some 25 pages are devoted to "Design and Build an Analog Computer" without going into much detail. The appendix provides circuits for a regulated power supply and an "IC control and readout board," along with photos of a breadboard using Augat sockets, subminiature banana jacks, and a Vectorboard with holes on $\frac{1}{8}$" centers.

Computer Structures: Readings and Examples

This is the title of a 668-page book, by Bell and Newell of Carnegie-Mellon University (McGraw-Hill, 1971, $16.50). It is a "case-study approach covering 40 distinct computer types."

In one convenient volume, the authors have collected a variety of historical and/or technical papers that cover the recent history of computers. Many of these papers are unpublished or difficult to obtain. Among the computers covered are the DEC PDP-8; LGP 30 and 21; IBM 1800, 1401, 7094 and 650; Midac; Illiac IV; and two desk calculators, the Olivetti Programma 101 and the H-P 9100A. Fine for browsing.

As Gene Witherup of Pa. puts it: "This is an excellent study of the development of computer systems, with emphasis on the language set and central-processor configuration. It contains 688 pages....It is not a "how to" book, but it is definitely of interest to the serious student of computer organization."

SURVEY FORM?

If you were sent a Survey Form and haven't returned it yet, please fill it in and send it to Darien.

ACS NEWSLETTER

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May 1973

USED UNIVAC COMPUTERS

Ed Moakler (Moakler Electronics, 500 E. Chestnut St., Jeffersonville, Ind. 47130) has a Univac 0 File Computer, which he bought as scrap. Ed has the arithmetic unit, program-control unit, 90-column reader/punch, sort-collate unit, tape-drive program controller, and six magnetic tape units. Original value, over $164,000. Ed hopes to make it work, and maybe use it in his business.

The File 0 takes much power and air-conditioning. Ed writes, "I had figured to use the outside winter air to get it turned on and see what I've got, and just close down in summer. As to space, not too bad: only about 400 or 500 square feet, pretty compact. I'm presently having 220 V installed to begin to turn on some of it."

Univac says they can't provide schematics for any machine this old. Each machine was somewhat different, various changes having been made to each during its life, and careful documentation had to be kept as to what was inside each. Many of the old schematics and documentation have been thrown out, and "no amount of money" could provide relevant schematics for one of these old machines, antiques at age 16.

There <u>are</u> manuals available for the Univac 1108: 20 to 30, each three inches thick, each costing $50.

A fair number of Univac Solid State computers were given away, to schools, which then came to Univac for documentation. The situation turned out to be "impossible," as there were no records available on updated blueprints.

"Maintenance in those days was a tricky thing," says Univac, "and the man who did it has long since been assigned to newer equipment, so there is nobody available from us today who knows how to service the old machines."

As to whether there are still any File Computers in operation, Univac says anybody who has one must have bought it, and so it's out of Univac's control, both as to documentation and maintenance.

One company was getting rid of its Univac I, and wanted to give it away. But Univac found that to take it apart carefully and reassemble it elsewhere would cost $100,000, so the machine was scrapped.

At one time, Univac did give older vacuum-tube machines to schools and non-profit institutions, but there were so many headaches with proper documentation that this was dropped. Even with some of the older transistorized computers, it's hard or impossible to provide updated schematics.

Univac gets 50 letters a month asking for information about computers, mainly from students. Univac sends a couple of booklets and a list of helpful books.

HARRINGTON'S MICROPROGRAMMED UNIT

Bob Harrington writes from Calif.:

"I solved the problem with programming the 8223 P/ROMs (Nov. 1972, p 6). I tried more juice to the point of frying the chip with no success. It turned out that the transient on the +12 volts caused by the current rush thrcugh the V_{cc} pin was in effect de-selecting

the output I was trying to program. I solved this by using separate 12-volt supplies.

"My computer is nearing completion. It has been operating through the panel controls (no I/O yet) for a couple of months. I am working on the I/O board now and have some microprogramming to do. Here are some updated specs:

"Word length: 12 bits. Registers (12 bits): accumulator, accumulator extension, index (1), storage address, storage buffer, instruction address, 16 scratch, console switches. Core memory: 3200 words, 8-usec cycle time. Clock: 1.25 MHz. Addressing: direct, relative, index. I/O: 8-bit bus, 8 interrupts, 8 strobes.

"Instructions: block load/store to/from scratch (1 to 4 words), load accumulator, store accumulator, add operand in any scratch register (load accum., add, subtract, multiply, and, exclusive or, or, increment, decrement, decrement & skip if neg.), branch & store inst. addr., jump on condition (8 cond.), 4 shift right N, 2 shift left N, shift left and count (normalize), clear link, add & clear link, enable interrupt, load output buffer & issue strobe, issue strobe, input data.

"I'm using a 5-bit op code, 3 modifier bits, and 4 bits for scratch register address. Some instructions use a second word for an address. The op-code bits control the address of a 256-bit ROM, the output of which controls the address in an array of four 256-bit ROMs arranged to give 64 16-bit words. These 16 bits are decoded in groups of four to 64 control lines. The address of the 64-word ROM is sequenced at 1.25 MHz beginning at the location selected by the first-mentioned ROM. Each instruction occupies one to five microprogram steps. I made elementary loops by using one control line to reset the least two significant bits of the address counter. Another resets all bits, causing a branch to 000000, where the fetch-next-instruction instruction resides.

"I used ordinary logic in addition to the microprogramming to squeeze more out of it. The four types of shift-right instructions, for example, all use the same microprogram, the differences being generated by hardware logic using the three modifier bits.

"The control panel is an 8-3/4" by 19" rack panel. The computer is completely enclosed in a cabinet which is 16" deep. The panel has four 12-lamp displays plus six auxiliary. All working registers can be displayed by means of a selector switch. The instruction address register can be loaded manually with the contents of the console switches, and core locations then examined or loaded in sequence. There is provision for single-step operation, and a manual interrupt is available.

"I am planning to use my computer in scientific/enginerring applications mostly. One application I've used it for so far was for testing commas for use in a digital communication system.

"For any who are just starting or not too far along, I would highly recommend (a) microprogramming (which I did), and (b) planning for future expansion (which I did not do)."

REISS ON LSI AND MICROPROGRAMMING

Russ Reiss of Conn. wrote last year:

"For about seven years now I've been planning to build my computer. Finally last June [1971] I complet-

ed the PhD in EE/Computer Science and thought I might have time to get going. The courses I'm now teaching as Asst. Prof. at RPI-Hartford Graduate Center such as Compiler Design, Digital System Design, Digital Communications, and Minicomputers, have really spurred my interest.

"Cost-wise the CPU is no problem. This summer I bought 600 ICs from Gerber Electronics when the price dropped to 22¢, but still haven't found the time. Memory is the killer! I'm convinced that core is on the way out and would like to go with IC memory. The recently introduced Intel in-20 does look like a pretty good deal, but not exactly cheap. Perhaps in quantities a group of ACS members could make this an economical approach. The cost factor keeps telling me to use a shift-register memory (such as the 1402A), but the speed would be horrible. I am considering some "tricky" swapping schemes between small RAM and SR memories, such as the "cache" system, but this problem is yet to be resolved.

"Enter the Intel 4004 and 8008 CPU on a chip!!! Both are complete CPUs with quite a bit of power (45 instructions) and flexibility (internal address stack for subroutine nesting, etc.). The 4004 is not as desirable since it is more complicated to control and doesn't look as much like a typical computer. The 8008, however, is a beaut!....

"The only drawback I see on these devices is their slow speed (about 1 MHz clock), yielding about 75k instructions per second. For amateur (and many commercial) uses this should be no real problem. Whether we wait 1 sec or 3 sec for an answer does not really matter. But a cost of $5k or $1k does matter! I believe this approach would be ideal for a "conversational/interactive" system using FOCAL, BASIC, APL-type languages. Writing the interpreters are not THAT much trouble either. My students are finding this out in Compiler Design class where each student writes his own compiler for a special-purpose language he creates -- in about ½ semester.

"One other point I've concluded is that any computer (and especially an amateur job for experimental uses) should be microprogrammed and (dynamically) microprogrammable. Commercially available ROMs are now reasonably priced (one can build his own programmer), or one could go the diode-matrix route. But I see no meaningful justification for hard-wired instruction sets. The use of an IC ALU with two input buses which derive signals from <u>any</u> register through a multichannel MUX, and the use of microprogramming, offer a very neat, simple, and flexible arrangement for any computer. Through microprogramming such a computer could emulate any other computer. Sixteen-bit registers also seem like the most appropriate choice. But I really think something like the Intel 8008 is an even less expensive route. This might form the basis of a "general" ACS computer as was discussed in the initial issues of the ACS Newsletter. I'd be happy to work with others toward this goal." (R.A. Reiss, RFD 1, Box 176A, School Rd., Bolton, Conn. 06040.)

The Intel in-20 is a 1k x 12 memory system, 950-nsec speed, on a 6" x 8" PC board, one for $620. The in-26, announced three months ago, is tailored for the 8008: 4k x 8 bits, 900 nsec, same size board, $750 for one.

PROGRESS REPORT ON MOLASSES I

Richard Dickey writes from Calif:

"With integrated-circuit technology simplifying computers faster than we can get the old stuff to work, it takes some determination not to junk the carefully-built arithmetic unit and just buy a tiny lump for $15 which does the whole job!

"Molasses I is still making progress. In 1966 I bought the diodes for switching the drum tracks; last year I got them soldered onto the printed-circuit boards. I have acquired a complete photoreader from a G-15, and am modifying it so that all the control logic is located inside the box, including a rewind system it never had before. Now if I only had the rest of the G-15, I'd be happy.

"Right now I have access (including keys) to 8 G-15's, a CDC 046, Burroughs 205, PDP-8L, and an Athena, but there's nothing like having your own."

HARDWARE: LSI

Signetics PIP Chip

Durk Pearson (Calif.) says that Signetics has a PIP (Programmable Integrated Processor) chip. The data sheet says "all data operations are performed on 8-bit bytes, and an 8-bit bus is used for all memory and I/O data transfers. A 13-bit memory address is used for direct addressing of up to 8k bytes of storage. There are four 8-bit general-purpose registers." Unit price is less than $100 (the PIP may be as low as $25 by 1974).

Another Microsystems MOS LSI IC CPU

Ken Karow sends word from Illinois on the Microsystems International (Canada) CPS/1 Micro-Computer System. The bulletin says: "The CPU contains two memory pointers: the usual program counter (PC) and a data pointer (DP), which allows logical, as well as physical separation, of program and data. Both PC and DP are 12 bits long and can directly address 4096 memory locations. A memory-expander chip is available to extend addressing capacity to 256k. Each memory location contains 4 bits of data (one nibble, which is half a byte)." A nibble??

MI also has a MF7114 (4-bit parallel Arithmetic Unit & 12-bit memory reference unit & Instruction and Control Unit) and an MF8008 (8-bit parallel adder & six 8-bit data registers & 8-bit accumulator & two 8-bit temporary registers & four flag bits & eight 14-bit address registers).

Oriental Wizardry

Myron Calhoun (Kansas) found this in Modern Data:

"Tang Juan, 22, an undergraduate at the National Chengkung University (Chenta), has succeeded in making the Republic of China's first fourth-generation computer. Nicknamed "Tang Go Go" (Brother Tang), it cost all of $60 and took Tang Juan six months to build. Except for the LSI components, all parts were bought from junk shops in Taiwan."

PUBLICATIONS

Computer Architecture

This is the title of a 225-page book by Caxton Foster of the Univ. of Mass. (Van Nostrand Reinhold, $12.50). It begins with binary numbers, has chapters on logic, storage, addressing, I/O, speeding up the computer, parallelism, and tessellated computers. Chapter 5 is 30 pages on An Elementary Machine, describes a "very simple computer, one that might sell for about $10,000 or so. BLUE (named

for the color of the cabinet; the author says "I'm weary of acronyms") has 4k words of 1-usec core, 16 bits per word, 16 commands, and a common-bus scheme. It looks possible to build a machine from the black-box diagrams, although the last sentence says the computer is "so simple that probably nobody would actually want to buy one." As Foster puts it previously, "none of the 'goody features' present on most current machines, e.g., indirect addressing, index registers, interrupt, etc., are present."

Computer History

"The Computer from Pascal to von Neumann" (Princeton University Press, 378 pages, $12.50) is by Herman H. Goldstine, who helped create ENIAC. The first part involves the early pioneers: Babbage, Boole, Hollerith, Bush, etc. The second covers ENIAC and EDVAC at the Moore School, and the third is on the postwar years at the Institute for Advanced Study at Princeton, through 1957 (after which the author joined IBM). There are only a couple of simple schematics, and the text does not get very technical, as it was intended for an audience beyond computerniks, but it is an interesting and informative narrative by a man who was there at the beginning.

DEC Sells a Book

Digital Equipment Corp., which has been giving books away for years, now has a "Digital Press" that publishes books for sale. The first of these is "Designing Computers and Digital Systems," by Bell, Grason and Newell of Carnegie-Mellon University; 447 pages for $3.95. The ad for this book is slightly misleading, as it says only that this is a "guide to the design of digital equipment using register transfer modules as the basic component." The subtitle of the book itself is properly explicit: "Using PDP-16 Register Transfer Modules." So this is not a cookbook on computer design, but rather a lengthy application note on DEC's RTMs, and thus is of little or no interest to amateurs. Any comments?

Popular Computing

This is the title of a monthly publication by Fred Gruenberger, which began last month, and is "designed for those who are interested in computing for its own sake." The first issue is 12 pages long, contains items on the 3X+1 problem, the Wells/Ulam Conjecture, notes on the Hewlett-Packard HP-35, statistical data on the calendar system, a book review of "Program Test Methods," and a list of subfactorials. The cost is $15 a year (or $12 if remittance accompanies the order): Popular Computing, Box 272, Calabasas, Calif. 91302.

Logic Newsletter

The "Logic Newsletter," advertised in at least one electronics hobby magazines at $1 for a sample copy (and for each issue) from UTI (P. O. Box 252, Waldwick, N.J. 07463) is published 10 times a year (Sept. to June) and is a curious mixture of bits and pieces. The first issue (Sept. 1972) consists of a 4-page wraparound with a page on logic function generators in textbook style, five simple circuits (gate, flip-flop, latching FF, RTL NOR, clock circuit), a book review, and very brief news items on publications and ICs. The four inserts are: truth-table summary of functions; powers of two; logic function chart; table of combinations (of two variables). And a 6-page logic-design example: decimal-to-8421 BCD encoder.

The first issue states: "Starting next month, each issue will contain a 4-page application note on

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the most popular UTI 7400 Series integrated circuits." A logic design example is to be included in each issue. The price is $9 for one year, $15 for two.

UTI also sells hardware, including 7400 ICs, a breadboard kit, semiconductor memories, etc.

HELP FROM TITUS ON INSTRUMENTS

Jonathan Titus (Titus Labs, P.O. Box 242, Blacksburg, Va. 24060) writes: "The logic probes that we are using here for trouble-shooting were developed here by our staff. They are better than the Hewlett-Packard probes and at least as good as the Kurz-Kasch probes that currently sell for $80 to $100. We have two designs for pulse and logic-level detection and one design for a pulser probe that allows in-circuit generation of pulses.

"We also have our own design for a logic clip, along the same lines as the HP type, but ours has only a couple of simple ICs inside and it still has the +5 and ground auto-seek features.

"We have been using two types of trace adaptors for some inexpensive scopes such as any of the Heath general-purpose scopes. One adapter uses a switched amplifier and the other uses a standard diode-switch arrangement. The diode switch is the one I would recommend. It has individual position and gain controls for each channel and it may be used with either AC or DC scopes. Chop rate is between 100 kHz and 1 MHz, and it can also be used in the alternate mode!

"Since we are in the business of doing special development of interfaces, we don't usually make our internal technical reports available to the public, but since there seems to be a need among amateurs, we have made an exception. Members of the ACS may obtain these reports from us for the cost of duplication and mailing. Please refer to the numbers and costs shown below:

"Technical Report #67, Logic Indicator Probes, $1; #68, Logic Pulser Probe, $1; #69, Logic Clip, $1; #72, Two- and Four-Trace Scope Adapters, $3. For $5 we will send all four Tech Reports. The reports contain a list of all needed parts (all standard) and full directions for duplication, along with schematics and checkout procedure."

About the Foster book (p 4), Jon says "It is an extremely easy to read, informative book that shows how a computer is developed. It is worth its cost many times over. Perhaps before any of the newer ACS members start on a computer they should read Computer Architecture."

FOR SALE: Jim Mims (307 Sudbury Rd., Linthicum, Md. 21090) has Ampex memories, 4K of 16 bits with read/write electronics, $300 or best offer; similar with 4K of 8 bits, half price; two Univac 1105 core stacks, 4K by 36 bits, $75 each, Bryant 7505 drum, asking $80.

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DICK SNYDER'S MININOVA 721

From Florida, Dick Snyder sent several dozen pages about his computer, and also his resume, whose last line says "Designed and built 8-bit computer." Dick says:

"The Mininova 721 is designed to be a miniature Nova 1200. I've used and programmed Data General's Nova 1200 minicomputer, and have been exposed to many other mfr's minicomputers. I feel the Nova is the finest mini available. I wanted to have a Nova for my very own, but couldn't afford it. I thought "someday when the price of ICs comes down I'll design and build my own minicomputer, a small-scale version of the Nova."

"Well, the prices of ICs came down tenfold or more in 1971-72, and that made my dream practical. The rest was innovation, enthusiasm, and a lot of careful planning. The result is my very own minicomputer, of which I'm really proud! The Mininova 721 has an instruction set very much like the Nova's. (The Nova has the finest, most powerful instruction set of any minicomputer on the market today, and I've carefully studied most of them.) The Mininova 721 has control switches very much like the Nova's. (The Nova's controls are the most practical I've seen on a minicomputer.)

"So I've incorporated very carefully the best features of the Nova instruction set and programmer's console, and designed the circuits to make a true stored-program, programmable digital computer (complete with loads of integrated-circuit MOS-RAM memory) that would execute 16 different very carefully selected instructions. These instructions were chosen so that some functions of the Nova instruction set could be performed directly, and others by a group of 3 or 4 instructions. For example, the Mininova instruction set includes a right-shift instruction, but no left-shift instruction. This is because it is hard to produce a right shift using other instructions, but easy to duplicate a left shift by adding two identical operands.

"After choosing my instruction set and control-panel-switch functions, I started (on paper) blocking out major registers. The instruction set was chosen to allow the machine to have two program-accessible data registers. These were set down, along with a few address registers. I determined what register transfers were needed to implement each instruction. Then I grouped related operations together, and placed them under the control of mode flip-flops. Then I began to assign the times when these operations would be enabled. I specified all the conditions and times to enable setting and clearing of the mode flip-flops, and then I was able to begin considering waveforms and circuits. I chose my logic family (7400 series TTL) and began to design. I chose my memory ICs (MOS-RAMs that require only the +5V DC power supply) and designed the circuits associated with the memory and major registers. I designed the circuits that implement the operations to be performed by the programmer's console control switches, and designed circuits to enable my computer to do DSA (i.e., DMA) transfers to and from a standard audio hi-fi cassette recorder. All this time I was involved in procuring, wiring, and test. I "design-

ed" my power supplies (I'm using a Lambda Power Kit and IC voltage regulators mounted on heat sinks for the +5V supply, and a home-brew rig with IC regulators to provide +12V for the lamps) and assembled these.

"All together I've put about five months worth of evenings and weekends, $360, and about 175 ICs and IC sockets, and a few hundred feet of wire into my minicomputer. I've made loads of plans for the future, such as new I/O capabilities like digital cassette and 4K of memory, all MOS RAM ICs, the kind that require only the +5V power supply. I've written and executed programs on my computer, and learned how painful it can be when you don't have indirect addressing, and when you have only two program-accessible data registers. Maybe I'll add an indirect addressing capability; I haven't decided yet. But anyway, it sure is rewarding! I've shown the Mininova to my employers and former employers, and friends, and received a wonderful red-carpet treatment wherever I've taken it.

"Most of all, I have the satisfaction of having done all this, and done it to the best of my ability. Some parts of the design of programs and design of machine timing took an awful lot of intense concentration on abstracts. I've got volumes of design notes, schematics, waveforms, etc., all carefully arranged, including every problem I encountered, and how I overcame the problems; the errors and overlooks in design philosophy, the wiring errors, etc. I realize that computers are easy to design, and kind of standard in makeup, but I started from scratch, with little more than enthusiasm and a desire to have a computer of my very own at any cost (except cost in money greater than about $500). I got a lot of general concepts and timing help from the old CDC 1704, which I know forward and backward, but most of it all I designed from scratch, and I'm very pleased with the result. I've learned a lot, and I'll learn lots more in the future as I continue the project. I don't intend to expand anything on this machine except memory size and address-register size (this will make all storage-reference instructions 4-word instructions) and I/O capability. To add more registers or enlarge the registers or add more bits to the instruction words (meaning add more bits per each memory location, more bits to the instruction registers, etc.); i.e., add more instructions, would change the machine too greatly and take it too far from the original challenge. Also it would require too much wiring! If I want a larger processor of the same (approx.) size, I'll buy an Intel MCS-4 system, based on the Intel 4004 computer-on-a-chip CPU.

"The Mininova is my dream come true, and also it is my resume in hardwired form. I've got a lot of initiative, ambition, and imagination, and I feel the Mininova clearly demonstrates my capability as a digital systems and circuit-design engineer."

The Mininova 721 is a mixed 4, 8 and 12-bit machine, with 4-bit and 12-bit instructions, 4-bit storage words, 8-bit operands (data words) and 8-bit storage addresses. The 16 instructions include 4-bit register reference instructions (shift, increment, complement, arithmetic, logical, test) and a control instruction (HALT). The storage reference instructions are three 4-bit-words; the first word is the instruction, the other two are storage address. There is a 4-bit I/O instruction. No parity checking, no interrupt system, no program protect system.

The instructions are HLT (halt),

JMP (jump), JSR (jump to subroutine), SMZ (skip if memory contents are zero), LDA (load A register), LDB (load B), STA (store A), STB (store B), RSB (right shift B), INA (increment A), CMA (complement A), MOV (move B to A), ADD (add A to B), AND (logical AND), SZC (skip on zero carry), SNB (skip on negative B).

The 721 operates on 8-bit single-word operands, handles signed numbers from -128_{10} to $+127_{10}$ and unsigned numbers from 0 to 255. The random-access memory has 256 storage locations, each containing a 4-bit word, addressed directly. The 721 executes about 300 instructions per second in run mode, 150 a second in mixed mode.

Future additions include changing the SMZ instruction to DSZ (decrement and skip on zero), the SZC to SCS (skip if carry is set), SNB to IOT (input/output transfer).

Dick asks if anyone's computer in the ACS does direct-storage transfers (DMA or DSA) to a cassette recorder or other magnetic-tape unit (Richard Snyder, 1910 N.W. 23rd Blvd., Apt. 181, Gainesville, Fla. 32605).

INTELLEC 4 AND 8 MICROCOMPUTERS

Two of the better-known CPU-on-a-chip ICs are the Intel 4004 and 8008, which are 4-bit and 8-bit, respectively. To help in developing hardware around these CPUs, Intel came out with the MCS-4 and MCS-8 "micro computer sets" of chips that can be combined and programmed to make a variety of microprogrammable general-purpose computers (see the June 1972 Newsletter, page 2).

Now Intel has gone a step further and "to make it easier to use these sets, now offers complete 4-bit and 8-bit modular microcomputer development systems called Intellec 4 and Intellec 8." They "provide a flexible, inexpensive, and simplified method for developing OEM systems. They are self-contained, expandable systems complete with central processor, memory, I/O, crystal clock, power supplies, standard software, and a control and display console."

The "complete table top development system" costs $2195 for the Intellec 4, $2395 for the 8. They come with system monitor, resident assembler, and text editor. At extra cost are a PL/M (derived from PL/1) compiler, and an assembler and a simulator, all three written in Fortran IV, and also available through three time-sharing companies (GE, Tymshare, Applied Logic).

Another option is a complete PROM programmer. After the program is firm, it may be placed in the non-volatile storage of the Intel 1702A PROM.

The cards making up the two computers can be bought separately. "The major benefit of the Intellec modular microcomputers is that random-access memories (RAMs) may be used instead of read-only memories (ROMs) for program storage. By using RAMs, program loading and modification is made much easier. In addition, the Intellec front panel control and display console make it easier to monitor and debug programs."

The Intellec 8 can directly address up to 16K 8-bit bytes of memory, which can be any mix of ROMs, PROMs or RAMs. There are 48 instructions, plus 8 input and 24 output ports (8-bit).

Intel has a Microcomputer Workshop in California for the MCS-4 (3 days, $350), MCS-8 (2 days, $250), and PL/M (2 days, $300); hands-on labs.

DIGITAL EQUIPMENT RTM BOOK

The May 1973 Newsletter had an item (page 5) about the DEC book, "Designing Computers and Digital Systems," saying it is a long application note on DEC's PDP-16 Register Transfer Modules, and so is of little or no interest to amateurs, and asked for comments.

Doug Jensen comments:

"In fact, this is a very important text in the professional computer literature, and should be of considerable value to the serious amateur. The register-transfer level of design has always been important but rather neglected; now technology (MSI, LSI) is forcing it into prominence. The book illustrates the concepts with the PDP-16 register transfer modules (which are the only ones commercially available as such), but the ideas apply directly to digital machines designed with conventional ICs. Almost no one designs their own gates from resistors and transistors any more (except for the fun or experience). Few professional engineers ever design counters, registers, etc.-- they use MSI and LSI. Design will continue to occur primarily at higher and higher levels; that's what designing with Register Transfer Modules is all about (there is an even higher level called the Processor/Memory/Switch level).

"If you recall, in a past issue of the ACS Newsletter I proposed that the Processor/Memory/Switch level (the use of commercially available microprocessors, memories, etc.) is the appropriate level for those ACS members whose primary goal is having and using their own computer. The only justification for getting involved with gate-level design is for the experience-- these days it is rarely going to be a cost-effective approach to acquiring a machine."

Glen Langdon also comments:

"On Foster's book, Computer Architecture (May 1973 Newsletter, page 4), it is true that in Chapter 5 on BLUE, it lacks many "goody" features -- but read on to the next chapter where he defines INDIGO with indexing. The book may not be as easy for a beginner to read as it seems to us....

"On the RTM book by DEC by Bell et al, don't sell it short. There is a lot of wisdom in it, involving their languages ISP and PMS, introduced in the book Computer Structures. The PDP-16 really isn't a computer, it's a set of cards. The timing philosophy one uses in applying these cards is "asynchronous" in the sense of "invitation" and "completion" signals controlling the sequencing of events. In this sense, it is not a cookbook on current practice, which uses a system clock."

DEC now offers the DEClab-RT, a training unit consisting of building blocks: arithmetic units, bus sense, memories, interfaces and controls, for learning to "understand digital system design utilizing the register transfer concept." The Basic Kit is $1425.

THE UGLY DUCKLING COMPUTER

Glen Langdon of upstate New York was loaned by IBM to the University of Sao Paulo in Brazil for a year ending June 1972. For the "Patinho Feio" (ugly duckling) computer project, Glen's group of graduate students designed "an instruction set to have about the power of the PDP-8, although the word size is 8 bits. The power supplies were designed and built by students. The 4K memory was imported from Philips. The circuits were T^2L from Fairchild.

We had a printed-circuit lab, and all the cards were done there. Some cards (the control cards) were mounted with 14-pin DIP sockets and wire-wrapped, to facilitate debugging. Having had success with making one-sided printed circuits, an attempt was made to do 2-sided ones with the plated-thruhole. We got two data-flow cards done with this technology (after much sweat; many necessary chemicals are not yet available in Brazil) before abandoning it and going to soldered wiring on the card. The cards plug into a Cambion rack, with wire-wrap sockets. The back panel was wire-wrapped; a computer program aided by listing the desired connections and their lengths.

"The I/O bus was sort of a cross between the PDP-8 scheme and the HP 2116B bus. A Teletype terminal, a plotter, and an optical paper-tape reader were interfaced with it. The panel display was LED, controls include read/write memory from switches/to display, plus single-instruction cycle, and single machine cycle."

NATIONAL SEMICONDUCTOR'S IMP-16C

Doug Jensen wrote further:

"R.A. Reiss' enthusiasm in the May issue over the primitive Intel 8008 is rather misplaced. For less than $500 in singles, one can purchase the five National Semiconductor GPCP MOS LSI chips and the two dozen TTL ICs needed to construct a 16-bit microprocessor. The resulting IMP-16C (as National calls it) has an instruction set similar to the Nova, although at about 5-10 microseconds per instruction it is quite a bit slower than a Nova. However, the IMP-16C is not only faster than an 8008 but also infinitely easier to program and to interface with. (Intel will shortly announce a much improved chip called the 8080.) Professional computer users are becoming more and more aware that programmability is crucial because software development usually requires far more time (and thus money) than hardware development.

"The subject of software brings me to the advantage that commercial microprocessors have over home-built machines, in that at least an assembler and some diagnostics and utilities are already available, although usually at a fee. Private individual members of ACS who have purchased the National GPCP components are welcome to contact me for a copy of the software listings at a nominal reproduction cost instead of the $2000 or so charged by National.

"If you are interested in the IMP-16-C approach, it is a worthwhile investment of $5 to purchase the application manual (4200021A) from National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, California 95051.

"Because the MOS microprocessors are so inexpensive, it is tempting to consider how a more powerful machine might be constructed out of more than one of them. This is a very non-trivial task; I have extensive experience in this area (including using IMP 16Cs), and will be happy to discuss the matter with those interested. Incidentally, the GPCP parts can be used to build a full 32-bit processor at less than twice the cost of a 16-bit one.

"A couple of TTL LSI microprocessors are nearing introduction, as is a one-chip MOS replacement for the PDP-8 CPU.

"Let me close with a crass commercial mention that I still have a few 5 volt/48 amp power supplies

The Amateur Computer Society is open to all who are interested in building and operating a digital computer that can at least perform automatic multiplication and division, or is or a comparable complexity.

For membership in the ACS, and a subscription of at least eight issues of Volume III of the Newsletter, send $5 (or a check) to:

Stephen B. Gray
Amateur Computer Society
260 Noroton Ave.
Darien, Conn. 06820

The ACS Newsletter will appear every two months or so.

left for sale. These very high quality units are new, factory-sealed Lambda LMF-5s, which currently list for $475 each; my price is only $150." (E. Douglas Jensen, M.S. A3340, Honeywell, Inc, 2345 Walnut St., St. Paul, Minn. 55113.)

MORE FROM DICK SNYDER

Right at this point I found a later letter from Dick Snyder that I'd forgotten. Perhaps I should rewrite this Newsletter, but I'd hate to delete Dick's infectiously enthusiastic letter. Dick wrote:

"I'm pleased that you intend to print up a lot of my introduction, but after carefully looking through all the ACS Newsletters I've just received, I'm afraid I'd be embarrassed to see some parts of that intro in the Newsletter. Really, my machine is almost nothing compared to some of these people's machines; I have such a small amount of memory, and no program access I/O yet, only DMA access I/O, and only to one external device.... Perhaps I'd better just say I like the Nova best, better than other multi-accumulator machines with standard architecture and complex instruction sets....

The only thing I think any of your readers would be interested in is my DMA circuits, since I'm using a standard unmodified audio cassette recorder. I'd be glad to share the plans for that with anyone who is interested, for $1.50...."

Dick also asks if any info is available on the pins, voltage levels, etc., for R/W control and data, for an Ampex 1K X 16 core memory, model 1024 RVS 16, assembly #3223634-10A, serial #414.

THE TRADING POST

A Batch of Boards, ICs, etc.

Ed Kirkley (7-B Ridge Rd., Greenbelt, Md. 20770) has a number of DEC Flip-Chip boards, digital ICs, relays, keyboard, and core memory (2K X 16), all for $250, with data sheets, and mostly unused. Also a Tektronix 511AD scope for $130.

Core Planes and Amplifiers

Gene Witherup (8220 Michener Ave., Philadelphia, Pa. 19150) has 8 planes of core, each 18 X 8 words, 18 bits. Also 4 boards of sense amplifiers for these cores. And 22 new and 45 used Motorola RTL circuits. For a list of items, send a self-addressed envelope.

MNH - Applied Electronics

Digital computer equipment is available from MNH - Applied Electronics, P.O. Box 1208, Landover, Md. 20785. Their latest catalog includes a Datacraft core system, 512 X 9, with 7400 series TTL, $45; keyboard, computer control and I/O device, $77; tape transport, $118; computer backplane and empty cards, space for 7000 ICs, $33. MNH also sells ICs, connectors, chassis hardware, etc.
