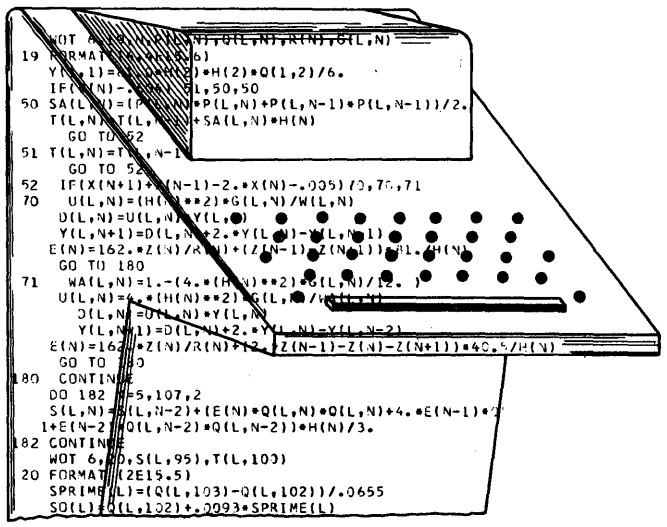
COMPUTER SCIENCE

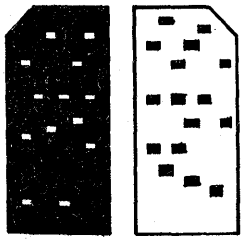


```
      WOT
19    FORMAT
      Y(
      IF(
50    SA(L,
      T(L,N)=T(L,
        GO TO 52
51    T(L,N)=T(L,N-1
        GO TO 52
52    IF(X(N+1)+
70      U(L,N)=(H(
        D(L,N)=U(L,N)*Y(L,
        Y(L,N+1)=D(L,N)*2.*Y(L,N)-Y(L,N-1)
      E(N)=162.*Z(N)/R(N)+(Z(N-1)-Z(N+1))*81.*H(N)
        GO TO 180
71      WA(L,N)=1.-(4.*(H(N)**2)*G(L,N)/12. )
        U(L,N)=4.*(H(N)**2)*G(L,N)/W(L,N)
          D(L,N)=U(L,N)*Y(L,N)
          Y(L,N+1)=D(L,N)*2.*Y(L,N)-Y(L,N-1)
      E(N)=162.*Z(N)/R(N)+2.*(Z(N-1)-Z(N)-Z(N+1))*40.5/R(N)
        GO TO 180
180   CONTINUE
      DO 182 L=5,107,2
      S(L,N)=S(L,N-2)+(E(N)*Q(L,N)*Q(L,N)+4.*E(N-1)*
     1+E(N-2)*Q(L,N-2)*Q(L,N-2))*H(N)/3.
182   CONTINUE
      WOT 6,20,S(L,95),T(L,103)
20    FORMAT(2E15.5)
      SPRIME(L)=(Q(L,103)-Q(L,102))/.0655
      SO(L)=Q(L,102)+.0093*SPRIME(L)
```

Save. Detailed Discription of Ellum II

DEPARTMENT

engineering open house



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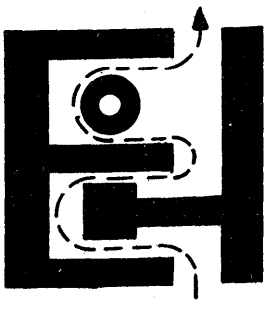

DEPARTMENT OF COMPUTER SCIENCE

UNIVERSITY OF ILLINOIS

URBANA, ILLINOIS

The Department of Computer Science is a department of the Graduate College of the University of Illinois. Activities include: research on the design of computers, their components and application; teaching in related subjects, and operation of computer facilities for instruction and research by all parts of the University. Though a graduate department, the Department of Computer Science has major responsibilities in the undergraduate teaching of computer-related topics, as well as providing scientific computing service to the entire University.

The Department, formerly known as the Digital Computer Laboratory, is internationally known for its contribution to computer development. Computers built under its auspices include ORDVAC, ILLIAC, ILLIAC II, and ILLIAC III, a pattern recognition processor now under construction. Its computer service facilities presently include five computers: an IBM 7094 with two IBM 1401's located in the Engineering Research Laboratory building and ILLIAC II with one IBM 1401 located in the Digital Computer Laboratory building.

A very recent acquisition is a Digital Equipment Corporation computer, PDP-7, being used on-line to ILLIAC II as a communications processor.

ILLIAC II

ILLIAC II is a general-purpose scientific digital computing machine. Planning for it began in mid-1957 and construction in 1958 when the Digital Computer Laboratory was completed. The machine ran its first major problem in the Fall of 1962.

ILLIAC II is the successor to the famous ILLIAC, built at the University of Illinois over a decade ago and then one of the fastest computers in existence. ILLIAC I was retired at the end of 1962 as too slow and expensive to operate after an IBM 7090 machine had been installed.

Though ILLIAC II surpasses the commercial machine in some respects, each has special capabilities and are both used presently to handle the great variety and number of problems amenable to high-speed digital computation.

A decade of advance in computers is graphically shown by comparing speed on a problem which has been estimated to take a century of work with pencil and paper. Even with the assistance of a mechanical desk calculator, this calculation could take ten years. In comparison ILLIAC could solve it in 18 minutes, the IBM 7090 in 37 seconds, and ILLIAC II in 12 seconds.

The machine's competitors in speed today are the IBM 7030 (STRETCH), the CDC 6600, and the Ferranti ATLAS of English design. ILLIAC II can carry out 400,000 additions a second, 150,000 multiplications a second, or 50,000 divisions a second. It can move information in or out of its memory at the rate of 550,000 numbers or words per second. Each of these operations is done on numbers equivalent to 15 decimal digits.

The internal memory now has a capacity of 8,192 words. Backing this up is a magnetic drum storage for 65,536 words, and 12,000,000-word storage capacity on magnetic disks. Also connected in the system are ten magnetic tape units.

A unique feature of ILLIAC II is a ten-word memory working in conjunction with the arithmetic units. Here information can be stored or retrieved at the rate of 5,000,000 numbers a second. Other features of the computer include asynchronous and parallel circuits which permit many operations to proceed at one time.

Wiring in the main machine is on large plug-in chassis. The chassis are mounted in ceiling-high racks which in the central machine are arranged in T-shape to reduce length of wiring. Compactness and direct point-to-point connection has been stressed within the computer units whose operations are measured in billionths of a second. (A billionth of a second or nanosecond is the time an electrical current moves a foot along a wire.) Wiring in the newer peripheral parts of the machine is on etched wiring cards.

ILLIAC II is completely solid-state. The complete machine has about 50,000 transistors and 100,000 diodes. Its magnetic core memories include more than a million tiny iron oxide beads, each only one-twentieth of an inch across, strung on grids of fine wires.

The cost of development of ILLIAC II was approximately $4,000,000. Contributions of money and equipment have been made by the Atomic Energy Commission, Office of Naval Research, International Business Machines Corporation, and the University of Illinois.

The most recent use of ILLIAC II is in the development of an operating procedure for processing user jobs called time-sharing. This operating procedure is really a machine system for the control of a computer.

Time-Sharing

"Time-sharing" is a term which is used to describe one of the two general modes of operation pertaining to digital computers. The other mode, "batch-processing", is simply the process of starting a given job, running it to completion and then starting the next job, etc. Time-sharing is then a mode in which new jobs may be started before previous ones are completed. As pertains to time-shared consoles (e.g. Teletypes) then, each time a new console signs on, a new job is started which is responsible for communicating with that console. Since computers are not capable of running more than one job at any one instant, all of the various jobs take turns--hence the computer time is being shared among a number of jobs. Due to the extreme difference between the human reaction time and the computer reaction time (if a human is typing full speed on a Teletype, ILLIAC II can execute 100,000 instructions for each character typed) it appears to the users that they are being run simultaneously.

From the user's point of view, time-shared consoles allow one a versatility and turnover time that is unobtainable through batch-processing. From an economic point of view, time-sharing allows a higher utilization of the computer time, yielding a lower cost per user.

ILLIAC III
AEC CONTRACTOR BUILDING A COMPUTER THAT CAN "SEE" PATTERNS
D.C.S. Contract 1018

An experimental computer using a new concept of "parallel" organization is being designed and constructed at the University of Illinois under Atomic Energy Commission contract.

ILLIAC III, also known as the Illinois Pattern Recognition Computer, is being built to test the parallel design concept for automatic recognition of similar patterns in a series of pictures or images which normally would require the close scrutiny of human eyes. The computer will be able to perform up to 1024 logical operations at once. It is expected to be the first of a new generation of computers which depart from today's "one step at a time" concept of computer design.

The ability to perform over a thousand operations on different parts of the picture at once will permit ILLIAC III to scan millions of photos, maps, graphs, or microscope slide images much faster than heretofore possible. The machine will be capable of reading the pictures fed to it and of doing the analysis necessary to detect patterns of interest to the user. For example, it might be programmed to detect certain diseased cells on a microscope slide, and to prepare a printed and annotated copy of the result.

The experimental computer is an outgrowth of studies begun in 1961 on systems to scan bubble chamber photographs of high energy particle tracks after collision "events" and convert them into more digestible numerical data. By late 1963 the scope of the contract was expanded to emphasize pattern recognition without reference to a specific scientific discipline.

The competence of the Illinois group, and the advance design of ILLIAC III have also attracted the interest of the Advanced Research Projects Agency (ARPA) of the Department of Defense. ARPA is adding a 65,536 word core memory, a disk back up store, and a closed circuit television communication system to the project. These additions will permit users with only

occasional data-processing demands to have access to the central pattern recognition computer from several remote consoles located around the Illinois campus, or beyond.

Fabrication of the machine is well under way at the Department of Computer Science at the University of Illinois, of which Professor John R. Pasta is the head. The project director for ILLIAC III is Professor Bruce H. McCormick.

Potential users of the computer may range from processing of bubble chamber and spark chamber photographs to processing electronic and optical microscope images, library automation, preparation of instructional material, design automation, and graphic arts automation. Existing computers being used to process pictures perform this task rather inefficiently since they were not designed for it. Picture processing is becoming increasingly important in a number of areas making it desirable to design computers to do the job efficiently. ILLIAC III is a pioneering development in this area.

The remainder of this file gives the physical location and names of the various hardware items that make up the two large computer installations of the Department of Computer Science.

(1) ILLIAC II - Located in the Digital Computer Laboratory at the Corner of Romine and Stoughton, University of Illinois,

(2) 7094 - Located on the ground floor of the Engineering Research Laboratory, University of Illinois.

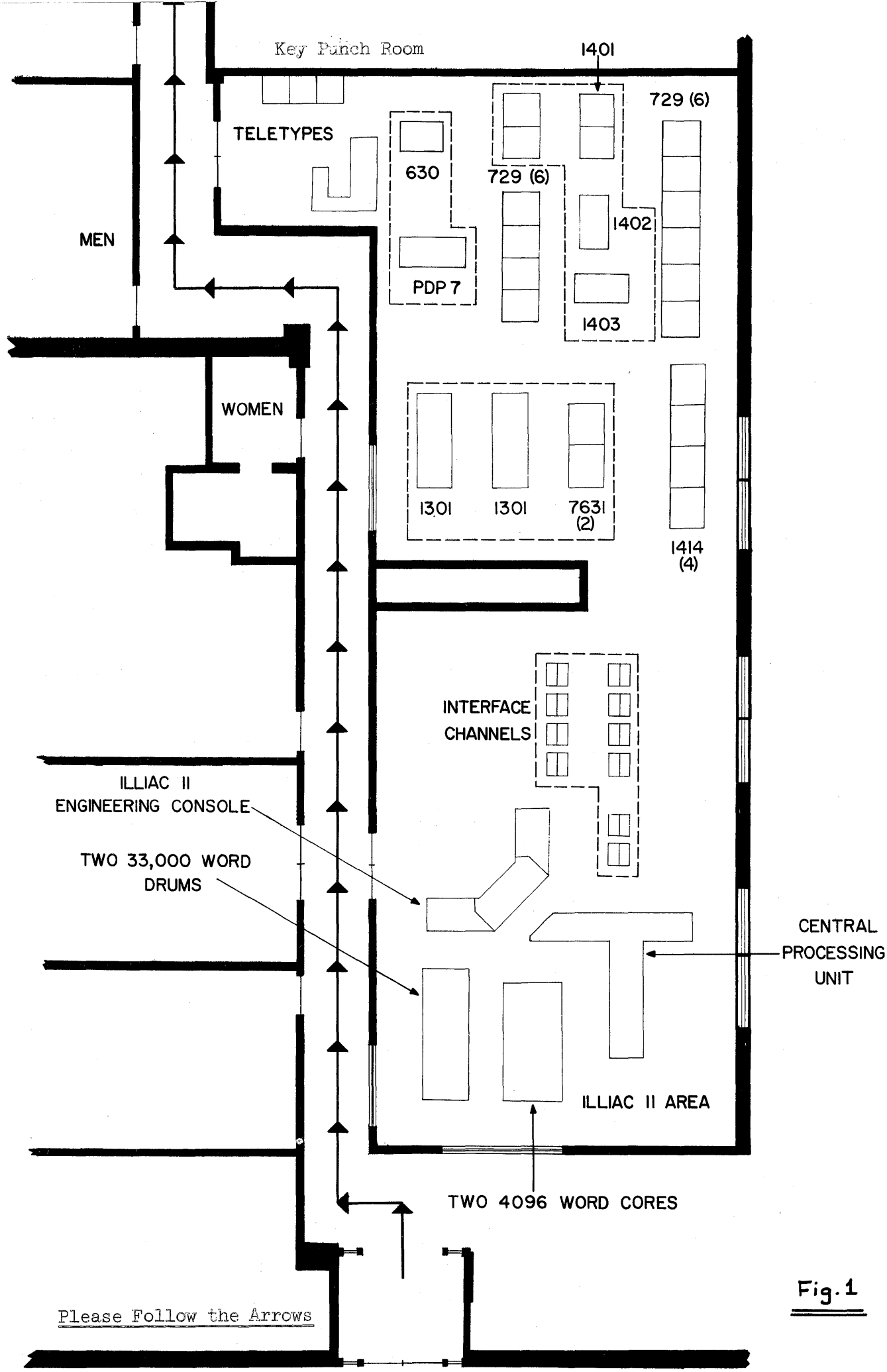
Key Punch Room
1401
729 (6)
TELETYPES
630
729 (6)
MEN
1402
PDP 7
1403
WOMEN
1301
1301
7631
(2)
1414
(4)
INTERFACE
CHANNELS
ILLIAC II
ENGINEERING CONSOLE
TWO 33,000 WORD
DRUMS
CENTRAL
PROCESSING
UNIT
ILLIAC II AREA
TWO 4096 WORD CORES
Please Follow the Arrows

Fig. 1

The Two 4096 Word Cores

(Refer to Figure 1)

This part of ILLIAC II consists of a 4096 core memory built by the Digital Computer Laboratory, a 4096 word core purchased from a commercial supplier and the Input-Output exchanger called Interplay Control.

The 4096 word core designed and built by D.C.L. can exchange words at the rate of 550,000 per second. It has been in operation for the past four (4) years and has proved to be more reliable than the commercial core that works with it.

The interplay control executes all input-output orders and contains a shared buffer word which allows up to 32 devices to communicate with ILLIAC II core. The very great advantage of this control is that it does not require the central processor except to start an input-output order.

Central Processing Unit

(Refer to Figure 1)

This part of the machine consists of the advanced control (supervisor), delayed control (arithmetic), main arithmetic unit and the fast access memory. All of the other equipment on this drawing is used in an effort to keep the central processor busy. The advanced control looks at each and every order of a given program and decides to:

(1) execute it completely;

(2) execute partially and give to delayed control;

(3) execute partially and give to interplay.

The delayed control looks at all arithmetic orders and logical orders pertaining to the main arithmetic unit and causes their complete execution. The main arithmetic unit is that part of ILLIAC II that performs addition, subtraction, multiplication, division and some logical functions. In most computers this is where the actual problem solving finally takes place. The fast access memory consists of 10 full word registers. This memory has four (4) uses of importance:

(1) Two full word order registers allows a more economic use of core memory.

(2) Four full-words-worth of (1/4) word modifiers make it possible for advanced control to carry out quite rapid index arithmetic.

(3) Two registers assigned to the main arithmetic unit to serve as one in register and one out register.

(4) Two registers assigned as user scratch registers or temporary storage during any one program execution.

The Drum Memory

(Refer to Figure 1)

This part of ILLIAC II contains two magnetic drums. These drums (supplied by a commercial company) are used as a back-up or auxiliary storage for the central processor core memory. Even though the drums were purchased, the completed storage system was designed and built by the Digital Computer Laboratory. This storage unit operates at the rate of approximately 143,000 words per second. Its capacity is 65,536 ILLIAC II words.

ILLIAC II Engineering Console

(Refer to Figure 1)

This "U" shaped table-like structure is a multipurpose part of ILLIAC II. Its main purpose is for engineering maintenance use when there is thought to be something wrong in the computer or a program using the computer. Another use is to house a paper tape reader and punch, used by some people for data input-output. In the developmental phase of the machine it has served as the home for many cards of electronics during the experimental use of various input-output devices.

Interface Channels

(Refer to Figure 1)

These boxes with printed circuit cards are the devices constructed by D.C.L. for the purpose of connecting commercial equipment to ILLIAC channels of interplay. Very typical of these pieces of commercial equipment are the

1301 disk file storage;
729 magnetic tape units;
1401 I.B.M. computer;
P.D.P.-7 communications computer.

The channel directly in front of the window is used as an on-line clock to keep real time for dating output for ILLIAC II.

The 1414 Synchronizer

(Refer to Figure 1)

The four units are commercial devices used to control magnetic tape units. They are attached by cable to the interface channels described above, thus having direct access to ILLIAC II core memory.

Each 1414 can control up to 10 magnetic tape drives. In our system we have only 10 magnetic tape drives total.

The 729 Magnetic Tape Drives

(Refer to Figure 1)

The units are controlled by the 1414 synchronizers making it possible to access the ILLIAC II directly from a reel of tape. There are 12-729 tape drives but two (2) are assigned permanently to the 1401 I.B.M. computer. Ten of the drives are assigned to the ILLIAC II 1414 channels.

Characteristics

	729 V	729 VI
Tape speed (Inches/sec.)	75	112.5
Density (Bits inch)	200 556 800	200 556 800
Character time (Millionth of sec.)	67 24 16	44 16 11
Character rate (Per second)	15,000 41,667 60,000	22,500 62,500 90,000

This means that ILLIAC can read or write words on magnetic tape at the rate of 10,000 to 12,000 per second.

The 1401 Computer

(Refer to Figure 1)

In the ILLIAC II application the 1401 computer consists of:

1 - 1401 - Central processor with 4,000 characters of core storage;

1 - 1402 - Card read-punch, reads cards at 800/min., punches cards at 250/min.;

1 - 1403 - Forms printer, prints 132 character-wide forms at 600 lines/min.;

1 - 1406 - Core storage, making a total of 12,000 characters available to the 1401;

2 - 729(V) - Magnetic tape drives.

This group of equipment is quite a sizeable computer and in many computer departments constitutes the complete computer power. With the ILLIAC II the 1401 system is used to prepare input tapes for execution by ILLIAC II and to print output tapes from ILLIAC II.

The 7631-1301

(Refer to Figure 1)

The 1301 disk file is a quantity storage medium with fairly good random access properties. Our disk storage consists of 2 units (1301) with 2 modules each. This can gives our system approximately 12,000,000 ILLIAC II words of storage. Each disk is controlled by a 7631 (IBM controller) which connects to an interface channel to ILLIAC II.

Characteristics of 1301 Disk File

Capacity - 56,000,000 ch. (2 modules)
10,000 tracks, 2,500 7-bit characters/track
34 millisecond min. } access motion
180 millisecond max. }

This means that at its best the disk when in the process of reading or writing can transfer one character each 14 microseconds.

When the disk file is used with ILLIAC II there is a slight reduction in useful area. Since our block definition is 256 words, this was chosen as the number of ILLIAC II words on each track. This makes each module has a storage of 2,560,000 words or a grand total of 10,240,000 words for "4" modules.

If we return to timing of words/second we will have about 7,550 words per second. This puts the access time close to that of our magnetic tape drive. It also turns out that the capacity of one of our 1301 units is very close to 2 (2400 ft.) rolls of magnetic tape or approximately one reel of tape for one module of the disk file.

The PDP-7-630

(Refer to Figure 1)

These two boxes are combined to form the Satellite Processor Communications System. This system is directly connected to ILLIAC II through an interface channel. The PDP-7 (a general purpose digital computer) will serve as a preprocessor of character information coming from Teletypewriters over Bell phone lines through the 630 unit.

Characteristics of PDP-7

(1) General purpose digital computer
(2) 18 bit word
(3) 8192 words of core storage
(4) Core transfer rate of 570,000 words/sec.
(5) 60 character/sec. paper tape punch
(6) 300 character/sec. paper tape reader

Characteristics of 630

The 630, connected to the PDP-7, is the unit that looks at phone lines for the purpose of interchange of character information. The 630 can look after as many as 64 teletype stations each operating at 10 characters per second. Its total job becomes one of sensing when there is need for service either in the direction of the PDP-7 or of the teletype and making the connections such that the service can be done.

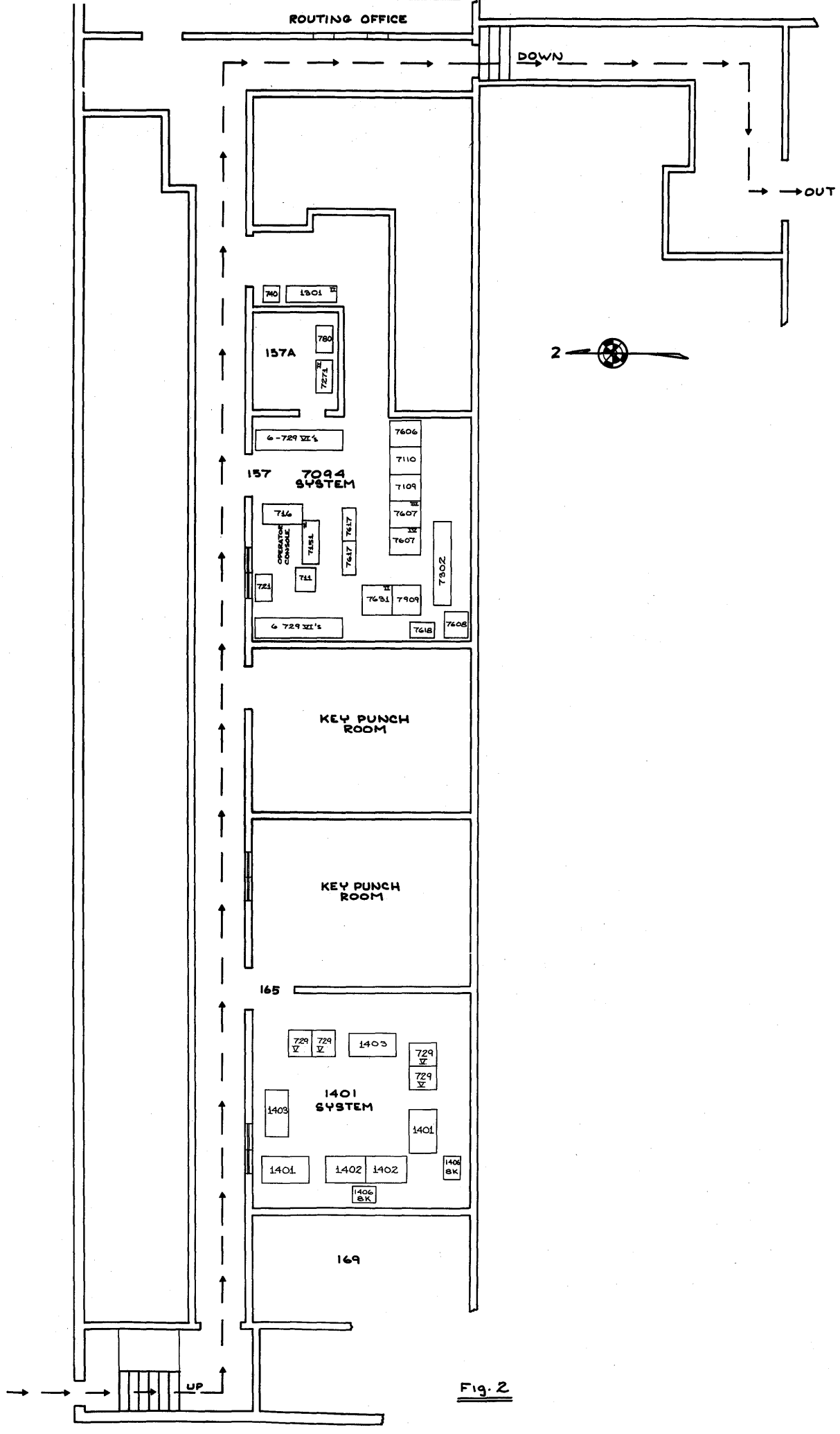
ROUTING OFFICE
DOWN
OUT
2
740
1301
780
157A
7274
6-729 VI's
157
7094
SYSTEM
7606
7110
7109
7607
7607
716
OPERATING CONSOLE
7251
7617
7617
711
721
7302
7631
7909
6 729 VI's
7618
7608
KEY PUNCH ROOM
KEY PUNCH ROOM
165
729 V
729 V
1403
729 V
729 V
1403
1401 SYSTEM
1401
1401
1402
1402
1406 8K
1406 8K
169
UP

Fig. 2

The 7094 - E.R.L. Branch of D.C.S.

This installation is the major service group of the Department of Computer Science as far as the general University user is concerned. It operates on a 24 hour-day/7 day-week basis and handles approximately 1,000 jobs daily. The mode of operation "batch processing" is the method used for handling user jobs. Essentially it goes like this:

(1) A prospective user consults with D.C.S. people for the acquisition of a user-problem-specification number (the user is responsible for his own programming);

(2) The user prepares input decks of I.B.M. cards on the card (electro-mechanical) equipment (supplied by the Department);

(3) These cards are handed in at a central routing room;

(4) The routing room operators prepare batches of cards in category groupings for preprocessing by one of two 1401 (I.B.M.) computers;

(5) The card images are read onto the magnetic tape reels of the 1401's;

(6) The tape reels are processed by the 7094 (I.B.M.) computer with a resulting output tape reel being formed;

(7) The output tapes are postprocessed by the 1401's giving output printed forms and punched cards;

(8) All of the material is returned to the routing room where completed decks and forms are prepared for the user to pick up;

(9) The user returns to the same routing room to claim his decks and forms;

(10) Any and all possible complications that can't be fixed by the user can be referred back to the consulting staff.

The success of this system and this installation has been as good as any in the world. It quite frequently is forced to run behind, mostly, because of the inability of the 1403 printers to keep up with the 7094 output printing load.

1401 (I.B.M.) Computers

(Refer to Figure 2)

This room contains the following:

2 each	1401	Central Processors
2 each	1402	Card Read-Punch
2 each	1403	Output Printers
4 each	729	Magnetic Tape Drives
1	1406	Magnetic Core Storage

These units are associated together such that two completely separate 1401 (I.B.M.) systems are usable as (card to tape - tape to card and forms) processors. These are operated completely as off-line computers and are not subject to being switched to on-line 7094.

Key Punch Rooms

The two rooms separating the 1401's from the 7094 are used as card preparation rooms by D.C.S. people as well as any and all users that need their service.

7094 (I.B.M.) Computer Complex

The complex is made up of:

7101	- Arithmetic	} Central Processor
7110	- Control (instruction)	} Central Processor
7302	- Core Storage (32,768 words)	
7607 III	- Data Channel A	
7607 IV	- Data Channel B	
7606	- Multiplexor	
7909	- Data Channel for Disk File (Channel E)	
7631 II	- Disk File Control	
1301 II	- Disk File	
2 each 7617	- Data Channel Consoles for Channel A and B	
10 each 729 VI	- Magnetic Tape Drives	
7151 II	- Operator Control Console	
711	- Card Reader on Channel A	
716	- Printer on Channel A	

721 - Punch on Channel A

7271 II - Cathode Ray Tube Adapter Unit

780 - Cathode Ray Tube Display

740 - Cathode Ray Tube Camera

7608 - 400 C.P.S. Power Converter

7618 - Power Controller

Central Processor (7109 - 7110)

These two parts of the 7094 system combine to form the central processor. In these parts of the machine the individual orders are decoded and the arithmetic (36 bit word) and logic processing is performed. Almost all other parts of the 7094 complex exist only to serve this central processor area. Important characteristics of the central processor are:

(1) Floating point multiplication can be completed in 10 μsec. -- or another way to say it is -- that 100,000 such multiplications can be accomplished in one second;

(2) Fixed-point addition can be completed in 4 μsec. or 250,000 such additions can be accomplished in one second;

(3) Seven index registers are used in modifier arithmetic to facilitate better economy in order execution.

Core Storage - 7302

This (I.B.M.) magnetic core storage has the capacity of 32,768 - bit words. Its operating cycle speed is 2 μsec./word or a speed of transfer of 500,000 words/sec. This means that if given a comparable store it could exchange total core loads at a rate of 15 times each second.

Data Channels - 7607

The channels are similar to ILLIAC II interplay channels. They are data paths which allow the central processor to service various input-output devices with a high degree of speed economy.

Multiplexor - 7606

This hardware item has the function of actually handling the data channels. It is specified such that it can operate at a speed equal to the sums of the individual device speeds of the channels serviced. The true time economy is involved with it.

Disk File - 7909, 7631, 1301

These boxes (in the 7094 complex) combine to form the disk file storage. This disk is the same as the one described under ILLIAC II. Its characteristics can be gotten from there.

Cards and Forms Out - 711, 716, 721

The 711 is a relatively slow I.B.M. card reader on-line to the 7094. Its use is very special purpose because the total system is geared to magnetic tape in and out. Primarily, it serves as an input card reader to bootstrap the operating system.

The 716 is a slow speed printer used as an operator console typewriter for system messages and execution listing.

The 721 card punch serves as a convenient output for user process time cards. The cards give an indication of how much time the 7094 system has spent in taking care of any one user.

Scope and Camera Output - 7271, 780, 740

These individual parts make it possible for the user to request a display of his output on a Cathode Ray Tube. A visual examination of the CRT face can give the user a feel for how well his output is doing. The camera (35 mm.) can record those frames that he desires to have on film.

Power - 7608, 7618

As is true with most University electrical and electronic devices the 7094 gets its power from the University power plant through the regular distribution lines. In the case of the 7094 and many other commercial computers the final use of this power is quite varied. In this system there are such uses as:

110 volts	60 cycles/sec.
208-220 volts	60 cycles/sec.
208 volts	400 cycles/sec.

The 7608 is a converter. It converts 208/60 cps to 208/400 cps.

The 7618 is a controller unit used for purposes of distribution and variation of the voltages to the individual boxes making up the 7094 system.

CEC/med
3/2/66