

### APPLICATIONS

Scientific computation and analysis.

### NUMERICAL SYSTEM

Internal number system	Binary coded decimal
Decimal digits per word	10 + sign
Decimal digits per instruction	7
Instructions per word	1
Instructions decoded	21
Instructions used	21

Arithmetic system Variable fixed decimal point location, can be set to any of 11 digit positions initially. It must remain at this location during any given sequence of operations, in order to obtain consistent results.

Instruction type Two-address (The machine originally was a one-address machine). The modification to a two-address machine facilitated access to storage and permitted execution of special instructions with significant savings in time.

Number range Variable  $\pm (10^{10} - 1)$

Number system used is the 2\*-4-2-1 system.

### ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add time	400-17,000	91
Mult time	10,000-26,000	800
Div time	10,000-26,000	1,200
Construction	400 Vacuum tubes 2,500 Diodes	
Basic pulse repetition rate	150 Kc/sec	
Arithmetic mode	Serial by char, parallel by bits	
Timing	Synchronous	
Operation	Sequential	

### STORAGE

Media	Words	Digits	Microsec Access
Magnetic Drum	10,000	110,000	1,000-17,000
Magnetic Tape	7,200 per 1,200 ft. tape		

### INPUT

Media	Speed
Magnetic Tape	1,000 words/min
Keyboard	Manual

Keyboard is located on main control panel.

### OUTPUT

Media	Speed
Magnetic Tape	1,000 words/min

Contents of tape translated by an off-line code transcriber and typewriter.

### CIRCUIT ELEMENTS ENTIRE SYSTEM

Tubes	1,200
Tube types	12
Crystal diodes	7,000
Separate cabinets	2

Computer is housed in one cabinet and the magnetic drum is housed in another cabinet.

### CHECKING FEATURES

Exceed capacity  
Unprogrammed stop  
Wrong combination  
Synchronized tape  
Divide by zero  
Product exceed capacity  
Tape runout, power and cooling failure fault checks.

### POWER, SPACE AND WEIGHT

Power, computer	23 KVA
Space, computer	600 cu. ft. 80 sq. ft.
Weight, computer	6,000 lbs.
Capacity, air cond.	10 Tons

The two cabinets measure 15 by 2.5 by 7 ft. and 4 by 5 by 6 ft.

### PRODUCTION RECORD

Produced	1
In production	1

This system was developed on a Research and Development contract for the Air Force.

### COST, PRICE AND RENTAL RATE

Approximate cost of basic system \$185,000

### PERSONNEL REQUIREMENTS

Daily Operation	Engineers	Tech and Operators
1-8 Hour shift	1	1
2-8 Hour shifts	1	2
3-8 Hour shifts	1	3

Engineer is on 24-hour call. Normally, he is present on the first shift.

## RELIABILITY AND OPERATING EXPERIENCE

Average error-free running period	15 hours
Good time	13,686 hours
Attempted to run time	16,733 hours
Operating ratio (Good/Attempted to run)	0.82

Figures based on period April 1953 to April 1956.  
Acceptance test April 1953.

## FUTURE PLANS

A new machine, which will have the following features, is being constructed for use in conjunction with OARAC:

The new machine will use the same codes and commands as OARAC in order that problems may be interchanged between machines without difficulty.

The problem exists with most computer installations that a considerable amount of machine time is required for checking out problems and it is planned to compensate for this by using the new machine, which will be faster than OARAC, for running checked-out problems only. All problems to be checked will be put on OARAC before being placed in the new machine.

The new machine will use a 10,000 word core memory, will be able to perform additions in 65 micro-seconds, excluding access time or in 130 micro-seconds, including access time and playback of the next instruction, multiply in 2.6 milli-seconds and divide on an average of 6 milli-seconds. This will result in an operating time savings of approximately 25 to 1 for most programs.

Consideration is also being given to allow a direct transfer of information from the OARAC Magnetic Drum memory to the Magnetic Core memory of the new machine, thus resulting in a considerable reduction in magnetic tape write and read times.

## INSTALLATIONS

Aeronautical Research Laboratory  
Wright Air Development Center  
Wright-Patterson Air Force Base, Ohio

# ORACLE

Oak Ridge Automatic Computer  
Logical Engine

## MANUFACTURER

Oak Ridge National Laboratory and  
Argonne National Laboratory



Picture by Oak Ridge National Laboratory

### APPLICATIONS

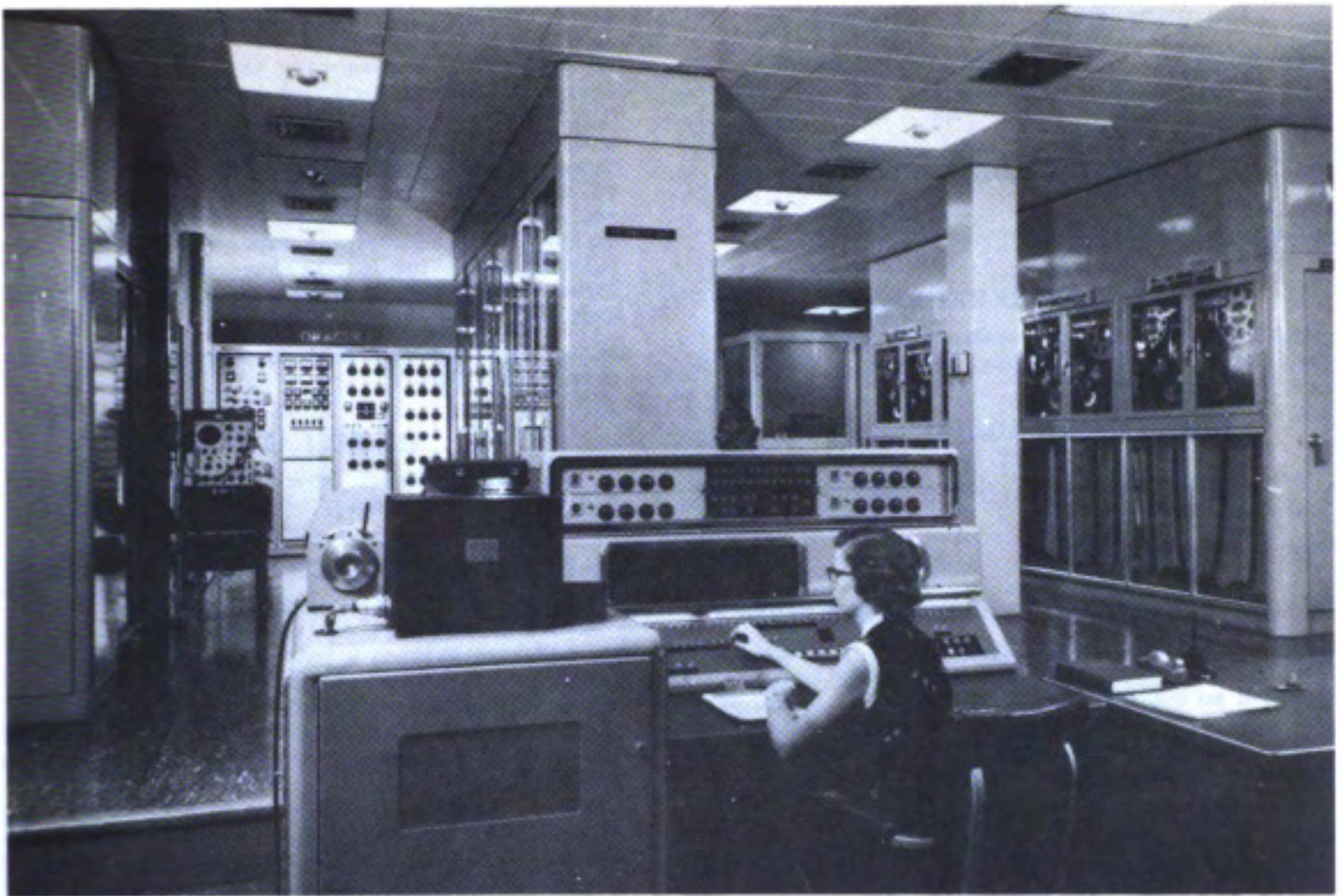
Scientific and engineering calculations

#### NUMERICAL SYSTEM

Internal number system	Binary
Binary digits per word	40
Binary digits per instruction	20
Instructions per word	2
Instructions decoded	103
Instructions used	103
Arithmetic system	Fixed point
Instruction type	One address
Number range	$-1 \leq n \leq 1 - 2^{-39}$

#### ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add time	50	10
Mult time	280 - 480	240 - 440
Div time	480	440
Construction	1,800 tubes	
Rapid Access word registers	4	
Arithmetic mode	Parallel	
Timing	Synchronous in storage and asynchronous in arithmetic.	
Operation	Sequential. Concurrent in magnetic tape hunting operations.	



Picture by Oak Ridge National Laboratory

### STORAGE

Media	Words	Digits	Microsec Access
Electrostatic (CRT)	2,048	83,968	18
Magnetic Tape	4,000,000	168,000,000	

The CRT's are RCA type 6571. The storage cycle time includes address selection, reading and rewriting. The magnetic tape is 2 inches wide. The tape information rate is 200 microsec/word with full redundancy. The standard stop time is 5 millisecc, the tape speed is 50 in/sec and the packing density is 200 pulses/inch.

### INPUT

Media	Speed
Paper Tape	200 char/sec

The paper tape reader is photoelectric. A seven-level tape for alphanumeric characters with a parity check is being installed.

### OUTPUT

Media	Speed
Paper Tape	60 char/sec
CRT	2,000 char/sec

The paper tape is teletype tape. The CRT plots points and characters on 35 mm. film, requiring 10 microseconds per point. A console typewriter and a 1,000 char/sec magnetic tape are being added.

### CIRCUIT ELEMENTS ENTIRE SYSTEM

Tubes	5,000
Tube types	50
Crystal diodes	125
Transistors	84
Separate cabinets	5

Half of the tube complement is distributed among 5 types.

### CHECKING FEATURES

Fixed  
Odd - even parity check on electrostatic storage, tape storage, and input-output equipment. Magnetic tape uses duplicate recording of all digits.

## POWER, SPACE AND WEIGHT

Power, computer	60 KW	0.9 PF
Space, computer	1,500 cu. ft.	1,600 sq. ft.
Capacity, air cond.	21 Tons	

## PRODUCTION RECORD

Produced	1
Operating	1

## COST, PRICE AND RENTAL RATE

Approximate cost of basic system \$700,000  
Approximate cost of additional equipment \$200,000

## PERSONNEL REQUIREMENTS

Daily Operation	Engineers	Tech and Operators
3-8 Hour shifts	2	5

Seven days/week operation

## RELIABILITY AND OPERATING EXPERIENCE

Average error-free running period	4 hours
Good time	3,869 hours
Attempted to run time	4,252 hours
Operating ratio (Good/Attempted to run)	0.91
Figures based on period	July 1955 to July 1956
Acceptance test	1 Sept. 1955

## FUTURE PLANS

New paper tape and magnetic tape processing equipment will be installed in the very near future. An important unit of the paper tape system will be a small compact console at which all the required paper tape preparation can be executed. This unit provides facilities for transcription, verification, reproduction, correction and assembly for paper tape. Narrow (5/8 inch) magnetic tape will be used as a fast output device (1,000 char/sec) and transcribed directly into an IBM typewriter without buffering storage.

Parity checking will be incorporated into all input-output equipment

## INSTALLATIONS

Oak Ridge National Laboratory  
P. O. Box X, Oak Ridge, Tennessee

## ADDITIONAL FEATURES AND REMARKS

Two operating modes are possible in the ORACLE. Mode 1 is the 1024 word mode in which time multiplex is used between a pair of Williams tubes to determine the stored information for each bit. When either tube reads a dash signal, a dash is replenished to both. This method overcomes the most common type of screen blemish which would prevent storage of a "1" (dot-dash).

Mode 2 is the 2048 word mode in which each tube stores 1024 bits. The first tube is regenerated in the first half of a major cycle and the second tube in the second half.

IAS type computer.



# ORDFIAC

Ordnance Fiscal and Inventory  
Automatic Computer (EIECOM 200)

## MANUFACTURER

Electronic Computer Division  
Underwood Corporation



Picture by Major Item Supply Agency, Letterkenny Ordnance Depot

### APPLICATIONS

Logistic and supply problems, general research in ordnance engineering, data handling and processing, computation of supply requirements.

### NUMERICAL SYSTEM

Internal number system	Bin coded dec
Decimal digits per word	8
Decimal digits per instruction	16
Instructions per word	One half
Instructions decoded	10
Instructions used	10
Arithmetic system	Fixed point
Instruction type	Three address
Number range	$.00000001 \leq n \leq .99999999$

The "excess three" binary code is used. The 10 instructions are used with variations.

### ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add time	81,100	1,685

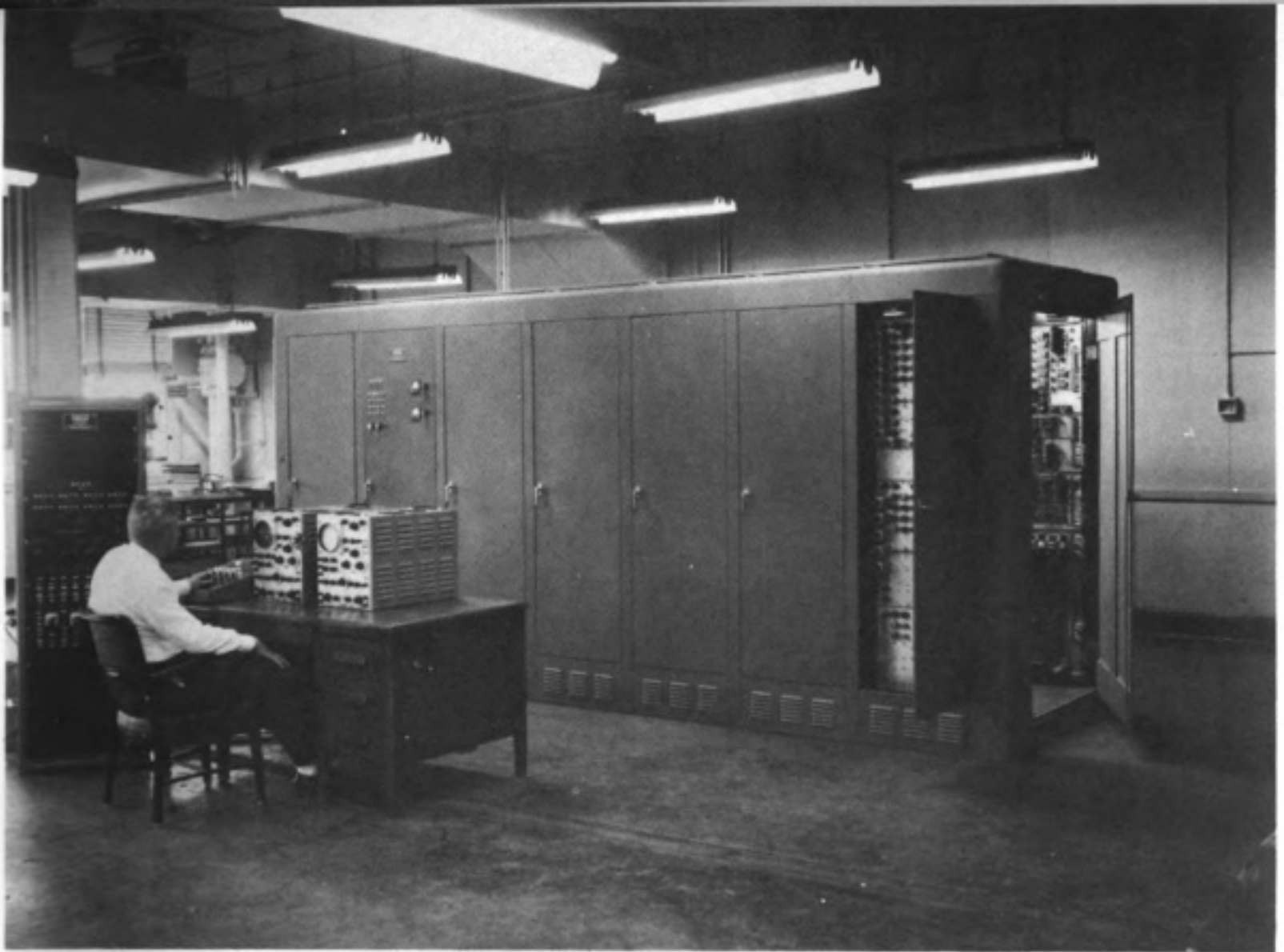
Mult time	91,900	16,513
Div time	97,000	21,568
Construction	Vacuum tubes	

Rapid access word registers	5
Basic pulse repetition rate	105 Kc/sec
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

Square root requires 7,400 microsec. Above operation times are average values. Arithmetic and logical instructions must wait for completion of input and output instructions. A special vector operation  $(a \times b_j) + c_j$ , for  $j$ 's from 1 to 99, can be performed in 1.7 sec, max. Vacuum tubes used are 12AT7, 6AG7, 2050 and 12AU7.

### STORAGE

Media	Words	Digits	Microsec Access
Magnetic Drum	10,000	80,000	337 min



Picture by Major Item Supply Agency, Letterkenny Ordnance Depot

Drum speed is 1800 RPM

### INPUT

Media	Speed
IBM 523 (Read-Punch)	100 cards/min (Max)
Two units, speed dependent on number of cards to be punched	

### OUTPUT

Same as Input

### CIRCUIT ELEMENTS ENTIRE SYSTEM

Tubes	600
Tube types	6
Crystal diodes	6,500
Separate cabinets	14 (Bolted together)

### CHECKING FEATURES

Fixed - Validity check, storage switch checks for disallowed numbers.  
 Optional - Program stop code, break point halt, transfer halt.

### POWER, SPACE AND WEIGHT

Power, computer	6 KVA
Space, computer	700 cu. ft. 80 sq. ft.
Frontage, width, height	16 x 5 x 7 1/2 ft.

### PRODUCTION RECORD

Produced	1
Operating	1
Time required for delivery from receipt of order was approximately 30 months.	

### COST, PRICE AND RENTAL RATE

Approximate cost of basic system \$200,000  
 Rental rates of additional equipment \$1,365/month

### RELIABILITY AND OPERATING EXPERIENCE

No temperature control has been installed  
 Acceptance test July 1954

### FUTURE PLANS

System will be used for general research in ordnance engineering

### INSTALLATIONS

This system has recently been transferred from the Major Item Supply Management Agency (MISMA) Letterkenny Ordnance Depot Chambersburg, Pa.

to  
 Picatinny Arsenal  
 Dover, New Jersey

Personnel requirements. One 8 hour shift requires 2 Engineers, 2 Technicians or Operators and 5 Programmers. Two 8 hour shifts require 3 Engineers, 3 Technicians or Operators and 8 Programmers.

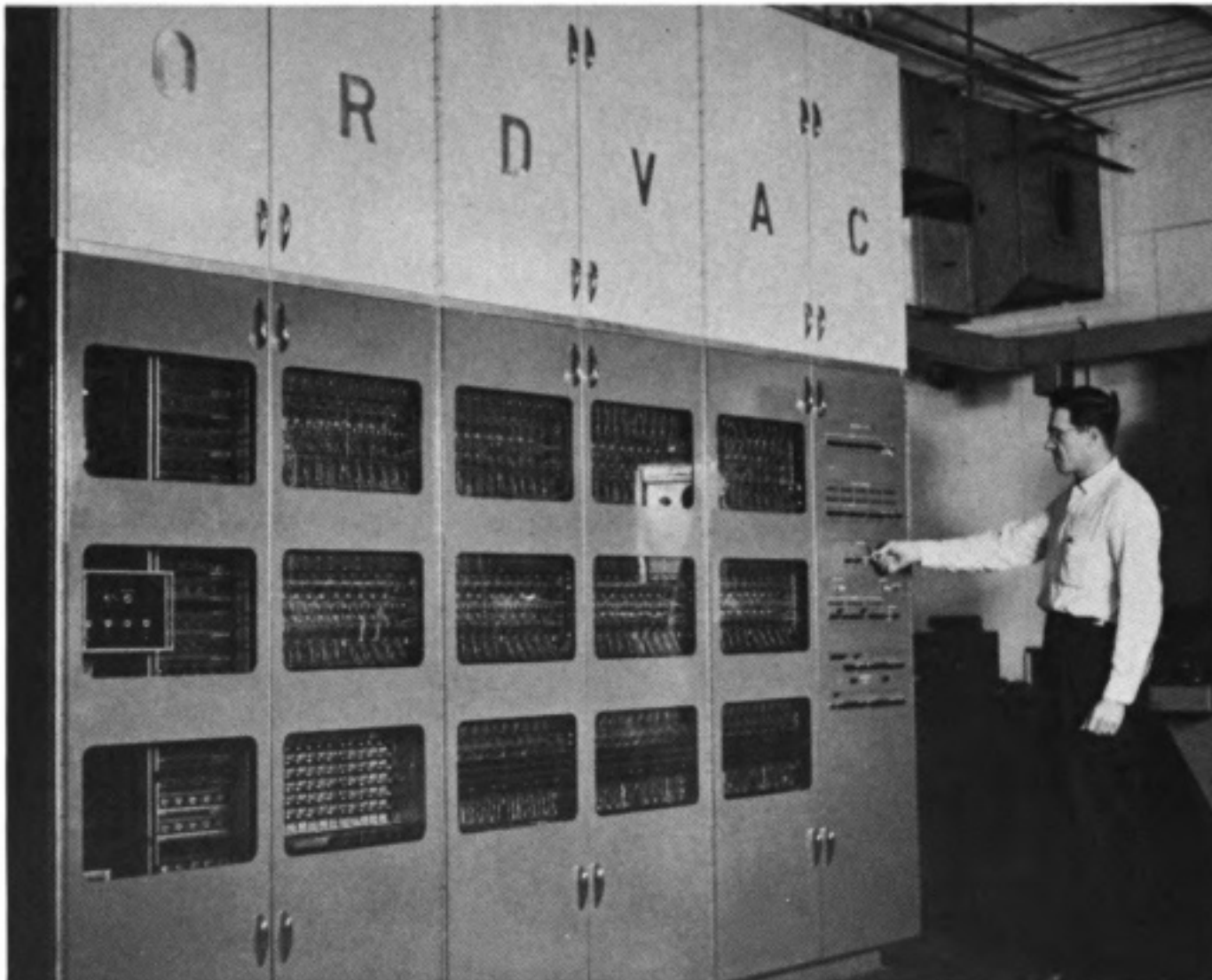


# ORDVAC

Ordnance Variable Automatic Computer

## MANUFACTURER

University of Illinois



Picture by Ballistic Research Laboratories

## APPLICATIONS

### Government

#### Ballistic Research Laboratories

Solution of ballistic equations; bombing and firing tables; fire control; data reduction; related scientific problems. A general purpose computer which may be used for solving many varieties of mathematical problems.

## NUMERICAL SYSTEM

Internal number system	Binary
Binary digits per word	40
Instructions per word	2
Instruction type	One Address
Binary digits in operation code	6 or 9
Binary digits in address	12 or 10
Instructions used	55 or 72
Arithmetic system	Fixed point
Number range	$-1 \leq x < 1$

Sexadecimal representation is used externally.

Negative numbers are handled as 2 complements. Floating point operation may be programmed.

Dual code - ORDVAC operates on a dual code basis. The codes are, on a two instructions per word basis, i.e. 20 digits per instruction:

Code A - 1,024 words of storage:

- 9 digit, command
- 1 digit, spare
- 10 digit, address

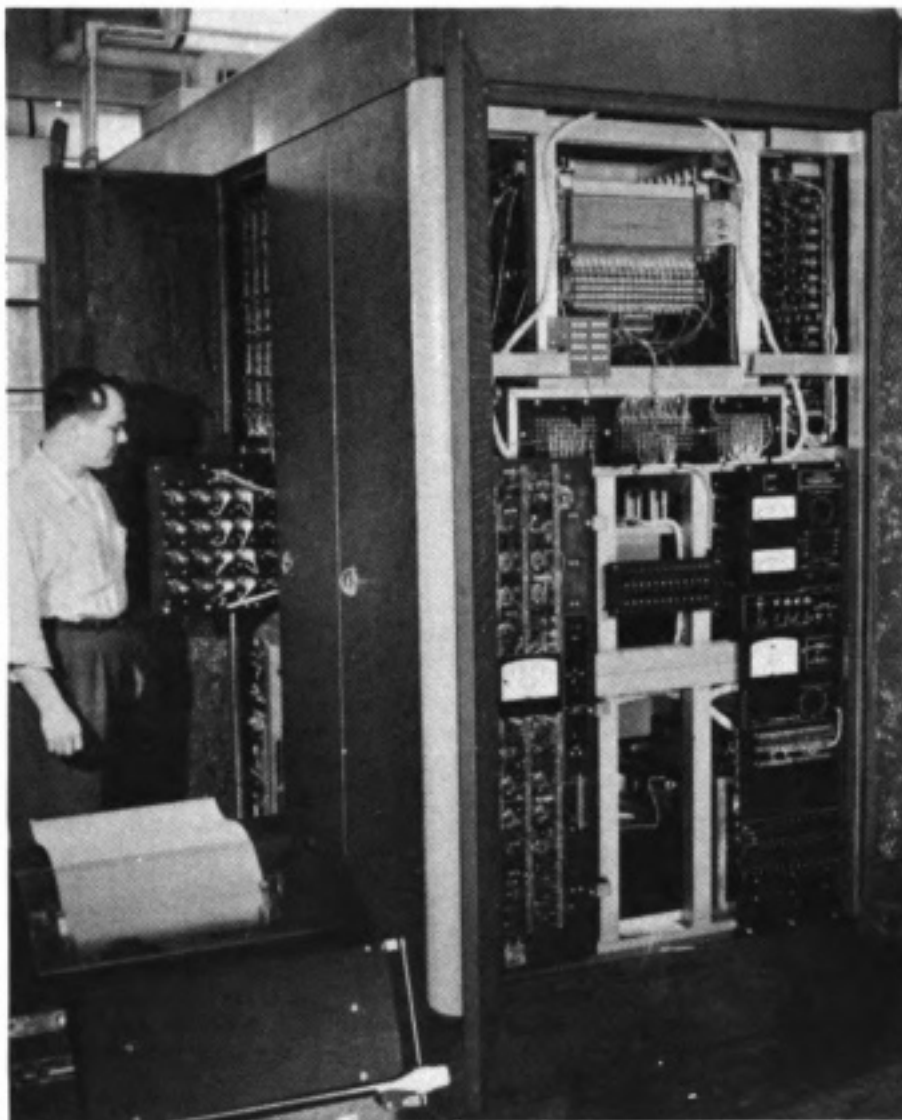
Code B - 4,096 words of storage:

- 6 digit, command
- 2 digit, spare
- 12 digit, address

This system permits utilization of routines developed previous to the 4,096-word operation change over.

## ARITHMETIC UNIT

Arithmetic mode	Parallel
Basic pulse rate	Not pulse controlled
Construction	Vacuum tubes
Rapid Access word registers	3



Picture by Ballistic Research Laboratories (Magnetic Core Storage)

Add time (exclud. stor. access) 50 microsec  
 Multiply time (exclud. stor. access) 750 microsec  
 Divide time (exclud. stor. access) 1,000 microsec  
 The shift time is 16  $\mu$ s. in the registers. Above times are average.  
 Timing Asynchronous  
 Operation Parallel

### STORAGE

Media	Words	Digits	Access
Magnetic core	4,096	163,840 bits	15 microsec
Magnetic drum	10,032	401,280 bits	80,000 " /48 words

Magnetic drum purchased from ERA Division of Sperry Rand, Incorporated. Magnetic core storage unit purchased from Telemeter Magnetics, Incorporated. Both above storage units adapted to ORDVAC and installed by Ballistic Research Laboratories personnel.

### INPUT

Media	Speed
Teletype tape (5 hole)	2.5 words per sec
Punched cards	40 words per sec (bin) 8 words per sec (dec)

### OUTPUT

Media	Speed
Teletype page printer	0.4 words per sec
Teletype tape	0.4 words per sec
Punched cards	40 words per sec (bin) 8 words per sec (dec)

Transistorized magnetic core contents display.

### CIRCUIT ELEMENTS ENTIRE SYSTEM

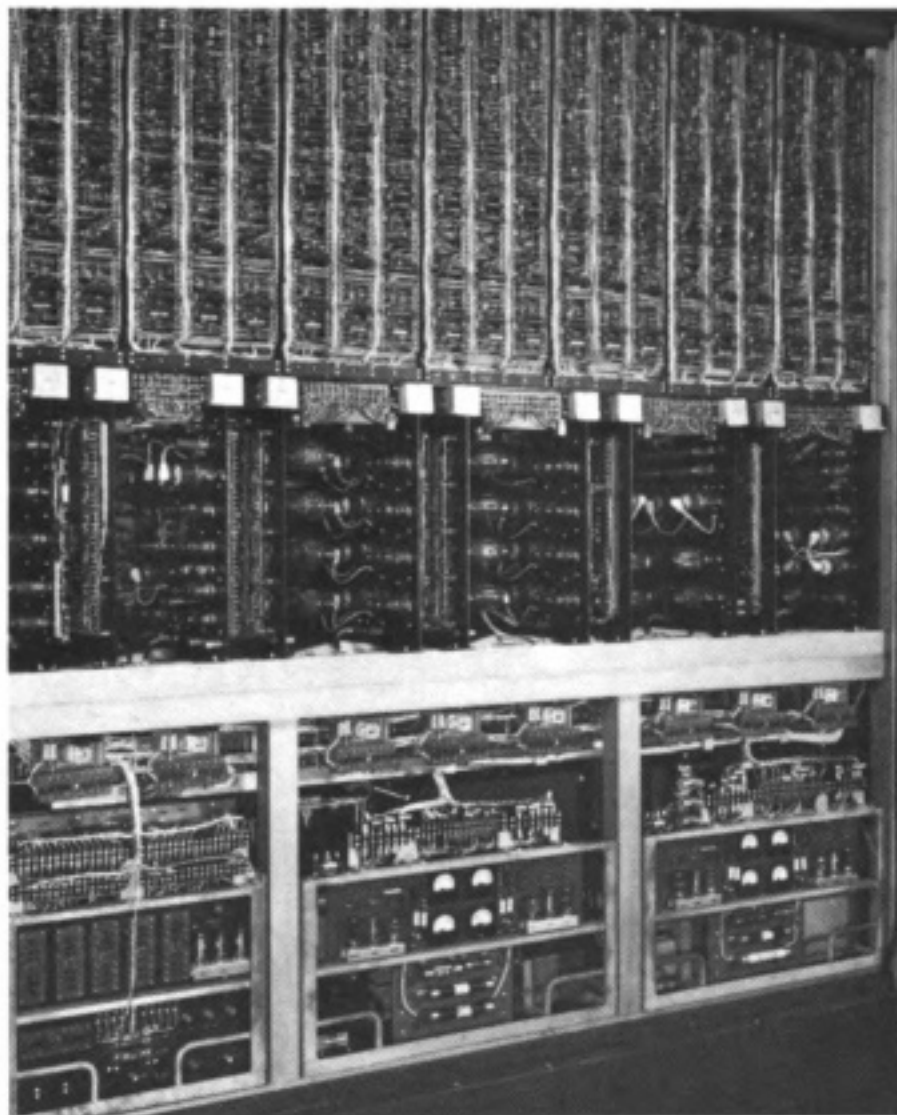
Tubes	3,324
Tube types	20
Crystal diodes	280
Transistors	250
Cores	177,408

### POWER, SPACE AND WEIGHT

Power Consumption, Computer	40 K.W.
Space occupied, Computer	630 cu. ft. 80 ft.
Total weight, Computer	3,000 lbs.
Capacity, air conditioning	15 tons

### PRODUCTION RECORD

Number produced to date	1
Number in current operation	1



Picture by Ballistic Research Laboratories (Magnetic Core Storage, internal view)

### COST, PRICE AND RENTAL RATE

Rental rates for additional equipment  
\$648.57 per month

The additional rented equipment is:

I.B.M. punch	\$ 83.32 per month
I.B.M. reader	\$ 82.50
I.B.M. reproducer	\$122.50
I.B.M. tabulator	\$360.25

### PERSONNEL REQUIREMENTS

Daily operation	No. of Tech.
3-8 hour shifts	8

No engineers are assigned to the operation of the machine; but are used for development and design of additions to the machine. The technicians consult the engineers when a total break-down occurs.

### RELIABILITY AND OPERATING EXPERIENCE

Average error-free running period	Approx. 6 hours
Good-time	4,915 hours
Attempted to run time	8,736 hours (All time)
Operating ratio	0.57

Above figures are based on the period from 1 January 1956 to 28 December 1956. The 3,821 hours of engineering time includes testing, servicing, bad

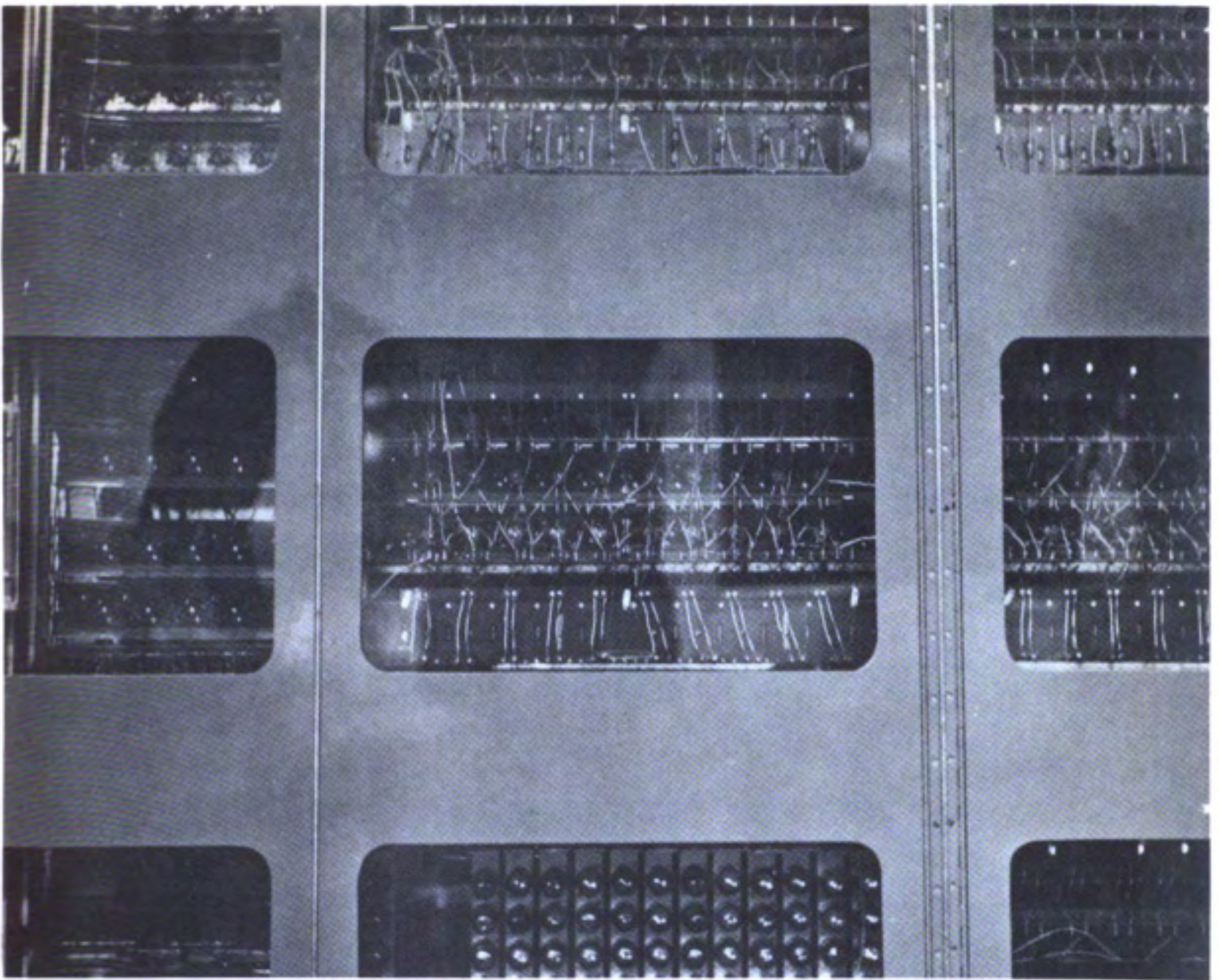
operation time, general machine improvement and the incorporation of new components. A major portion of this time was utilized for replacing the 1,024-word electrostatic storage unit with the 4,096-word magnetic core storage unit. The 4,915 hours was good time during which production, code checking or duplication were performed.

### ADDITIONAL FEATURES AND REMARKS

The ORDVAC belongs to the group of computers whose basic logic was developed by the Institute for Advanced Study and utilized in the IAS computer. This IAS family of computers is made up of such machines as the ILLIAC, ORACLE, AVIDAC, MANIAC and the JOHNNIAC.

The ORDVAC is a direct-coupled machine using three-dimensional construction. A direct-coupled machine is one that connects the voltage level of one component directly to the input of the next, without voltage isolation between. This feature is very helpful in trouble-shooting the system. Three-dimensional construction is sometimes called low-capacitance wiring. In the ORDVAC, three-dimensional wiring is employed by placing the arithmetic unit and other controls on opposite sides, and inter-connected wiring running across the open space between. The machine can be remotely controlled from commercial Teletype units.

The following items are in process of being install-



Picture by Ballistic Research Laboratories (Arithmetic Unit)

ed or are being considered for installation:  
 High-speed Ferranti paper tape reader  
 Magnetic tape  
 High-speed card reader  
 Transistor Track Selector for magnetic drum

ORDVAC is equipped with the option of two different instruction codes. Code -9 (nine bits per instruction) makes 1,024 words of high speed core storage available to the operator while Code -6 (six bits per instruction) makes 4,096 words of high speed storage available. Each code shares a common nine-bit decoder; however, when the code -6 option is used the instruction first passes through a code translator which translates the six bit instruction into its 9-bit equivalent. There is no loss of time while making the code translation.

The translator uses the following number of circuit elements

Transistors			
SB 100	135		
2N 43	24		
2N 140	<u>12</u>	171	
Crystal diodes		253	
Resistors		305	
Capacitors		23	

The above components are mounted on 21 printed circuit boards. Power dissipation is approximately 5 watts.

Ballistic Research Laboratories  
 Aberdeen Proving Ground, Maryland